Investigation of the thermally generated Au/Ag nanoislands for SERS and LSPR applications

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I. Introduction

Gold and silver nanoparticles are widely used as signal amplification elements in various electrochemical and optical sensor applications.

Metallic nanoparticles could be used for:

Localized surface plasmon resonance (LSPR) is a very sensitive optical phenomenon and can be utilized for a large variety of sensing purposes (chemical sensors, gas sensors, biosensors, etc.).

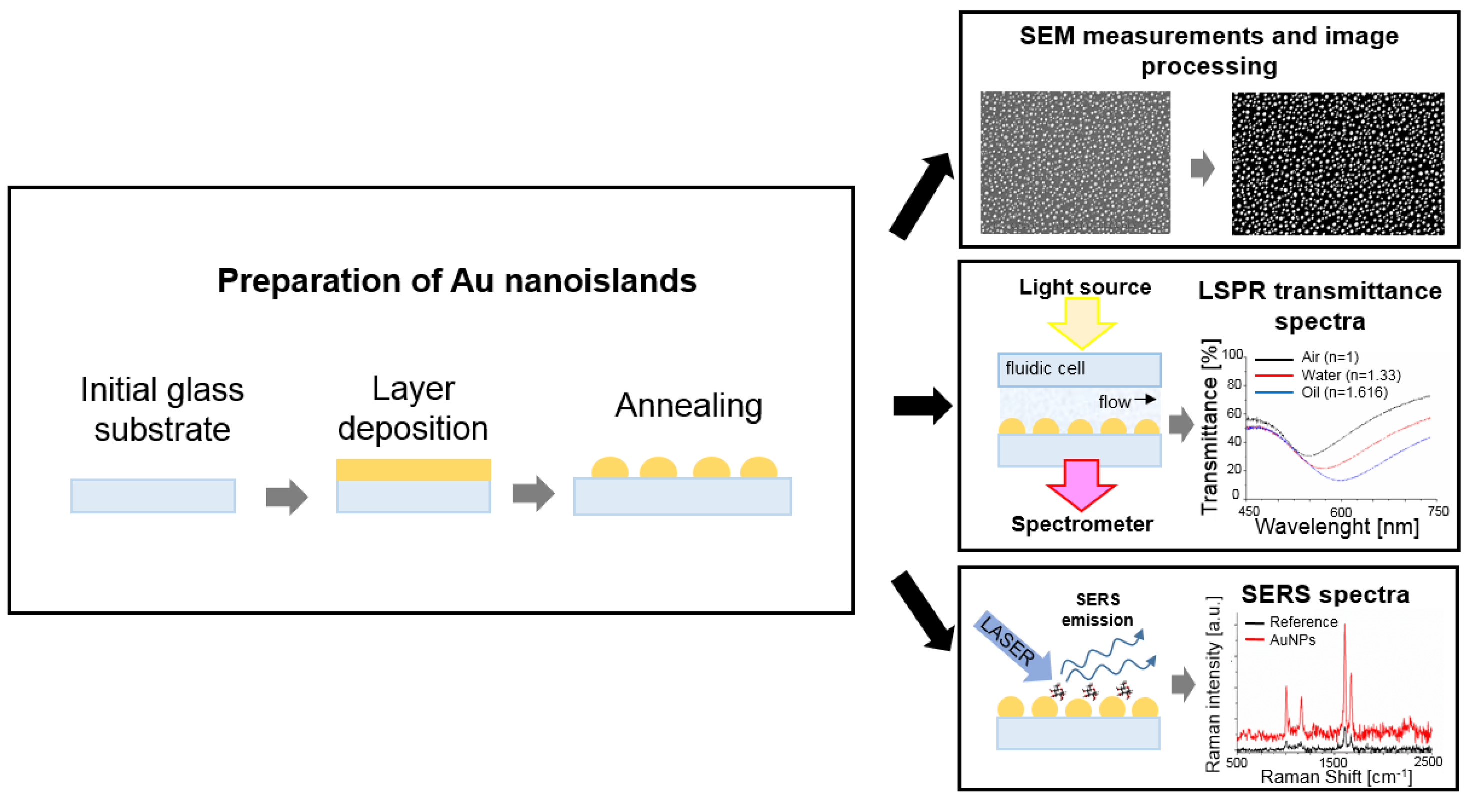
Surface enhanced Raman spectroscopy (SERS) is an analytical method which can significantly increase the yield of Raman scattering of target molecules adsorbed on the surface of metallic nanoparticles.

The sensitivity of the photonic elements strongly depends on the used material, on the size and distribution of the metallic nanoparticles.

