Atto-Plasmonic Sensors for Point-of-Care Tests

Nunzio Cennamo[1] *, Francesco Arcadio[1] , Natalia Abategiovanni[1] , Antimo Amato De Serpi[1] , Dalila Cicatiello[1] , Chiara Marzano[1] *, Rosalba Pitruzzella[1] , Laura Pasquardini[2] , Olivier Soppera[3] , and Luigi Zeni[1]

[1] Department of Engineering, University of Campania Luigi Vanvitelli, Via Roma 29, 81031 Aversa, Italy

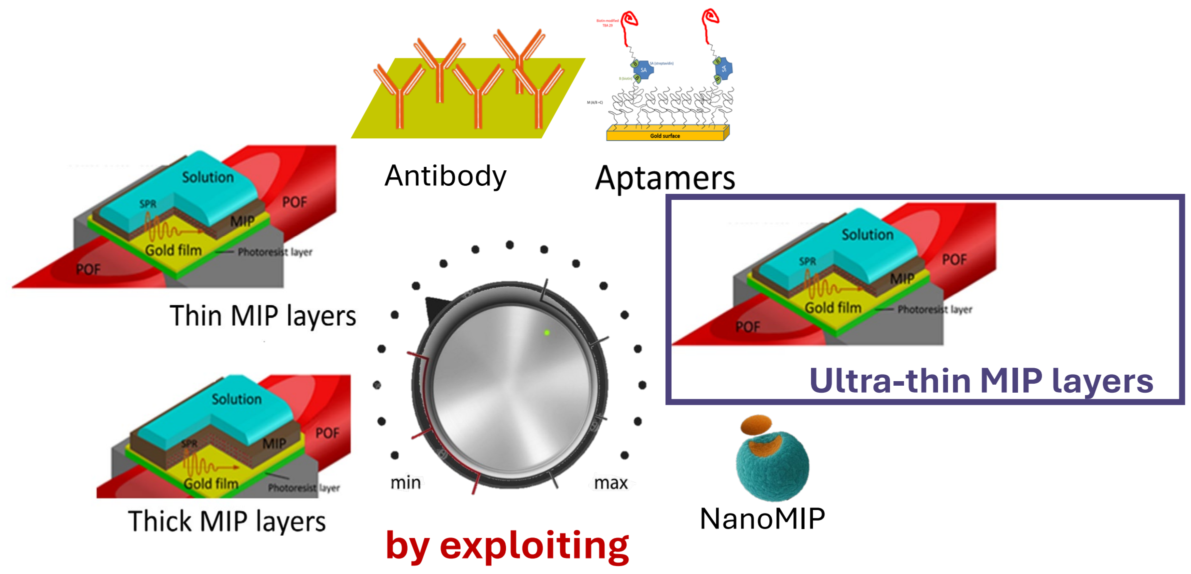
[2] Indivenire srl, Via Sommarive 18, Trento 38123, Italy

[3] Centre National de Recherche Scientifique, Institut de Science des Matériaux de Mulhouse, Université de Haute-Alsace, 68100 Mulhouse, France

