5th International Symposium on Sensor Science

AXA Convention Centre

Barcelona, Spain

27-29 September 2017

Conference Chair

Arben Merkoçi

Session Chairs

Dermot Diamond

Evgeny Katz

Jandro L. Abot

Stefano Mariani

Vladimir M. Mirsky

Organised by

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CONTENTS

5th International Symposium on Sensor Science
27-29 September 2017, Barcelona

	Wednesday 27 September 2017	Thursday 28 September 2017	Friday 29 September 2017
Morning	Check-in	S3. Bio-inspired and Bio-based Strategies for Sensing and Fluidics Chair Dermot Diamond	S4. Sensors for Structures Chair Jandro L. Abot
Morning	Program Overview and Introduction Chair Arben Merkoçi		
Morning		**Coffee Break**	
Morning	S1. Biosensors *(Part 1)* Chair Evgeny Katz	S3. Bio-inspired and Bio-based Strategies for Sensing and Fluidics	S4. Sensors for Structures
	Lunch & Poster Session		
Afternoon	S2. Chemosensors Chair Vladimir M. Mirsky	S1. Biosensors *(Part 2)* Chair Evgeny Katz	S5. Sensors Applications Chair Stefano Mariani
	Coffee Break		
Afternoon	S2. Chemosensors	S1. Biosensors	S5. Sensors Applications
		Conference Dinner	**Awards Ceremony**

Wednesday 27 September 2017: 08:30 - 10:15 Check-in / 10:15 - 12:45 / 14:00 - 18:00

Thursday 28 September 2017: 08:30 - 13:00 / 14:00 - 18:15 / Conference Dinner: 20:30

Friday 29 September 2017: 08:30 - 12:45 / 13:45 - 18:00

Symposium Programme

Wednesday 27 September

08:30 – 10:15	Check-in
10:15 – 10:30	Introduction and Program Overview by Arben Merkoçi
	Session 1 – Biosensors (*Part 1*) Chair: Evgeny Katz
10:30 – 11:15	**Jose M. Pingarrón – Keynote Speaker** "Improving Cancer Outcomes Through Electrochemical Biosensing of Early Diagnosis/Prognosis Biomarkers in Human Biopsies"
11:15 – 11:45	**Lital Alfonta** "Genetically Engineering of Enzymes and Electrode Modifications for Biosensing Applications"
11:45 – 12:15	**Michael J. Schöning** "Label-Free DNA Detection with Capacitive Field-Effect Devices—Challenges and Opportunities"
12:15 – 12:30	**Manel del Valle** "Molecularly Imprinted Polymers for TNT Analogues. Development of Electrochemical TNT Biosensors"
12:30 – 12:45	**So Yamamoto** "Redox Cycling Realized in Paper-based Electrochemical Biosensor for highly-selective Detection of Potassium Ferrocyanide in the presence of Ascorbic Acid"
12:45 – 14:00	Lunch and Poster Session

Session 2 – Chemosensors
Chair: Vladimir M. Mirsky

14:00 – 14:45	**Kenneth S. Suslick – Keynote Speaker** "The Optoelectronic Nose"
14:45 – 15:00	**Fabio Di Francesco** "Disposable Sensors for Monitoring Chronic Wounds"
15:00 – 15:15	**Irene Lara-Ibeas** "Conception and Development of Microfabricated Elements for Microfluidic Analytical Devices"
15:15 – 15:30	**Andrea Gaiardo** "Silicon Carbide: a Gas Sensing Material for Selective Detection of SO2"
15:30 – 15:45	**Luigi Zeni** "SPR Chemosensors Based on D-shaped POFs and MIPs: Investigation on Optimal Thickness of the Buffer Layer"
15:45 – 16:15	Coffee Break
16:15 – 16:45	**Thomas Hirsch** "Two-dimensional Carbon Nanomaterials for Electrochemical and Plasmonic Sensing Applications"
16:45 – 17:00	**Matteo Valt** "Room Temperature Chemoresistive Gas Sensor Based On Organic-Functionalized Graphene Oxide"
17:00 – 17:30	**Vladimir M. Mirsky** "Detection of Single Sub-Micrometer Objects of Biological or Technical Origin Using Wide Field Surface Plasmon Microscopy"
17:30 – 18:00	**Radislav A. Potytailo** "High Value Chemosensors in the Era of Industrial Internet: Innovations in Materials, Transducers, and Data Analytics"

Thursday 28 September

Session 3 – Bio-Inspired and Bio-based Strategies for Sensing and Fluidics
Chair: Dermot Diamond

08:30 – 09:15	**Jaap den Toonder – Keynote Speaker** "Bio-inspired and Bio-based Strategies for Sensing and Fluidics"
09:15 – 09:30	**Larisa Florea** "Stimuli-Controlled Manipulation of Synthetic Micrometre-Sized Vehicles for Bio-inspired Fluidics"
09:30 – 10:00	**Francisco Javier Andrade** "Potentiometry, Nanostructured Materials and the Emergence of Paradigm-shifting Analytical Platforms"
10:00 – 10:30	Coffee Break
10:30 – 11:00	**Luis Fermín Capitán-Vallvey** "Coupling Sensing and Imaging Devices: Towards a Complete Handheld Analytical System"
11:00 – 11:15	**Margaret McCaul** "Wearable Sensor for Real-Time monitoring of Electrolytes in Sweat"
11:15 – 11:45	**Huangxian Ju** "In Situ Biosensing of Cancer-Related Cellular Biomolecules"
11:45 – 12:00	**Augusto Márquez** "Portable and Miniaturized Lab on a Chip with Regenerable Membrane for Sanitary Emergencies"
12:00 – 12:15	**Shadi Karimi** "Microfluidic Enabled Portable ABO Reverse Typing Sensor"
12:15 – 12:30	**Maciej Cieplak** "Semi-Covalent Imprinting for Selective Protein Sensing at a Femtomolar Concentration Level"
12:30 – 13:00	**Dermot Diamond** "Stimuli-Responsive Materials and Biomimetic Fluidics: Fundamental Building Blocks of Chemical Sensing Platforms with Futuristic Capabilities"
13:00 – 14:00	Lunch and Poster Session

Session 1 – Biosensors (*Part 2*)
Chair: Evgeny Katz

14:00 – 14:45	**Wolfgang Schuhmann – Keynote Speaker** "From Reagentless Biosensors to Biofuel Cells and Self-Powered Bioelectrochemical Devices"
14:45 – 15:15	**Marcos Pita** "ATP Synthesis and Biosensing Coupled to the Electroenzymatic Activity of a Hydrogenase on an Electrode/Biomimetic Membrane Interface"
15:15 – 15:45	**Dmitry Kolpashchikov** "Nucleic Acid Analysis Using Multifunctional Hybridization Sensors"
15:45 – 16:00	**Riccarda Antiochia** "A Comparative Study between Hydrogen Peroxide Amperometric Biosensors Based on Different Peroxidases Wired by Os-polymer: Applications in Water, Milk and Human Urine"
16:00 – 16:15	**Yulia Gerasimova** "Split Deoxyribozyme Sensors for Pathogen Detection"
16:15 – 16:45	Coffee Break
16:45 – 17:00	**Yuri Arutyunov** "The Development of the "Sleeping Gene" Type Biosensor as a Method to Increase the Efficiency of the Magnetocardiograph Performance"
17:00 – 17:15	**Denise Molinnus** "Development of a Biosensor for the Detection of Acetoin during Wine Fermentation"
17:15 – 17:30	**Thomas Knieling** "Printed and Flexible Electrochemical Lactate Sensors for Wearable Applications"
17:30 – 17:45	**Mehmet Özsöz** "Electrochemical and SERS Based Biosensors for Cancer Biomarkers Detection"
17:45 – 18:15	**Evgeny Katz** "Integration of Biomolecular Sensing, Logic Processing of the Signals and Actuation"
20:30	**Conference Dinner**

Friday 29 September

Session 4 – Sensors for Structures
Chair: Jandro L. Abot

08:30 – 09:15	**Thomas Schumacher – Keynote Speaker** "Development of Self-Sensing Carbon Nanotube-based Composites for Civil Infrastructure Applications"
09:15 – 09:45	**Tommy Chan** "Recent Advances in Using Sensors for Structural Health Monitoring for Civil Structures"
09:45 – 10:15	**Dirk Lehmhus** "Linking Additive Manufacturing and Sensor Integration: A Direct Path towards Structural Electronics?"
10:15 – 10:45	Coffee Break
10:45 – 11:15	**Christophe Delebarre** "Innovative Aeronautical Structural Health Monitoring Ultrasonic Sensor: from Autonomy to High Sensibility"
11:15 – 11:30	**Miguel Vicente** "A Novel Laser- and Video-Based Displacement Measurement System to Monitor Vertical Deflections in Bridges"
11:30 – 11:45	**Guido Luzi** "Microwave Sensors to Monitor the Displacement of Civil Structures: Recent Experimental Campaigns and Last Issues towards Advanced Sensors"
11:45 – 12:00	**David Valentin** "Feasibility to Detect Natural Frequencies of Hydraulic Turbines under Operation Using Strain Gauges"
12:00 – 12:15	**Mónica Egusquiza** "Optimized Use of Sensors to Detect Critical Full Load Instability in Large Hydraulic Turbines"
12:15 – 12:45	**Jandro L. Abot** "Structural Health Monitoring Using Carbon Nanotube Yarns: Sensing Concept and Applications in Composites"
12:45 – 13:45	Lunch and Poster Session

Session 5 – Sensors Applications
Chair: Stefano Mariani

13:45 – 14:30	**Maurizio Porfiri – Keynote Speaker** "Multiphysics Modeling Ionic Polymer Metal Composites, with Application in Underwater Sensing"
14:30 – 15:00	**Eleni Chatzi** "A Monitoring Approach to Smart Infrastructure Management"
15:00 – 15:15	**Yi Yang** "Performance Analysis of LIDAR Assist Spatial Sensing for the Visually Impaired"
15:15 – 15:30	**Mariana Medina Sánchez** "Lab-in-a-tube, biosensors, cell detection, molecule detection"
15:30 – 15:45	**Abraham Mejia-Aguilar** "Landslide Monitoring with Multi-sensor and Temporal Scale Approaches : a Test Site in Alpine Environment"
15:45 – 16:00	**Louis McCarthy** "Sensor Excitation and Measurement Techniques for CNT Thin Film Sensors"
16:00 – 16:30	Coffee Break
16:30 – 16:45	**Stefano Mariani** "Health Monitoring of Composite Structures via MEMS Sensor Networks: Numerical and Experimental Results"
16:45 – 17:00	**Marco Messina** "Design and Optimization of a MEMS-based Piezoresistive Accelerometer for Head Injuries Monitoring: A Computational Analysis."
17:00 – 17:15	**Paul Rawiel** "Integration and Synchronization of different sensors for the positioning of moving vehicles"
17:15 – 17:30	**Larysa Baraban** "Nanosensors for Monitoring Bacterial Growth Kinetics and Response to Antibiotics"
17:30 – 17:45	**Diego Rivera** "Protecting Sensors in an IoT Environment by Modelling Communications as Resources"
17:45 – 18:00	**Closing Remarks & Awards Ceremony**

Welcome by Arben Merkoçi

Dear Colleagues,

It is a great pleasure to welcome you in Barcelona for this sensors congress!

Sensors field is growing continuously since several decades ago. Of great importance has been the emergence of nanomaterials and nanotechnologies that together with advances in communication technologies and IoT are offering new opportunities for sensors. Nanomaterials, such as nanoparticles, graphene, smart materials and devices including nanomotors are bringing important advantages to sensing technologies. This congress will be the forum for sensor community all over the world to show new advances in the field, discuss synergies and applications of sensors in important fields that include health monitoring, environment control, food safety and security beside industrial applications.

I really wish you enjoy the conference, poster session and, of course, the great city of Barcelona!

Arben Merkoçi
Conference Chair

General Information

Sensors (ISSN 1424-8220; CODEN: SENSC9) is the leading international, peer-reviewed, open access journal on the science and technology of sensors and biosensors. Sensors is published monthly online by MDPI. It provides an advanced forum for the science and technology of sensors and biosensors. Moreover, it publishes reviews (including comprehensive reviews on the complete sensors products), regular research papers and short notes. Our aim is to encourage scientists to publish their experimental and theoretical results in as much detail as possible.
Among other databases, *Sensors* is indexed by the Science Citation Index Expanded (Web of Science), MEDLINE (PubMed), Ei Compendex, and Inspec (IET).

Journal Webpage: http://www.mdpi.com/journal/sensors
Impact factor: 2.677 (2016); 5-Year Impact Factor: 2.964 (2016)

The **5th International Symposium on Sensor Science** will be held at the AXA Convention Centre Barcelona (Spain) from 27 - 29 September, 2017.

This exciting three-day event seeks to gather together experts in the field of Sensor Science covering topics from biosensors, chemosensors, bio-inspired and bio-based strategies for sensing and fluidics, sensors for structures and other applications. This is an opportunity to discuss important breakthroughs in sensor technology and related fields; broaden your knowledge, meet sensor scientists from other areas and perhaps develop new mutually beneficial collaborations.

Conference Venue

AXA Convention Centre
Avinguda Diagonal, 547, 08029 Barcelona
Spain

Registration Desk

The desk for registration, information and distribution of documents will be open from 8:30, 27 September 2017.

Certificate of Attendance

Upon request, the participants of the symposium will receive an electronic Certificate of Attendance by email once the event is concluded.

Barcelona and Catalonia

Catalonia has become one of the favourite tourist destinations of Spain, mainly because of Barcelona, a city that never sleeps and knows how to please the big majority. With a history among the oldest in Europe, Barcelona offers a mixture of inland and seaside charms that panders the interests of everybody. The variety of artistic treasures, Romanesque churches and the works of famous artists such as Dali, Gaudi, Miro or Picasso will make of your visit to the city a remarkable experience.

Parc Güell (Source: www.viajero-turismo.com)

Barcelona is the capital and largest city of Catalonia and Spain's second largest city, with a population of over one and half million people (over five million in the whole province).

This city, bathed by the Mediterranean Sea, has become one of most cosmopolitan cities of Europe which has transformed it into the very modern, yet incredibly old city. This beautiful city is full of what European cities are known for (outdoor markets, restaurants, shops, museums and churches) and which makes it the perfect scenario to get lost in its pictouresque streets and avenues. Moreover, Barcelona's extensive and reliable Metro system will take you to more far-flung destinations. The core centre of the town, focused around the *Ciutat Vella* ("Old City"), provides days of enjoyment for those looking to experience the life of Barcelona while the beaches the city was built upon provide sun and relaxation during the long periods of agreeably warm weather. [Source: www.wikitravel.org]

Plaza España (Source: www.viajero-turismo.com)

The AXA Convention Centre

The event will be held at the Auditorium AXA of the AXA Convention Centre, which is part of an enormous complex located on the main artery of Barcelona that integrates a shopping centre, two hotels, 48.000 m² of offices, a parking lot, two schools, a sport centre and a public park. City communications are excellent and access from Barcelona's Airport and Sants Station is very quick.

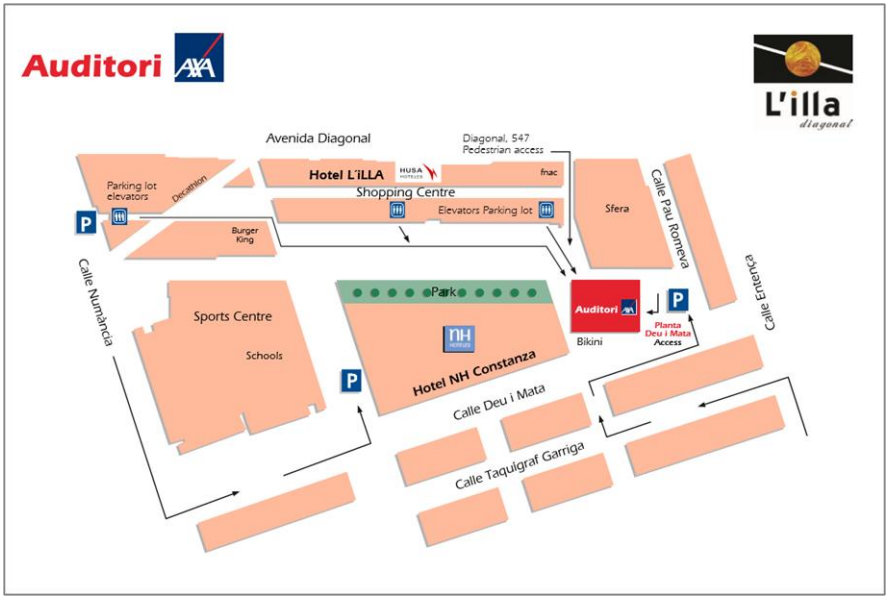
The avant-garde design and construction quality emerge from each and every detail of the building, turning the l'ILLA complex into an emblematic reference of the city.

As a whole, it is more than an auditorium: it is an infrastructure designed to offer quality, flexibility and integral attention through its wide range of services.

AXA Convention Centre (Source: www.axa.es)

How to Reach the Venue

Address: Avinguda Diagonal, 547, 08029 Barcelona, Spain



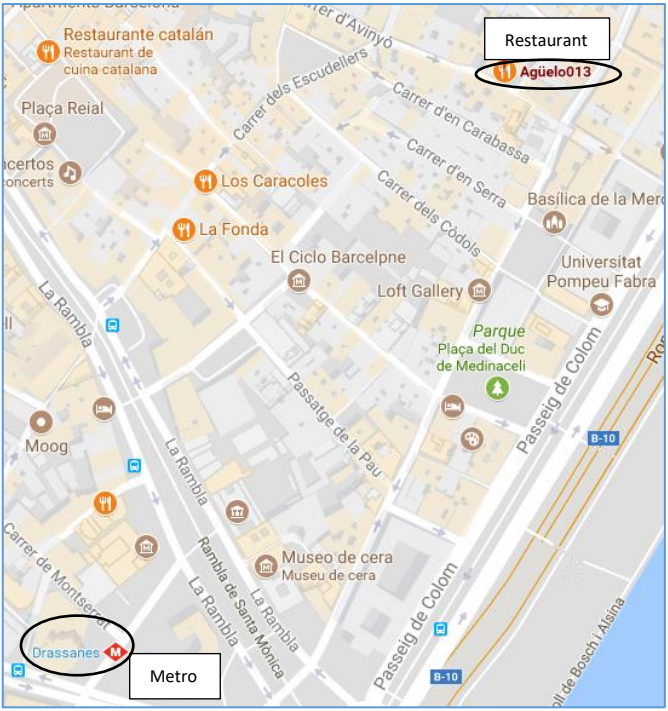
Venue Location (Source: www.axa.es)

Conference Dinner

Thursday 28th September, 20:30

The conference dinner will be held at Agüelo013, a cutting-edge restaurant specialised in Mediterranean cuisine which, in addition to its emblematic location in the Gothic Quarter of Barcelona and its picturesque dining rooms, will make your evening at the restaurant an experience to remember.

Agüelo013 is located at *Carrer Avinyó* 37, a street at the heart of the Gothic Quarter and only a couple of minutes away from the must-see avenue *Las Ramblas*. The restaurant is easily reached from the Conference Venue either by taxi or by Metro. If you were to choose the second option, the easiest way to get there is by taking the Metro Line L3 at Maria Cristina Station and drop off at Drassanes Metro Station after 8 stops.



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Emergency Information

All emergencies in Spain: 112 (no area code needed)

Ambulance (Ambulancia) and health emergencies: 061 or 112
Fire brigade (Cuerpo de bomberos): 080 or 112
Spanish National Police (Policía nacional): 091

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Abstracts

Session 1: Biosensors

Biosensors (ISSN 2079-6374; CODEN: BIOSHU) is an international, peer-reviewed, open access journal on the technology and science of biosensors published quarterly online by MDPI. *Biosensors* provides an advanced forum for studies related to the science and technology of biosensors and biosensing. It publishes original research papers, comprehensive reviews and communications. Our aim is to encourage scientists to publish their experimental and theoretical results in as much detail as possible.
Biosensors is indexed in the Emerging Sources Citation Index (ESCI - Web of Science) from Vol. 6, as well as Inspec (IET) and Scopus.

Journal Webpage: http://www.mdpi.com/journal/biosensors

Welcome by Evgeny Katz

Dear Colleagues,

Welcome to the Biosensors Session of the 5th International Symposium on Sensor Science. The Biosensors Session covers many interesting multi-disciplinary topics, all integrated by the goal of analysis of biomolecular species using various chemical and physical methods. The outcomes of the research and engineering in biosensor area are important for many biomedical, biotechnological applications, for forensic science, environmental analysis and for recently emerged biomolecular computing. The reports presented at the Session will cover many of the important sub-topics, including analysis of biomarkers signalling on health problems, design of multi-functional biosensors, end-user and point-of-care biosensors, various scientific and engineering approaches to biosensing of biomolecules and biological species. Novel analytical methods for in vitro and in vivo analysis will be presented at the Session. The invited speakers representing different sub-areas of the biosensor research will cover the most important and novel advances in biosensing. This session also includes many interesting posters presented by junior scientists and students, providing for them excellent opportunity to discuss the research results at the international scientific environment.
Overall, we hope that this meeting will provide excellent opportunity for each participant to present novel results and to learn new developments in the area. Welcome to the Biosensors Session!

Professor Evgeny Katz
Session Chair

Improving Cancer Outcomes through Electrochemical Biosensing of Early Diagnosis/Prognosis Biomarkers in Human Biopsies

José Manuel Pingarrón[1], Susana Campuzano[1], Rebeca Magnolia Torrente-Rodríguez[1], Víctor Ruiz-Valdepeñas Montiel[1], Eva Vargas[1], Rodrigo Barderas[2]

[1] Departamento de Química Analítica, Facultad de CC. Químicas, Universidad Complutense de Madrid, Madrid, Spain
[2] Departamento de Bioquímica y Biología Molecular I, Facultad de CC. Químicas, Universidad Complutense de Madrid, Madrid, Spain

Cancer is the second leading cause of death after cardiovascular diseases and responsible for over 8 million deaths worldwide. Although substantial progress has been made in the prevention and treatment of different cancer types, its incidence and prevalence is increasing in recent years. Therefore, the development of efficient, simple, quantitative and disposable devices with short response times, low cost, and that are suitable to perform decentralized and reliable determination of early diagnosis cancer biomarkers could help to reduce cancer mortality due to its detection at early stages, when the disease can be efficiently treated and cured in more than 90% of cancer patients.
Within this context, the main characteristics of novel biosensing scaffolds for the determination of cancer related-miRNAs [1-3] and autoantibodies [4] against tumour associated antigens (TAAs), relevant biomarkers considered for both early diagnosis and prognosis, will be presented. The developed methodologies, based on the coupling of attractive bioreceptors and bioassay formats, functionalized magnetic microcarriers, and electrochemical detection at disposable transducers, have demonstrated practical applicability for the accurate determination of the endogenous concentration of the target analytes in solid (fresh and FFPE breast human tissues) and liquid (human serum from colorectal and ovarian cancer patients) biopsies.
The developed easy handling single- or multiplexed platforms, readily applied to the determination of other biomarkers, provided results in agreement with conventional methodologies but with lower cost and in remarkably shorter times. These interesting features make them suitable alternatives in the implementation of user-friendly and affordable devices, particularly attractive to perform routine determinations in both clinical and basic research settings to improve cancer diagnosis and prognosis.

References:
1. Torrente-Rodríguez et al. *ACS Sensors.* **2016**, *1*, 896–903.
2. Torrente-Rodríguez et al. *Biosens. Bioelectron.* **2016**, *86*, 516-521.
3. Torrente-Rodríguez et al. *J. Biotech. Biomed. Eng.* **2016**, *3*, 1064.
4. Garranzo-Asensio et al. *Anal. Chem.* **2016**, *88*, 12339–12345.

NOTES

Redox Cycling Realized in Paper-based Electrochemical Biosensor for highly-selective Detection of Potassium Ferrocyanide in the presence of Ascorbic Acid

So Yamamoto, Shigeyasu Uno

Department of Electrical and Electronic Engineering, Ritsumeikan University, Japan

Redox cycling is a phenomenon that occurs for redox species due to close interelectrode distance. Two electrodes, the generator electrode (GE) and the collector electrode (CE), can detect steady-state current which are oxidation and reduction current when those are held at oxidation and reduction potential. Using redox cycling, redox species such as dopamine can be measured in the presence of interfering irreversible species [1-3]. However, redox cycling needs expensive micro-fabrication process for electrode arrangement.

In this work, we show detection of potassium ferrocyanide (Ferro) in the presence of ascorbic acid under redox cycling condition using paper-based biochemical sensor (PBBS). PBBS has a feature which defines the interelectrode distance by the thickness of paper (180um) without any micro-fabrication process [4]. To define the interelesctrode distance, we sandwiched chromatography paper (ChrPr) between two gold plates (5mm*10mm) acting as GE and CE. Mixed solutions were prepared by adding Ferro (0, 1, 3, 6, 10mM) to phosphate buffered saline (PBS) in the presence or absence of 10mM L(+)-Ascorbic Acid Sodium Solt (L-AAS). Ferro and L-AAS are known as reversible and irreversible species, respectively. Measurements of each solution were performed through chronoamperometry (CA) technique by applying constant oxidation potential (+500mV) and reduction potential (-200mV) to GE and CE, respectively.

As a result, we obtained the reduction current from Ferro, not from L-AAS. These results indicated that the electrochemical current flowing through CE were due to electron transfer to the redox species. Steady-state current of mixtures obtained in CE were in agreement with the result of Ferro solution. Thus, these experimental results indicate that our sensor can selectively detect reversible redox species by excluding the interfering irreversible species. This study suggests potential applications such as the measurement of dopamine.

References:

1. Dam, V.A.T.; et al. *The Analyst.* **2007**,*132*, 365–370.
2. Chen, Q.; et al. *J.Phys.Chem. C.* **2016**, *120*, 17251–17260.
3. Aggarwal, A.; et al. *Anal. Bioanal. Chem*. **2013**, *405*, 3859–3869.
4. Fukayama, K.; et al. *TELEKOMNIKA* **2017**, *15*, 842–846.

NOTES

Molecularly Imprinted Polymers for TNT Analogues. Development of Electrochemical TNT Biosensors

Anna Herrera-Chacon, Inmaculada Campos, Lourdes Bottone, Manel del Valle

Universitat Autònoma de Barcelona, Barcelona, Spain

Trinitrotoluene (TNT) is a widely employed explosive compound; for that reason, an electrochemical sensor able to perform on-field measurements could be an interesting tool. In this work, a molecularly imprinted polymer using the TNT analogue DNP as a template is developed. Next, the obtained MIP is chemically characterized towards DNP and TNT.

MIPs synthesis was done following the protocol by co-precipitation using methacrylic acid (MAA) as a monomer, ethylene glycol ethylene glycol dimethylacrylate (EGDMA) as a crosslinker, azobisisobutyronitrile (AIBN) as a radical indiciator and ethanol as a solvent. Template removal was performed with a Soxhlet using MeOH:HAc. Control non-imprinted polymers (NIPs) were also synthesized for the purpose of comparison.

Microscopy studies were performed to confirm similar morphologies among these polymers; the material was also characterized by a Scatchard plot to calculate the Kb (the affinity constant) and Bmax (maximum amount bound) values.

The presented work reports a polymeric material able to capture TNT and DNP and it is ready to be implemented as a recognition element for an electrochemical biosensor.

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Integration of Biomolecular Sensing, Logic Processing of the Signals and Actuation

Evgeny Katz

Department of Chemistry and Biomolecular Science, Clarkson University, Potsdam, NY, USA

A new approach to bioelectronic Sense-and-Act systems was developed with the use of modified electrodes performing sensing and substance-releasing functions. Signal-controlled release of DNA from Fe^{3+}-cross-linked alginate hydrogel electrochemically deposited on an electrode surface was studied. The multiple input signals were logically processed with the help of the enzyme biocatalyzed reactions. Boolean logic gates, OR, AND, INH, were realized with the biocatalytic reactions performed by the enzymes entrapped in the alginate film. Hydrogen peroxide produced by the enzymatic reactions resulted in the degradation of the alginate hydrogel and DNA release. The alginate degradation was facilitated by the formation of free radicals in the Fenton-type reaction catalyzed by iron cations cross-linking the alginate hydrogel. The studied approach is versatile and can be adapted to various chemical signals processed by various enzymes with differently implemented Boolean logic. This work illustrates a novel concept of functional integration of biomolecular sensing, logic processing of the signals and actuation.

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Label-Free DNA Detection with Capacitive Field-Effect Devices—Challenges and Opportunities

Michael J. Schöning

Institute of Nano- and Biotechnologies (INB), University of Applied Sciences, Achen, Germany

Field-effect EIS (electrolyte-insulator-semiconductor) sensors modified with a positively charged weak polyelectrolyte layer have been applied for the electrical detection of DNA (deoxyribonucleic acid) immobilization and hybridization by the intrinsic molecular charge. The EIS sensors are able to detect the existence of target DNA amplicons in PCR (polymerase chain reaction) samples and thus, can be used as tool for a quick verification of DNA amplification and the successful PCR process. Due to their miniaturized setup, compatibility with advanced micro- and nanotechnologies, and ability to detect biomolecules by their intrinsic molecular charge, those sensors can serve as possible platform for the development of label-free DNA chips. Possible application fields as well as challenges and limitations will be discussed.