Objectives of our work were the investigation and optimization of the technological parameters of thermally generated pure Au and Ag nanoislands in order to fabricate cheap but sensitive SERS and LSPR photonic elements.

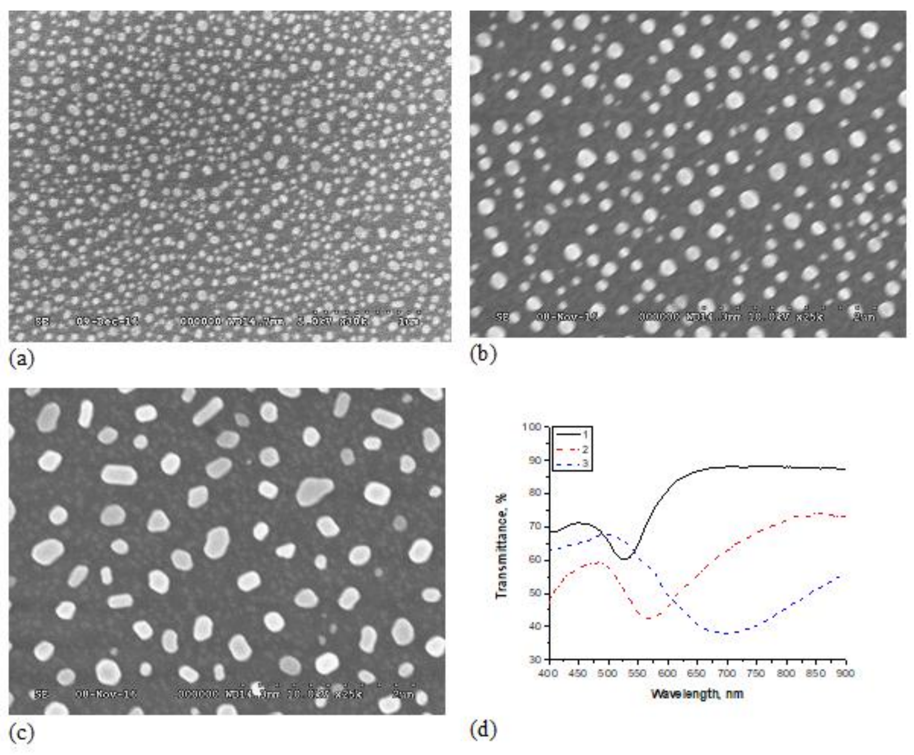
II. Preperation of metallic nanoparticles

For nanoparticle fabrication previously cleaned glass slides were coated with gold and silver thin films in various thickness with a vacuum thermal evaporation system.
The thin films were subsequently thermally annealed for given time periods in a ceramic oven.



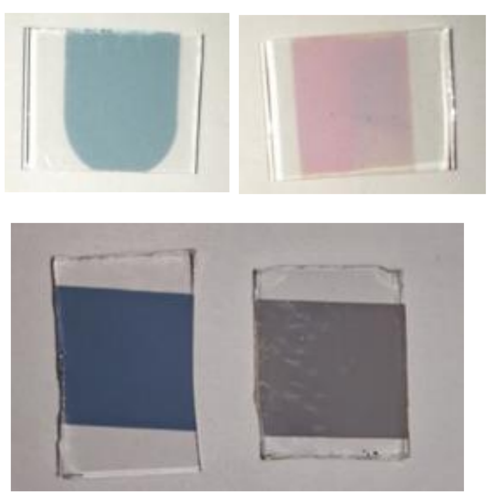
III. Investigation of the created nanoparticles

Technological parameters of created metallic nanoparticles (annealing temperature was 550 °C in all cases).



a), b), and c) original SEM image of the samples d) The corresponding optical transmittance spectra of the samples.