nunzio.cennamo@unicampania.it; chiara.marzano@unicampania.it

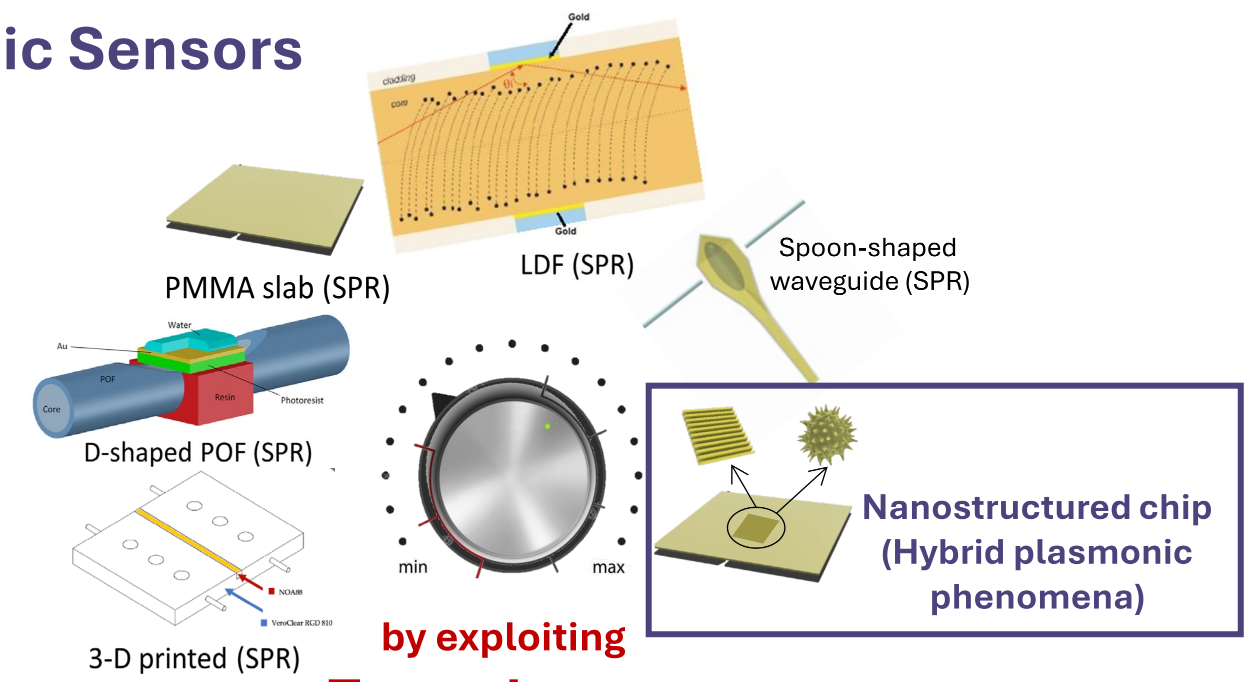
The ultra-high sensitivity of several bio/chemical plasmonic sensors can be exploited to detect substances of interest in attomolar concentration ranges in real-world scenarios. This goal can be achieved using simple and low-cost equipment in small-size experimental configurations, combined with disposable sensor chips based on ultra-highly sensitive plasmonic phenomena or ultra-efficient receptor layers. More specifically, extrinsic and intrinsic fiber optic sensing schemes can be realized by exploiting the characteristics of plastic optical fibers (POFs) combined with simple equipment that only requires a white light source and spectrometers to achieve point-of-care tests (POCTs).

Bio/Chemical Plasmonic Sensors



by exploiting

Receptors



by exploiting

Transducers

Atto-molar concentration level detection via efficient receptor layers

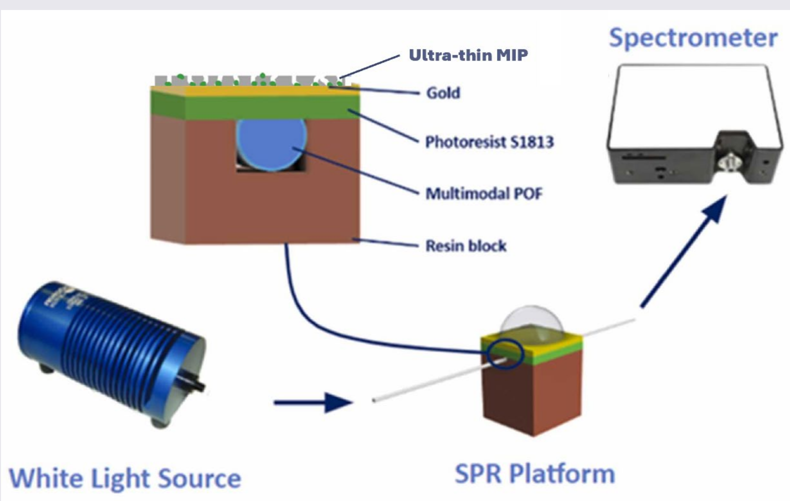


Figure 1. Outline of the experimental setup used to test the SPR-POF-based chip with ultra-thin MIP layer.

The SPR-based platform has been combined with an ultra-thin MIP for the detection of perfluorooctanoic acid (PFOA) at ultra-low concentrations. The experimental setup, shown in Fig. 1, consists of a white light source, a SPR-based platform, and a spectrometer connected to a laptop.