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A comparative study between Hydrogen Peroxide Amperometric Biosensors based on different Peroxidases wired by Os-polymer: applications in water, milk and human urine

Paolo Bollella[1], Massimo Marcaccio[2], Andrey Poloznikov[3], Dmitry Hushpulian[3], Rafael Andreu[4], Donal Leech[5], Lo Gorton[6], Riccarda Antiochia[1]

[1] *Sapienza University of Rome, Rome, Italy*
[2] *Università di Bologna, Bologna, Italy*
[3] *Rogachev Center of Pediatric Hematology, Oncology and Immunology, Moscow, Russia*
[4] *Universidad de Sevilla, Sevilla, Spain*
[5] *National University of Ireland, Galway, Ireland*
[6] *Lund University, Lund, Sweden*

In the last few years, hydrogen peroxide (H_2O_2) real-time monitoring has attracted great interest due to its large employment in industrial processes: in particular, H_2O_2 is released into the environment in small or large amounts, since it is used as an oxidant, bleaching and sterilizing agent [1]. Recently, H_2O_2 has been found as a valuable biomarker present in human urine which may elucidate specific levels of oxidative stress in vivo [2].

A comparison has been made between two plant peroxidases, cationic horseradish peroxidase (HRP) and anionic tobacco peroxidase (TOP) [3], wired by a cationic osmium polymer ($[Os(dmp)PVI]^{+/2+}$) [4,5] to prepare highly sensitive, stable and selective hydrogen peroxide biosensors. HRP and TOP peroxidases were immobilized onto graphite rod (G) electrodes by a simple drop-casting procedure using a solution of poly(ethyleneglycol) diglycidyl ether (PEGDGE), as cross linking agent.

Cyclic voltammetry experiments were carried out in order to investigate the influence of the charge of the enzyme and the polymer on the efficiency of the electron transfer (ET) between the enzyme and the wiring redox polymer and the efficiency of the electrocatalytic reduction of H_2O_2. TOP modified electrode showed an enhanced ET rate due to the attraction between the anionic enzyme and the cationic Os-polymer. pH influence, stability and selectivity of both biosensors were carefully investigated. Both peroxidase modified biosensors exhibited a wide linear range (1-500 mM H_2O_2) and a low detection limit (0.3 mM H_2O_2). TOP based electrode showed a higher sensitivity (467.4 nA μM^{-1} cm^{-2}), a higher catalytic constant (63.5 s^{-1}), a lower K_M^{app} (302 mM) and an improved long-term stability (current decrease of 17.3% upon 30 days) compared to HRP.

Both HRP and TOP based biosensors were successfully tested in real samples of contact lens cleaning solutions and in real “spiked” samples of water, milk, dairy products and human urine.

References:
1. Baldry, M.G.C. The bactericidal, fungicidal and sporicidal properties of hydrogen peroxide and peracetic acid. *J. Appl. Bacter.* **1983**, *54*, 417-423.
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NOTES

ATP Synthesis and Biosensing Coupled to the Electroenzymatic Activity of a Hydrogenase on an Electrode/Biomimetic Membrane Interface

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Cells generate energy by coupling a proton gradient across a phospholipid bilayer membrane with the activity of a cross-membrane ATP synthase enzyme. In an effort to mimic this process in an artificial environment, we show that ATP can be efficiently produced starting from molecular hydrogen as a fuel. The proton concentration in an electrode/phospholipid bilayer interface can be controlled and monitorised electrochemically by immobilizing the membrane-bound [NiFeSe]-hydrogenase from *Desulfovibrio vulgaris* Hildenborough.[1] The electro-enzymatic oxidation of H_2 generated a proton gradient across the supported biomimetic membrane that can be coupled to the in vitro synthesis of ATP by reconstituting ATP-synthase from *E. coli* on the biomimetic system.[2] Such a system is also suitable for developing an electrochemical biosensor of ATP.

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NOTES

Development of a Biosensor for the Detection of Acetoin during Wine Fermentation

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Acetoin is most commonly used in food, flavor, cosmetics and chemical synthesis and is formed during fermentation by the microbial activity of lactic bacteria and yeast. For example, acetoin is the key compound of the biosynthesis of diacetyl which is an important wine flavorant synthesized during alcoholic and malolactic fermentation. Therefore, the detection of acetoin content during the fermentation process could improve the quality of wine due to its involvement in its bouquet. A silicon-based biosensor chip for the detection of acetoin has been developed with a novel acetoin reductase from *B. clausii.* Acetoin will be reduced by the enzyme while NADH will be oxidized to NAD^+. This reaction is accompanied by a pH shift that can be detected by a capacitive field-effect sensor. The sensor's ability has been investigated using constant-capacitance measurements at acetoin concentrations from 50 µM to 200 µM in MES (2-(*N*-morpholino)ethanesulfonic acid) buffer at pH 6.8. The possibility to monitor acetoin by this new type of biosensor could provide an advantage in controlling the fermentation in winemaking.

NOTES

Electrochemical and SERS Based Biosensors for Cancer Biomarkers Detection

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The discovery of microRNAs (miRNAs) opened up a new area of research for noncoding RNA molecules. miRNAs play an important function for gene expression regulators at the transcriptional and post-transcriptional level. microRNAs are about 22 nucleotides in length and regulate the expression of mRNA targets with perfect or imperfect complementarity, leading to mRNA degradation or repression of translation, respectively.

Enzyme amplified biosensing of microRNA (mir-21, a breast cancer biomarker) from cell lysate of total RNA has been studied electrochemically[1]. In this work, the oxidation signal of enzymatic reaction product, alpha naphtol (a-NAP), which occurs after hybridization, has been detected by Differential Pulse Voltammetry on a disposable Pencil Graphite Electrode (PGE).

Electrochemical oxidation signal of Carnation Italian ringspot virus p19 protein has been used for the detection of mir21[2]. P19 senses dsDNA as a molecular caliper and sequesters miRNAs in a size-dependent, sequence-independent manner.

Carbon nanotube-based field-effect transistors functionalized with the p19 protein have been used for the detection of miRNA-122a[3]. The probe-miRNA duplex has been determined by measuring the change in resistance of the biosensor resulting from its binding to p19, which takes in dsRNA in a size-dependent manner.

Graphene-modified disposable pencil graphite electrodes have been used for the detection of mir-21 from cell lysates by voltammetric and impedimetric methods[4]. The electrodes were modified via electropolymerized polypyrrole (PPy)[5].

The prostate cancer marker miR-145 has also been detected to levels below 1 fM by both electrochemical capacitance and voltammetric techniques using PNA probes and gold nanoparticles[6]

Surface enhanced Raman spectroscopy (SERS) methods have been used recently for detection of trace amounts of miRNAs. In addition, 5,5'-Dithiobis(2-nitrobenzoic acid) (DTNB) has been used as the SERS active substrate. DTNB-labelled, rod-shaped nanoparticles have been investigated for miR-21 detection. In the work, SERS active substrate has been used to enhance the reproducibility and sensitivity[7].

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NOTES

From Reagentless Biosensors to Biofuel Cells and Self-Powered Bioelectrochemical Devices

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Coupling of biocatalytic redox reactions with electrode surfaces is, on the one hand, the basis for the design of targeted biosensors, the electrochemical readout of DNA assays and, on the other hand, the basis for harvesting energy using biomolecules as recognition elements and catalysts. Due to the fact that the redox centers are often deeply buried within the protein structure of suitable enzymes, wiring of the enzyme integrated redox sites to the electrode surface is of utmost importance.
This presentation focuses on recent developments in:

1. Wiring of enzymes using designed redox polymers
2. Design of biofuel cells with increased open-circuit voltage
3. Self-powered biosensors and instrument-free substrate determination
4. Improving the power output of biofuel cells based on biosupercapacitors

NOTES

Genetic Engineering of Enzymes and Electrode Modifications for Biosensing Applications

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Biosensing efficiency, selectivity and sensitivity rely first and foremost on a successful interfacing between enzymes and sensing surfaces. An interface that allows, on the one hand, a specific analyte recognition and, on the other hand, an efficient signal transduction. Some of the challenges in biosensing stem from the incorrect orientation of the enzyme towards the sensing interface and from the need to use mediated electron transfer with a diffusional redox mediator due to difficulty in relaying a signal from a redox center that is deeply buried inside the protein matrix. Using genetic code expansion tools, and genetic engineering approaches, we were able to modify redox enzymes and surfaces for biosensing and biofuel cell applications so they could have superior properties over native enzymes. In my talk, I will demonstrate how site specific wiring of redox enzymes, which is genetically encoded, can improve electron transfer due to controlled and short electron transfer distances and due to proper enzyme orientation. I will also demonstrate how rational genetic engineering of an enzyme gives it superior properties for biosensing purposes compared to those of the native enzyme.

NOTES

Nucleic Acid Analysis Using Multifunctional Hybridization Sensors

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Hybridization of nucleic acid probes remains one of the most common strategies for sensing of specific DNA and RNA sequences. Formats that use hybridization probes include qualitative PCR, microarrays, fluorescent in situ hybridization (FISH), to name a few. Moreover, specific recognition of RNA sequences is in demand for gene silencing approaches, e.g., antisense and siRNA. Hybridization probes are nucleic acid oligomers of 15−25 nucleotides (or longer) designed to be complementary to targeted analytes. The formation of a probe–analyte hybrid testifies that the analyte contains a nucleotide sequence complementary to the probe. This approach suffers from low selectivity (especially for temperatures <40°C), high cost for fluorescent probes, and poor target accessibility if folded natural RNA are analyzed. Part of the sensing problem arises from the affinity/selectivity dilemma: the higher the probe–analyte affinity, the lower the selectivity. To address these and other problems, we design multicomponent hybridization probes (MHP) that consist of several oligonucleotide components, which associate with the RNA/DNA target and produce a detectable signal. Each MHP component serves a specific function, thus enabling simultaneous improvement of multiple key characteristics. My presentation will cover the design of a probe that can differentiate single nucleotide substitutions in DNA in the entire temperature interval of 5–40 °C; a molecular machine that tightly binds the RNA analyte while remaining highly selective; a strategy for the recognition of highly variable viral genomes with high selectivity.

NOTES

Printed and Flexible Electrochemical Lactate Sensors for Wearable Applications

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The development and production of bendable, electrochemical biosensors on PET foil for the detection and analysis of lactate are described. Moreover, the electrochemical measurement of biomolecules concentration in fluids by these sensors is presented. Measurements rely on redox cycling for signal amplification, in this case using 300 mV for oxidation and −250 mV for reduction. The electrodes to be functionalized of the latter have been manufactured either by wet etching of an evaporated gold layer or by screen printing of gold (counter electrode). Silver/silver chloride (reference electrode) and carbon (working electrode) have also been screen printed. It is shown that there are only minor deviations between values measured by conventional silicon-based and in-house-manufactured sensors compared with those produced on flexible foils. Since the sensors have also been proven to withstand rough environments, such as limited time in sweat, the potential now exists for sensor integration into filled textiles and sports garments for non-invasive lactate monitoring in sweat, which is correlated to blood lactate concentration.

NOTES

Split Deoxyribozyme Sensors for Pathogen Detection

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Deoxyribozymes (Dz), catalytic DNA molecules, are promising tools to design nucleic acid sensors. In comparison with conventional hybridization probes and assays relying on protein enzymes, Dz-based sensors offer an advantage of signal amplification without compromising the sensor stability. Here, we present split Dz (sDz) sensors, which consist of two Dz subunits, each containing a half of the Dz catalytic core, as well as target-complementary fragments. In the presence of a specific nucleic acid target, the catalytically active construct is formed by binding the two subunits to the abutting target fragments, and a signal (e.g., fluorescence or color change) is generated due to the Dz catalytic activity. The signal depends on the target concentration, and is therefore able to monitor for target detection and quantification. This approach is also applicable to design integrated sensors, which have an additional computing element to convert the target-recognition event into a signal based on the embedded logic function. We demonstrate the advantages of the sDz approach by applying the sensors for detection of bacterial and viral pathogens including *Mycobacterium tuberculosis* and ZIKA virus.

NOTES

The Development of the "Sleeping Gene" Type Biosensor as a Method to Increase the Efficiency of the Magnetocardiograph Performance

Yuri Artemovich Arutyunov[1], Yevgeny Anatolyevich Chaschin[2], Andrey Anatolevich Mitrofanov[2], Aleksandr Aleksandrovich Drobyazko[3], Pavel Aleksandrovich Shashok[3]

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This paper recommends using a biosensor of the "sleeping gene" type to raise the effectiveness of magnetocardiogram diagnosis at an early stage of myocardial pathological development.

The myocardium is known to be of the “Moebius leaf” topology. The MCG research results have also shown that the magnetic strength amplitude in the myocardium normal condition reaches 50 pT, whereas the heart biomagnetic field strength amplitude increases in the case of the myocardial pathology.

This paper reports that in the heart topological model approximation, the record of the heart magnetic strength peak values and the dispersion of microalterations under the controllable external electromagnetic influence can be effectively used as diagnostic markers of oncoming functional changes in the myocardium.

This enables the myocardial pathological processes to be traced at an early stage of their development.

The obtained results suggest a possibility of early diagnosis of myocardial pathological development by recording amplitude parameters of the heart magnetic strength, where expensive SQUIDs can be replaced by much cheaper and smaller milligauss meters.

NOTES

Abstracts

Session 2: Chemosensors

Chemosensors (ISSN 2227-9040; CODEN: CHEMO9) is an international, scientific, open access journal on the science and technology of chemical sensors published quarterly online by MDPI. Our aim is to encourage scientists to publish their experimental and theoretical results in as much detail as possible. All aspects of chemosensing are welcomed from theoretical concepts to education and training as well as manuscripts on classic chemical sensing, drug testing, medical/diagnostic testing, or assay validation.
Chemosensors is indexed in the Emerging Sources Citation Index (ESCI - Web of Science), in Chemical Abstracts (ACS) and in Inspec (IET).

Journal Webpage: http://www.mdpi.com/journal/chemosensors

Welcome by Vladimir M. Mirsky

Dear Colleagues,

Welcome to the session of Chemical Sensors of the 5th Symposium on Sensor Science. There was essential progress in this field during the last years, therefore one can expect that the session will be so interesting and exciting as it was at our former Symposiums. The session will cover most aspects of chemical sensing: implementation of new transducing principles, new approaches in the development of sensor arrays, application of nanomaterials for selective binding and for signal amplification. The speakers of the Chemosensors Session will discuss the development of chemical sensors for such unusual operating conditions as space stations, or for such unusual types of analytes as colloid particles. Also, a number of sensor related technologies will be discussed, for example new concepts of microfluidics, MEMS or new approaches for data analysis.
I am looking forward to seeing you at the 5th Symposium of Sensor Science and I wish you a true pleasure of creative intellectual work at our session!

Professor Vladimir Mirsky,
Session Chair

Detection of single sub-micrometer objects of biological or technical origin using wide field surface plasmon microscopy

Vladimir M. Mirsky

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Detection of nano- and microparticles is an important task for chemical analytics, medical diagnostics, food industry, biotechnology, environmental monitoring and for many other fields of science and industry. For this purpose, a method based on the detection and analysis of minute signals of surface plasmon resonance images due to adsorption of single particles was developed.

The new technology allows one a real-time detection of interaction of single nano- and microparticles of different origin with sensor surface. Adsorption of each nanoparticle leads to characteristic diffraction image whose intensity depends on the size and chemical composition of the particle. A number of the nanoparticle–surface binding events per time and surface area characterizes volume concentration. A large monitored surface area of the sensor surface allows one to detect many hundreds events in each frame or totall up to a million particles on the sensor surface, this leads to a very high dynamic range of counting and to a correspondingly high dynamic range in the concentration scale. Depending on the type of particles and experimental conditions, the detection limit for aqueous samples can be below 1000 nanoparticles per microliter. Stable analysis of nanoparticles in very complex environment (fruit juice, cosmetic formulations) was demonstrated.

For determination of chemical composition of single nanoparticles separately, the wide field surface plasmon microscopy can be used as a tandem technique. For example, for analysis of technical nanoparticles it can be assisted by electrochemical analysis. In this case, the gold sensor surface is used both for plasmon microscopy and as a working electrode of electrochemical cell. Applying a linear potential sweep to this electrode, adsorbed nanoparticles can be subjected to electrochemical conversion leading to the change of their refractive index; the value of electrical potential of this conversion characterizes material of the particular nanoparticle. Notably, such analysis is performed simultaneously but independently for each adsorbed particle.

The method of wide filed surface plasmon microscopy can be applied for ultrasensitive detection and analysis of nano- and microparticles of biological (bacteria, viruses, endosomes), biotechnological, (liposomes, protein nanoparticles for drug delivery) or technical (metallic, oxides, plastic, etc.) nano- and microparticles.

NOTES

Disposable Sensors for monitoring chronic wounds

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The longer life expectancy in Western countries brings forth the challenge of a growing burden of chronic illnesses like chronic wounds. Wearable sensors are creating great expectations for improving knowledge on the biochemical processes in action in these wounds and combining quality of treatment and low cost.

We report here the fabrication, testing and validation of disposable sensors, namely a resistive sensor based on reduced graphene oxide for the measurement of temperature and a potentiometric sensor based on graphene oxide for the measurement of pH in the wound bed. In-vitro validation with model solutions and real samples established accuracies of ±0.5 °C (range 20-40 °C) and ±0.2 pH units (range 5.5-9 pH units). Issues concerning biocompatibility for the use in contact with the wound bed are addressed as well as the potential applications in other fields.

NOTES

High value chemosensors in the era of Industrial Internet: Innovations in materials, transducers, and data analytics

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Modern monitoring scenarios of gases for industrial safety and productivity, medical diagnostics, environmental surveillance, and other Industrial Internet applications demand new high value sensing capabilities of better accuracy, lower power consumption, and unobtrusive form factors. This talk will provide a critical overview of developments of a new generation of chemical sensors based on radio frequency identification (RFID) transducer platform and multivariable response principles to meet these new demanding sensing requirements. Multivariable sensors provide several partially or fully independent responses from an individual device to allow quantitation of several individual components in mixtures, rejection of interferences, and correction for environmental instabilities. Such multivariable sensors have been developed for monitoring of trace levels of toxic gases and environmental pollutants. We will discuss the design criteria of these sensors and the key roles of sensing materials and data analytics to achieve desired sensor performance. These developed multivariable sensors are attractive when selectivity advantages of classic off-line analytical instruments are cancelled by requirements for no consumables, low power, low cost, and unobtrusive form factors. We will conclude with a perspective for future needs in fundamental and applied aspects of chemosensing and with the 2025 roadmaps for ubiquitous gas monitoring.

NOTES

Room Temperature Chemoresistive Gas Sensor Based on Organic-Functionalized Graphene Oxide

Matteo Valt, Barbara Fabbri, Andrea Gaiardo, Sandro Gherardi, Cesare Malagù, Giulia Zonta, Nicolò Landini, Vincenzo Guidi

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In the wide palette of chemoresistive sensing materials, hybrid nanocomposites have quickly gained a prominent position. So far, the research focused on graphene-based materials has led to an extensive assortment of highly performing devices. Graphene Oxide (GO) nanosheets possess quite a large number of hydrophilic groups, such as hydroxyl, epoxy and carboxyl on the basal plane. Epoxy groups provide some active sites for chemical reactions such as the nucleophilic addition. Cyclic aza-ethers can easily react with the epoxy sites on the GO surface, resulting in the formation of carbon–nitrogen covalent linkage. FGO nanosheets were synthetized and deposited by drop-casting onto alumina substrates with interdigitated gold electrodes, producing a series of thick-film gas sensors. SEM, XRD, TEM, IR and XPS analyses were performed on the obtained nanosheets, confirming the functionalization reaction. Among the several gases tested, the FGO films turned out to be selective to humidity. A deepened electrical characterization at room temperature showed that the response and recovery times depend on the humidity concentration as far as the response value. Furthermore, the sensing performance is dependent on the graphene:ether rate. The diverse FGO devices show great stability and repeatability over time, confirming that the cyclic ether acts as a receptor in the sensing mechanism.

NOTES

Conception and Development of Microfabricated Elements for Microfluidic Analytical Devices

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Portability and low energy consumption are of a great importance for on-site real-time monitoring of indoor air quality. Therefore, this work is focused on the miniaturization of the elements which are the bulkiest and require the highest energy supply in analytical devices. More specifically, micro-fabrication techniques were deployed so that a pre-concentrator and a gas chromatography micro-column with integrated heaters and temperature sensors were developed on silicon wafers of small dimensions of 20 x 12 mm and 50 x 50 mm, respectively.

Heating elements and sensors were fabricated by thermal evaporation of titanium, silver and gold. In the GC micro-column, four resistances of 82 Ω allow a temperature increase up to 200 °C in 150 s whereas two 430 Ω resistances function as sensors. In the case of the pre-concentrator, three different designs containing heaters of 32–46 Ω and sensors of 120–420 Ω were proposed in order to investigate the most appropriate configuration to achieve a temperature increase up to 250 °C in 10 s.

Furthermore, a study of wet etching kinetics of Si <100> with KOH (40%) was performed to evaluate its suitability for the fabrication of micro-channels. Silicon etching rates were determined to be between 14.7 and 63.1 µm/h at different temperatures from 50 to 80 °C. Afterwards, three GC micro-columns of 1, 2 and 3 m in length containing 106 and 146 µm deep microchannels were etched using KOH (40 %) at 70 °C, thus demonstrating that wet etching is an alternative and cheaper technique to fabricate micro-columns.

NOTES

Silicon Carbide: a Gas Sensing Material for Selective Detection of SO_2

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Silicon carbide (SiC) is a long-time known material with exceptional mechanical properties. Ceramics obtained by sintering SiC grains are very hard and find application in car brakes, bulletproof vests and, in general, in high endurance applications. Moreover, its thermal strength and chemical stability are also extraordinary, maintaining stability at even above 1000 °C, making it possible for use in high temperature applications. Considering these characteristics of silicon carbide, through the combination of stability and surface reactivity, it is possible to obtain a gas sensor suitable for commercial use. Therefore, this study was focused on the investigation of the chemoresistivity properties of SiC thick films in thermo-activation mode. Commercial Silicon Carbide nanopowder was characterized from the morphological, structural and chemical point of view. Then, it was screen-printed onto alumina substrates to obtain thick films and tested as chemiresistive gas sensors. The SiC layers were exposed to 13 gases belonging to different chemical classes, in concentrations within the ppm range and chosen through the Threshold Limit value. The sensors proved to be insensitive to almost all gases analysed, while they showed a significant response to sulphur dioxide in dry conditions. This cross selectivity increased in wet conditions, highlighting a possible sensing application of this material.

NOTES

SPR Chemosensors Based on D-Shaped POFs and MIPs: Investigation on Optimal Thickness of the Buffer Layer

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A comparative analysis of different optical sensing platforms, designed for chemical applications and based on molecularly imprinted polymers (MIPs), is presented. The optical platforms are based on surface plasmon resonance (SPR) in a D-shaped plastic optical fiber (POF), with a buffer layer between the exposed POF core and the thin gold film (60 nm thick). These optical platforms are realized by removing the cladding of POFs along half circumference, spin coating a buffer layer on the exposed core (with different velocities to obtain different thicknesses), and finally sputtering a thin gold film. The buffer layer proposed in this analysis is the photoresist Microposit S1813, with a refractive index greater than the one of the POF core. This photoresist buffer layer is required in order to increase the performances of the sensor.
We intend to show how, in the refractive index range used for chemical applications based on MIPs, the sensor's performances change when the thickness of the photoresist layer changes. The results show that when the thickness of the photoresist layer decreases, the sensor's sensitivity increases. The experimental results are congruent with the numerical studies and this analysis is instrumental for chemical applications.

NOTES

The Optoelectronic Nose

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We have developed an entirely new class of lightweight chemical identification systems based on disposable colorimetric sensor arrays: essentially, a digital, multidimensional extension of litmus paper. The design of the colorimetric sensor array is based on two fundamental requirements: (1) the use of chemically diverse indicators that respond to changes in their chemical environment (i.e., interact with analytes of interest), and (2) the coupling of this interaction to an intense chromophore to provide a visible readout. The first requirement implies that the interaction must not be simple physical adsorption, but rather must involve other, stronger chemical interactions. By immobilizing chemically responsive indicators (including a range of both free base porphyrins and four- and five-coordinate metalloporphyrins) within nanoporous sol-gel matrices, we have developed a cross-responsive sensor array. Although no single chemically responsive pigment is specific for any one analyte, the pattern of color change for the array proves to be a unique molecular fingerprint. For the detection of volatile organic compounds (VOCs), we have demonstrated high sensitivity (below PEL levels) for the detection of a wide range of toxic industrial chemicals (TICs). Striking visual identifications of many TICs can be made even at ppb levels, for example to hydrogen sulfide, ammonia, SO_2 and phosgene (i.e., sensitivities better than GC-MS detection). Classification analysis reveals that the colorimetric sensor array has an extremely high dimensionality with the consequent ability to discriminate among a large number of TICs and explosives over a wide range of concentrations. In addition, highly selective discrimination of pure analytes and of complex mixtures has been demonstrated. The technology is also particularly suitable for detecting many of the most odiferous compounds produced by bacteria. We are able to distinguish bacterial growth even at very low levels of detection and can easily identify one pathogenic bacterium from another. Additionally, the arrays are highly effective at discriminating among closely related odors (e.g., subtle differences among coffees, beers, soft drinks, meats as they spoil, etc.). Finally, we will briefly discuss evidence that the olfactory receptors are often metalloproteins (most probably Zn^{+2}, $Cu^{+/+2}$, and perhaps Mn^{+2}) and have a highly conserved tripodal metal ion binding site in the large majority of their amino acid sequences.

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NOTES

Two-Dimensional Carbon Nanomaterials for Electrochemical and Plasmonic Sensing Applications

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Two-dimensional carbon nanomaterials are very popular in chemo- and biosensor development. The high surface area and the outstanding electrochemical and electronical properties make them attractive candidates as sensing material. To date, it is still challenging to prepare well-defined, defect-free 2D-nanomaterials in a reproducible way. Here, chemical and mechanical methods for the fabrication of colloidal stable graphene dispersions with focus on the flake-size distribution, the number of defects and the physicochemical properties are discussed. A method is proposed to transfer the graphene materials on electrodes and nanostructured gold surfaces for sensor development. As one example for a feasibility study, amperometric sensors were constructed with various types of graphene using glucose as the model analyte. Selectivity was introduced by electrochemical deposition of Nickel nanoparticles on top of the 2D-nanomaterial. For plasmonic sensing, graphene is shown to enhance surface plasmon resonance sensitivity, especially for small molecules such as plastisizers or purine-based biomarkers when combining nanostructured gold substrates with 2D-nanomaterials.

NOTES

Session 3: Bio-inspired and Bio-based Strategies for Sensing and Fluidics

Remote Sensing (ISSN 2072-4292) is an open access journal about the science and application of remote sensing technology, and is published monthly online by MDPI. *Remote Sensing* publishes regular research papers, reviews, letters and communications covering all aspects of the remote sensing process, from instrument design and signal processing to the retrieval of geophysical parameters and their application in geosciences. Our aim is to encourage scientists to publish experimental, theoretical and computational results in as much detail as possible so that results can be easily reproduced.
Among other databases, *Remote Sensing* is indexed by the Science Citation Index Expanded (Web of Science), Ei Compendex, and Inspec (IET).

Journal Webpage: http://www.mdpi.com/journal/remotesensing
Impact Factor: 3.244 (2016); 5-Year Impact Factor: 3.749 (2016)

Welcome by Dermot Diamond

Dear Colleagues,

Session S3 is focused on bio-inspired and biomimetic approaches to sensing and fluidics. Currently, many of the strategies for creating chemical sensors and biosensors, and microfluidics are largely engineering inspired ideas and concepts from the 1960s and 1970s. However, recent breakthroughs in materials science and fabrication technologies will drive fluidics and sensing towards approaches that are much more bio-inspired in nature. In this session, we will discuss the current state of the art in sensing and fluidics, and speculate on the potential disruptive impact bio-inspired concepts might have on this area.

Professor Dermot Diamond
Session Chair

Coupling sensing and imaging devices: towards a complete handheld analytical system

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The development of new outside-the-lab analytical methodologies and technologies to gather in situ and real time chemical information using low cost and compact devices is one of the most challenging issues facing the analytical sciences.

One organoleptic characteristic of matter that is widely used in chemical analysis is colour, although it was not until the advent of colour sensors and the later explosive development of consumer electronics in the late 20th and early 21st century that colour began to be used as a quantitative parameter, opening the door to the development of new methodologies for chemical detection and analysis.

The widespread use of imaging devices, along with sensor systems involving the change, appearance or disappearance of colour or any property measured through a colour change, such as luminescence, has paved the way for the development of novel complete analytical systems for outside-the-lab applications: chemical recognition + transduction + signal processing + data transfer.

In this presentation, we will discuss some recent developments in the use of computer vision in analytical chemistry referring to the colour spaces used, analytical system architecture for colorimetric determination including both commercial and portable instrumentation, and the strategies developed for analyte recognition.

Special attention is given to the use of mobile phones, which are at the core of these analytical systems because of their multiple and complementary capabilities: high resolution imaging detectors, high computational power and multiple connectivity links (4G, Bluetooth, USB and RFID interfaces). In fact, it is possible to develop innovative passive devices based on radiofrequency identification tags with sensing capability (RFID) powered by a phone, as we will discuss.