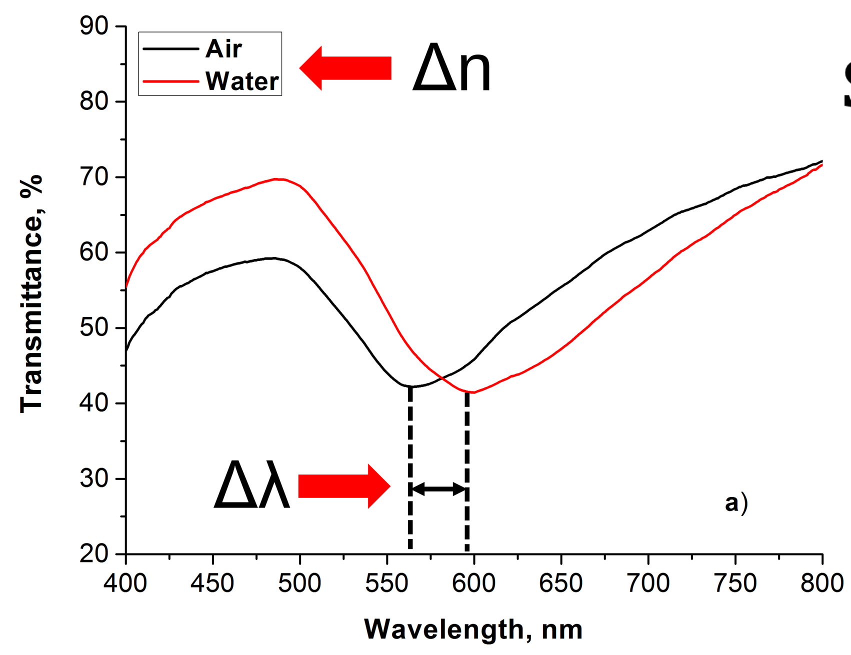
The images of the as-deposited and annealed gold and silver thin layers.



The created samples were investigated by SEM – the average size and distance were estimated and its deviation.

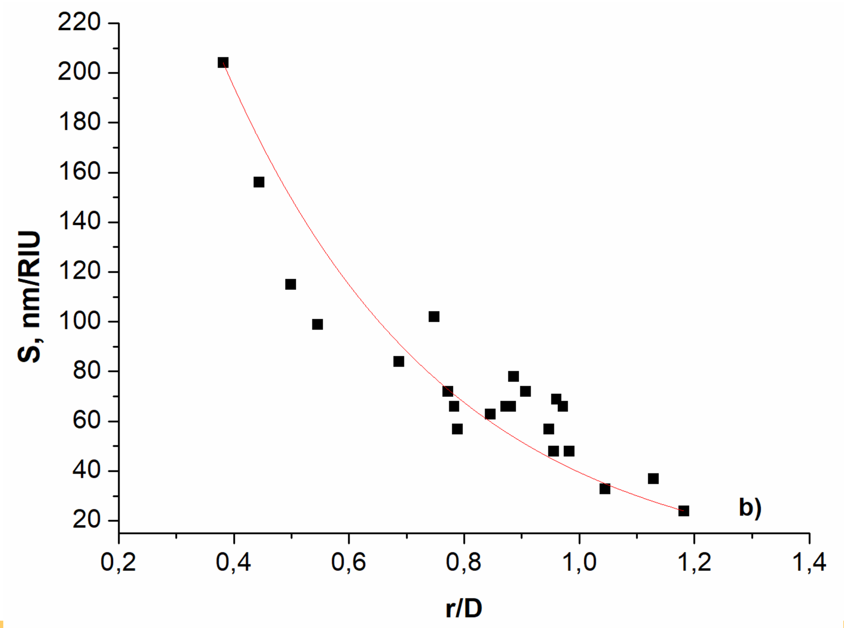
The optical parameters were measured by Ocean Optics USB 650 spectrophotometer.

IV. LSPR application



$$S = \frac{\lambda_2 - \lambda_1}{n_2 - n_1} = \frac{\Delta\lambda}{\Delta n} [nm/RIU]$$

LSPR transmittance shift of the AuNP sample measured in air (n=1) and water (n=1.33), respectively, $\Delta\lambda$=28nm, $\Delta\lambda/\Delta n$=84.08nm/RIU.