Binding assays aimed at detecting PFOA using molecularly imprinted polymers (MIPs) obtained by near-field photopolymerization [1]. The resulting SPR spectra, shown in Fig. 2A, showed a blue shift in the resonance wavelength with increasing PFOA concentration, ranging from 0.1 fM to 100 fM. The data fitted to Langmuir's model (Fig. 2B) confirmed that an SPR-POF-based chip combined with an ultra-thin MIP layer ensures a detection limit of 53 aM [1].

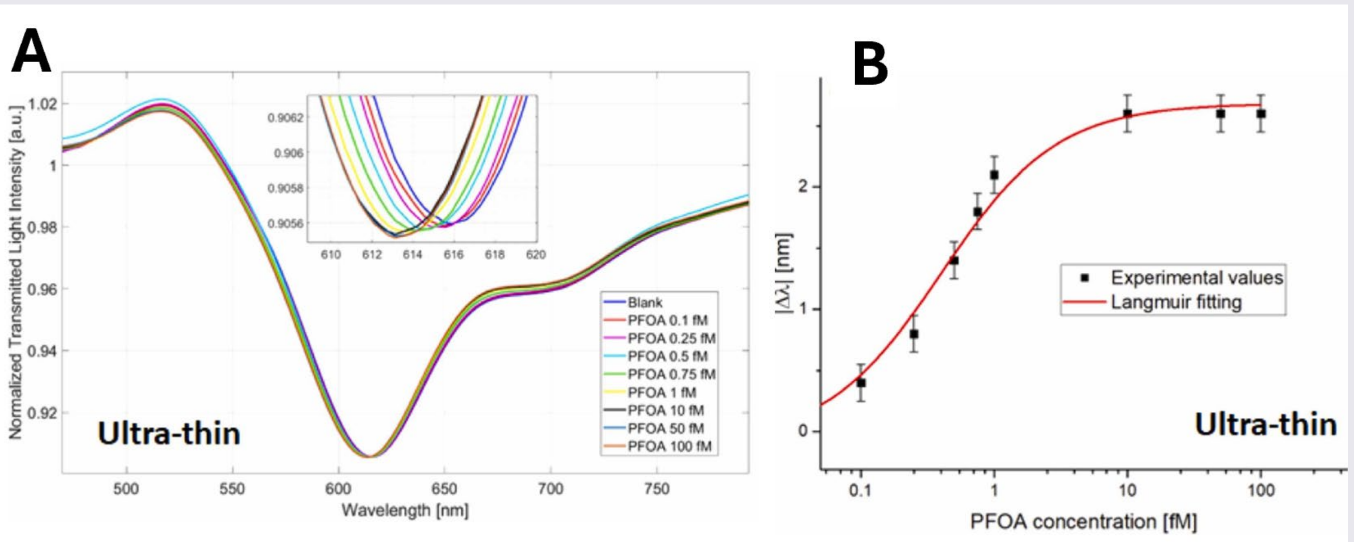


Figure 2. PFOA detection in buffer: **(A)** SPR spectra obtained via different PFOA concentrations; **(B)** dose-response curve. [1]

[1] Khitous, A., Arcadio, F., Zeni, L., Cennamo, N., & Soppera, O. (2025). In situ synthesis of molecularly imprinted polymers by near-field photopolymerization for ultrasensitive PFOA plasmonic plastic fiber optic sensors. Sensors and Actuators B: Chemical, 442, 137992.