The interesting alternative of colour-based sensing devices, of which some examples are shown, use capillary microfluidics based on materials such as paper, thread and cloth, which allows different analytical operations to be carried out on the material itself, as well as the immobilization of reagents such as enzymes or nanomaterials.

NOTES

Microfluidic enabled Portable ABO reverse typing sensor

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Blood typing is especially important in any emergency transfusion and during pregnancy. Transfusion of a non-compatible blood type can carry out severe health problems, since hemoagglutation reaction with opposite antibodies stick cells together.

Conventional blood typing test in most countries require direct and reverse blood typing. The second step, called reverse typing is done using the natural antibodies from the patient's plasma. The plasma of blood without cells is mixed with blood that is known to be type A and type B. Persons with type A blood have anti-B antibodies, and those with type B blood have anti-A antibodies. Type O blood contains both types of antibodies. The agglutination of the aforementioned cells will allow the determination of the blood type from the natural antibodies of patient's plasma.

Currently, this step is done in clinic labs since it requires a centrifuge to separate plasma from blood. This study presents an approach that combines a microfluidic a blood plasma separator and a paper-based blood type detector.

The proposed high throughput blood plasma separator device has been designed to use cross flow filtration in order to extract higher volume of plasma (0.1 µl) from fresh undiluted blood (2 µl) with high purity (100%) in an admissible time (5 min) to implement for blood typing tests.

The main advantage of this design is the efficiency and maximization of the amount of obtained plasma from initial sample. The results of this microfluidic system have been compared with commercial lateral flow assays to validate the quality and quantity of the extracted plasma and to prove its capability as a blood back typing input.

NOTES

Potentiometry, nanostructured materials and the emergence of paradigm-shifting analytical platforms

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Some of the recent social and technological trends, such as telemedicine, point of care and chemical sensing networks, are creating a growing demand for systems that can generate chemical information everywhere, in real time. Since the traditional lab-centred approaches cannot cope with the increasing levels of scale and speed required, devices that can generate information with minimal expertise and infrastructure, in real time are required. In the near future, home-based analytical devices connected to mobile phones, embedded in garments or as part of other daily use objects should become common. This is a paradigm-shifting challenge where the traditional notion of analytical performance based purely on detection features (e.g. sensitivity, selectivity, limits of detection, etc.) must be broaden to embrace also aspects such as speed, affordability, simplicity of operation, versatility and scalable manufacturing.

In this presentation we will discuss recent developments to build simple, compact and ultra-low-cost analytical and bioanalytical platforms. In particular, the use of nanoporous and nanostructured systems to create new electrochemical sensing interfaces with ability to create flexible platforms for (bio) sensing will be presented. Recent advances in the development of wearable electrochemical sensors and ultra-low-cost (under 0.10€) chemical sensors with ability to measure ions, organic and biological molecules in different settings outside the lab. Examples of paper-based electrochemical sensors and sensing textiles with wireless connectivity will be shown. The ability of these novel tools become a widespread platform to tackle emerging social challenges will be discussed, and their use in real scenarios will be presented.

NOTES

Bio-Inspired Microfluidics for Wearable Sensors

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Wearable sensors are positioned close to, on, or even inside the human body and measure vital functions such as heart rate, temperature, or even biochemical parameters. These parameters give essential information on the health and well-being of humans, and therefore wearable sensors will find applications in health monitoring, well-being, and sports.Sweat is an interesting and convenient body fluid for wearable sensor applications. The amount of sweat and its composition can be used to detect, for example, dehydration or cystic fibrosis. To enable the continuous and non-invasive monitoring of this body fluid, we have developed a wearable sweat sensor using principles that were inspired by biology. Water transportation in plants is successfully mimicked in a flexible microfluidic system: we realized a system in which (1) liquid can be collected from the skin by an absorbing structure; (2) liquid is transported through a microchannel structure by capillarity; and (3) evaporation through a porous structure at the device outlet drives a continuous and prolonged flow through the channel (by evaporative pumping). [1] We integrated a pH sensor chip in the device. Our proof-of-concept experiments show that our prototype can be successfully used for continuous sensing. [2] It offers a base platform to integrate heterogonous sensing systems in a flexible and possibly low-cost way not only for sweat sensing but also for other applications such as continuous water quality monitoring or other bio-sensing applications where continuous flow over a sensor is required.

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NOTES

In Situ Biosensing of Cancer-Related Cellular Biomolecules

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Cancer-related cellular biomolecules have been regarded as attractive targets for biomedical research, molecular diagnostics and cancer therapy. Our recent efforts have been devoted to in situ analysis and highly selective detection of various cancer-related cellular biomolecules and precise near-infrared cancer therapy. Some research results in in situ biosensing of cancer-related cellular biomolecules with different detection techniques, including electrochemical, chemiluminescent, scanometric, fluorescent, Raman and mass spectroscopic imaging have been published. These cellular biomolecules include glycans [1] and protein-specific glycans [2] on living cell surfaces, intracellular microRNA [3], sialyltransferase and lysosomal neuraminidase [4], telomerase [5], ATP and caspases [6]. Some nanoprobes designed for real-time targeted imaging and precise near-infrared therapy against cancer are also discussed [7,8].

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NOTES

Portable and Miniaturized Lab on a Chip with Regenerable Membrane for Sanitary Emergencies

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A humanitarian crisis requires portable, integrated and versatile systems for fast and in situ analysis. Miniaturized and portable Lab on Chip (LoC) architectures integrating transduction, fluid management and signal processing are of interest in this field. In amperometric biosensors, biomolecules such as enzymes are used as a selective recognition element, which limits the application of the system to a single analyte. However, if this sensitive recognition part is refreshed with new and/or different recognition elements, reconfigurable devices are obtained, enabling ad lib selection of the analyte to be sensed. In the presented work, an electrodepositable alginate hydrogel is used to immobilize enzymes close to a microfabricated Pt transducer. After detection, the membrane is discarded and a new catalytic membrane can be electrodeposited on the same transducer. We demonstrated the possibility to sequentially quantify glucose and lactate with the same device without crosstalk and with no need for recalibration due to the repeatability of the electrodeposited membrane. This LoC also features signal digitalization and automatic measurement control enabled through a novel low-cost custom potentiostat architecture implemented with few standard dicrete electronic components presenting high versatility (from cycling voltammetries to chronoamperometries), high resolution (16 bits), simple connectivity (USB-OTG) and transducer cleaning capability.

NOTES

Semi-Covalent Imprinting for Selective Protein Sensing at a Femtomolar Concentration Level

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Protein imprinting is challenging mainly because of their large size. It is very difficult to estimate which and how many groups on the protein template molecule surface are accessible for binding. To overcome this drawback, we introduced semi-covalent protein imprinting [1]. We prepared a conducting molecularly imprinted polymer (MIP) based on bis(2,2¢-bithien-5-yl)methane for human serum albumin (HSA) determination. A very high imprinting factor (IF >20) and selectivity of the devised chemosensor proved that the MIP featured molecular cavities of well-defined structure and high affinity to HSA. This success encouraged us to improve this approach even further. For that, we prepared a new artificial receptor material in the form of a thin macroporous MIP film with an unprecedented hierarchical nanostructure controlled at three different size scale levels [2]. The introduction of this nanostructure resulted in the extraordinary properties of this recognizing material. That is, its very high selectivity of MIP based extended-gate field-effect transistor (EG-FET) chemosensor was accompanied by high sensitivity and detectability at an impressive femtomolar concentration level. These analytical parameters were among the best reported in literature not only for MIP chemosensors but in the field of bio- and chemosensors in general.

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NOTES

Stimuli-Controlled Manipulation of Synthetic Micrometre-Sized Vehicles for Bio-inspired Fluidics

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Controlled movement in fluids is essential to the function of living systems. The desire of scientists to understand such complex motility in great detail, for over two centuries, has furthered our understanding of its intricacies. At the microscale, movement has been essential to the survival of all life, where individual cells can react to various chemicals by moving in a pre-programmed manner. This phenomenon is known as chemotaxis. To emulate such structures and processes, we present micro-vehicle droplets, based on ionic liquids (ILs) which show chemotactic behaviour. Such movement is generated through asymmetric release of an IL surfactant, which results in an imbalance in the local surface tension, causing the droplet to move spontaneously towards regions of higher surface tension. This behaviour can be exploited for programmed migration to specific locations in microfluidic devices, without the need for pumping or external stimulation of the system. Herein, we have developed signalling and seeking IL droplets, which chemotactically find each other in open fluidic networks by harnessing the chemical potential of their constituents and their environment. Additionally, we present chemotactic IL droplets which interact intimately with their fluidic system, offering the ability to make decisions, perform chemical reactions, carry out dynamic sensing-reporting and implement damage detection-repair. Such self-directed, multi-purpose movement of micro "vehicles" offers many intriguing opportunities in the microfluidics field. This could potentially stimulate novel research in droplet microfluidic devices, where the driving force for movement is dictated by the chemistry of the fluidic system itself, rather than through external control by the user. The realization of multifunctional biomimetic fluidic systems with advanced functionality, such as detection and repair of damage, self-management and healing could affect areas far beyond the frontiers of this research field.

NOTES

Stimuli-Responsive Materials and Biomimetic Fluidics: Fundamental Building Blocks of Chemical Sensing Platforms with Futuristic Capabilities

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Since the initial breakthroughs in the 1960s and 1970s that led to the development of the glucose biosensor, the oxygen electrode, ion-selective electrodes, and electrochemical/optochemical diagnostic devices, the vision of very reliable, affordable chemical sensors and bio-sensors capable of functioning autonomously for long periods of time (years) remains unrealized. This is despite massive investment in research and the publication of many thousands of papers in the literature. It is over 40 years since the first papers proposing the concept of the artificial pancreas, by combining glucose monitoring with an insulin pump [1]. Yet even now, there is no chemical sensor/biosensor that can function reliably inside the body for more than a few days, and such is the gap in what can be delivered (days), and what is required (years) for implantable devices, it is not surprising that in health diagnostics, the overwhelmingly dominant paradigm for reliable measurements is still single-use disposable sensors. Realising disruptive improvements in chem/bio-sensing platforms capable of long-term independent operation requires a step back and rethinking of strategies, and considering solutions suggested by nature and materials science, rather than incremental improvements in existing approaches [2].

Through developments in 3D fabrication technologies in recent years, we can now build and characterize much more sophisticated 3D platforms than was previously possible. We can create regions of differing polarity and hydrophobicity, mix passive and binding behaviours, and regions of differing flexibility/rigidity, hardness/softness. In addition, we can integrate materials that can switch between these characteristics, enabling the creation of biomimetic microfluidic building blocks that exhibit switchable characteristics such as programmed microvehicle movement (chemotaxis), switchable binding and release, switchable soft polymer actuation (e.g., valving), and detection. These building blocks can be, in turn, integrated into microfluidic systems with hitherto unsurpassed functionalities that can contribute to bridging the gap between what is required for many applications, and what we can currently deliver [3]. The emerging transition from existing engineering-inspired 2D to bioinspired 3D fluidic concepts represents a major turning point in the evolution of microfluidics. Implementation of these

disruptive concepts may open the way to realise biochemical sensing systems with performance characteristics far beyond those of current devices. A key development will be the integration of biomimetic functions such as self-diagnosis of condition and self-repair capabilities to extend their useful lifetime [4].

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NOTES

Wearable Sensor for Real-Time monitoring of Electrolytes in Sweat

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The measurement of sweat electrolytes has a number of important applications including monitoring the performance of athletes [1] and providing information on medical conditions such as cystic fibrosis [2]. Herein we present on a wearable non-invasive electrochemical-sensing platform for the detection of different electrolytes in sweat. The platform accesses sweat emerging through the skin during exercise, which is drawn across the sensors by capillary action to a highly adsorbent material reservoir. The sweat electrolyte composition is accessed via integrated solid-state ion-selective electrodes that can track their concentration in real time. The sensor data is digitised, stored locally, and subsequently transmitted via Bluetooth to a laptop. The platform design and fluidics have been optimised through several iterations using rapid prototyping technologies such as 3D printing. Results obtained during on body trials over a period of exercise are consistent with previously published data [3] on the use of wearable sensors for the real time monitoring of electrolytes levels in sweat.

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NOTES

Abstracts

Session 4: Sensors for Structures

Photonics (ISSN 2304-6732) is an international scientific open access journal on the science and technology of optics and photonics, published quarterly online by MDPI. Our aim is for *Photonics* to become a leading venue for publishing high impact fundamental research but also applications of optics and photonics. The journal particularly welcomes both theoretical (simulation) and experimental research.
Photonics is indexed in the Emerging Sources Citation Index (ESCI - Web of Science) from Vol. 3, and Inspec (IET) from Vol. 4.

Journal Webpage: http://www.mdpi.com/journal/photonics

Welcome by Jandro L. Abot

Dear Colleagues,

Welcome to the Session on Sensors for Structures!

Structural health monitoring of aerospace, civil and mechanical structures and components are becoming increasingly relevant to minimize maintenance costs and provide additional layers of safety for the users. This session on Sensors for Structures focuses on the progress of existing or novel sensing concepts including synergies among sensing approaches. All sensing mechanisms including piezoelectrics, piezoresistive, electrostrictives, magnetostrictives, shape memory alloys or polymers and optical are included in this session. The presentations will highlight experimental studies and computational approaches that include applications and experimental results.

Professor Jandro L. Abot
Session Chair

Recent Advances in Using Sensors for Structural Health Monitoring for Civil Structures

Tommy Chan

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Structural Health Monitoring (SHM) for civil structures involves the use of various sensing devices and ancillary systems to monitor the in situ behaviour of a structure to assess the performance of the structure and evaluate its condition. As SHM has demonstrated well its effectiveness in helping reduce operational costs and increase safety and reliability, it has attracted numerous researchers working in the area for the last three decades. SHM research can be divided into three main categories: (i) system development, (ii) sensors/measurement and (iii) applications. This presentation will report the recent advances in SHM in these three categories. In the first category, a number of test-beds have been selected covering a range of civil structural systems from laboratory models (two large-scale bridge models) and four real structures (i.e., a highway bridge, one 5-star-green rated medium-rise building, and two footbridges at QUT). In the sensors/measurement category, much of the recent work has been done to enhance the Fibre Bragg Grating (FBG) sensing technology. Recent developments include new FBG strain modulation methods and new FBG accelerometers using axial and/or transverse forces and vertical displacement measurements. The application category includes a number of ongoing projects on developing various Damage Detection (DD) methods, e.g., correlation Modal Strain Energies (MSE) with Multi-Layer Genetic Algorithm (ML-GA) based optimization; a multi-criteria approach using a combination of natural frequencies, Modal Frequencies (MF) and MSE to detect damage in bridges, buildings and dams; a correlation based method using the ratio of geometric MSE and natural frequency (GMSEF); time domain based methods based on Auto-Regressive (AR) and Auto-Regressive Moving Average (ARMA) models; enhanced MF for locating damage in suspension bridge main cables and hangers. Apart from DD topics, a group has been involved in developing methods to identify the effective prestress force in prestressed concrete box girder bridges by combining various Moving Load Identification (MLI) methods and Electromagnetic Ultrasonic Transducers. Besides, the use of SHM for asset management will also be discussed.

NOTES

Structural Health Monitoring Using Carbon Nanotube Yarns: Sensing Concept and Applications in Composites

Jandro Abot

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Non-destructive evaluation and structural health monitoring techniques can provide frequent or immediate feedback of the condition of a structure including potential damage. However, these techniques cannot detect initiating damage in composite materials with high compaction or multifaceted construction. More critically, they are unable to achieve damage detection without altering the microstructure of the composite material. An alternative method of strain monitoring and damage detection that may offer the advantages of structural health monitoring without their drawbacks consists of using piezoresistive-based carbon nanotube (CNT) yarns integrated in polymers and composite materials. The concept is that the CNT yarns form a continuous sensor circuit and their inherent piezoresistive sensitivity detects strain within the host material through resistance measurements without adding much weight or altering the integrity of the host material. This presentation includes a summary of the piezoresistive response of CNT yarns and the concept and latest experimental results on damage detection in laminated polymeric composite materials and distributed and localized strain measurement. Experimental results also show the ability of a combination of different yarn sensors to detect the exact location and extent of delamination in real time. CNT yarn sensors may provide an adaptive, practical, and sensitive structural health monitoring technique.

NOTES

Development of Self-Sensing Carbon Nanotube-based Composites for Civil Infrastructure Applications

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Worldwide, civil infrastructure systems are aging and deteriorating due to maintenance neglect, increasing traffic, and an environment that is becoming increasingly severer. In particular, bridges play a critical role in the transportation network. With limited monies available for maintenance and repair, a need exists for effective yet inexpensive solutions to strengthen and monitor bridges. This presentation provides an overview of the development of carbon nanotube (CNT)-based composites, which offer a means to strengthen and monitor adeteriorated bridge member simultaneously. CNT sensors are created by infusing a fabric, which can be structuralor non-structural, with carbon nanotubes to form a piezo-resistive network. Changes in the measured resistance between electrodes, which are attached to the composite layer, have been found to directly correlate to deformations and the formation and accumulation of internal damage. The resulting novel self-sensing composites are sensitive, inexpensive, and able to adhere to almost any shape. Two particular civil infrastructure applications will be presented and discussed in detail. First, two large-scale reinforced concrete beams were strengthened with a composite layer that had an embedded sensing layer and then loaded to failure using load cycles of increasing amplitude. The objective of the second application was to increase the remaining fatigue-life of a cracked steel bridge member. For this application, ASTM E647 test specimens were rehabilitated with self-sensing composites and loaded cyclically to failure. Both applications highlight the potential of CNT-based composites in bridge rehabilitation and monitoring.

NOTES

A Novel Laser- and Video-Based Displacement Measurement System to Monitor Vertical Deflections in Bridges

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Long-term monitoring of in-service bridges is useful for estimating the structural condition and its variation over time. The information obtained through a sensor network installed on the bridge is essential to aid in more inexpensive and effective maintenance strategies. Among the parameters typically measured, vertical deflection in some key points is the most useful and interesting one.

An ideal measurement system is accurate, reliable, robust and inexpensive. It also would be able to provide real-time information about the behaviour of the structure, in order to be integrated in a decision-making tool.

This presentation introduces a novel system to measure vertical deflections in bridges, based on laser and video technology. This solution successfully addresses the desirable features previously discussed. The key elements are a Full-HD video camera, laser pointers, and LED lights placed on a translucent panel.

The video camera records the relative position between the dots created by the laser pointers on the panel and the LED lights. Using specific software, it is able to determinate the vertical deflection of the bridge over time.

The proposed system is inexpensive, accurate, and can be applied remotely. A particular advantage is that the camera motion is automatically excluded.

NOTES

Feasibility to Detect Natural Frequencies of Hydraulic Turbines under Operation Using Strain Gauges

David Valentin, Alexandre Presas, Matias Bossio, Mònica Egusquiza, Eduard Egusquiza, Carme Valero

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Nowadays, hydropower plays an essential role in the energy market. Due to its fast response and regulation capacity, hydraulic turbines operate at off-design conditions with a high number of start and stops. In this situation, dynamic loads and stresses over the structure are high, documenting some failures over time, especially in the runner. Therefore, it is important to know the dynamic response of the runner under operation, i.e., natural frequencies, damping and mode-shapes, in order to avoid resonance and fatigue problems. The detection of natural frequencies of hydraulic turbine runners in operation is challenging because they are inaccessible structures strongly affected by the confinement in water.

Strain gauges are used to calculate stresses of hydraulic turbine runners under operation. However, in this paper, the feasibility to use them to detect natural frequencies of hydraulic turbine runners under operation is studied. For this purpose, a large Francis turbine runner (444 MW) was instrumented with several strain gauges at different positions. First, a complete Experimental Modal Analysis (EMA) of the runner in air was performed using the strain gauges. Then, the natural frequencies of the runner were estimated during operation by means of analyzing accurately transient events or rough operating conditions.

NOTES

Health Monitoring of Composite Structures via MEMS Sensor Networks: Numerical and Experimental Results

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Laminated composites often develop hidden damages, e.g., delamination. Such events can be effectively sensed through embedded structural health monitoring (SHM) systems, taking advantage of the interlaminar regions to place sensors; experimental campaigns proved that this approach may turn out to increase the sensitivity to small defects and reduce the remaining lifetime of the structure. In former studies, we proposed the adoption of a surface-mounted SHM system based on (inertial) MEMS sensors, which has the advantages of low cost and of suppressing the mentioned effects on lightweight structures. On the other hand, the relatively low accuracy of MEMS sensors may hinder reliable monitoring of the system state; this can be overcome through redundancy and an efficient sensor placement. An automatic approach is presented to define the optimal topology of a network featuring a limited number of sensors, wherein the extent and location of stiffness degradation due to damage are assumed to be unknown. The goal of the optimization procedure is to maximize the overall sensitivity to damage of the measurements collected through the whole SHM system. The method has been implemented in a multi-scale frame, to efficiently handle sensors, damaged regions and structural components of different sizes. Although based on deterministic modeling, results are provided to show how measurement noise can be dealt with; a comparison with a stochastic approach based on Bayesian experimental design is provided too. Experimental data collected by testing composite specimens and panels are finally discussed, to assess the identifiability of damage through the collected (noisy) measurements.

NOTES

Innovative Aeronautical Structural Health Monitoring Ultrasonic Sensor: from Autonomy To High Sensibility

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Since aeronautical structures tend to be more and more sophisticated today, it becomes necessary to develop Non Destructive Testing techniques for the monitoring of last generation aircraft. This concept also called Structural Health Monitoring has as main objective to detect and locate damages occurring within the aircraft structure during its flight. To ensure a good efficiency of this SHM system, a sensor network covering all the monitored areas has to be deployed which induces at the same time numerous difficulties due to connection and wiring aspects. Consequently wireless communications as well as energy autonomy capabilities are required in order to satisfy the future aeronautical certification steps for SHM systems. In this paper, the aim is to control aeronautical composite structures on production line since composite materials that are currently employed at an intensive rate for aircraft primary structures are extremely vulnerable to impact damages due to tool drops for example. To be able to detect and locate such an event on the full composite structure (wingbox for example), a piezoelectric SHM wireless and autonomous sensor network has been developed.Therefore, the feasibility of an innovative technique based on a piezoelectric harvesting device to obtain a self-powered SHM system is presented. More precisely, the SHM system aims to have a double functionality: it will carry out classical SHM tasks using piezoelectric transducers bonded onto the aircraft structure and will also be fully autonomous since the same transducers will be used to convert the mechanical vibrations of the structure into electrical power.

As natural vibrations are not available during the production process, the energetic autonomy of the system is provided thanks to a Lamb waves emitter strategically located in the middle of the sensor array. Using this new harvesting energy solution, it is shown that this system is able to harvest 7.4 milli watts for a 100 milli watts mechanical power applied to the structure. This electrical power can be used both by the electronic detector and the WIFI transmitter for the detection of impacts of less than 0.1 Joule. Finally, numerous ways of application such asnuclear industry are proposed in the paper.

NOTES

Microwave Sensors to Monitor the Displacement of Civil Structures: Recent Experimental Campaigns and Last Issues towards Advanced Sensors

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Using interferometric processing, a coherent radar is capable of detecting the displacement of structures with submillimetre accuracy and from large ranges, with the limitation that only the component along the line of sight can be measured. Many papers have been published focused on the ambient vibration test of bridges, cables, wind turbines, towers, and buildings. Although the development of interferometric radar sensors for the monitoring of civil engineering structures dates back to the 1990s, and the effectiveness of the working principle has already been consolidated, the study of advanced sensors is progressing slowly. Recently, some papers proposed novel sensors, aiming not only at improving performances and capabilities of interferometric radar, but also at proposing instrumentation with reduced costs. A few innovative systems have been tested but not yet definitely commercialized, and expected improvements have only been achieved in theoretical or trivial examples.

In this presentation, the authors summarize, with experimental examples, the main technical features of the available radar sensors, and how they are linked to the final performances of the dynamic measurements. Main performances are dictated by radar parameters as the swept bandwidth or the achievable SNR, which affect the range resolution, i.e., the capability to distinguish two different targets or parts of a surface, and the available accuracy respectively. We also discuss the possible improvements achievable using an updated technology. The development of advanced systems able to provide an optimum configuration of the proposed technology demands a strong interaction with the user communities. Finally, we also introduce a novel sensor working at a higher frequency, able to provide some improved performances presently under development at CTTC.

NOTES

Optimized Use of Sensors to Detect Critical Full Load Instability in Large Hydraulic Turbines

Alexandre Presas Batllo, David Valentin, Monica Egusquiza, Matias Bossio, Eduard Egusquiza, Carme Valero

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Nowadays, hydropower plants are of paramount importance for the integration of intermittent renewable energy sources in the power grid. In order to match the energy generated and consumed, Large Hydraulic Turbines have to work at off-design conditions, which may lead to dangerous unstable operating points involving the hydraulic, mechanical and electrical system. Under these conditions, the stability of the power grid and the safety of the powerplant itself can be compromised. For many Francis Turbines, one of these critical points, that usually limits the maximum output power, is the full load instability. Therefore, these machines usually work far away from this unstable point, reducing the effective operating range of the unit. In order to extend the operating range of the machine, working closer to this point with a reasonable safety margin, it is of paramount importance to monitor and to control relevant parameters of the unit, which have to be obtained with an accurate sensor acquisition strategy.

In the frame of a large EU Project, field tests in a large Francis Turbine located in Canada (rated power 444 MW) have been performed. Many different sensors were used to monitor several working parameters of the unit for all its operating range. Particularly for these tests, more than 80 signals, including ten types of different sensors and several operating signals that define the operating point of the unit, were simultaneously acquired. The present study focuses on the optimization of the acquisition strategy, which includes type, number, location, acquisition frequency of the sensors and corresponding signal analysis to detect the full load instability and to prevent the unit from reaching this point. In this way, the operating limits of the unit can be more accurately defined and therefore the effective operating range increased.

NOTES

Abstracts

Session 5: Sensors Applications

micromachines

Micromachines (ISSN 2072-666X) is an open access journal on the technology and science of micro-scale machines and micromachinery, published monthly online by MDPI. *Micromachines* is an international, peer-reviewed, open access journal, which provides an advanced forum for studies on micro- and nanoscale machines. The journal publishes reviews, original research articles, and communications in this field. *Micromachines* is dedicated to a high scientific standard. All manuscripts undergo a rigorous reviewing process with internationally renowned experts, and decisions are based on the recommendations of these independent reviewers.
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Welcome by Stefano Mariani

Dear Colleagues,

Welcome to the Session on Sensors Applications!

In the digital age of smart cities and internet of everything, the goal of a sensorized world is becoming reality. Within this frame, in the current Session we focus on emerging applications of existing sensors (and actuators) instead of discussing the development of new devices. Allowing for the burst in sensor use provided by micro- and nano-technologies and by additive manufacturing, applications are envisaged by the Session talks in the fields of health, robotics, monitoring of the environment and of civil structures, assistance of impaired people and energy harvesting in hybrid vehicles.

Professor Stefano Mariani
Session Chair

Nanosensors for Monitoring Bacterial Growth Kinetics and Response to Antibiotics

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Miniaturized and cost-efficient methods aiming at high throughput analysis of microbes is of great importance for the surveillance and control of infectious diseases and the related issue of antimicrobial resistance. Here, we demonstrate a miniature nanosensor based on a honeycomb-patterned silicon nanowire field effect transistor (FET) capable of detecting the bacterial growth and antibiotics response in microbiologically-relevant nutrient media. We determine the growth kinetics and metabolic state of *Escherichia coli* cells in undiluted media via the quantification of changes in the source-drain current caused by varying pH. Furthermore, by measuring the time-dependent profile of pH change for bacterial cultures, treated with antibiotics, we demonstrate for the first time the possibility to electrically distinguish between bacteriostatic and bactericide drug effects. We believe that use of such nanoscopic FET devices enables parameters that are not easily accessible by conventional optical methods to be addressed in a label-free format, i.e., monitoring of microbial metabolic activity or stress response.

NOTES

Lab-In-A-Tube: From Molecule to Cell Detection

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The intriguing properties of self-assembled microtubular architectures open new possibilities to develop three-dimensional functional devices for molecule and cell analysis. Here, we present an overview of novel applications ranging from highly sensitive protein detection towards cell analysis by either in-flow detection or impedimetric microtomography. The concept “lab in a tube”, introduced previously by E. Smith in our Institute in 2012 was presented as the integration of different components into a single microtube. It not only constitutes an interesting three-dimensional platform for cell analysis, but also serves as a building block for the incorporation of sensing and actuation components. This concept is based on rolled-up nanotechnology, which consists on deposition of strained nanomembranes on a sacrificial layer that is later selectively etched, transforming a 2D architecture into a tube-like device. In our group, we have developed high-performance electrochemical sensors by integrating electrical transducers in such microtubes. The axial configuration enhances the sensing capabilities in microfluidic devices as the sensing surface per fluid volume and total capacitance increase, favoring in this way the signal coupling with the detection volume of the sample. Our reported DNA biosensor showed superior sensitivity of four orders of magnitude compared to the equivalent planar counterparts, achieving attomolar detection levels of Avian Influenza Virus H1N1 DNA, without amplification or labeling. As a follow-up application, we proposed a direct and ultrasensitive detection system of VP40 matrix protein from Ebola virus, a virus of high relevance due to its high fatality rate. In this approach, we immobilized the capture antibody in the inner part of the tube and by incubating the analyte in-flow, attomolar levels of detection were achieved with high reproducibility and repeatability. The different functionalization steps were confirmed by XPS and AFM measurements. Further electrode nanopatterning within the tubular cavity will be developed in order to increase the sensitivity of the sensor. Our second device is a rolled-up high-throughput cell detection platform, which differs from existing ones because of its particular geometry and electrode configuration that allow highly sensitive detection with a simple readout system. In this approach, multiple rolled-up electrodes within a single tube, precisely integrated in a microfluidic channel, are implemented. Finally, as a complementary technique, a tubular electrical impedance microtomography (EIT) device was fabricated. This approach gives access to

EIT devices with tunable sizes in the sub-100 µm range. EIT images of silicon dioxide microparticles were obtained as proof of principle. These devices could enable the impedimetric analysis of biological samples, such as single cells or small cell clusters. In the future, measurements will be carried out to study the behavior of single cells towards external stimuli, e.g., drugs or implant materials.

NOTES

A Monitoring Approach to Smart Infrastructure Management

Eleni Chatzi

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Technical infrastructure forms a main pilar of the modern world, hosting our built environment, serving transportation and communication needs, as well as enabling the generation and transfer of energy. Within this context, engineers and owners need to warrant safe and robust operation of these systems for ensuring a smooth societal flow and resilience against short- (extreme events) and long-term threats (deterioration and fatigue processes). In tackling this challenge, engineers are becoming increasingly aware of the benefits stemming from Structural Health Monitoring, i.e., the process of gathering feedback from engineered systems via use of appropriate sensory systems. Developments in low-cost and easily deployed sensors allow for instrumentation of large scale structures, such as bridges, buildings, dams or wind turbines, generating a Big Data stream of diverse information, such as acting loads, strains, cracking and dynamic response.

When adequately interpreted through fusion with appropriate models, this data may then be transformed into effective knowledge on structural performance thereby facilitating the operation and maintenance of infrastructure. This talk will discuss methods and tools for tackling the multiplicity of challenges in this non-trivial task. Among others, we will discuss the monitoring, simulation and protection of systems that are of uncertain nature, either due to modeling imprecision or due to influence of continually varying and little known environments; the challenges of non-linearity and high-dimensionality; the extraction of salient features and robust performance indicators able to warn of damage and deterioration, as well as policy-planning for getting more out of engineered components, systems and networks.

NOTES

Multiphysics Modeling Ionic Polymer Metal Composites, with Application in Underwater Sensing

Maurizio Porfiri

Tandon School of Engineering, New York University, USA

Ionic polymer metal composites (IPMCs) are a novel class of soft active materials that are receiving considerable attention as sensors and actuators. For instance, IPMCs have found application in biomimetic actuators for underwater propulsion and manipulation. Moreover, they have been utilized as flow, touch, and force sensors and have been integrated in several fluid energy harvesting devices. IPMCs have been shown to produce large mechanical deformations in response to a modest voltage applied across their electrodes, and, conversely, to generate a measurable voltage across their electrodes when subjected to an imposed mechanical deformation. In this talk, we present a novel physics-based modeling approach developed to describe the chemoelectromechanical behavior of IPMCs and, especially, resolve the complex interface phenomena taking place in the vicinity of the electrodes. The chemoelectromechanical constitutive behavior is obtained from a Helmholtz free energy density, which accounts for mechanical stretching, ion mixing, and electric polarization. Structural modeling and perturbation theory are leveraged to establish tractable reduced order models. We focus on sensing and present a few case studies spanning base excitation, impulsive loading from an impinging vortex ring, and impact on the free surface of a quiescent fluid. Analytical insight on the mechanics of the coupled fluid structure problem is used to interpret experimental results and provide design guidelines for sensors based on active compliant materials in fluids.

NOTES

Design and Optimization of a MEMS-Based Piezoresistive Accelerometer for Head Injuries Monitoring: A Computational Analysis

Marco Messina[1], Chrisovalantis Palas[1], James Njuguna[2]

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This work focuses on the design improvement of a tri-axial piezoresistive accelerometer specifically designed for head injuries monitoring where medium-G impacts are common, for example, in sports such as motorsport and American football. Given the particular biomedical and biomechanical application, the device requires the highest sensitivity achievable with a single proof mass approach, where basically all three axes of measurements are detected with a single mass suspended by surrounding beams. Moreover, a very low error, below 1%, is expected for these types of applications where accuracy is paramount. The optimization method differs from previous work as it is based on the progressive increment of the sensor mass moment of inertia (MMI) in all three axes. The work numerically demonstrates the hypothesis that an increment of MMI determines an increment of device sensitivity with a simultaneous reduction of cross-talk in the particular axis under study. A final optimal shape is selected as the best possible output of the optimization process and the final device shows a sensitivity increase of about 80% in the Z-axis and a reduction of cross-talk of 18% with respect to state-of-art sensors available in the literature. Sensor design, modelling and optimization are presented, concluding the work with results, discussion and conclusion.

NOTES

Integration and Synchronization of Different Sensors for the Positioning of Moving Vehicles

Paul Rawiel

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For intelligent mobility concepts in growing urban environments, positioning of cars and generally moving objects is a fundamental prerequisite. Global Navigation Satellite Systems (GNSS) are commonly used for this purpose, but especially in urban environments under certain conditions they offer limited accuracy due to buildings, tunnels etc., that can deviate or mask the satellite signals. The installation of other motion sensors inside the vehicle can be used to describe the movement of the cars independently of GNSS. This conforms to the concept of Dead Reckoning (DR). Both systems (GNSS and DR) can be integrated and prepared to work together since they complement their respective weaknesses efficiently. In this presentation, a method to integrate different sensors (gyroscope, altimeter, accelerometer and wheel-ticks) and GNSS is developed. Extended Kalman Filter (EKF) is the base of calculations to perform data integration.
Several driving tests are realized to check the performance of the models. The results show that the developed system is able to improve GNSS positions and even fully substitute this system, e.g., in tunnels, where no GNSS signal is available, as long as this situation is not prolonged too much in time.

NOTES

Landslide Monitoring with Multi-Sensor and Temporal Scale Approaches: A Test Site in Alpine Environment

Abraham Mejia-Aguilar, Romy Schlögel, Christian Kofler, Mehdi Darvishi

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Landslides in alpine environment are present as earthflows, rock falls, shallow slides, debris flows, among others. The dynamics of the surface deformations have many causes, among them the inner geomorphological processes, extreme weather events or human activities that aggravate or accelerate it.
In this work, we combine diverse technologies (sensors) at different spatial and temporal scales (platforms) to better understand the complexity of the gravitational mass movement located in Corvara in Badia, Italian Dolomites. The setup consist of: (i) a monthly surveying GNSS for tracking artificial corner reflectors (reflecting objects) used in three different scales for determining velocity vectors: in situ, proximal and remote sensing. (ii) two in situ stations equipped with a DSLR camera with an automatic time-lapse program based on a low-cost solution system acquiring two daily images covering active part of the landslide for tracking objects and conducting photogrammetry analysis, (iii) an UAV platform with compact cameras flying yearly on the active landslide (8 ha.) for *proximal* sensing scale retrieving DEM, orthomosaics and cloud points determining 6-axis movement in objects and (iv) Sentinel-1 imagery processed by Synthetic Aperture Interferometry (InSAR) as *remote* sensing application combined to the previous ones. The benefits and drawbacks of every approach will be presented.

NOTES

Linking Additive Manufacturing and Sensor Integration: A Direct Path towards Structural Electronics?

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Additive manufacturing (AM) of polymers, metals and ceramics has received tremendous attention since maturing from a prototyping to a full-fledged manufacturing technology for geometrically complex objects. Several products have already been realized on a commercial basis, covering application areas as demanding as the aerospace industry. Additive manufacturing offers a design freedom which is unparalleled by subtractive manufacturing or forming processes. This feature would, in itself, create business opportunities in several scenarios that build on high complexity or customization, allowing, for example, the assembly of numerous parts to be integrated in a single component, and structurally optimized bionic designs to be realized. All this is true for AM parts made from a single, homogeneous material. This, however, is not the end of the approaches' generic capabilities. Instead, more and more technologies are emerging which use the fact that most AM approaches grant direct access to each individual voxel of a component volume to locally modify material properties. Some processes even allow the selective deposition of different materials. Besides hybrid approaches, it is these specific solutions which allow the creation of a direct link between Additive Manufacturing and Sensor integration, ultimately leading to the vision of structural electronics or 3D-printed electronics in a single manufacturing system, or even a single process.
The presentation explains the different classes of Additive Manufacturing processes available and attempts to classify them with respect to their capability of realizing (a) multi-material parts and (b) parts with integrated interconnects, sensors and/or electronics. Practical approaches to the creation of structural electronics parts via AM techniques are discussed. Typically, these rely on a more or less tight integration of different manufacturing processes—typically a generic AM process which is combined with one or more direct write or similar processes in a manufacturing chain, a manufacturing cell or even a single manufacturing system. Beyond these, special attention is reserved for AM techniques that allow in-process switching of materials at high resolution: in principle, these have the potential to realize complex systems, not by a combination of processes, but via a single deposition and consolidation process. Further to the introduction of processes, application scenarios which benefit specifically from the combination of AM and sensor integration are presented.

NOTES

Performance Analysis of LIDAR Assist Spatial Sensing for the Visually Impaired

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Echolocation can enable people with vision impairment to comprehend the surrounding spatial information. However, this technique often requires long term training, and the accuracy of echolocation is subject to varying conditions. Furthermore, people often has generate the sound and process the received information simultaneously. This work presents a proof of concept LIDAR Assist Spatial Sensing (LASS) system focuses on overcoming these restrictions by detecting the location of surrounding obstacles of the user through a LIDAR and translating this spatial information into stereo sound at different pitch. Both the stereo sound and the pitch informs the user of the obstacles' orientation and distance, thus granting visually impaired users with enhanced perception of spatial areas and obstacles. The work is divided into two phases. Phase I involves hardware and software engineering. Phase II focuses on system efficacy study. 18 blindfolded human participants equipped with the LASS system were studied, which was cleared by the Penn State IRB. Our study demonstrates that with minimal training, blindfolded individuals equipped with the LASS system, were able to identify the number of obstacles, rank their distance, and perceive obstacles' relative location.

NOTES

Protecting Sensors in an IoT Environment by Modelling Communications as Resources

Luis Cruz-Piris, Diego Rivera, German Lopez-Civera, Enrique De la Hoz, Ivan Marsa-Maestre, Juan R. Velasco

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The growth of the internet has generated new types of services based on novel data sources. Among these services, the use of sensors and actuators to create hybrid services that allow humans to interact with the physical environment in a natural way is especially remarkable. These services compose what is called the Internet of Things (IoT). One of the biggest challenges is the protection and access control to the sensors and actuators exposed to the Internet, becoming a critical factor in IoT scenarios. We propose the abstraction of the IoT communication elements as Resources that can be protected using conventional access control schemes. To achieve this, we propose using User-Managed Access (UMA), an existent OAuth2 profile originally developed for the protection of Internet services. To validate our proposal, we have selected MQTT, one of the simplest message-based communication protocols used in IoT environments. We have developed a prototype implementation and a use case using a developer board based on the MCU ESP8266 as an IoT device. The performed tests have been focused on validating the proposed solution in terms of the correctness of the access control system, energy consumption and communication delays.

NOTES

Sensor Excitation and Measurement Techniques for CNT Thin Film Sensors

Louis McCarthy

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The need for low-power sensing in noisy Electromagnetic Interference (EMI) environments presents a challenge to harvesting meaningful data from high-impedance sensors. DC–DC converters, line noise, and high-speed digital communication lanes can wreak havoc on our conversion chain. This talk will cover various front-end analog designs, including voltage dividers, constant current sources, Wheatstone bridges, and beyond, along with their benefits and drawbacks. We will start with a brief introduction to Carbon Nanotube (CNT) sensors: what they sense, their nominal value, and their value range. Next, we will detail sensitivity and noise, by providing examples and data using various CNT sensors, for each of the following circuit designs: adding a single resistor to form a simple voltage divider, driving the voltage divider using a precision voltage source, using a constant current source to feed the sensor, and adding three resistors to form a Wheatstone bridge. The third part will focus on using AC sources to generate frequency-modulated or amplitude-modulated values and to aid in noise filtering. In conclusion, we will show how to improve designs using instrumentation amplifiers, programmable gain amplifiers, and active filters.

NOTES

Abstracts

Poster Exhibition

Inventions (ISSN 2411-5134) is an international scientific open access journal published quarterly online by MDPI. The journal *Inventions* is an international, peer-reviewed journal that publishes original scientific research of significance concerning innovation/invention, or patent-based/extended/reviewed research papers in all fields of science, engineering and product development processes. Also covered would be research concerning improvements of machines or products; new processes for creating an object; inventions in advanced technologies; and short technical reports regarding transferring technology. Our aim is to publish high quality papers concerning the discovery of completely unique functions or results, offering readers radical breakthroughs and novel contributions. We encourage authors to give special attention to patent-based/extended researches.

Journal Webpage: http://www.mdpi.com/journal/inventions

1 A Common Assessment Space for Different Sensor Structures

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The study of the evolution process of our visual system indicates the existence of variational spatial arrangement; from densely hexagonal in the fovea to a sparse circular structure in the peripheral retina. Today's sensor spatial arrangement is inspired by our visual system. However, we have not come further than rigid rectangular and, in a minor scale, hexagonal sensor arrangement. Even in this situation, there is a need to be able to directly assess differences between the rectangular and hexagonal sensor arrangements, i.e., without the conversion of one arrangement to another. In this paper, we propose a method to create a common space for directly assessing the differences among any spatial arrangements, e.g., between the rectangular and hexagonal. Such a space is created by implementing a continuous extension of discrete Weyl Group orbit function transform which extends a discrete arrangement to a continuous one. The implementation of the space is demonstrated by comparing two types of generated hexagonal images from each rectangular image with two different methods of the half-pixel shifting method and virtual hexagonal method. In the experiment, a group of ten texture images are generated with variational curviness content using ten different Perlin noise patterns adding to an initial 2D Gaussian distribution pattern image. Then, the common space is obtained from each of the discrete images to assess the differences between the original rectangular image and its corresponding hexagonal image. The results show that the space facilitates an easy tool to assess the changes between different spatial arrangements by which, in the experiment, the hexagonal images show richer intensity variation, nonlinear behavior, and larger dynamic range in comparison to the rectangular images.

2 A Portable Fluorescence Lifetime Spectroscopy Detector for Molecular Diagnosis

Joan Canals, Nil Franch, Oscar Alonso, Anna Vilà, Angel Diéguez

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Fluorescence-based techniques are amongst the most widely used methods in molecular analysis in life science with multiple applications in clinical analysis and biomedical diagnosis. Considerable efforts have been directed toward the miniaturization of the fluorescence-based instruments, in an effort to reduce both cost and form factor for point of care (PoC) applications, but at the expense of increasing the complexity of the system or losing sensitivity. A new technology is being developed to build a PoC device based on fluorescence lifetime detection for molecular diagnosis with a sensitivity comparable to the bulky optical instruments and with a diagnosis time of a few seconds. Our PoC is a low-cost, simple, fast and easy to use general purpose platform, aimed at carrying out a fast diagnostics test through label detection of a variety of biomarkers.

The system is designed to eliminate the optical requirements associated with traditional fluorescence lifetime instruments. With an array of ultra-sensitive detectors based on CMOS SAPD (single photo avalanche diode) technology along a custom microfluidic polydimethyl-siloxane (PDMS) cartridge on top of the sensor to insert the sample. The proximity of the sample and the SPAD sensor conjointly with the gate mode operation of the sensors, makes the use of lenses and optical filters unnecessary. The device is operated in Time Correlated Single Photon Counting (TCSPC), measuring the time of arrival of the photons after excitation of the fluorescence with a nanosecond laser diode. The sensor, which is extremely sensitive to light in the rage from 400 to 1000 nm, and of ultra-high speed, works in gated mode, which makes it practically unaffected by the intrinsic noise.

The system has been characterized with several concentrations of fluorescent quantum dots (Qdot®605 streptavidin conjugate from Life Technologies) as proof-of-concept for lifetimes of several nanoseconds. The lifetime of the quantum dots is 35 ns, and is measured in only 15 seconds.

3 A Study on Optimal D-InSAR Filtering Technique according to Landform relief

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The InSAR technique measures the displacement of an indicator using SAR image interference. The technique of interfering two SAR images among InSAR techniques is called Differential InSAR (D-InSAR). In the process of D-InSAR, the filtering uses the Unwrapped Mask, usually the GoldStein method. However, since the Goldstein method removes the noise on the path, it is difficult to derive the displacement value in the agricultural area where the relative coherence is low. In Korea, more than 50% of the whole country consists of mountainous regions and agricultural regions, so it is difficult to use the Goldstein technique polysynthetically. In this study, we set the test-bed for the urban area and the agricultural area based on Coherence, and introduce Goldstein and Boxcar Filter. Through this process, we want to draw the conclusion which is displacement values in the agricultural area and urban area by two different filtering type. And we find that Boxcar have better efficiency than Goldstein at agriculture area, but in case of urban area, Goldstein method have better efficiency than boxcar filter.

4 Analysis of SPR Sensors in D-shaped POF Realized by Hand and Mechanical Polishing

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Optical fiber sensors based on Surface plasmon resonance are today widely proposed for applications in different areas of bio-chemical and chemical sensing. Among them, SPR sensors based on plastic optical fibers (POFs) can offer advantages due to their low cost, flexibility, robustness and simplicity of fabrication. Recently, authors reported several bio-chemical and chemical applications based on an SPR sensor platform in D-shaped POFs. The adopted D-shaped fabrication procedure is based on the insertion of a portion of the POF fiber (about 10 mm long) in a resin support and on a successive hand grinding of the fiber surface. This procedure guarantees an easy and low-cost effective way for the removal of the cladding layer in the POF sensing region and for the reduction of the exposed core. At the end, a thin gold film (60 nm thick) can be deposited on the flat hand grinded D-shaped POF core, for exciting SPR resonance at the metal/external medium interface. Despite the straightforwardness of the hand polishing method, described above, in this work we want to compare performances of a hand polished SPR D-shaped POF platform with the ones achieved by a mechanical polishing procedure. Actually, the performances are influenced by small variations in the morphology of the D-shaped region (roughness and total depth) resulting from the manual process used for the preparation of the sensors.

5 Combination of Multispectral and 3D Imaging Sensors for the Detection of Skin Cancer

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This study proposes the combination of multispectral and 3D imaging sensors to improve the detection of skin cancer. The multispectral system consists of a CCD digital camera and light emitting diodes (LED) of eight different wavelengths (414 nm to 995 nm) with a working distance of 4 cm and a field of view of 15 mm x 20 mm. Parameters based on spectral features of the lesions such as reflectance and color as well as others empirically computed using reflectance values were calculated pixel by pixel from the images obtained. The 3D system is composed of two monochrome CCD cameras placed in a standard stereo geometry, a light picoprojector and a color camera, both located between the two monochrome cameras. All cameras had an objective lens with fixed focal length (25 mm) with a working distance of 110 mm, obtaining a field of view of 19x14 mm. Parameters based on the shape, border irregularity and height of the lesion were obtained by a stereovision technique combined with the projection of a sinusoidal pattern set shifted over the skin. More than 80 skin lesions including malignant and benign lesions were analyzed by means of both sensors and the combination of parameters allowed for a higher detection of melanomas (Sensitivity: 93%, Specificity: 54%). Therefore, the proposed sensors could be useful as a supporting tool to current methods used in dermatology such as dermoscopy and confocal microscopy.

6 Development of a Smart Sensor Network with Application in Self-Adapting Energy Management Systems for Buildings

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To satisfy ever-increasing needs for efficiency and environment protection, the energy management systems for buildings have become more and more complex products that integrate advanced sensor networks and control algorithms into their structure. The integration of these two modules allows the development of new context-aware responses for the control strategies that allows the system to adapt better to the building and environment dynamics. In this paper, the results of developing such a system are presented. The controlled environment was developed using Matlab simulation software. The smart sensor network was developed and optimized using this virtual environment. The data provided by the sensor network are used to better control the energy consumption in the building. For this, a model-based control algorithm was developed which takes advantage of the extra information provided by the network. The obtained system is tested using hardware in the loop approach on the dSpace and Discovery STM32F4 real-time simulation platforms. The obtained results show that the proposed approach offers good results and increases the efficiency of the building.

7 Electrical and Gas Sensing Properties of p-type Co_3O_4 Loaded n-type TiO_2 Nanotubes Heterostructures

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P-type Co_3O_4 particles loaded onto *n-type* TiO_2 nanotubes (NTs) with controlled Co_3O_4 density were synthesized using a two-step electrochemical deposition procedure. Morphology and structure of the fabricated samples were characterized by Scanning Electron Microscopy equipped with Energy Dispersive X-ray Spectroscopy and the X-ray Diffraction method. The effect of loading density on the electrical and gas sensing properties of the loaded *n-type* TiO_2 NTs was investigated. *C-V* and *I-V* characteristics were obtained and the heterojunction barrier height was determined. Sensor properties of hydrogen (H_2), NO_2 and VOCs with varying operation temperatures were measured. The results show that Co_3O_4 particle density on the surface of TiO_2 NTs directly affects the sensor performance such as selectivity and sensor response, even at low operation temperatures.

8 Flexible Thermoelectric Generator Module as Body Energy Harvester

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One of the technical issues for enabling in situ sensors is to energize them through a battery pack which is often obtrusive and compromises the ecological validity of the system performance. A flexible thermoelctric generator became an attractive technology due to its wide use, especially for curved surfaces applications. This study proposes a unique approach to replace or supplement existing battery power through harvesting thermal energy from the human body in order to transform wearable sensors into personalized care. The energy harvester module includes ink-based thermoelements made of nano-carbon bismuth telluride materials. N- and P-type thermoelectric elements that are designed electrically in series and thermally in parallel provide electrical potential due to temperature difference available between the body skin and ambient. The proposed design of heat transfer surfaces in this work improves thermal conductance between the skin and the warm side of the harvester and between the cold side of the harvester and the ambient, and can enhance the electrical energy conversion performance of the thermoelectric harvester. The presented harvester in this study is supposed to produce 100 µV to feed the used sensor in the thermoelectric system. In this design, the effect of ambient conditions, such as temperature and heat transfer coefficient due to natural convection, and also dimension of the TEG thermoelements on the power generation, are studied.

9 Improvement in Limit of Detection of Paper-Based Electrochemical Enzymatic Biogas Sensor

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Breath analysis is an attractive method for chronic diseases because it offers noninvasive, point-of-care diagnostics. Biomarkers of chronic diseases and many volatile compounds are included at low concentrations (sub ppm to ppt levels) in human breath [1,2]. Thus, gas sensors for exhaled breath require high selectivity and low limit of detection (LOD).

A study of highly selective biogas sensors utilizing the specificity of enzymes has been reported [3]. The detection area is fabricated simply by using chromatography paper where the enzyme / mediator solution is dried and immobilized. The $[Fe(CN)_6]^{4-}$ (Ferro), one of the mediators, changes to $[Fe(CN)_6]^{3-}$ (Ferri) due to the enzyme reaction when the target gas is blown on the detection area. Then the Ferri is reduced by the electrode with negative potential, and the current flows. However, it is difficult to measure low concentration substances in exhaled breath using the previous gas sensor because of the background current (BC: current at zero concentration), and its standard deviation is large. We assumed that the BC is caused by degradation of Ferro into Ferri during drying process because of the redox potential relationship between dissolved oxygen and Ferro.

This study is an attempt to decrease the background current and lower the limit of detection. We measured BC by optimizing the conditions of mediator, dissolved oxygen, and Ferro concentration, as well as temperature and time in drying process. The optimum condition was obtained with removing dissolved oxygen as soon as possible, Ferro concentration 3 mM, drying temperature 40°C, and drying time 20 minutes. In this condition, LOD of ethanol gas sensor was improved from 39 ppm to 15 ppm (61.5%).

This result presents a new possibility which can be applied to biosensors for low concentration substances in human breath and diagnosing chronic diseases.

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10 Suppression of Scalloping and Inter-Scan Banding in Non-Stationary ScanSAR Images Based on Kalman Filter and Image Segmentation

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The antenna pattern of a SAR sensor can be represented as a two-dimensional sinc function, whose width is determined by the size of the antenna sensor. Therefore, the brightness of a SAR image at the center is higher than that at the edge, which needs to be corrected. However, due to the antenna pattern calibration error in practice, the brightness imbalance cannot be completely compensated, which results in the degradation of image quality, especially in ScanSAR mode. ScanSAR mode obtains wide-swath coverage by periodically switching the antenna elevation beam to points in several range sub-swaths, which results in scalloping and inter-scan banding (ISB) effects and image quality degradation. To solve this problem, a novel method is proposed based on the Kalman filter, especially in the case of the complex scene. First, a two-dimensional periodic variation noise model is presented to describe the scalloping and ISB phenomenon. Then, on the basis of analysis of image statistical characteristics, image segmentation and brightness modification are performed, which provided a precise precondition for implementing the linear Kalman filtering operation. Finally, experimental results validate the proposed method.

11 System Based on RFID Technology for Product Transport Tracking

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This work focuses on the development of a radio-frequency identification (RFID) system devoted to real-time traceability of products shipped by transportation companies. This system provides control over a container (one or more products) or individual product, which can be configured and adapted to any desired environment.

In order to achieve the goals mentioned above, RFID tags are monitored by a dedicated hardware device based on a Raspberry Pi, easing the storage and analysis of both location and identification of any tracked product with no possibility of error.

It is worth mentioning the capability of the system to be adapted not only regarding the features of the products, but also the parameters that will be monitored. That is, the user must define an appropriate set of constraints so that the system can warn the user when a value for a monitored feature exceeds its specified limits.

This system can be considered a highly innovative one, since it integrates RFID technology to any transportation scheme, such as the sanitary environment, where stability and preservation conditions are exceptionally important to guarantee the patients' safety and to ensure the quality of the processes that are carried out within the daily clinical practice in a hospital.

12 Time-To-Failure Modelling in On-Chip LiDAR Sensors for Automotive Applications

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In general, when forward-looking on-chip LiDAR is considered, the role of these sensors in vehicle collision avoidance is very important. Therefore, the reliability assessment related to accuracy in obstacle detection from information provided by LiDAR sensors has become a key issue to be researched by the scientific community. The analysis of reliability must be focused on certain critical points such as solution to navigation errors, measurement range error, error in the scanning angle, divergence in the laser, etc. This paper establishes a relationship based on models for obstacle detection and classification in complex traffic scenarios. These models have been generated from data collected, provided by LIDAR sensor models, implemented in a commercial simulation tool such as SCANeR studio. For this, a traffic scenario has been created in this simulation tool. To create models, the proposal combines two widely reported pattern recognition methodologies, including fully flexible Bayesian Networks and k-nearest neighbors algorithm. Subsequently, a comparison is made during a model simulation in a traffic scenario, obtaining very promising results in terms of accuracy based on two merit figures: distance root mean square and mean root square error. Finally, the best results have been reached with k-nearest neighbors algorithm.

13 Sustainable Water Management: Sensors for Precision Farming

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The application of Site Specific Crop Management (SSCM) consists of the knowledge of the variability of soil and yield. In particular, for sustainable water management, it is fundamental to obtain a differentiated response in terms of selective irrigation, analyzing and evaluating the water content of the soil or the water requirement of plants. The innovative contribution of this work lies in designing, developing and validating a technology platform consisting of multi-sensorial hardware for the measurement of parameters characterizing the soil–plant–atmosphere system of intensive crops, i.e., tomato and corn. In order to determine the water content of this system, the two portable sensing units allow to detect gamma-rays emitted from the soil (VIS, BRG and panchromatic, NIR, TIR, range) and to monitor target gases (MOX sensors) related to the crops emissions, such as moisture and VOCs, respectively. The results obtained are compared to reference values defined by the Ground Control Parameters for various types of soil and crops. Finally, in order to improve the variable rate approach of irrigation technologies, georeferenced data obtained are integrated in an experimental computer platform (IRRINET) for the control of water rate and for the creation of an irrigated recipe to interface with the irrigation equipment.

14 Development of an Automated System for the Analysis of Cell-Free Fetal DNA from Maternal Plasma for Non-Invasive Pre-Natal Diagnostics

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The analysis of circulating cell-free (cf) DNA from plasma, serum or urine, has the potential to serve as a non-invasive approach to detect and monitor targets associated with certain diseases. In 1997, the presence of fetal DNA in the plasma and serum of pregnant women was demonstrated [1]. This opened new perspectives in the field of non-invasive pre-natal diagnostics since the analysis of cell-free fetal (cff) DNA can provide information about pregnancy-related disorders (pre-eclampsia, pre-term labour), chromosomal aberrations (aneuploidies) and genetic disorders (cystic fibrosis, thalassaemia, Huntington's disease) [2].

We report on the development of an automated and integrated modular system for the isolation, amplification and detection of cffDNA from maternal plasma for non-invasive pre-natal diagnostics. The system consists of a first module for the cfDNA isolation from plasma based on silica-coated magnetic beads technology. Subsequently, the cfDNA obtained is introduced to a second module which is based on a polymeric microsystem containing a capillary electrophoresis step for the size separation of the fetal DNA from maternal DNA. Finally, the cffDNA is transferred to the amplification/detection module. This module consists of PCB (Printed Circuit Board) electrode arrays functionalized with surface immobilised primers for the multiplexed isothermal recombinase polymerase DNA amplification (RPA) and electrochemical quantitative detection of specific genetic sequences.