Atto-molar concentration level detection via sensitive optical transducers

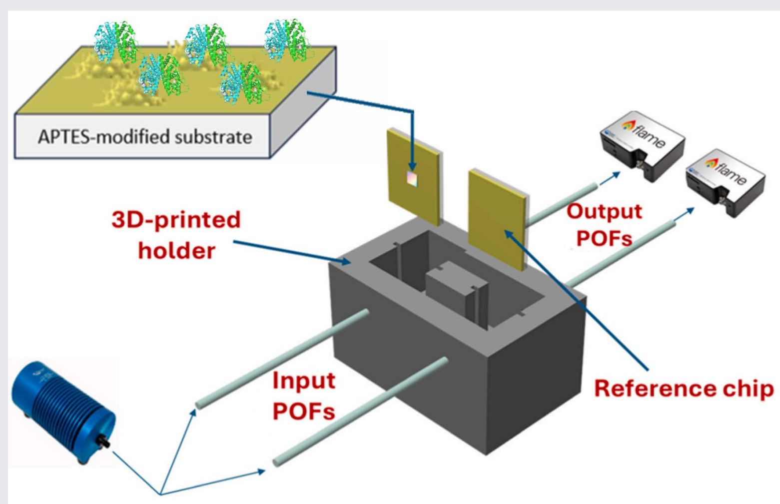


Figure 3. Outline of the experimental setup used to test pollen-based chips with an estrogen receptor.

The experimental setup, outlined in Fig. 3, consists of a white light source that, with a POF-based optical splitter, directs the light to two chips: a reference chip (without nanostructures) and a pollen-based chip functionalized for the estradiol detection. The transmitted light is collected and sent to two spectrometers, which are connected to a laptop.

The binding tests in [2] involved detecting estradiol using the estrogen receptor (ER) as a bioreceptor. The resulting plasmonic spectra, shown in Fig. 4A, showed a blue shift in the resonance wavelength with increasing estradiol concentration, ranging from 0.1 aM to 1000 aM. The data fitted to Langmuir's model (Fig. 4B) confirmed high sensitivity of pollen-based plasmonic biochips and a detection limit of 0.37 aM [2].

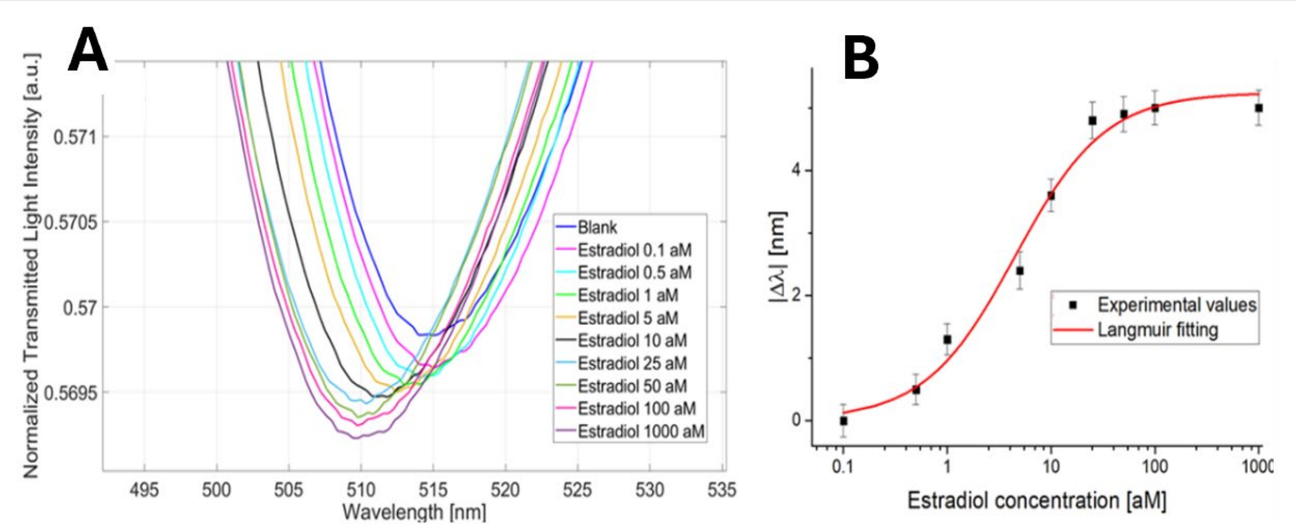


Figure 4. Estradiol detection in buffer: **(A)** plasmonic spectra obtained via different estradiol concentrations; **(B)** dose-response curve. [2]

[2] Cennamo, N., Pasquardini, L., Arcadio, F., & Zeni, L. (2025). Pollen-based natural nanostructures to realize nanoplasmonic biochips for single-molecule detection. Sensors and Actuators B: Chemical, 422, 136404.