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15 Label-Free Aptasensor for Lysozyme Detection Using Electrochemical Impedance Spectroscopy

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This research develops aptasensors for Lysozyme protein detection [1] using the Electrochemical Impedance Spectroscopy (EIS) technique which is simple, low-cost and follows the rapid high-sensitivity transduction principle to monitor biosensing events that take place at the surface of an electrode; the EIS technique is also capable of showing responses at a very low concentration level [2]. To achieve the main objective of this work, electrodes based on Graphite–Epoxy Composite (GECs) were constructed. The chosen immobilization technique was covalent bond using carbodiimide chemistry; for this purpose, carboxylic moieties were first generated on the graphite by electrochemical grafting.

The detection is performed using $[Fe(CN)_6]^{3-}/[Fe(CN)_6]^{4-}$ as the redox marker. After recording the frequency response, values are fitted to its electric model; for this purpose, a nonlinear least-squares regression protocol with complex arithmetic using Z-view is performed that utilizes the principles of equivalent circuits. The aptasensor showed a linear response range of 0.25 µM to 5 µM for Lysozyme and a limit of detection (LOD) of 0.19 µM. The sensitivity of the method established was 0.0889 μM^{-1} in relative charge transfer resistance values.

The aptasensor can be regenerated by breaking the complex formed between the aptamer and Lysozyme using 2.0 M NaCl solution at 42 °C, showing its operation for five cycles. The main proteins' interference response, such as bovine serum albumin (BSA) and Cytochrome c (Cyt c), has also been characterized. To finally verify the performance of the developed aptasensor, it was applied to wine analysis. The developed aptasensors indicate their suitability given that they can detect Lys in a complex matrix such as wine obtaining recovery yields of 77%.

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16 Optical Fiber Exhaled Breath Sensor Based on Lossy Mode Resonance Using a Graphene Oxide Sensitive Coating

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Optical fiber sensors (OFS) have attracted increasing attention due to their benefits over traditional sensors, such as small size, biocompatibility, remote sensing ability or safety in flammable environments. Among the different existing configurations of OFS, those based on electromagnetic resonances are very popular as they are reliable, robust and very sensitive. In particular, sensors based on lossy mode resonance (LMR) are very interesting as a wide range of materials, including metal oxides and polymers, can support them and they do not require specific equipment to tune the optical polarization.
Graphene-based materials such as graphene oxide (GO) or reduced graphene oxide (rGO) have become the most explored materials since Novoselov and Geim achieved its isolation in 2004. Their superior properties, such as high surface area or extreme sensitivity to the external environment, make them ideal candidates for the fabrication of the sensitive coatings required by LMR-based sensors.
In this work, the fabrication and characterization of a small and portable exhaled breath LMR-based OFS using GO as sensitive coating is presented. Refractive index changes have been detected showing a fast repetitive behaviour with a response time of 150 ms from inhalation to exhalation and a high average sensitivity of 410 nm/RIU.

17 Screen-Printed Electrodes as a Platform for Smart and Low-Cost Point of Care Devices

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Screen-printing is one of the most promising approaches towards simple, rapid and inexpensive production of biosensors and it is particularly suited to the mass production of low-cost disposable biosensors. One of the most prominent commercialized applications of screen-printed electrodes is the glucose biosensor used for diabetes, which represents a billion dollar per year global market. This shows the potential of commercialization of screen-printed sensors (or biosensors) point of care devices for applications with a significant global market.
CSEM is a research and technology organization specialised in the transfer of technologies and know-how from fundamental research to industry; and point of care devices based on screen-printed sensors technology is one of the fields where CSEM is involved in terms of technology-based activities that address the next generation of trends. Our fields of activity comprise, among others, wearable technologies for wellness and medical applications and development of point of care testing for diagnostics. Recent projects were focused on the development of point of care systems for the detection of biomarkers in non-invasive body fluids. Systems for tuberculosis detection by urine analysis or diagnosis of kidney diseases by saliva analysis were realized.

18 Selenocystine Modified Screen-Printed Carbon Electrode as an Alternative Sensor for the Voltammetric Determination of Metal Ions

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Heavy metals are present in the environment from both natural and anthropogenic sources. Their bioaccumulation and persistence constitutes a serious threat to human health, demanding suitable methods for heavy metal monitoring. In this sense, anodic stripping voltammetry is especially appropriate for measuring trace metals. Conventionally, stripping techniques were connected to the use of mercury-based electrodes. Nevertheless, concerns about mercury toxicity have led to focus on the development of more environmentally friendly alternatives such as chemically modified electrodes (CME). The commercial availability of screen-printed electrodes (SPE) has largely expanded the field of application of modified electrodes as substitutes for mercury.

The molecule immobilization procedure is a key aspect in the design of CMEs. Particularly, the molecule immobilization based on aryl diazonium salt anchored on the electrode surface has proven to be a suitable approach for the development of sensors.

This work focuses on the development of a selenocystine modified sensor via electrografting on a screen-printed carbon-nanofiber substrate (SeCyst-SPCNFE). This sensor was applied to the determination of Cd(II) and Pb(II) and compared to a sensor modified with L-Cystine (Cyst-SPCNFE) providing a better analytical performance. Finally, the applicability of SeCyst-SPCNFE was tested in a wastewater sample.

19 A flow injection methodology for acetamide determination using a tubular bioreactor and an ammonium sensor

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Pseudomonas aeruginosa (*P. aeruginosa*) is a Gram-negative bacterium quite versatile that grows in the soil, in coastal marine habitats, as well as in the tissues of plants and animals. *P. aeruginosa* is the source of amidase (acylamide amidohydrolase E.C. 3.5.1.4) which catalyzes the hydrolysis of a small range of short aliphatic amides into the corresponding carboxylic acids and ammonia.
A low cost piezoelectric quartz crystal coated with a selective membrane for ammonium was used to detect the reaction product.
Conversion of amide into the correspondent amine was achieved both with cell-free extract of *P. Aeruginosa* or the whole cells. This conversion was first performed in batch and later on injected into the sensor system where a buffer carrier was flowing over the coated crystal. Another approach consisted in incorporating a conversion reactor with the immobilized cell-free extract of *P. Aeruginosa* in the FIA system. Amide solutions were injected and carried by the buffer stream through the reactor and then directed to the sensor. Different supports were used for immobilization, such as calcium alginate beads, glass beads and the inside walls of a hollow glass column.
The best arrangement allowed acetamide determination without sensitivity lost for 1-month period.

20 A Near-Field Split-Ring Resonator-Based Monopole Sensor for Permittivity Characterization

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Many passive electromagnetic sensors have been recently studied. One of their advantages is that they can be easily merged with antennas, resulting in wireless and cheap devices. For instance, these sensors can be used for the characterization of the dielectric permittivity, with application in industry, biology or medicine, among others. In this work, a low-cost passive monopole sensor is designed and manufactured. The structure is composed of two Split-Ring Resonators (SRRs) coupled to a short-circuited printed monopole antenna. The permittivity of the dielectrics that are placed over the sensor is characterized within a near-field link between the sensor and a wireless reader, avoiding the use of wired connections. The sensing principle is based on the reader detection of the notch introduced by the SRRs in the power reflected by the sensor. Specifically, when the sensor is covered with a material, the change in the effective permittivity produces a frequency shift of the notch detected by the reader. It is shown that the system can reliably estimate the permittivity of the materials over a reading distance of 1 cm by means of a linear approximation with a small error. As future work, this sensor could be monitored with novel Internet-of-Things readers.

21 Deployment of mobile air sensing network for urban air pollution monitoring in Hong Kong

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Epidemiology studies have demonstrated an association between airborne pollutant and adverse effects on human health. People living and working in metropolitan cities are directly exposed to air pollution from surrounding environment. In the meantime, vehicle emissions contribute a larger portion to urban air pollution. The increased vehicle use gives rise to an increase in traffic related pollutant emission such as CO/CO_2, NO_X and particulate matters (PM). The present study employed a mobile air sensing network (MASEN) with high resolution and precision in monitoring on-road pollution in Hong Kong. It could be a complementary method of common pollutant measurement in terms of updating pollutant distribution map at specific time interval. A cross comparison was also carried out with regulatory stationary monitoring stations. The result showed gas pollutant was moderate correlated with traffic volume ($0.4<r<0.6$, $p<0.05$) but PM distributed more evenly citywide. The result also found that on-road pollutant was consisted of local background pollutant and foreign transported pollutant. Local background pollutant was correlated with urban monitoring station background while foreign transported pollutant was dominated by on-road environment. Pollutant concentration hot spots were also identified and analyzed in the result. The present study provides a better understanding of on-road pollutant distribution as well as its major affection factors. The low emission zones (LMZ) implementation and traffic emission control policy are discussed with recommendations for future measurement and policy making.

22 Fast Analysis of Glucose Content in Food Samples Using a Chitosan-GOx/TiO_2NTAs/Ti Amperometric Biosensor.

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Among all the analytes that are monitored for quality control in the food sector, glucose is assuming a priority role because it has been associated with chronic health consequences. Numerous methods have been reported for glucose analysis in food, however, most of the adopted methods are time consuming or expensive. The development of fast, cheap, practical and selective methods for detecting glucose in food is still a popular research area. In this context, enzymatic-based biosensors can be used to produce easy-to-use, compact and inexpensive analytical tools.

In the present work, an amperometric glucose biosensor based on glucose oxidase (GOx) immobilization onto highly ordered titanium dioxide nanotube arrays (TiO_2NTAs) was used to determine the glucose content of commercial food samples (soft drinks and soy sauces). The fundamental analytical parameters of the proposed biosensor were evaluated in order to guarantee that the analytical methodology is accurate, specific, reproducible and robust. The obtained results proved sufficient repeatability (RSD=1.9%), reproducibility (RSD=2.5%), accuracy (recovery between 95% and 105%) and robustness (RSD=3.3%). Finally, the glucose content of different samples was measured using the biosensor and compared with the HPLC value. In the worst case scenario, a deviation smaller than 7% was obtained from the 11 samples evaluated.

23 Fringe visibility enhanced fiber-optic Fabry-Perot interferometric sensor for highly sensitive ultrasound detection

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A fringe visibility enhanced fiber-optic Fabry-Perot functionalized diaphragm based ultrasonic sensor is proposed and experimentally demonstrated for ultrasound sensing. The sensor consists of a fiber-optic collimator and a PTFE diaphragm to form an Fabry-Perot interferometer. Due to the significantly increase in the slope of the sensor spectral sideband and the smaller Young's modulus of the PTFE, a high response to both continuous and pulsed ultrasound with a high SNR of 42.92 dB in 300 kHz is achieved when the spectral sideband filter technique is used to interrogate the sensor.

24 Fundamental Analytical Parameters of a Glucose Biosensor Based on TiO_2 Nanotube Arrays and Chitosan as Immobilization Matrix.

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Numerous analytical techniques are used for glucose determination, such as spectrophotometry, amperometry, HPLC, polarimetry and capillary electrophoresis. However, only electrochemical biosensors based on the use of glucose oxidase (GOx) have been able to combine the analytical power of electrochemical techniques with the specificity of biological recognition processes. Commonly, this combination of biological components with electrodes is used to produce low-cost, easy-to-use and compact devices for glucose quantification. Since the development of the first glucose biosensor, great efforts have been made in order to improve the response performances of these enzyme electrodes.

In the present work, we present the fundamental analytical parameters of an amperometric glucose biosensor based on GOx immobilization using a polymeric hydrogel (Chitosan) onto highly ordered titanium dioxide nanotube arrays (TiO_2NTAs). The biosensor optimal working potential was evaluated and then fixed at −0.4 V. After that, the fundamental analytical parameters of the biosensor (linear range, limit of detection, sensitivity) were determined, as well as its storage stability. This biosensor showed a linear range from 0.3 mM to 1.5 mM, low limit of detection (0.07 mM) and high sensitivity (5.46 $mA \cdot mM^{-1}$). Furthermore, its lifetime was evaluated. After 30 days, the biosensor retained 85 % of its initial current response.

25 Identification of miRNA146a in inflammatory macrophages using gold nanoparticle oligonucleotide sensor constructs

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Background: Biomarker profiling constitutes a prominent approach to human medicine and molecular sciences. Due to their high stability and unequivocal link to signaling pathways, miRNA species are of high interest. Wide applications of miRNA profiling are currently applied in body fluids and tissue lysates of a variety of physiological and pathophysiological processes. By contrast, single cell approaches are comparatively sparse. We here applied a procedure to diagnose the nature of inflammatory versus anti-inflammatory macrophages isolated from patients with autoinflammatory, infectious and malignant diseases using gold-nano-particle-based constructs equipped with fluorescently labeled oligonucleotides. Methods: Based on previously published procedures (Elghanian and Mirkin US2010/0167290 A1), we here optimized the procedure of the so-called Aussalzmethode, to derivatize citrate-stabilized gold nano particles with thiol-modified oligonucleotides by SpeedVac concentration, the derivatization time frame can be downscaled to less than 2h. Passivation is obtained by either alcene thiols or polyethylene glycol (PEG) at concentrations. Nanoparticles of 20nm in diameter are sufficient to bind 1-3, 10 (+2), 20 (+2), 40 (+3) and 60 (+3) binding oligonucleotides. All gold nano particle preparations were functionalized with the same oligonucleotide (5‘ Fluo-CCT CCT TTA CCG TGA TT-Thiol) and were used as single strand constructs with short complementary strands (5‘ TCA CCG TAA AGG) or long complementary strands (5‘ CAA TCA CGG TAA AGG AGG). For the intracellular detection of miRNA 46a, the following constructs were synthesized: 5’ ACT GAA TTC CAT GGG TT – Cy3 CCT CCT TTA CCG TGA TTG (SS)3 –Au-NP AC TCT TGA CTT AAG GTA CCC AA G GGA GGA AAT GGC ACT AAC. Results: After hybridization in macrophages in vitro, Cy3-specific fluorescence was positive in inflammatory macrophages and corresponded with NFkB translocation to the cell nucleus. The amount of nanoparticles ingested by inflammatory macrophages could be quantified by confocal laser scanning microcopy and fluorescence detection by the reflection mode. Summary: The use of probe covered nanoparticles appears to be a sensitive method to identify inflammatory macrophages on a single cell level.

26 Practical considerations towards repeatable measurements in Force Sensing Resistors (FSRs)

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The usability of Force Sensing Resistors (FSRs) has been thoroughly demonstrated in applications demanding non-invasive force measurements, such as Gait Analysis (GA) and Object Manipulation (OM). The FSRs benefit from its light weight, customizable dimensions and low cost. Nonetheless, some authors have reported sensitivity degradation in FSRs when loaded to cyclic forces; this condition is a major concern that limits the extensive usage of FSRs. With the aim of replicating the conditions that cause such sensitivity degradation, a testbench has been built to exert dynamic force profiles over FSRs. The experimental tests were performed over FlexiForce A201-1 and Interlink FSR 402 sensors manufactured by Tekscan, Inc and Interlink Electronics, Inc, respectively. It was found that sensitivity degradation occurs only when the sensor is cyclically loaded and the sourcing voltage is greater than 1.5 V. Conversely, by setting a sourcing voltage below 1.5 V sensitivity degradation was not observed despite high-frequency mechanical forces. The underlying basis for this undesired phenomenon is not fully understood yet, but practical considerations are presented to avoid sensitivity degradation and to yield repeatable measurements; this is of great importance in certain applications with cyclic loading such as GA and OM.

27 Rapid and label-free electrochemical DNA biosensor for detecting Hepatitis A virus

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The hepatitis A virus (HAV) presents one of the most important foodborne pathogens causing a worldwide health problem each year. The control of HAV outbreaks remains difficult as conventional PCR-based methods fail to detect low levels of the virus in water and foods. We developed a highly sensitive and specific analytical method for detection of HAV. The device comprises a thiol-terminated DNA probe, complementary to the specific HAV sequence, embedded onto a gold electrode where the DNA hybridization is a sensing mechanism. The electrochemical measurements demonstrated that this device detected HAV DNA template over a wide concentration range from 10 fg/µL to 1 ng/µL with the calculated limit of detection of 0.398 fg/µL for the complementary ssDNA sequence and 3.2 fg/µL for viral cDNA obtained by PCR, respectively. The DNA-sensor developed can be potentially adopted as an easy-to-use and low cost method for screening HAV in contaminated food samples.

28 Self-reporting molecularly imprinted polymer for label-free selective electrochemical sensing of *p*-synephrine

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Molecularly imprinted polymers (MIPs) are excellent example of bio-mimicking recognition materials.[1] They have found numerous applications in selective chemosensing.[2] For electrochemical determination of electro inactive analytes, usually some external redox probe is added to the sample solutions. It is assumed that binding of target analyte molecules by MIP molecular cavities causes MIP film swelling or shrinking. This behavior leads to changes in MIP film permittivity for the redox probe and thus changes in faradaic currents corresponding to reduction or oxidation of the redox probe (so called "gating effect") in CV and DPV determinations.[3, 4] However, this mechanism seems to be inadequate for electrochemical sensors with conductive MIP film recognition units. For example, electrochemical impedance spectroscopy spectra recorded in our previous research[5, 6] clearly indicate that redox probe diffusion to the electrode surface was not affected by analite binding into MIP film. Moreover, well pronounced changes in charge transfer resistance were observed. These changes strongly suggest that drop of the redox probe oxidation peak in DPV determination originates from changes in electrochemical properties of the MIP film. Therefore, we can speculate that diffusion of a redox probe is a not crucial issue in terms of selective determination with the MIP film coated electrode. Therefore, a new specially designed monomer, vis., *p-bis*(2,2'-bithien-5-yl)methyl-ferrocene benzene was used for deposition of a self-reporting MIP film. This monomer acted as both a crosslinking monomer and an internal redox probe. It was electropolymerized together with 2,2'-bitiofen-5-carboxylic acid in the presence of the *p*-synephrine template – a diet supplement that is suspected of causing serious cardiovascular diseases. These self-reporting MIP film modified electrodes were used for electrochemical determination of *p*-synephrine in the absence of the external redox probe. For that, appropriate counterions were immobilized within the MIP either by lipophilic chromopropoic acid entrapment inside the MIP matrix, or by copolymerization of thiophene-2-methylsulfonic acid. In both cases, DPV measurements using PBS (pH = 7.4) showed oxidation of ferrocene at ~ 450 mV vs. Ag/AgCl and a relative change of the DPV peak current was proportional to the concentration of *p*-synephrine in the range of 10 to 100 nM with LOD equal to 5 nM.

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29 Surface modification of diamond for sensor applications

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Diamond is a very interesting material for sensor applications: it has a high bio-compatibility which makes it interesting for in-vivo applications and in the form of boron-doped diamond it is a p-type semiconductor which makes diamond potentially useful in electrochemical sensor applications.
Even so diamond can be synthesized with relative ease as bulk material or in the form of (structured) films (CVD-diamond), it is not as common as e.g. gold in sensor applications. This may in part be due to the impression, that diamond is not easily modified with hapten or detection molecules. In reality the surface chemistry of diamond is versatile and rather easily accessible by classical wet chemical methods.
As an example, the introduction of hydroxy-groups by oxidation/reduction of nanodiamond and the subsequent modification with an activated double bond was carried out. Using the double bond to immobilize an amino modified oligonucleotide, a system for detection of miRNAs in living cells, based on fluorescence quenching, was assembled on nanodiamond.

30 Tyrosinase immobilization in multi walled carbon nanotube and gold nanowires matrice for catechol detection

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Catechol biosensing with a low limit of detection is an essential topic for researches due to catechol's easily oxidizable and easy to follow amperometrically properties. S creen-printed electrodes are disposable devices that find widespread use in the field, including analytical chemistry, drug control, clinical and environmental analysis [1, 2]. In this work, a novel catechol biosensing platform is suggested with the synergetic effect between multi walled carbon nanotube, gold nanowires and tyrosinase enzyme. Tyrosinase is a multifunctional copper-containing enzyme that catalyzes two distinct reactions of melanin synthesis using catechol, which is a well-known substrate of Tyrosinase.

All the parameters affecting the biosensing response are optimized and the method is further validated. Using the synergetic effects between multi walled carbon nanotube and gold nanowires, sensitive catechol determination was found with LOD and values 0.027 and 0.080 µM, respectively.

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31 Voltammetric resolution of dopamine in complex mixtures using graphene-modified electrode and artificial neural networks

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Dopamine (DA) is an important catecholamine neurotransmitter that plays a relevant role in the human body's function. Disorders in DA concentrations are related to several neurological diseases such as Parkinson, Alzheimer and schizophrenia. Common physiologic interferences of this neurotransmitter via voltammetric determination are, among others, uric acid (UA), ascorbic acid (AA) and serotonin (5-HT).

The use of graphene derivatives in sensors field offer possibilities such as low-cost devices, easy monitoring, miniaturization and biocompatibility. Moreover, electrochemical detection techniques coupled with nanomaterials lead to the enhancement of sensor sensitivity and selectivity due to their chemical and electrochemical properties.

The goal of the study is to determine DA in biological systems using a laboratory made electrode, built employing a composite mixture formed by graphite and epoxy resin as transducer material. The surface of this transducer is coated via drop casting with electroreduced graphene oxide (ERGO) to obtain the finally used sensor with improved electrochemical response. Multicomponent determination is accomplished employing the complete voltammogram signal, after its processing using artificial neural networks (ANNs). The followed approach allowed the resolution of signal overlapping and the quantification of the individual species sought.

32 A Novel Microfluidic Formaldehyde Microanalyser for Continuous Real-Time Monitoring in Indoor Air: Analytical Development and Validation

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Formaldehyde is a major and harmful pollutant of indoor air due to its multiple sources and its carcinogenic effect. This work reports the development of a novel analytical method based on microfluidic technologies for the detection of low airborne Formaldehyde concentrations, representative of those found in indoor air, i.e., 10–100 $\mu g.m^{-3}$. The new analytical technique operates as follows: 1) gas sampling, 2) gaseous Formaldehyde uptake into the aqueous solution using an annular gas/liquid flow at room temperature, 3) derivatization reaction with acetylacetone solution at 65 °C producing 3,5-Diacetyl-1,4-dihydrolutidine (DDL) and 4) fluorimetric DDL detection.
Laboratory experiments were performed to determine the experimental conditions permitting to obtain a stable annular flow, i.e. gas to liquid flow rate ratios greater than 1000. From liquid and gas calibrations, an uptake yield of 100% and a detection limit of 1 $\mu g\ m^{-3}$ were determined. Finally, our portable instrument is fully controlled by homemade software and has a response time of 10 min, a temporal resolution of 2 seconds and an autonomy of 100 hours with 100 mL reagent. Finally, this formaldehyde microanalyser was then deployed during several field campaigns and compared with the ISO 16000-3 reference method, i.e., the active sampling on DNPH cartridges.

33 A Novel Sensor for a Bio-Mimetic Finger

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We have designed and integrated a novel fibre-optic based sensor for force discrimination on a biomimetic finger. The sensor is free of any metallic and electrical components and immune to electromagnetic disturbances. A cantilever mechanism was designed in order to embed the sensor at the fingertip of the finger phalange. The design has been optimized by Finite Element Analysis (FEA).

The biomimetic finger has been manufactured using Acrylonitrile–Butadiene–Styrene (ABS) via 3D printing processes. Two optical fibres (i.e., SH1001-1.0 Eska Super PE jacket), and light reflective surface are integrated at the tip of the phalange. Sensor calibration has been conducted using a digital optical amplifier (i.e., Keyence FS –N11MN), USB National Instruments DAQ card (NI USB-6000) and a six-axis Force and Torque sensor (F/T IIT-FT17).

The sensor was mounted on a linear guide in order to face the IIT-FT17 force sensor on its longitudinal axis. Software setup has been developed based on LabVIEW and C ++. The loading and unloading experiments were performed and force and corresponding voltage values have been logged using the developed software setup. Regression analysis shows high correlation between the two data (i.e., force and voltage) with coefficient of determination (R^2=0.97). Based on the calibration result, the sensor has better sensitivity (i.e., 097 V/N), an input range of [0–5N] and resolution of 0.02N.

Unlike other sensors, this sensor's biocompatible design, simplicity and reliability make it ideal for challenging working environments (high voltage and electromagnetic noise).

34 A Tunable and Versatile Anchoring System for Gold-Surfaces

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The anchoring of hapten/detector molecules is a crucial step in the preparation of gold-based detectors. The established anchoring strategies rely mainly on the thiol–gold interaction (~45 kcal/mol), which is considerably weaker than a regular atomic bond. By synthesizing a cyclic dithiol moiety for the modification of oligonucleotides, 2, 4, 6 or more thiol–gold bonds may be applied for the anchoring of each oligonucleotide. These oligonucleotides may be used as detecting units as such, as a hybridization anchor for more sophisticated (e.g., beacon-like) constructs or they may be terminally modified (amine, biotin, alkine, carboxyl) to bind other (bio)molecules. This method can be used for extended, flat surfaces such as electrodes as well as for nanoparticles, where the introduction of oligonucleotides has the additional benefit of decreasing the tendency of their agglomeration. The anchoring via several dithiol groups increases the stability towards thermal stress, enabling the use of such sensors at elevated temperatures or under PCR conditions and decreases displacement by thiol-bearing molecules which are regularly a constituent of biological samples and it increases the long-term storage stability of modified particles and surfaces. The maximum loading of oligonucleotides is nevertheless only moderately decreased by increasing the number of dithiol units. By varying the number of dithiols, the properties of the surface can thus be tailored to the needs and to the design of the application under consideration.

35 A Water-Soluble Polymeric Probe for the Selective Sensing of Cu(II) Ions in Aqueous Media with pH-Tunable Detection Sensitivity

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In recent times, the efficient and selective detection of transition metals has gained significant importance in the research area due to their vital role in biological processes and highly toxic nature. Among them, Cu^{2+} ions, being the third most abundant element in the human body, have received more attention as they can have both positive and negative impacts on human health and the environment. Cu^{2+} ions are crucial components in biological processes such as bone formation, cellular respiration, and connective tissue development and also serve as a catalytic co-factor for several metalloenzymes. On the other hand, unbound Cu^{2+} ions, beyond a certain limit, can harm the human body as well as the environment because of their high toxicity. It is well known that many neurodegenerative diseases, such as Alzheimer's disease, Wilson's disease, Menke's disease, etc., can cause deficiency or over-consumption of Cu^{2+} ions. Thus, development of single ion responsive molecular probes for the fast, selective and efficient detection of Cu^{2+} ions, is very necessary and important in the field of chemo and biosensors. A water-soluble polymeric sensor based on thiosemicarbazone was developed for the selective colorimetric detection of Cu^{2+} ions with pH-tunable sensitivity. *N,N*-dimethylacrylamide (DMA) and 3-vinylbenzaldehyde (VBA) were copolymerized by reversible addition-fragmentation chain transfer (RAFT) polymerization to produce p(DMA-*co*-VBA), herein P1. The aldehyde group of P1 was reacted with 4-phenylthiosemicarbazide to yield poly{DMA-*co*-[*N*-phenyl-2-(3-vinylbenzylidene)hydrazinecarbothioamide]}, [p(DMA-*co*-PVHC)], herein P2. The selective and efficient colorimetric sensing of Cu^{2+} ions with P2 in an aqueous solution was demonstrated. Upon the addition of Cu^{2+} ions to the aqueous solution of P2, the color of the solution turned from colorless to yellow due to the formation of Cu^{2+}/phenylthiosemicarbazone complexes. The availability of the electron-rich imino nitrogen in the phenylthiosemicarbazone units allowed P2 to show excellent sensing behavior toward Cu^{2+} ions. P2 showed excellent selectivity toward Cu^{2+} ions over other alkali and transition metal ions. P2 has remarkable pH-switchable sensing properties toward Cu^{2+} ions. While the efficient colorimetric sensing was observed at neutral or high pH, no appreciable color changes happened at low pH. The protonation of the imino nitrogen prevented the formation of Cu^{2+}/phenylthiosemicarbazone complexes. Thus, these pH-responsive ON–OFF switching properties of P2 can offer new insights into the tunable colorimetric detection of Cu^{2+} ions.

36 Accurate 3D Face and Body Scanning Using an Irritation-Free Pattern Projection System

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Three-dimensional scanning of human bodies or body parts is gaining increasing importance in applications where moving people need to be captured. This could be, for example, people tracking, lip reading, or gesture detection.
The advantages of optical 3D sensing in these fields are the contactless measurement and the high potential concerning speed and measurement accuracy. However, classical illumination by structured light may disturb personal activities. In this paper, a new 3D scanning system is introduced which is absolutely irritation-free based on the structured light illumination by aperiodic sinusoidal fringe patterns in the near infrared range. Hence, it is particularly suitable for continuing human face scanning. The illumination system is based on the GOBO principle.
Applications interpreting human facial expressions or gestures often require a very short latency time of the data capture because of the necessary subsequent processing of the 3D point clouds. The presented 3D scanner setup achieves a latency time of approximately 100 ms until the 3D data of a 4MPx scan is available.
Examples of the acquisition of sequences of face and body scans are given.
The measurement accuracy was evaluated by experiments and will be presented and discussed. An outlook of future work is given.

37 Adrenaline Bi-Enzyme Sensor Using Signal Amplification Principle to Support Adrenal Venous Sampling

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Primary aldosteronsim (PA) is the most frequent cause of secondary hypertension. Adrenal venous sampling (AVS) is the only reliable way to correctly diagnose PA. However, AVS is a demanding technique due to the positioning of the catheter into the right adrenal vein. The detection of adrenaline during AVS could be, therefore, used as an indicator for the correct position of the catheter, since the adrenaline concentration in adrenal blood (100 nM) is about 100 times higher in comparison to peripheral blood (1 nM). An amperometric bi-enzyme biosensor for the detection of adrenaline based on the substrate recycling principle has been developed. A genetically modified laccase and a glucose dehydrogenase were immobilized on a galvanic oxygen electrode. A low detection limit of 0.5 nM at pH 7.4 (corresponding to the blood pH value) was achieved by performing measurements in phosphate buffer at 30 °C. The cross-sensitivity to other catecholamines (noradrenaline, dobutamine) has been studied. Long-term stability of several days of the bi-enzyme biosensor could be demonstrated. Furthermore, preliminary measurements in real blood samples have been performed. The possibility of an application of the developed bi-enzyme sensor could open new prospects in the field of medical diagnosis.

38 Agricultural Management Integrated System Based on Smart Sensing Technology

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Precision agriculture implies, alongside conventional issues, the use of information in the management and execution of agricultural tasks in order to increase the productivity of crops. The use of an integrated information system allows farmers to observe and check the progress of agricultural parameters and make the right decisions to increase the productivity. The implementation of an automated strategy for managing this approach involves knowing the dynamics of agricultural culture, developing a specific management strategy, using the systems and technologies of acquiring, processing and visualizing the information of interest, respectively, and the existence of a system for implementing decisions. This paper details the management of this approach for potato crops. Specific solutions for the equipping of terrestrial and aerial mobile systems with the sensory platforms needed to acquire specific information are brought to attention. Equipment for the processing and visualization of agricultural parameters, their advantages and disadvantages in relation to the specific architecture are analyzed. Technical solutions for terrestrial system are proposed to ensure flexibility and adaptability in the acquisition process in relation to the monitored culture or its monitoring period. Experimental data regarding spectral response and specific vegetation indices for experimental potato lots are provided and analyzed.

39 Amperometric Immunosensing Scaffolds for Rapid, Simple, Non-Invasive and Accurate Determination of Protein Biomarkers of Well-Accepted and Emerging Clinical Importance

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New amperometric immune-scaffolds for the rapid, sensitive and reliable determination of human protein biomarkers of well-accepted (p53) and emerging (endoglin and fibroblast growth factor receptor) clinical relevance in the diagnosis and prognosis of cancer, will be described. These are based on sandwich immunosensing configurations where specific capture antibodies are covalently immobilized on magnetic microcarriers (MBs). After the specific capture of the target proteins followed by incubation in solutions of peroxidase labelled specific secondary antibodies, the resulting modified MBs are magnetically captured on the surface of disposable screen-printed carbon electrodes. The electrocatalytic reduction of hydroquinone at an applied potential of −0.20 V vs the Ag pseudoreference electrodes in the presence of H_2O_2 by linked HRP is used to determine the target biomarker concentration. The three immunoplatforms offer attractive operational and analytical characteristics with low detection limits (in the range 2.8 fg mL^{-1}1.29 ng mL^{-1}) and short assay times (15–45 min). Accurate results on the determination of these proteins in minimally pretreated human serum samples and different cancer cells lysates will be shown. The developed bioscaffolds may be integrated in portable multiplexed systems, and applied in the implementation of point-of-care (POC) devices useful in hospital routines.

40 Amplified Detection of the Aptamer–Vanillin Complex with the Use of Bsm DNA Polymerase

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The decreased sensitivity for electrochemical detection of low-molecular-weight targets with the use of aptamers is a great problem of scientific importance. The amplification of the signal is a promising approach for analyzing the formation of the aptamer–analyte complex. For this purpose, a biocatalytic amplification technique using Bsm DNA polymerase (EP0691, Thermo Fisher) was chosen. At first, we showed that Bsm reaction can be detected by the ion-sensitive field effect transistor (ISFET) with Ta2O5 gate at 22oC. Main components of this reaction are a hairpin fluorescence probe (FP), a short primer (PR) and target probe (TP), which can hybridize with FP and the stem of the hairpin is opened. After that, the hairpin anneals with the primer and triggers the polymerization reaction Polymerase has strong strand displacement activity and lacks exonuclease activities, so TP is displaced and hybridized to another FP. Thus, this is the amplification of the signal at a low concentration of TP. We showed the detection of 1 fmol of TP with the ISFET. Secondly, these results allowed the detection of the dehybridization probe (DP), which is released from the aptamer during addition of the target molecule. As a proof-of-concept, we used immobilized aptamer for vanillin, which was obtained by us during Capture-SELEX (http://dx.doi.org/10.1155/2012/415697), and designed DP that can act as TP in the Bsm reaction. This approach allowed us to decrease the limit-of-detection (LoD) of vanillin by the ISFET compared to simple dehybridization and, to date, the LoD of vanillin is 8.4E-08 M.

41 An Array-Based Sensor for Identifying Foodborne-Associated Genotypes of Human Noroviruses and Hepatitis A Virus

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Human noroviruses are the leading cause of human gastroenteritis in populations of all ages and are linked to most of the foodborne outbreaks worldwide. Hepatitis A virus is another important foodborne enteric virus and is considered a common agent causing acute liver disease worldwide. Laboratory surveillance networks revealed a subset of virus genetic types, associated frequently with consumption of various food commodities in the United States and Europe. In the present study, a focused, array-based biosensor was developed and validated for the simultaneous identification of foodborne-associated genotypes of norovirus and hepatitis A. By employing a novel algorithm, oligonucleotide capture probes were designed to target variable genomic regions, commonly used for typing these foodborne viruses. Validation results showed that probe signals, specific for the tested virus genotypes, were on average 200-times or 38-times higher than those detected for non-targeted genotypes, respectively. To improve the detection sensitivity of this sensor, a 12-mer oligonucleotide spacer sequence was designed and further attached to the capture probes, and the results indicated a detection of less than 10 cRNA virus transcripts, a sensitivity threshold below the infectious dose of these foodborne viruses. These findings have indicated that this virus-typing sensor has the accuracy and sensitivity for identifying relevant genotypic profiles of norovirus and hepatitis A, predominantly linked to food poisoning. This virus-typing sensor provides highly relevant and valuable information for use in outbreak attribution and has led to the development of an emerging detection platform for the real-time and automated surveillance of foodborne viral pathogens.

42 Analyzing Amyloid Beta Aggregates with a Combinatorial Fluorescent Molecular Sensor

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The self-assembly of amyloid beta (Aβ) peptides into insoluble aggregates is thought to play a major role in the progression of various neurodegenerative diseases, including Alzheimer's disease (AD). Although various studies have shown that subtle variations in the dynamics and compositions of Aβ aggregates could have a significant impact on their physicochemical and pathological properties, currently there is no effective means to straightforwardly characterize the Aβ aggregation state. Fluorescent assays, which mainly rely on the 'turn-on' properties of a thioflavin T (ThT) molecule, can only detect the fibril formation, whereas other techniques that can determine the content of these assemblies require special expertise and are not high-throughput. To improve the ability to analyze Aβ aggregates, we have developed a combinatorial fluorescent molecular sensor that generates a wide range of unique emission 'fingerprints' upon binding to distinct Aβ aggregate species. The molecular sensor has been used to discriminate among aggregates generated from different alloforms (i.e., $A\beta_{40}$ and $A\beta_{42}$) or through distinct pathways, and it has also been used to track dynamic changes that occur in Aβ aggregation states, which result from the formation of low molecular weight (LMW) oligomers, high molecular weight (HMW), oligomers, protofibrils, and fibrils. To demonstrate the versatility of our approach, we have also shown that the sensor can discriminate among aggregates of other amyloidogenic proteins, such as lysozyme, prion, insulin, and amylin fibrils (Published in *J. Am. Chem. Soc.* **2017**, *139*, 2136-2139. *Highlighted in JACS Spotlights)*

43 Bacteriophages-Carbon Nanofibre Modified Electrodes for Biosensing Applications

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Carbon nanomaterials have aroused substantial interest in various research fields. Their uniqueness derives from their remarkable surface properties, good electrical conductivity and well developed surface. These properties make them suitable for application as elements in electrochemical sensors [1]. The improvement of their properties might be achieved via the application of viral particles which could change the surface and electrical properties of carbon nanomaterials. Recently, bacteriophage particles due to their unique properties (high active surface area, the ability to form self-assembled, periodically ordered, three-dimensional structures) have appeared as an interesting addition to electrochemical devices [2].
We show that utilization of these particles for modifying an electrode with carbon nanofibres (CNF) leads to the generation of a material with a highly developed surface and thus an electrode with a large active area which is desirable when preparing sensing platforms.
The obtained electrode was thoroughly characterized by SEM, AFM and cyclic voltammetry. Our results show that electroactive surface area is better developed when the bacteriophages are added to the CNF-based electrodes, than for bare electrodes, or those modified only with CNFs. Also, the electrocatalytic activity towards the oxidation of cysteine, homocysteine and gluthatione, is improved in the case of additional application of bacteriophages for CNF-based electrode modification.

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44 Characterization and Implementation of In-To-Out Body Wireless Sensor Data Transmission for Smaller Ruminants

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Among bioclimatic indicators for ruminants, the rumen stability is crucial to determine the animal's health status. A modern solution to monitor the rumen condition consists of an implant sensing bolus that collects and transmits bioclimatic ruminal data, such as temperature and pH value, and a wearable on-body receiver which also communicates with a remote control platform. Such a solution is being adopted in cattle management as the bovine animal size does not impose strict requirements on the dimensions and weight of the bolus. However, for smaller ruminants such as sheep and goats, research on autonomous health monitoring and ruminal sensing bolus development is lagging behind. In this work, we characterized numerically the in-to-out body wireless data transmission in smaller ruminants using the 3D electromagnetic finite-difference time-domain (FDTD) solver available in sim4life (ZMT, Zurich, Switzerland). First, we dimensioned a spiral antenna operating at 433 MHz for integration in a ruminal bolus whose volume is 70% less than that of a bovine bolus while taking into account the frequency detuning due to the proximity of the printed circuit board (PCB) and animal tissues. Next, we investigated the in-to-out body path loss in a homogeneous animal model and verified it with a bioequivalent phantom. The in-to-out body path loss analysis can be used to predict in vivo propagation with living adult sheep or goats.

45 Colorimetric Sensors Based on Responsive Polymeric Micelle for the Detection of Mercury

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Polymeric probes with dithioacetal units in the hydrophobic segment of the micelle were designed and synthesized for the controlled condition and selective colorimetric sensing of Hg^{2+} ion in aqueous solutions. These polymeric colorimetric sensors were prepared by a reaction between aldehyde groups of the hydrophobic segment in the micelle and ethanethiol or 3-mercaptopropionic acid using BF_3 as a Lewis acid. In aqueous solution, they exhibited micellization. The key to designing a polymeric probe is to construct chromophore and light responsive characteristics of hydrophobic segments. Sensing is not possible in the case of micelle type; however, the UV-range wavelength (365 nm) was exposed, there was a significant change in the hydrophilicity of the micelle and selective Hg^{2+} sensing is possible. In aqueous solution, they exhibited a 30–40 nm red shift in their maximum absorption upon addition of Hg^{2+} ions and they exposed a UV-range wavelength (365 nm). In particular, it took less than 1 min to complete Hg^{2+} ion detection at low pH. These polymeric sensor changes color the solution, from pale yellow to dark red. Hg^{2+} promoted a deprotection reaction of dithioacetal groups to form aldehyde functionalities. The sensors have selectivity toward $Hg2^{+}$ ions over other alkali and transition metal ions. Given the selectivity and control of the ion detection abilities of the sensing condition Hg^{2+}, these polymeric probes take advantage of the unique potential platforms for the light responsive segment in polymeric micelle with sensing behaviors.

46 Computational Improvement in Human Dynamics Estimation

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In the context of human–robot interaction, control of robots could be improved by adding human dynamics as a feedback to robot controllers. A computational framework for the estimation of whole-body human dynamics is provided in [Nori et al., 2015].

The estimation procedure starts from the Newton–Euler algorithm, in which boundary conditions are replaced with measurements coming from sensors. The proposed algorithm computes an estimation of human dynamic variables, assumed as stochastic variables with Gaussian distributions, providing as a Maximum-A-Posteriori (MAP) their mean and covariance conditioned on available measurements.

In this computation, inverses of high-dimensional sparse matrices are calculated. In order to reduce the related high computational cost, Cholesky factorization is used. Clolesky factorization is a decomposition of a positive-definite matrix into the product of a lower triangular matrix and its transpose. The solution of a MAP linear system is computed by decomposing the covariance matrix with Cholesky factorization and then with forward and backward substitutions. Moreover, since the covariance matrices maintain the same structure, a permutation matrix is computed only once and then employed to each computational temporal-step to further improve the Cholesky factorization/computational performance. The computational time of the MAP algorithm decreases by about 15%.

47 Cooperative Monocular SLAM for Multi-UAV Systems

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The capacity of autonomous navigation is an important requirement for applications involving micro aerial vehicles (MAVs). In this sense, GPS represents the typical solution for determining the position of a MAV operating in outdoor and open environments. However, for indoor or cluttered environments, GPS is not reliable enough. Also, the magnitude of the GPS error can be unacceptable for applications requiring high precision localization. In this context, the visual-based approaches represent an interesting alternative for addressing the problem of MAV navigation. In particular, the visual SLAM (Simultaneous Localization and Mapping) techniques have received great attention from the research community. Using SLAM, a mobile robot can localize itself using only its on-board sensors while it moves across an unknown environment. This research treats and presents a novel cooperative visual SLAM system that is used for addressing the navigation problem of a team of MAVs operating in GPS-denied environments. In this case, it is shown that using only visual information obtained from monocular cameras equipped on-board of the MAVs, the observability properties of the system can be improved. The above is achieved by incorporating measurements of the relative distance between the MAVs. The experimental results validate that the proposed system provides a good estimation of the position and orientation of each MAV.

48 Cryptographic Protocols in Wireless Sensor Networks: A Critical Review

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Wireless sensor networks (WSNs) play a fundamental role in new paradigms such as the Internet of Everything or the Industry 4.0. Usually, these networks are constituted by hundreds or thousands of sensor nodes with limited resource capabilities whose main goal is to monitor, collect, compute and communicate data from the environment in an efficient and distributed way.
WSNs are widely used in several different fields such as environmental management and research, e-health, military and risk management, etc. In many of these applications, the security of the network is a fundamental issue. Consequently, it is crucial to guarantee the confidentiality, integrity, authenticity and availability of the data transmitted trough the WSN.
Most of the cryptographic protocols implemented in WSNs for key establishment and data encryption (secret-key cryptosystems and public-key cryptosystems) are adaptations of those used in other types of environments without the limited resources and capabilities of WSNs.
The main goal of this work is to perform a critical review of such cryptographic protocols, focusing the attention on secret-key cryptosystems since this type of protocol requires less processing time than public-key algorithms. The problems, solutions and challenges dealing with this topic will be identified and explicitly shown.

49 Design of a Portable and Low-Cost Mass Sensitive Quartz Tuning Fork Sensor

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The resonance frequency of quartz tuning fork (QTF) depends on the mass adsorbed to its prongs, so it is used to measure minor mass changes and detect target analyte at picogram levels. Although, in several studies, QTF transducers have been implemented in sensors (mass, viscosity, humidity, temperature etc.) or biosensors, their electronic set-up has been expensive and non-portable. Moreover, explanations on details of their instrumentation have been limited and based on noncommercial products. In this study, a low-cost, portable, compact and relatively new QTF sensor device is presented. The instrument is based on a low-cost microcontroller which controls both the direct digital synthesizing (DDS) chip and data acquisition. QTF is excited by the aid of a DDS chip and its output is directly read via the same microcontroller. Moreover, six different types of QTFs with 32 kHz, 32.768 kHz, 40 kHz, 65.536 kHz, 75 kHz and 100 kHz resonance frequencies have been tested. As a case study, temperature effects on stability are studied for the most common type of QTF with the resonance frequency of 32.768 kHz. Consequently, a QTF sensor device is fabricated with more advanced features compared to its alternatives, leading to a more accurate measurement method.

50 Development of a Confocal Laser Doppler Flowmeter Using Optical Feedback Interferometry Techniques

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We are presenting a novel confocal laser Doppler flowmeter based on optical feedback interferometry. The system determines the Doppler shift occurring in an 830 nm laser diode when a small portion of the emitted light is back-reflected into the laser cavity after interacting with the particles of an emulsion flowing into a capillary; this second field modulates the laser emission and the changes in the optical output power are used to determine the Doppler frequency regarding the flow velocity. The confocal setup employs a diaphragm to delimit the beam diameter and reduce the phase noise and the out-of-focus particle effect, allowing real-time measurements of the velocity at which the particles are flowing in a very specific region inside the capillary. We demonstrate the benefits of this technique comparing the Doppler spectrum obtained without the confocal arrangement against a confocal measurement.

51 Distributed Water Pollution Source Localization with Mobile UV-Visible Spectrometer Probes in Wireless Sensor Networks

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Pollution accidents that occur in surface water, especially in drinking water source areas, greatly threaten the urban water supply system. Focused on the challenge of localizing the water pollution source under complicated pollutant spreading conditions, this paper investigates a distributed localization method in wireless sensor networks equipped with mobile UV-visible spectrometer probes. A wireless sensor network is defined for water quality monitoring, where unmanned surface vehicles and buoys serve as mobile and stationary nodes respectively. Both types of nodes carry UV-visible spectrometer probes to acquire in-situ water quality multi-parameter measurements, in which a self-adaptive optical path mechanism is designed to flexibly adjust the measurement range. A novel distributed algorithm, Dual-PSO, is proposed to search for the water pollution source, where one particle swarm optimization (PSO) procedure computes the water quality multi-parameter measurements on each node, utilizing UV-visible absorption spectra and the other one finds the global solution of the pollution source position, regarding mobile nodes as particles. Besides, this algorithm uses entropy to dynamically recognize the most sensitive parameter while searching. Experimental results demonstrate that online multi-parameter monitoring of a drinking water source area with a wide dynamic range is achieved by this wireless sensor network and water pollution sources are localized efficiently with low-cost mobile node paths.

52 Effect of Automatic Gain Control on Non-Contact Capacitive Measurement of Respiratory Movements during Sleep

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An unobtrusive device capable of measuring electrocardiogram (ECG) and respiratory movements (RM) of the chest and abdomen is under development by using non-contact electrodes under the bedsheet. However, when the coupling between the body and the electrode changes from capacitive to resistive by sweat during sleep, amplitude of the RMs tends to decrease. Consequently, detection accuracy (DA) of RMs becomes unstable. In this study, we introduced an automatic gain control (AGC) circuit to improve DA. The AGC circuit was composed of a variable gain amplifier, a RMS-to-DC converter, a standard voltage circuit, and a comparator. We examined the efficacy of the AGC circuit by comparing the DAs before and after introduction of AGC circuit during sleep. Analysis for the initial one hour sleep in three subjects revealed that DAs in the chest improved for all subjects and increased by 15.4% on average. In the abdomen, the number of undetected RM decreased considerably in subject #1, whereas that of the false detection increased modestly in subject #3. Advanced analysis implied that the introduced AGC circuit was useful for the reduction of the number of undetected RM due to amplitude attenuation, but tended to increase that of false detection caused by the deformative waveform of RM.

53 Electrochemical Current Measurement by CMOS Potentiostat Integrating Chrompatography Paper Fluidic Channel and CMOS LSI Chip for Small Biosensors

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Biosensing using CMOS chip equipped with sensor electrodes on the surface has been studied for small biosensors [1]. The conventional method uses external pump to transport sample solution to the electrodes and hence is not suitable for miniaturization. Because of this, we have focused on using water absorbency of Chromatography Paper (ChrPr), instead of external pump, to transport solution, and already succeeded in simulatenous detection of glucose and ethanol on CMOS chip using ChrPr [2]. However, the measurement was conducted by electrochemical analyzer connected to the on-chip electrodes, not on-chip sensor circuits, since the previous work focused on transporting sample solution and setting up electrochemical cell directly on the chip.

In this work, glucose detection was conducted using CMOS chip equipped with both measurement circuits and sensor electrodes. In particular, we carried out glucose detection in sample solution by electrochemical current measurement using CMOS potentiostat composed of two operational amplifiers, supposing blood glucose measurement. The CMOS chip (0.18 μm process) is 5mm square and has electrodes on the surface for three electrode system. Working electrode and counter electrode are fabricated from graphene ink, and reference electrode is fabricated from Ag/AgCl ink. Solution transport is conducted as follows. Firstly, hydrophobic area is defined on ChrPr by applying silicone resin. After that, the ChrPr are laminated so that 3-D fluidic channel is formed, utilizing the fact that the solution moves spontaneously into the overlapping hydrophilic area. By setting the laminated ChrPr on the CMOS chip, dropped solution is transported to the electrodes. Glucose oxidase and potassium ferricyanide, which are chemicals for glucose detection, are immobilized in the hydrophilic area before laminating process. Thus, the sample solution intermingles with the chemicals in the process of being transported to electrodes. The voltage is applied so that the potential between the working electrode and the reference electrode is +0.5V which is an adequate voltage to conduct glucose detection. As a result, the observed current was found to be proportional to the glucose concentration. Thus, we successfully realized small biosensor chip integrating many functions, such as sensor electrodes, solution transport without external pump, and circuits conducting electrochemical measurement, in a single small chip. This work was supported by JSPS KAKENHI Grant Number 26289111.

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54 Electrochemical Deposition of Silver–Gold Nanoparticles for Sensitive Dopamine Detection

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Dopamine (DA) is a catecholamine neurotransmitter, which plays a crucial role as chemical messengers in the central nervous system, hormonal, cardiovascular and renal systems. Recently, much attention has been paid to trace level determination of DA, because small changes in concentration are coupled with various disorders such as Alzheimer's disease, epilepsy, Parkinson's disease and schizophrenia [1]. In this context, the selective and sensitive approach for DA level determination is vital for diagnosing diseases.

Due to its electroactivity, DA can be detected by electrochemical techniques, but requires large oxidation potential, which results in the formation of phenoxy radicals and, respectively, formation of polymeric films on the electrode, passivating the surface. It has been shown that metal nanoparticles in combination with carbon material can enhance the sensing activity of electrodes for dopamine oxidation [1–3]. Carbon nanotubes (CNTs) decorated with different metallic nanoparticles have been frequently used to modify the surfaces of commercially available screen-printed electrodes to decrease the overpotential and improve sensitivity.

This work demonstrates the effective surface electrodeposition of bimetallic Ag–Au nanoparticles onto CNT substrate for sensitive and selective detection of dopamine. The double-pulse amperometry method has been used for Ag–Au deposition, with different deposition parameters such as pulse time, metal ions ratio and total time of deposition. Scanning electron microscopy was used for morphologic characterization of deposited nanoparticles, while cyclic voltammetry and differential pulse voltammetry were involved in the electrochemical characterization of the sensors towards dopamine detection.

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55 Exploiting Brillouin Sensors for Refractive Index Measurements

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In this paper, we investigate the capability of a Brillouin Optical Time-Domain Analysis (BOTDA) sensor to act, for specific fiber sections, as a refractometer. In the BOTDA configuration, a pump pulse is launched from one end of the sensing fiber, while a frequency-detuned probe wave is injected from the opposite end. Measuring the output probe intensity as a function of time and for several pump/probe frequency shifts, the strain and/or temperature changes can be recovered at each position. The same apparatus can be used for refractive index measurements in selected points, provided that some means is found to convert the refractive index changes in optical transmission changes. In fact, the localized optical loss can be easily recovered from the acquired data, as each attenuation point along the fiber will induce a step-like change in the detected signal. The minimum distance between consecutive refractinve index sensing points is dictated by the spatial resolution of the BOTDA sensor (and therefore by the duration of the pump pulse), while the maximum number of sensing locations will be limited by the ratio between the optical budget (i.e. the maximum optical loss that can be tolerated by the interrogation system) and the (maximum) optical loss in each sensing location.

56 Exploiting Optical Fibers and Slab Waveguides for a New Intensity-Based Refractometer

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Refractive index sensors based on optical fibers have more advantages than those based on different approaches, for example, the possibility of remote sensing. A plasmonic sensor in plastic optical fibers (POFs) has been recently proposed by the Authors and consists of a D-shaped POF with a buffer layer between the exposed POF core and a thin gold film. In the present investigation, a new intensity-based sensor platform for refractive index sensing, is presented. It is based on a special holder, a slab waveguide and two POFs. The optical fiber is used to launch the light into the slab waveguide and to collect the light emerging from the waveguide and conveying it to a spectrometer. A photoresist (Microposit S1813) buffer layer is deposited over a PMMA chip (slab waveguide) by a spin coater. This photoresist buffer layer is required in order to increase the performances of the sensor. The experimental results indicated that this new sensor can be useful for chemical sensing applications. The advantages of this new approach are the possibility of sensing with a removable chip, the easy production of an engineered platform and the use of a new holder, which is also suitable for thermo-stabilized flow cells implementation.

57 Feasibility Study on S-Band Microwave Radiation and 3D Thermal Infrared Imaging Sensor-Aided Recognition of Polymer Materials from ELVs

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With the increasing worldwide consumption of vehicles, abandoned end-of-life vehicles (ELVs) have been rapidly increasing for the last two decades. Metallic material scraps are easily recycled and reused from crushed ELVs, the mixture residues of elastomers, plastics, printed circuit boards (PCBs), foam materials, and woody materials, etc; scraps are classified as hazardous materials, in which elastomers and plastics constitute the vast majority. Their further treatment is strictly restricted and according to new legislation in the principle industrial countries, they are required to be materially recycled to achieve 85%–95% in mass by 2020. However, there are neither sufficient theories nor technologies for the identification and separation of elastomers and plastics from the mixture residues with high efficiency. To make matters worse, most applied vehicle elastomers were black or dyed a dark color which makes them unavailable for use in spectral sensors. In this research, we provide a novel method by using S-Band microwave radiation together with 3D thermal infrared sensors for recognition of elastomers from ELVs. In this study, an industrial microwave emitter array with 2.45 GHz was utilized as a radiation source. More than four kinds of crushed ELV residue mixtures were tested. The mixture residues were designed to be convoyed through the microwave radiation with certain periods. According to the chemical structure and additive difference, the residue materials' sensitivities to the microwave radiation were also different and further led to variation of rising temperature. The variations of heating effect were obtained by a 3D-thermal infrared imaging sensor and the residue scraps of different materials were recognized for further sorting. The results show that, in the tested mixtures, elastomers heated up to more than 30 °C have the best recognition efficiency, and a minimum temperature variation of5 C is needed to successfully fully distinguish different materials; the mixture residues heated up to less than 22 °C were not able to be recognized. The plastics had only very limited heating effects through microwave radiation. The sorting efficiency was independent of particle size but could be influenced by microwave power and radiation period. Generally, a mixture of more than 75% elastomers and plastics could be successfully recognized. Conversely, some of the residue materials could be more sensitive with a different frequency band of microwave radiations; therefore, in further experiments, other bands should be implemented for tests.

58 Gas Sensing Using OneDimensional (1D) DNA Templated Cadmium Sulphide Nanowire

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One-dimensional (1D) nanostructured inorganic materials have generated increasing interest in recent years due to their use as transducers in gas sensors because of their large surface to volume ratio and extraordinary opto-electronic properties. The sensing of volatile organic compounds (VOC) is very important for environment and human safety[1]. The ability of semiconducting metal sulphide DNA-templated nanowires to act as a transducer in a gas sensor is due to the change in electrical conductivity of nanowires as a result of the interaction between the active sites of the nanowires' surface and the absorbed target gas[2]. DNA templated 1D Cadmium sulphide (CdS) nanowires are particularly suitable for this application because of their selectivity to VOC, chemical stability and their ability to operate at room temperature. The λ-DNA templated CdS nanowires were synthesised by reacting an aqueous solution of λ-DNA with $Cd(NO_3)_2$ and Na_2S in solution. This produced smooth, uniform and continuous one-dimensional nanowires. The chemical composition, morphology, current–voltage measurement and the sensing response of the synthesized nanowires were determined. These nanowires have potential as an effective transducer for sensing ethanol.

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59 Impact of Poly(3-hexylthiophene) Chains Length and Other Applied Side-Chains on the Sensitivity of Gas Sensors Based on Conducting Graft Copolymers

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In this work, novel conducting graft copolymers: DodecSil (Poly(dimetylesiloksane)-co-[poly(metylhydrosiloksane)-graft-2-winyl-poly(3-heksylthiophene)]-co-[poly(dimetylsiloksane)-graft-dodec-1-en]) and PEGSil (Poly(dimetylsiloksan)-co-[poli(metylohydrosiloksane)-graft-2-winyl-poly(3-heksylthiophene)]-co-[poly(dimetylsiloksane)-graft- metakrylane ethere metylene poly(etylene glicole)]]) were tested as gas receptor thin films in resistance gas sensors. For both graft copolymers, two variants were tested: fractions with shorter (hexane fraction -H) and longer (chloroform fraction -CH) side-chains of P3HT. Sensors were obtained using the spin coating method on interdigital transducers (Au on Si/SiO_2). Sensor responses to NO_2 (1–20 ppm) were tested and compared. Experiments were carried out in the dry nitrogen atmosphere at different operating temperatures (room temperature (RT), 50 °C and 100 °C). Results showed that both copolymers with PEG side-chines had higher response to NO_2 than materials with dodec-1-en side-chains. What is more, results showed that in both cases hexane fractions are more sensitive than chloroform fractions. Measured responses ($R_a/R_g \cdot 100\%$) to 1 ppm of NO_2 at RT are: 250% DodecSIL-CH, 460% DodecSIL-H, 600% PEGSil-Ch and 1330% PEGSil-H. Similarly, in other operating temperatures, PEGSil film responses were higher than DodecSil ones, and H fractions were more sensitive than CH fractions. This showed that graft copolymers of P3HT have a huge potential for low temperature NO_2 sensing, and the proper choice of other side-chains can improve their sensing properties.

60 Label-Free QCM Immunosensor for the Detection of Ochratoxin A

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Mycotoxins are one of the most important food and feed contaminants threatening human health. Ochratoxins are the mycotoxins produced by some Aspergillus (commonly *A. ochraceus*) and Penicillium (*P. verrucosum* and *P. carbonarius*) species. Ochratoxin A (OTA) is the most dangerous and common ochratoxin and poses a major risk for human and animal health. Cereal grains are the most common commodity contaminated with OTA. As they are both directly consumed as food and used as animal feed, the transfer of OTA through the food chain causes OTA contamination in products of animal origin such as animal tissues and dairy products. Moreover, OTA contaminated feed not only affects human health through the food chain, but also reduces the animal growth rate and impacts productivity especially in pork and poultry production. Due to its carcinogenic, nephrotoxic, hepatotoxic, neurotoxic, teratogenic and immunotoxic effects as well as direct impact on animal husbandry, OTA content in food and feed products is regulated. Although the laboratory-based methods used for the quantification of OTA; such as LC MS, GC, HPLC; provide quite sensitive and reliable results, these methods are time consuming, expensive and require a trained operator. Biosensors provide fast, easy, cheap, sensitive and specific analysis. In addition to these advantages, biosensors enable on-site monitoring of samples without the need to carry them to the laboratory.

In this study, a QCM biosensor capable of measuring OTA in the 50–200 ppb range was developed. Due to the low molecular weight of the toxin, a competitive assay format was used. In this competitive assay, OTA is immobilized on the gold surface and competes with free toxin found in the sample to be identified for binding of anti-OTA antibody. For immobilization of OTA, gold surface was functionalized with 11-mercaptoundecanoic acid in the first place and then amine groups were generated for conjugation of the toxin. The developed assay exhibited a perfect linear correlation with 99,8 % R2 value within the range of 50–200 ng/mL and a detection limit of 17,35 ng/mL. The Commission of the European Communities Recommendation (2006/576) guidance values for OTA in feedstuffs are 250 ppb for cereals and cereal products, 50 ppb for feedstuffs for pigs and 100 ppb for feedstuffs for poultry. So, the developed sensor may be used for on-site monitoring of OTA in feedstuff within the limits and contribute to efficient screening of OTA by reducing the workload and dependence on laboratory-based methods. Further studies may enable the use of this sensor for food analysis by the addition of a pre-concentration step using immunoaffinity columns.

61 Low-Cost Bluetooth Low Energy Positioning and Timing System for Sports Events

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Timing points used in running races and other competition events are generally based on radio-frequency identification (RFID) technology. Athletes' times are calculated via passive RFID tags and reader kits. Specifically, the reader infrastructure needed is complex and requires the deployment of a mat or ramps which hide the receiver antennae under them. Moreover, with the employed tags, it is not possible to transmit additional and dynamic information such as pulse or oximetry monitoring, alarms, etc. In this proposal, we present a system based on Bluetooth Low Energy which allows complete real-time position monitoring of the users using mobile phones on the organizer side and BLE sensors on the participants' side. Along with the proposal, we present a complete architecture and an extensive analysis of metrics which are determinant for evaluating the performance of the proposed system: detection probability, range, mobility patterns of runners in real races, detection delay, packet collision, energy consumption, performance under high sensor density, etc. All these results, obtained through both experimental measurements and computer simulation, will demonstrate the viability and benefits of the system against other alternatives for the intended application.

62 Low-Cost Sensor System for Multi-Pollutant Measurement for Exposure Assessment

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Air pollution, both indoor and outdoor, has acute and chronic effects on human health, and air quality is affected by pollutants such as nitrogen dioxide, carbon monoxide and particulate matters. For human exposure assessment, it is crucial to understand when a person is exposed to which microenvironments under which pollutant concentration level and for how much time. Such measurement was not easy before due to the large size of the traditional monitors. However, with the rise of sensors, a portable sensor system, with the size of 36 cm length*23 cm width*56 cm height, was designed and developed specifically to meet this monitoring requirement for gas and particle measurement, which can operate both by 220 V mains power and an inbuilt 12 V, 20 Ah battery. Important environmental factors, for example pressure, temperature, relative humidity and GPS location, are also included. According to our previous study, gas sensors are sensitive to environmental change from temperature and humidity. To easily and effectively solve this problem, a heating module was added in the sensor system to heat the drawn gas sample to a certain level; and a Nafion tube was added to neutralize the sharp change of the humidity. More importantly, an auto-zero module constituted by air scrubbers was added to flush 'zero' air through sensors for baseline identification and zero correction. Tests have been carried out on the system by walking through different microenvironments and valid results have been obtained.

63 LSPR-based label free sensing in absorbance mode: sensing of Therapeutic Antibodies in Serum

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Gold nanoparticles support localized surface plasmons, which are coherent oscillations of the metal conductance electrons. While surface plasmon polaritons of gold films (used in surface plasmon resonance (SPR)-based sensing) require special methods to match the energy and momentum (such as the use of prisms or grating), localized surface plasmon resonance (LSPR) of gold nanoparticles can be directly excited by light propagating in free space.
The position of the surface plasmon resonance peak can be interrogated by measuring either transmitted light (absorbance mode) or scattered light (scattering mode). In both modes the position of the plasmon peak is known to be sensitive to the refractive index of the medium in the close vicinity of the nanoparticle's surface. Although the scattering peaks shifts more than the absorbance peak when the refractive index of the medium changes, absorbance measurement are more compatible with instrumentations available at any biochemistry lab, such as UV-VIS absorbance spectrometers.
The detection of antibodies in a complex media (cell culture media or human serum) is an important analytical problem with both biotechnological applications (in the case of recombinant antibodies producing cells, for example) and medical applications (in the case of allergy detection or immunotherapy supervision).
Here we present our results on the label-free detection of antibodies in complex media. We show that sub-nM concentration of antibodies can be detected, both in buffer and in complex media. We report on the effect of dilution of the complex media with buffer and we compare the use of gold nanoparticles in solution vs. surface bound gold nanoparticles. We then apply this method for the detection of Infliximab (a therapeutic antibody used for the treatment of autoimmune disease) in full serum.

64 Luminescent Molecular Chemosensors for Rapid and Nondestructive Detection of Thickness of Polymer Coatings

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Molecular chemical sensor, especially optical luminescent sensor, technologies are a rapidly growing topic in science and product design, embracing development in chemistry, biochemistry and life science research. It is expected that in the XXI century, optic-chemical sensor science and technology will address two major problems that present a great challenge. One is related to the applications of sensors in different fields of science such as material science, for example, polymer industry. The other problem refers to the chemical world and is related to obtaining completely new synthetic products and new materials.
Moreover, strict control of the quality of the final cured polymer coatings is required for high production standards. Therefore, there is a high demand for a quick and reliable method of thickness monitoring that would be applicable directly in production lines. Luminescence molecular chemosensors based on rare metal complexes are the answer to this type of need, because they are based on the use of luminescent probes as molecular sensors and quanta of light for information transfer between the probe molecules and the monitoring system. The luminescent chemosensors react to changes occurring in their vicinity within nanoseconds. Hence, the luminescence sensors meet the requirements of measurement speed.

65 Magnetic Tunnel Junction Chip Based to Detect the Magnetic Field of Neuronal Signals: A Platform for In Vitro Studies

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Magnetoencephalography (MEG) has revolutionized neuroscience, offering a tool with unprecedented spatial and temporal resolution. Today, MEG has clinical uses in detecting and localizing pathological activity in patients with brain tumors or intractable epilepsy [1].
Despite the wide clinical applications, the nature of MEG signals at local level is still not well understood [2]. In this context, there is evident crucial interest in developing a new generation of devices for local magnetic recording for an in vitro system. Several recent studies have implied that MagnetoResistive (MR) technologies can detect a biological magnetic field at local scale [3], [4] (i.e., brain slice, muscle in vitro). However, to date, no attempts have been carried out for neurons in culture due to the long-term biocompatibility required.
In this work, we will present a platform based on MR sensors array, namely magnetic tunneling junctions (MTJs) to detect the activity of neurons in culture from a magnetic point of view. We will show the biocompatibility of our devices and the preservation of the physical properties of the sensors. Murine embryonic hippocampal neurons were grown on top of the MR sensors array. We achieve a lifetime of the on-chip neuronal networks of longer than 20 days. Neurite growth was studied during development with immunostaining analysis.
In conclusion, we achieved the biocompatibility conditions of a MR platform suitable for studying the magnetic field generated by the activity of in vitro neuronal networks.

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66 Method of the Determination of Exterior Orientation of Sensors in Hilbert Type Space

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The following article presents the new algorithm of the isometric transformation based on the transformation in the newly normed Hilbert type space. The presented method is based on so called virtual translations, already known in advance, of two relative oblique orthogonal coordinate systems – interior and exterior orientation of sensors – to a common, known in both systems points. Each of the systems is translated along its axis (the systems have common origins) and at the same time the angular relative orientation of both coordinate systems is constancy. The translation of both coordinate systems is defined by the spatial norm determining the length of vectors in the new Hilbert type space. Such the way reduced the displacement of two relative oblique orthogonal systems to zero. This makes possible to direct calculation of rotation matrix of sensor. The next and last step is the return translation of the system along already known track. The method can be used for big rotation angles. The method was verified in laboratory conditions for test data set and measurement data (field data). The accuracy of the results in laboratory test is on the level of 10^{-6} of the input data. This confirmed the correctness of the assumed calculation method. The method is the further development of the Total Free Station (TFS) transformation (Stępień et al. 2017) to several centroids in Hilbert type space. This is the reason why the method is called as Multi-Centroid Isometric Transformation – MCIT. MCIT transformation is very fast and enable, through reduce to zero the translation of two relative oblique orthogonal coordinate systems, direct calculation of exterior orientation of sensors.

67 Miniaturized Flow-System Integrating Enzymatic Electrochemical Biosensors for Monitoring the Malolactic Fermentation of Red Wines

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During the malolactic fermentation (MLF) of red wines, L-malic acid is mainly converted to L-lactic acid. The concentration of both acids along the process have a significant influence on the quality of the final wine, therefore real-time monitoring of the MLF would be interesting for the winemaking industry. The traditional methods used at present require laboratory equipment; therefore, the results are not known in real-time. In order to solve that issue, a miniaturized and portable flow-system device that integrates amperometric enzymatic biosensors is proposed in this work. The system allows the simultaneous determination of both acids (L-lactic and L-malic acids) involved in the MLF of red wines using very low samples and reagents volumes. Biosensors for lactic and malic acids are based on thin film platinum microelectrodes fabricated with standard photolithographic techniques and polypyrrol enzymatic membranes. The electrode cell is based on a silicon chip with four electrodes in parallel: a 2.5 mm^2 pseudo-reference electrode (p-RE), two 2.5 mm^2 working electrodes (WE) and a 5 mm^2 counter electrode (CE). This cell architecture allows the integration of the two biosensors for the determination of both acids in the same chip. The surface of the platinum WEs is electro-modified with a three-dimensional polypyrrole membrane by applying the potentiostatic conditions in PB solutions containing the monomer and the entrapped chemical reagents. The fabrication conditions for both electrosynthesized biosensors were optimized previously by our group [1,2]. The sensor chip is implemented in a low-cost, robust and portable polymethyl methacrylate (PMMA) and pressure-sensitive adhesive (PSA) module with the required fluidic channels for the management of samples and reagents and a small chamber for the electrochemical cell (10 µL).

The analytical performance of both biosensors was studied by chronoamperometry. The L-lactate biosensor had a sensitivity of $-173\pm8\times10^2$ µA M-1 cm^{-2} (r = 0.997, n = 7) in a linear range from 5×10^{-6} M to 1×10^{-4} M and a LOD (3σ IUPAC criterion) of $3.2 \pm 0.3\times10^{-6}$ M. Regarding the L-malate biosensor, a sensitivity of $(5.53\pm0.6)\times10^2$ mA M^{-1} cm^{-2} (r = 0.997, n = 5) in a linear range from 1×10^{-7} M to 1×10^{-6} M and a LOD of $6.7\pm 0.2\times10^{-8}$ M have been obtained. The RSD was calculated for both biosensors using three biosensors fabricated under the same conditions on the same day, obtaining a value lower than 8 % and 6 % for the L-lactate and the L-malate biosensor, respectively. Both biosensors showed long-term stability, retaining more than

the 90 % of their initial sensitivity after more than 30 days, meeting the requirements of the proposed application.

Finally, the fluidic system was applied to the monitoring of the malolactic fermentation of samples recollected during this process for several red wines, with the results obtained by the proposed system showing excellent agreement with those obtained with the standard method.

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68 Monitoring and Registering of Rumen Movement in Ruminants

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Teams composed of electronic engineers and animal science scientists are nowadays collaborating to find mechanisms that help to understand rumen behavior in order to prevent diseases and improve animal goods. Temperature analysis, internal motility, and chemical composition of rumen, are physical magnitudes of interest.

In this way, this paper presents a system for registering and monitoring the internal motility of the rumen in ruminants using an embedded system with an Inertial Measurement Unit (IMU). The total system is composed of an electronic bolus (the device introduced to the ruminant) and an external base station (attached to the ruminant). The bolus is configured as an embedded system with an IMU responsible for registering the rumen motility. The external host registers (using a second IMU) the animal movements. Rumen behavior and ruminant movement are separated in a posterior data process.

An RF link at 433 MHz is used to maintain communication between the bolus and external base station. This flag-based communication is used to synchronize the ruminant and rumen movements registered by the IMUs.

In the end, the paper shows results obtained in real experimentation performed in collaboration with the Animal Science Department of our university.

69 Monitoring Hemolysis with a Parallel Plate Capacitor

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It is well known that a parallel plate capacitor can be used as a high resolution sensor of the electrical characteristics of a liquid sample contained by the capacitor. We are interested specifically in using parallel plate capacitors to characterize and monitor processes in biofluids. In this case, only dynamic measurements of the capacitance and resistance at a fixed frequency are generally possible. In biofluids, the high polarizability of water and the electrical conduction by the ions in solution, determine the electrical response of the system. When there are biological cells in suspension, the ion density is, in general, different inside the cell than outside it. Then, cells may act as strong polarizable entities, through the so-called Maxwell–Wagner effect. In addition, the formation of an electrical double layer at the interfaces between the biological fluid and the electrodes can influence both, the capacitance and resistance of the system. All these electrical effects combined must be taken into account to interpret measurements of the equivalent capacitance and resistance at a given frequency of the system. In this work, we combine all the mentioned effects into a practical model appropriate for frequencies above 10 kHz. Then, we present results of monitoring the process of hemolysis in human blood samples exposed to different values of osmotic stress. We use the model to interpret the obtained results. Overall, our conclusion is that electrical-impedance monitoring of a parallel plate capacitor containing blood is in fact sensitive to the hemolysis process and, more generally, can be a competitive way to characterize the osmotic fragility of biological cells. We discuss how to optimize measurements for future development of ad hoc sensors.

70 Multi-Sensor Enabled Live Virtual Geographic Environment: A Way to the Implementation of Mirror World

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With the two cores of database and model-base, Virtual Geographic Environment (VGE) breaks the limitations of the traditional Geographic Information System (GIS), which provides new support to the study and understanding of our world. VGE is proposed as a new generation of geographic language that is characterized by "feeling it in person, knowing it beyond reality". Unlike traditional data-centered GIS, VGE is a human-centered environment that represents and simulates both physical and human environments.

In the past, the data that fueled GIS/VGE was typically created to represent the state of the geoscape at a specific moment in time ("historic" or "current"; or "future" to represent a future modeled state). While this kind of data has been proven to be very valuable for numerous applications and analyses, even the "current" snapshot quickly falls out of sync with the real world. The fast-paced, constantly changing world makes the "current" snapshot outdated as soon as it is created. Fortunately, advances in sensor technology are revolutionizing the way in which geospatial information is collected and analyzed. For example, cameras and GPS sensors have the ability to provide continuous streams of geospatially-rich information.

In this topic, the emergence of integrating multi-sensor data and VGE is illustrated firstly. For this, multi-sensor enabled Live VGE is proposed as a new branch of VGE study to describe the ever-changing world, which is a way to implement the Mirror World. Mirror World is the virtual environment that is parallel the real world to facilitate its understanding and engagement through tools for interpreting massive data streams and shared decision-making at varying temporal and spatial scales. In our multi-sensor enabled Live VGE, multiple kinds of sensors such as GPS, in-situ sensors, visual sensors, etc., are used to incorporate the temporal aspect and real-time information into the geographic environment. A framework of Live VGE is given based on the proposed concept, in which multiple sensor data are geo-coded and integrated with the 3D VGE platform. A customized geosensor network service for Live VGE is provided to manage all the sensors and format the sensor data stream. After that, a new reconstruction method for these sensor data, especially the mobile sensing data, is mentioned to meet the demands of real-time visualization and simulation. Finally, environmental monitoring and simulation based case studies and experiments are also presented.

71 Multivariate Analysis as a Tool to Identify Concentrations from Strongly Overlapping Gas Spectra

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Multivariate analysis (MVA) was introduced in the early 20th century and first applied in psychology under the name of Multiple Factor Analysis (MFA). It is based on principle component analysis (PCA) and can be of great use in other research fields as well. MVA results in a reduction of unnecessary data, thereby reducing the error and simplifying further processing. The method of Partial Least Square Regression (PLS) can be applied after PCA to link the measured data with target values.
In this work, we will apply MVA on spectroscopic data of gas mixtures in the Mid-IR in order to calculate the concentrations of compounds with strongly overlapping absorption spectra. This is a common challenge in broadband spectroscopy. Photoacoustic spectroscopy (PAS) in the wavelength region of 3200 nm to 3500 nm serves as an example detection technique. We will apply the analysis to measurements of different organic compounds and show the possibilities offered by MVA. After preprocessing of the raw data photoacoustic signals, approximately 1300 equally spaced wavelengths are selected. PCA is used to reduce the whole spectrum to only a few Principle Components (PC) and afterwards PLS regression serves to recalculate the spectra and determine concentrations.

72 Nanoparticle Effect on Interaction of Epirubicin with DNA

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Epirubicin, (7S,9S)-7-[(2R,4S,5R,6S)-4-amino-5-hydroxy-6-methyloxan-2-yl]oxy-6,9,11-trihydroxy-9-(2-hydroxyacetyl)-4-methoxy-8,10-dihydro-7H-tetracene-5,12-dione, which is an antineoplastic in the anthracycline class, is a 4'-epi-isomer of the anthracycline antineoplastic doxorubicin. It is a topoisomerase inhibitor which inhibits topoisomerase II and intercalates into DNA, thus inhibiting DNA replication and ultimately, interfering with RNA and protein synthesis. Epirubicin is limited because of dose-dependent side effects including cardio toxicity, bone suppression, low blood counts, hair loss, nausea and vomiting. Drug–DNA interaction studies can give us brief information on the journey of the drug in the human body. In this study, an electrochemical DNA-based biosensor was developed for the detection of DNA–Epirubicin interaction through the electroactive properties of guanine and adenine nucleotides. Initially, interaction time and concentration of Epirubicin in response to guanine were optimized. Moreover, nanoparticles were used to modify the screen-printed electrodes surface to enhance the electrochemical signal. The effect of silver nanoparticles (AgNPs) and platinum nanoparticles (PtNPs) was further studied in detail. Layer-by-layer modification of the screen-printed electrode-based DNA biosensor gave the highest guanine response and resulted in a well-followed decrease in guanine signal after interaction with 0.5 ppm Epirubicin. With 5 min interaction time, the SPE/PtNPs/AgNPs/AgNPs DNA biosensor gave a linear response between 0.1 and 1 ppm Epirubicin.

73 New Fluorescent Molecular Probes for Monitoring of Very Fast Photopolymerization Processes of Monomers

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Extremely interesting and important applications of luminescent sensors have been found in research testing polymeric materials by fluorescence spectroscopy. This type of research has contributed to the development of Fluorescence Probe Technology (in short: the FPT method), which is used in the development of applications for fluorescence sensors in a range of kinetic studies of photopolymerization processes and polymerization. This is due to the fact that we have observed dynamic growth in new materials cured by photopolymerization, such as new monomers and photoinitiators as well as their new applications. Most recently, the development of new materials has been supplemented with new techniques for monitoring the progress of very quick photopolymerization reactions, because precise control of the photopolymerization processes is ultimately necessary to achieve a high-quality final polymeric product. In particular, there are high hopes for the possibility of monitoring the photopolymerization progress on-line by rapid measurements of such process parameters as the degree of cure, because many properties of the final product depend on the polymerization conditions. Moreover, strict control of the quality of raw materials and the final cured products is required for high production standards. Therefore, there is a high demand for a quick and reliable method of polymerization progress monitoring that would be applicable directly in production lines. Fluorescence Probe Technology is the answer to this type of need, because it is based on the use of fluorescent probes as molecular sensors and quanta of light for information transfer between the probe molecules and the monitoring system. The fluorescent probes react to changes occurring in their vicinity within nanoseconds. Hence, the fluorescent sensors meet the requirements of measurement speed.

On the other hand, recent advances in modern electronics and computer techniques have provided means for rapid analysis of fluorescence emitted by the probes, so it has become possible to acquire and analyse even 10 or more fluorescence spectra of a probe per second, which is necessary for monitoring rapid photopolymerization processes. In the FPT method, changes of fluorescence characteristics of appropriate molecular sensors, caused by changes of polarity or microviscosity of the medium in which the probe is dissolved, are monitored in real time.

In this work, we present new fluorescent molecular probes which can be used to follow photopolymerization processes in full conversion range of monomers. The aim of the work is to study the influence of the structure of the probes on their sensing properties. The properties of the new probes have been compared with those of the classical probes.

74 Ni–Co Bimetallic Nanostructures Based Electrochemical Sensors for Glucose Detection

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Electrochemical sensors based on metallic nanoparticles and different forms of carbon have been intensively studied in the past years as electroanalytical measurement devices. A key aspect in the study of metallic nanostructures as electrocatalysts is the preparation and characterization of nanoparticulate electrodes, which often consist of metallic nanoparticles dispersed or anchored on a carbon support material [1]. The formation and electrochemistry of Ni–Co nanoparticles at the electrode surface as well as their variations with different electrodeposition conditions have been determined by cyclic voltammetry. The changes in chemical composition and morphology of the nanoparticles-modified electrode surface has been studied by the scanning electron microscopy technique (SEM), including microanalysis by the energy dispersive X-ray method. Cyclic voltammetry and amperometry methods were used to study the electrocatalytic measurements of glucose in 0.1 M KOH electrolyte solution. Results: Comparative modification of the electrodes through electrochemical deposition of nickel–cobalt bimetallic nanoparticles onto carbonaceous materials is evaluated. Optimizing the electrodeposition parameters and conditions enables effective control over the morphology of bimetallic nanostructures, thus providing a great opportunity to improve their electrochemical properties [2].The electrocatalytic activity of the Ni–Co nanoparticles deposited on graphene, carbon nanotubes and fullerene was comparatively assessed by voltammetry and amperometry towards the glucose oxidation, corroborated with SEM images, demonstrating the enhanced analytical response of modified electrodes with MWNT used as support materials for electrodeposited nanoparticles.

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75 Non-Contact Measurement of Electrocardiogram in Neonates and Infants Using Sheet-Type Fabric Electrodes with Modified Driven-Seat Ground

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This study was aimed at developing a non-obtrusive and non-contact measuring device for the electrocardiogram (ECG) of neonates and infants by using sheet-type fabric electrodes placed under a bed-sheet. The electrodes form two capacitive couplings via clothing to the dorsal skin of the laid subject, and derive alternating biopotential difference of ECG in a non-contact manner through the couplings. Neonates and infants, however, have such a light weight and a small dorsal area that their non-contact ECG (NcECG) is likely to bear an unstable baseline and a deteriorated common-mode rejection ratio (CMRR). We therefore introduced modified driven-seat ground (mDSG) to improve baseline stability and the CMRR of NcECG. In an evaluation test of three adults, we confirmed both shortening of baseline restoration time and improvement of the CMRR of NcECG in all subjects after introduction of the mDSG. In NcECG recording experiments for neonates (24, 26 days) and infants (69, 104 days), we could observe distinct R waves and P waves during sleep or at near-complete rest. Detection sensitivity was 88.7% for R wave and 60.2% for P wave, respectively. These results infer that the proposed device with mDSG is capable of detecting NcECG of neonates and infants at near-complete rest.

76 Novel Algorithm for Calibration-Free Absorption Spectroscopy Sensor

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Due to the enormous progress in availability and performance of laser light sources and electro-optical components, tunable laser diode absorption spectroscopy is currently more and more used for quantitative assessments of gas in several fields, such as medical breath analysis, atmospheric environmental monitoring, chemical analysis, industrial process control, and high-resolution molecular spectroscopy.
One of the most common limits to sensor performance is the presence of unwanted interference fringes arising, for example, from interfaces in the optical path. In this work, a novel algorithm is presented, which allows the extraction of a spectroscopic line from a background with arbitrary periodical disturbances without having any knowledge of their functional form or their time dependence.
A sensor using this algorithm, being insensitive to fringes and their change in time, will maintain its accuracy and will not need periodic calibrations. To demonstrate its performance and robustness, the algorithm is applied to simulated data and to oxygen absorption measurements. The results show that this method has the potential to further push the sensitivity of spectroscopic methods.

77 Novel TDT Sensor for Soil Moisture Profile Probe

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The aim of the work was to experimentally determine the sensitivity and resolution of a single sensor installed in a profile probe for moisture measurement at various soil profile depths. Its design and the principle of operation were based on a novel patent-pending implementation of the time-domain-transmissionmetry (TDT) technique using differential signals.
The sensor consisted of two stainless steel stripes wound around a plastic tube 40 mm in diameter in the form of cut loops, comprising a differential balanced line connected to a PCB placed inside the tube. Two symmetrical input and output ports were formed at the connection points. The delay of the input signal measured at the output depended on dielectric permittivity of a material surrounding the probe.
The difference in the signal delay registered for the probe, surrounded by air and water, divided by the sensor resolution, obtained from the phase loops jitter, allowed the determination of the sensor sensitivity, which was found to be under 0.1% of volumetric water content. The sensitivity can be further enhanced by elongating the length of the transmission line by increasing the probe diameter.

78 Oil Slicks Detection in SLAR Images with Autoencoders

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In this manuscript, the main aim is to detect candidate regions to be oil slicks in Side-Looking Airborne Radar (SLAR) images using Deep Learning techniques. The proposed approach is based on Autoencoders to allow us to automatically discriminate oil spills without *hand*-crafted features or other features extracted from traditional computer vision techniques. Each image is acquired from two SLAR sensors located on both sides of an aircraft. The method can work well although the regions have a high probability of having artefacts and noise caused by the aircraft maneuvers. Those artefacts and noise are caused by not only the looking angle of both antennas which generate a blind swath beneath the aircraft, but also by other error measurements obtained when the aircraft turns. The presented method is implemented as a denoising Autoencoder that uses the Convolutional Neural Network (CNN) as encoder and decoder functions, where the decoder function learns to detect only the oil slicks. This approach can be used for detection of oil spills in emergency missions. The behavior method has been tested using SLAR images acquired from a TERMA radar for mapping the sea surface and surveillance of Spanish coasts. The results show that our method works suitably in different weather conditions and with different natural phenomena such as shoals of fish or seaweed.

79 On the Optimization of a MEMS Device for Chemoresistive Gas Sensors

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In recent years, research in the gas sensor field has experienced a significant boost. Gas sensors represent crucial elements in gas monitoring systems and olfactory systems for several applications: environmental monitoring, safety and security, quality control of food production, medical diagnosis and so on. From the point of view of the gas sensing design, the substrate plays a fundamental role, because it acts as a heater, mechanical support and transducer of the sensor response. The application of MEMS technology for the fabrication of a silicon device with very low power consumption has offered new opportunities for innovative gas sensor design. In this work, we studied different approaches in order to realize and adapt silicon microheaters for chemiresistive gas sensors, available for high operating temperatures (650 °C) through MEMS technology. In order to assess a reliable microdevice for this application field, in this work, we studied the different processing steps required to obtain a silicon microheater: layout of the device, types of metals used as a heater and interdigitated contacts, type of insulator and heat treatment to be adopted during the microfabrication. Finally, we propose the processing that provided the best results.

80 On-Line Monitoring of the Metabolic Activity of Bacteria and Eukaryotic Cells Utilizing Light-Addressable Potentiometric Sensors

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On-line monitoring of the metabolic activity of eukaryotes and microorganisms can avoid complex process disturbances at an early stage in various biotechnological applications. For instance, downtimes in a biogas plant caused by metabolically inactive microorganisms can induce irreversible hindrances and cost-intensive interventions, which can be prevented by utilizing an efficient monitoring system. Short response times, small sizes, mass fabrication and solid-state nature of field-effect-based (bio-)sensors such as LAPS (light-addressable potentiometric sensors) are promising properties enabling a low-cost and precise monitoring system. LAPS provide a spatially resolved concentration detection of an analyte solution and can record 2D-chemical images of concentration changes of (bio-)chemical species on its flat surfaces. In this work, a LAPS-based multi-chamber measuring system was developed. By means of 3D-printed polymer-based structures combined with LAPS chips, differential and simultaneous measurements were realized. The differential measurement principle was carried out to eliminate the external influences, such as temperature fluctuations, pH value variations and sensor signal drifts. Simultaneous measurements were facilitated by applying four-chamber cells reducing the measurement time. As test samples, *Escherichia coli* K12 bacteria and Chinese Hamstery Ovary cells have served to study the metabolization rate of those assays after glucose uptake.

81 Open and Closed Loop Modelling of Soft Polymer Photoactuators for Microfluidic Flow Control Applications

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Recent advances have demonstrated reproducible and reversible photo actuation of polymer hydrogels for flow control in microfluidics can be achieved [1, 2]. This work characterises the actuation of one such hydrogel, a spiropyran-functionalised pNIPAAm hydrogel, photopolymerised around pillar structures, for use in microfluidic valving applications. The assembled valve system was characterised and modelled using classical control engineering methodologies. The system input consists of a 450nm LED incident on the valve assembly while the system output was the resultant measured flowrate, through the valve, under a defined head of pressure. The developed open loop system model is one of a non-linear first order over the measured volume flow rate range of 3-17 uL/min. In order to facilitate the implementation of a simple, proportional, closed loop control strategy, the open loop system was linearised over a volume flow rate range of 3-9 uL/min. A closed loop system model was then developed around this linearised model. This model was then used to effect closed loop control on the valve. Predicted and measured experimental data were shown to be in good agreement, enabling user selected flow rates through the microfluidic channel over the defined linearised range.

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82 Optical Fiber Link Failure Prediction System Based on Long-Period Fiber Grating Mechanical Sensor

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High data rate optical fiber links are usually deployed in core IP networks to transport bulky information from router to router. In this context, failure prevention mechanisms are highly important since any short-time failure may represent bulk data loss and additional delay. Although link failures can be caused by multiple factors, in some scenarios, these failures are preceded by mechanical movement of the physical medium.
In this context, we propose an optical fiber link failure prediction system for high-speed optical networks based in a long-period grating (LPG) sensor. The proposed system uses a LPG sensor to monitor mechanical changes in an optical fiber link and, in the case that relevant mechanical deformation is detected, the system re-routes packets through a redundant copper cable, instances before the communication is disrupted in the main link.
The proposed system was tested under multiple network loads using a set of failure scenarios, where the optical link disruption is preceded by mechanical changes. In these conditions, the results show that the proposed system effectively reduces the packet loss to the minimum observed for the best case scenario of continuous connectivity.

83 Performance Evaluation of Direct Printed Flexible Tactile Sensors

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We developed a direct-printed flexible tactile-sensor-based robotic gripper system for object grasping and experimentally verified the system performance. These flexible tactile sensors are based on pressure-sensing materials that allow pressure to be measured according to resistance change that in turn results from changes in material size because of compressive force. The sensing material consists of a mixture of multi-walled carbon nanotubes (MWCNTs) and TangoPlus, which gives it flexibility and elasticity. The tactile sensors used in this study were designed in the form of array structures composed of many lines so that single pressure points can be measured. To evaluate the performance of the flexible tactile sensor, we used specially designed signal-processing electronics and tactile sensors to experimentally verify the sensors' linearity. To test object grasp, tactile sensors were attached to the surface of the fingers of grippers with three degrees of freedom to measure the pressure changes that occur during object grasp. The results of these experiments indicate that the flexible tactile sensor-based robotic gripper can grasp objects and hold them in a stable manner.

84 Piezoelectric Speed Bump Power Supply for Wireless Sensor Nodes in Autonomous Vehicle Systems

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Recently, in the field of autonomous vehicle systems, technology for transmitting the road surface information to the vehicle by embedding a wireless sensor node on the road has been developed, and a power device development technique is required to drive the sensor node. The purpose of this study is to design and test a piezoelectric speed bump power supply that supplies power to the wireless sensor nodes. The piezoelectric speed bump power supply developed in this study is a “push down” type. When the vehicle passes the speed bump, the vehicle wheel applies pressure to the piezoelectric element to convert the mechanical energy into electrical energy. We simulated a piezoelectric speed bump power supply to the simulators and tested it by installing a real speed bump. The electrical output power of the piezoelectric speed bump power supply is higher than the output power of the existing piezoelectric energy harvester. Finally, the output power of the piezoelectric speed bump power supply charged the general smartphone battery. From this result, we confirmed that we can drive a small wireless sensor node with the output power of the piezoelectric speed bump power supply. The piezoelectric speed bump power supply developed in this study can be applied to the construction of a smart road infrastructure system and can be applied as a driving power source for sensors used for information exchange communication between roads and automobiles in an autonomous vehicle system.

85 Portable Multianalyte Sensor System for On-Site Monitoring of Fermentation Processes

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Process control of complex fermentation processes requires monitoring of various key parameters. In this regard, knowledge about specific process-related metabolites, in particular, is of great interest. Herein, an electrochemical multianalyte sensor system is presented that enables simultaneous analysis of four different metabolites, namely ethanol, formate, D- and L-lactate. The platinum sensor chip (14 × 14 mm^2) comprises five working electrodes (each 2 mm in diameter) and an integrated counter electrode. Each working electrode is functionalized with an immobilized enzyme membrane, consisting of a specific nicotinamide adenine dinucleotide (NAD^+)-dependent dehydrogenase in combination with a diaphorase from *Clostridium kluyveri*. Amperometric detection is performed at an applied potential of +0.3 V vs. Ag/AgCl by anodic oxidation of enzymatically produced ferrocyanide. Thereby, the generated current is proportional to the analyte concentration in the sample solution. The compact and portable electrochemical sensing device comprises the biosensor chip in combination with a multiplexer potentiostat. In this way, rapid on-site monitoring of organic acids and alcohol is realized. Additionally, application of the sensor system in real samples from a biogas plant will be presented in this work.

86 Principles of Refractive-Index and Optical-Extinction Sensing of Microliter Samples of Nanocolloids

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We analyze theoretically and experimentally a new way of sensing the real and imaginary parts of the effective refractive index of nanocolloids by coherent reflectance from a confined film of a liquid sample. The method is suitable for developing compact sensors with high resolution. We perform a theoretical analysis using a recently developed coherent-scattering model for a turbid colloidal film, which considers absorption and scattering by the particles as well as surface effects. The configuration to measure the coherent reflectance of light from the sample consists of an optical prism in contact with a nanocolloid layer of the sample backed with a glass slide. In this configuration, there are two critical angles for light incident from the prism side, one between the prism's glass and the air outside, and another one between the prism and the nanocolloid sample. The model predicts a high sensitivity of the reflectance to the optical properties of the nanocolloid just before and at the critical angle, to the imaginary and the real part of the effective refractive index, respectively. We also present experimental reflectance measurements of gold and TiO_2 nanocolloids in the proposed configuration and demonstrate the high sensitivity of both measurements. We illustrate the method for chemical sensing by monitoring changes in PH and temperature of nanocolloids.

87 Quasi-Static Measurement with Piezoelectric Sensors in Regard to Structural Health Monitoring of Wind Turbines

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Structural health monitoring of wind turbines is becoming more important with regard to the increasing demand of wind energy and growing capacities of wind turbines. To predict the lifetime, the mechanical load is measured by strain gauges which are part of an active control system. At present, other sensor principles are investigated for structural health monitoring of wind turbines. In particular, the piezoelectric methodology is interesting due to its specifications but it only operates in dynamic frequency range. Since the blade root strain occurs in a frequency range below 10 Hz, the performance of piezoelectric sensors in quasi-static frequency range is investigated in this work. To simulate an unidirectional strain of a rotor blade, a four-point bending test is performed on various specimens. Sensors of different piezoelectric effects and size are attached on the specimen to measure strain under variable climatic conditions. The effects of climate, frequency, size, strain and host structure on performance of the sensors are assessed. The evaluation approves that the piezoelectric sensor M8507-P2 is suitable for quasi-static strain measurement. The signal conditioning of the piezoelectric sensors is carried out by a charge amplifier module which has been developed in terms of wireless signal conditioning in this work.

88 Research on a Wireless-Based Acoustic Signal Acquisition Smart Sensor Platform for Structural Health Monitoring of the Piping System in a Power Plant

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A sensor is a device that has functions of converting physical quantities such as temperature, pressure, acceleration, and displacement into an electrical signal, and is an essential element for constructing a system that can be used for various purposes. For their utilization, those sensors are being developed to have characteristics such as improved performance, size, and special purpose through research, and are widely used in industry. In the mid-2000s, with the development of wireless-based industrial networks, studies on the functional and structural development of sensors for various applications and research on merging them with a wireless network have been conducted. As a result, they have started to be applied throughout the industry and the Information and Communication Technology (ICT) including the Internet of Things (IOT). Because of its abilities to compensate the limitations of the general sensor element related to the development of the ICT technology, the smart sensor can be used independently and can monitor a wide range by configuring the network. In addition, it has a micro-controller and can be independently used to control measurements and performances such as data processing, storage, automatic correction, self-diagnosis, making decision and communication. These various types of smart sensors are applied to various fields such as automobiles, mobile devices, robots, environment, defense/security, medical devices, household appliances, and industrial/measuring instruments.

Structural health monitoring (SHM) is used to identify, diagnose, and evaluate structures—a wide range or a large number of structures—such as power generation facilities. In this case, the sensor used to evaluate the safety of the structure is used in various applications and it is necessary to have a high-performance collection module. Currently, most of the sensors and signal acquisition modules used to monitor the health of structures are high-performance products based on wired lines. Because of measurement processes requiring manpower, there is an unnecessary use of time and money.

In this study, a smart sensor platform based on wireless and standalone technology was constructed to monitor the health of structures and it was applied to examine the leakage phenomenon that can occur in the piping system in the power plant. The smart sensor that is capable of one channel and 20~20 Khz sound signals input was used and three sensors were installed at intervals in a test bed of 3.6 × 4.5 m and all signals generated by

leak signals at arbitrary positions were collected. The collected signal is used to determine whether leakage occurred through the signal processing, and the data transmitted to the wireless monitoring server is used to estimate the location of the leak source by the time delay difference between two channels. As a result, it was possible to estimate the leakage phenomenon and the location of the leakage source in the testbed and it has a position error of up to 300 mm.

90 Soil Dielectric-Spectrum Characterization Based on One-Port VNA Measurement System

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The output of soil moisture and salinity dielectric sensors may significantly depend on soil texture and mineralogy. Therefore, reliable characterization of broadband complex dielectric permittivity (CDP) spectra of soils is of practical importance for improvement of moisture and salinity measurement methods. However, CDP spectra determination of highly heterogeneous materials is problematic in terms of measurement system construction and calibration, especially in the microwave frequency range.

We present a new CDP spectrum determination method which is solely based on one-port vector-network-analyzer (VNA) measurements in the 1 MHz–3 GHz frequency range. The sample was placed in a 1 5/8" coaxial measurement cell. A two-step calibration procedure based on the Bauer–Penfield one-port calibration method [1] was applied in order to obtain scattering parameters of the cell solely from one-port measurements. Next, the CDP spectrum was determined based on classical Nicholson–Ross–Weir algorithms. Comparison with direct two-port VNA measurements shows that our method is more repeatable since the movement of measurement cables is avoided. Another advantage of the presented method is lower cost of the measurement system.

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91 The Capacitive Sensing of NS1 Dengue Biomarker for Diagnosis

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NS1, a non-structural dengue protein, has been used as a biomarker for the detection of viremia in dengue diagnosis and was herein selectively quantified by electrochemical capacitive sensing (an impedance-derived capacitance methodology wherein the redox probe is contained in the receptive layer) aiming at dengue diagnosis in phosphate buffer saline and blood serum environments (up to the neat level). The capacitive sensing was compared to the traditional concurrent impedimetric approach (in which the redox probe is added in the biological solution) and other transient methods stated in the literature regarding figures of merit such as limit of detection, linear range, relative standard deviation and affinity constant. Capacitive and impedimetric assays showed equivalent results for linear range, repeatability, sensitivity and constant of affinity. Nonetheless capacitive assays presented better reproducibility with a relative standard deviation (RSD) of 3 ± 1 and 7 ± 4 (all in percentage) in PBS and serum, respectively; meanwhile, for impedimetric assays, the RSD values were 9 ± 5 in PBS and 12 ± 6 in serum. Thus, by using capacitive assays, an improvement on the analytical performance was observed with the limit of detection about sixty-fold lower in neat serum (~0.5 ng mL^{-1} for capacitive over ~30 ng mL^{-1} for impedimetric assays) compared to traditional electrochemistry methods in general, hence demonstrating the superior detection sensitivity for NS1 protein. Accordingly, redox tagged capacitive assays are suitable for the development of multiplex point-of-care neglected disease sensing applications.

92 The PAMONO-Sensor Enables Quantification of Individual Microvesicles and Estimation of Nanoparticle Size Distribution

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In our recent work, the plasmon assisted microscopy of nano-objects (PAMONO) was successfully employed for the detection and quantification of individual viruses and virus-like particles in aquatic samples (Shpacovitch et al., 2015). Further, we adapted the PAMONO-sensor for the specific detection of individual microvesicles (MVs), which have gained growing interest as potential biomarkers of various physiological and pathological processes. Using MVs derived from human neuroblastoma cell line cells, we demonstrated the ability of the PAMONO-sensor to specifically detect individual MVs. Moreover, we proved the trait of the PAMONO-sensor to perform a swift comparison of relative MV concentrations in two or more samples without a prior sensor calibration. The detection software developed by the authors utilizes novel machine learning techniques for the processing of the sensor image data. Using this software, we demonstrated that nanoparticle size information is evident in the sensor signals and can be extracted from them. These experiments were performed with polystyrene nanoparticles of different sizes. We also suggested a theoretical model explaining the nature of observed signals. Taken together, our findings can serve as a basis for the development of diagnostic tools built on the principles of the PAMONO-sensor.

93 The Piezoelectric energy harvesting system with potential energy for wireless sensor network

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Recently, research is being conducted to construct a network that activate sensors based on piezoelectric energy harvesting modules. Piezoelectric energy harvesting modules can eliminate the need for batteries driving sensors. However, since output time of the previous piezoelectric harvester module is short, a new study of piezoelectric harvester module for sensor is required. In this study, we have designed and tested the harvester that generates continuous output for a longer time than previous harvester to drive sensors seamlessly with only one input. This harvester module uses the potential energy to increase time of output power. After the input energy is stored as potential energy of the steel balls, as the balls fall down slowly, it generates electric energy. Experimental result shows that the new harvester increases time of driving sensors compared to the conventional harvester at the same number of input. In addition, the new harvester can be used without batteries in a variety of places, from large-scale highways to small-scale bicycle roads.

94 Thermal Activity Surveillance System: Measuring Mountain Bike Trail Use

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We present a small system for counting and classifying bikers and pedestrians on nature trails. The system consists of a low-cost capture system based on the Raspberry Pi 2 and an embedded thermal camera. Besides the benefit of enabling both day- and night-time surveillance, thermal imaging also helps address the privacy concerns that usually plague surveillance systems. The camera is very low resolution, but it is able to provide sufficient information for a detector to locate and discriminate between bikers and pedestrians. The detector uses a typical sliding window-based approach and performs classification based on HoG features. Detections are collected in tracks from which a final decision is made on whether a biker or pedestrian has passed through the camera's view. The system is trained and evaluated on a challenging new dataset with more than 25 hours of thermal imagery. Data was captured from varying view points and from multiple geographical locations. The purpose is to show the feasibility of using a collection of classic computer vision methods and low-cost components for a real-time thermal surveillance system that is capable of classifying the different actors that make use of nature trails.

95 Trace Electroanalysis of Perfluorinated Alkyl Substances with Molecularly Imprinted Polymer Sensors

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Pollution of natural and drinkable waters by perfluorinated alkyl substances (PFAs) is a problem of global concern [1]. Molecularly imprinted polymers (MIPs) are promising materials being explored extensively as recognition elements for sensors since they offer improved stability, cost effectiveness and rapid fabrication [2]. In this study, the preparation and characterization of novel sensors for PFAs based on the electrosynthesis of MIPs is reported. In particular, we focus on the trace detection of perfluoro octane sulphonate (PFOS), for which recommended concentration limits in water are the lowest (60 pM). The PFOS-sensitive MIP was prepared by electropolymerization of o-phenylenediamine (o-PD) on a gold electrode in the presence of the analyte as the template. The template molecules were then removed from the modified electrode surface by using suitable solvents. Electrochemical methods and electron microscopies were used to monitor the electropolymerization, template removal and binding of the analyte. A ferrocenyl derivative was used as the reporting electrochemical probe which generates the analytically useful voltammetric signal. The incubation of the MIP-modified electrode in PFOS containing samples resulted indeed in the progressive suppression of the electrochemical signal of the reporting probe, which scaled inversely with the PFOS content. Conditions for achieving a linear dependence between voltammetric signals and concentration of PFOS in the sample were optimized, obtaining a detection limit of 38 pM [3] and a dynamic range extended over 2 orders of magnitude. Real water samples were analysed, providing results in satisfactory agreement with those obtained by HPLC-MS-MS measurements. A similar approach was applied also to develop a sensor for perfluoro octanoic acid (PFOA). To the best of our knowledge, this is the first example of use of MIP-modified electrodes for the detection of perfluorinated alkyl pollutants at ultra-trace concentration levels.

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96 Traceability of Prêt à Porter Clothing through Cryptographic Protocols

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In recent years, several methods for monitoring processes and different types of activities have been developed as characteristic of the connected industry and Internet of Things (IoT). Several research papers and patents have been published for observing construction projects, controlling and avoiding damages in mechanical structures, monitoring and analysing cardiorespiratory signals and snoring, measuring temperatures, etc. The blockchain technology has arisen as an emerging paradigm and part of the IoT distributed systems and connected world. Several companies are increasingly using such technology with connected sensors to provide traceability, authenticity, visibility, and security to their supply chains. A blockchain could be considered as a distributed ledger in which all transactions are securely recorded. Roughly speaking, a blockchain is a protocol that gives the user the possibility to group documents into blocks and link those blocks together in a chain. These blocks contain the identification of a transaction, the transaction's contents, and a hash pointer to the previous block. A blockchain is a log data structure which receives and stores data with the particularity of detecting any data tampering, in such a way that any change in the existing transactions will be detected, as the successive blocks will be affected. Blockchain thus offers a cutting-edge way of transmitting incorruptible marketing messages to customers. Moreover, it extends the possibility of individualised interaction though products themselves and allows users to record specific details about when and where products were made and about the people that made them. Consequently, this technology could be used for information protection, including trademark registration details, legal information, assignment and chain of title information and/or evidence of (first) use in trade or commerce.

It is well known that textile manufacturing has been significantly improved in developing countries to reduce operation costs. In addition to suppliers and customers, spinning factories, knitting factories, and trading firms involve strategic supply chain partners. The enhancement of product accuracy and visibility, at each stage of a supply chain in the apparel industry, has become essential. The objective of this paper is to present a critical review of the more recent traceability proposals for ready-to-wear clothing, ensuring the authenticity, reliability, validity, and integrity of the final product and also of the whole supply chain.

97 UAV Visual and Laser Sensors Fusion for Detection and Positioning in Industrial Applications

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Recent developments in micro-electro-mechanical systems (MEMS) have greatly contributed to the availability of unmanned aerial vehicles (UAVs) and sensing technologies. The increasing maturity of these technologies has led to the development of novel real-world applications in industrial scenarios. Though historically, industry has been slow to adopt newer technologies, UAV-related technologies have produced interest in outdoor-based industries, especially for inspection and supervisory tasks in dangerous or inaccessible environments. One of the most common challenges is the detection, recognition and positioning of pipes in industrial environments, as this problem must be solved in several tasks where pose between the UAV and the pipe is required. Both vision and laser range finder (LRF)-based approaches present weaknesses and strengths: monocular vision cannot solve depth estimation in real-time, and it is weak against visual artifacts and disruptions, while LRFs present a slow rate and errors that are hard to reduce. In this work, the authors describe a sensor fusion architecture which enables the provision of real-time detection and positioning of a UAV with respect to industrial pipes, with the accuracy and rate of a vision-based system and the robustness of LRF sensors.

98 Ultra-Sensitive Immunofluorescence Assay Based on DNA Elongation by Surface Plasmon Heating

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We present here a novel ultra-sensitive immunological fluorescent method of assaying bacterial and viral pathogens. The assay is based on the selective heating of a target binding-site by the surface plasmon (SP) that is induced on a flat gold film in response to excitation with a high-power, near-infrared laser light. This 'localized' heating induces rolling-circle DNA amplification (RCA; i.e., continuous isothermal DNA elongation using a circular template) at the pathogen binding-site. The resulting DNA amplicon can then be detected via fluorescent staining.

To enable selective heating of the target binding-site, a primer sequence-modified antibody is first immobilized on the surface of the gold film as a spot with which to capture target pathogens. Since a pathogen-bound antibody produces a larger SPR angle (q') than a free antibody (q), SP fields are generated at the binding-site in response to laser illumination at a slightly offset incident angle (q'' = q' + qoffset) from the q'. The SP damping heat can then induce selective DNA elongation from the primers immobilized on the antibodies binding pathogens. This allows pathogens to be covered by the amplicons, and produces large DNA spheres that can be fluorescently stained, and then easily visualized and counted using a low-magnification microscope or imager.

In the present study, we used 3-µm IgG-conjugated latex beads as a model of pathogen and confirm the validity of the assay. Anti-IgG and anti-BSA (control) antibodies were modified by 5'-NH_2-M13M4-primers using bis-NHS linkers. A 6-mm silicon rubber through-hole well was then attached to a 50-nm gold film that had been evaporated onto a coverslip. The two antibody conjugates were immobilized on the NHS-terminated gold surface to form 1-mm test and control spots, respectively. After immuno-reaction with the model particles, the surface was immersed in an RCA solution (comprising M13mp18, Bst polymerase, and dNTPs), and illuminated by a p-polarized 808-nm 600-mW laser light for 30 min through a glass prism, and at the incident angle (q''). The resulting amplicons were stained with SYBR Green-I, and observed via confocal microscopy (x40 magnification). A strong fluorescent signal was observed specifically at the test spot. The locations of the fluorescence spots were consistent with those of the particles in the transmission image at higher

magnification. This result indicates that SP heating successfully induced RCA at the binding site of the 3-μm latex beads.

Although the observed background fluorescence intensity at the control spot was significantly lower than that at the test spot in the present study, non-specific heating and/or background RCA could decrease image contrast in other instances. Thus, setting the offset angle (qoffset) will likely be crucial during practical application of this method, particularly if the assay is used to detect viral pathogens that only generate a small SPR angle change (dq = q' - q) upon binding to the antibody. The optimization of the offset angles for various size pathogens will therefore be discussed.

99 Ultrasensitive Detection and Discrimination of Cancer-Related Single Nucleotide Polymorphisms Using Poly-Enzyme Polymer Bead Amplification

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We report the development of a new ultrasensitive approach for label-free DNA detection using magnetic nanoparticle (MNP)-assisted rapid target capture/separation in combination with signal amplification using poly-enzyme tagged polymer nanobead. The sensor uses a MNP linked capture DNA and a biotin modified signal DNA to sandwich bind the target followed by ligation to provide high single-nucleotide polymorphism discrimination. Only the presence of a perfect match target DNA yields a covalent linkage between the capture and signal DNAs for subsequent conjugation of a neutravidin-modified horseradish peroxidase (HRP) enzyme through the biotin–nuetravidin interaction. This converts each captured DNA target into a HRP which can convert millions of copies of a non-fluorescent substrate (amplex red) to a highly fluorescent product (resorufin) for great signal amplification. The use of polymer nanobead each tagged with thousands of copies of HRPs as the signal amplifier greatly improves the signal amplification power, leading to greatly improved sensitivity. This biosensing approach can specifically detect an unlabelled DNA target down to 10 aM with a wide dynamic range of 5 orders of magnitude (from 0.001 fM to 100.0 fM). Furthermore, our approach has a high discrimination between a perfectly matched gene and its cancer-related single-base mismatch targets (SNPs): it can positively detect the perfect match DNA target even in the presence of 100-fold excess of co-existing SNPs. This sensing approach also works robustly in clinical relevant media (e.g., 10% human serum) and gives almost the same SNP discrimination ratio as that in clean buffers. Therefore, this ultrasensitive SNP biosensor appears to be well-suited for potential diagnostic applications of genetic diseases.

100 Verifying Sensors in Smart Toys Designed to Help Professionals in the Early Detection of Psychomotor Developmental Disorders

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Toys are key elements in the development of children. In fact, some of them are included in child development tests used by professionals to assess whether or not children are able to perform a specific task. However, traditional toys do not detail how they do it. In the present research, we have designed Smart Toys (including accelerometers, gyroscopes, LDRs) and defined a system architecture based on wireless communications between the toys and a data collector device. Besides, we are carrying out a developmental delay screening system (DDSS) to provide a data analysis of the Smart Toys. Our main objective is to determine the variables of movement that explain the level of psychomotor development of children in order to build an automatic system of assistance to decision making by professionals, starting from the activity of children playing with Smart Cubes.
An experiment was carried out to evaluate the performance of 65 toddlers (ages between 23 and 32 months) making a tower of cubes. The Smart Toy-based sensors recorded the activity of the children for further comparative analysis. In addition, four experts in child development assessed children's performance. The results show that the Smart Toy was successful with separate distinct levels of performance.

101 Viability Analysis of Spore-Based Biosensors in Sterilization Processes

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The use of microbiological tests is the state-of-the-art method to validate the efficacy of several sterilization processes, for instance, gaseous H_2O_2 from aseptic filling machines. In these tests, microbiological spores are used as a probe due to their high resistance to the sterilization process under investigation. As the viability of the spores is highly reduced due to the sterilization, their efficacy can be assured. However, these microbiological methods are slow and time-consuming; the results can be obtained at the earliest after 24 h. Recently, a first type of spore-based biosensor was suggested to evaluate sterilization processes in aseptic filling machines within a few minutes. It consists of a glass substrate with temperature sensors and several interdigitated electrodes (IDEs) as transducer elements, where the spores can be immobilized on one of the IDEs, whereas the other IDE is utilized as a reference sensor (differential measurement setup). The spore-based biosensor is then exposed to a H_2O_2 gas stream (e.g., 10 m^3/h) and heat (e.g., 240 °C); as a result, a signal change (e.g., impedance) can be measured. Nevertheless, little is known about the principle of this biosensor and the relation between the viability of the spores and the sensor signal. In this work, therefore, micro particles (e.g., PMMA, SiO_2) will be used as a model system for the spores to investigate their physical (e.g., morphology) and electrical (e.g., capacitance, impedance) properties after sterilization with H_2O_2 and heat.

102 Voltammetric Electronic Tongue for the Resolution of Ternary Nitrophenol Mixtures

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Nitrophenols have been widely employed in different applications from explosives to weight loss drugs but the main environmental problem is their generation as degradation products of the more common herbicides. This work reports a quantification method for picric acid, 2,4-dinitrophenol and 4-nitrophenol using electrochemical sensing coupled with advanced mathematical processing; this approach is known as electronic tongue.

The array was formed by an epoxy graphite composite, gold, platinum and silver. The electrochemical technique employed was cyclic voltammetry in a phosphate buffer pH = 6.5. An electrochemical cleaning step was performed between samples to ensure a steady and reliable response and to prevent any fouling of the electrode surfaces.

Artificial neural networks (ANNs) were the chemometric tool used for modelling as they allow a superior capability for non-linear information. In this particular case, the electrochemical data was compressed using Discrete Wavelet Transform and the resulting coefficients were fed to the ANN, the architecture of which was sequentially optimized. The resolution of the mixtures was achieved with a total normalized root mean square error (NRMSE) of 0.076 for the test subset, allowing a fast and acceptable detection of these nitroaromatic compounds.

103 Optimization of Variable Radius Spiral Micromixer

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A novel single-layer passive mixer is designed which takes advantage of gradually increasing the radius of curvature of a spiral micro mixer. The mixing efficiency is further optimized via iterations on key geometric parameters using numerical simulations. Numerical results indicate that the optimized mixer has better mixing efficiency than the conventional constant radius of the curvature spiral channel for a wide range of the Reynolds number. The spiral shape guarantees the best surface area occupation and provides the maximum mixing length with a reduced pressure drop. According to the numerical results, the mixing efficiency can reach up to 99.5% at the outlet and it is improved by 20% compared to constant radius spiral micromixers. The proposed micromixer can be manufactured using a wide range of processes since its geometry is embedded on a single layer.

biomimetics

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