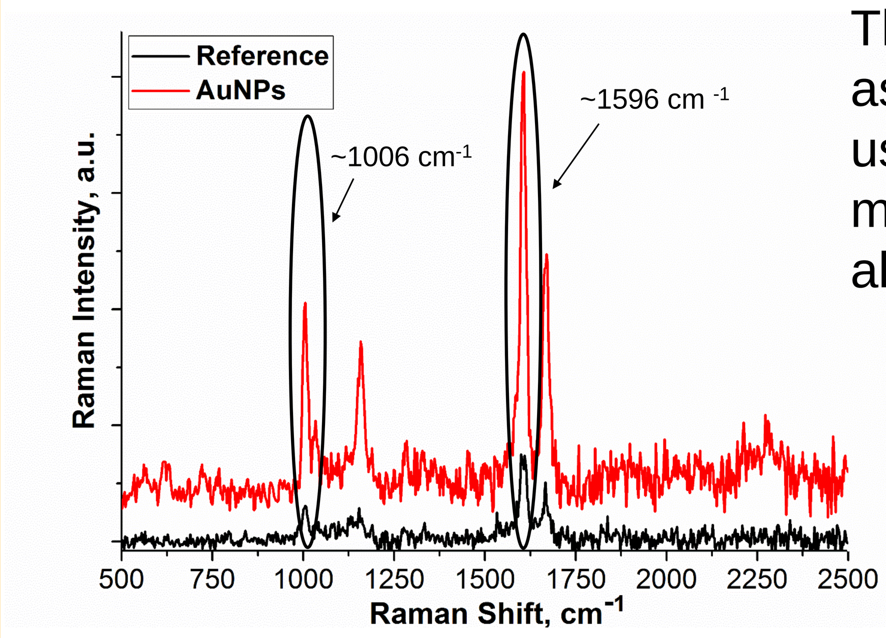


LSPR transmittance shift dependence on the ratio of average particle distance to average particle size (r/D) of the AuNPs

Decrease the distance/gap between two nanoparticles –

increase near field between them – increase the LSPR sensitivity

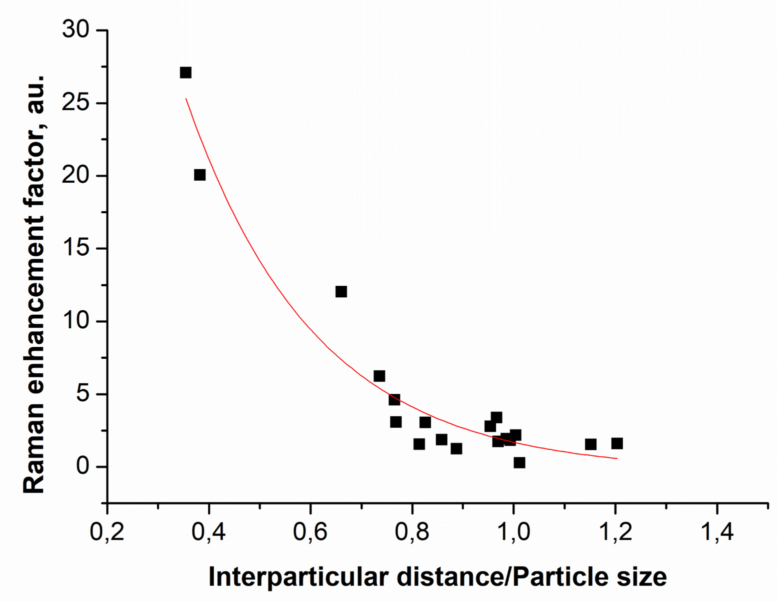
V. SERS application

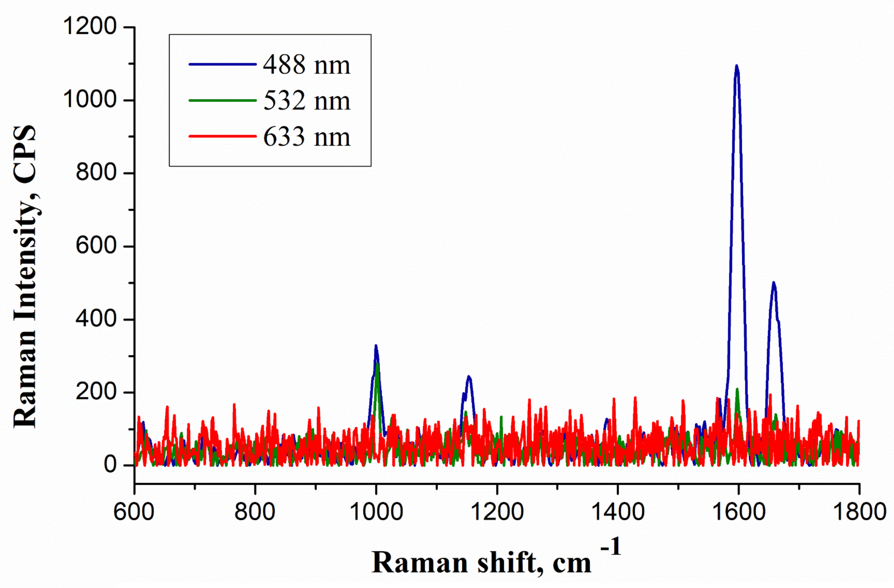


The SERS enhancement was calculated as an analytical enhancement factor using two peaks of the investigated material, benzophenone-izopropyl alcohol solution :

$$AEF = \frac{I_{SERS}/C_{SERS}}{I_{RS}/C_{RS}}$$

Larger and more densely packed gold and silver nanoparticles will result in better SERS performance. Also, the plasmon peak and the working wavelength of the Raman spectroscopy influence on the enhancement.





VI. Conclusions

The performance of thermally generated pure Au and Ag nanoislands for LSPR and SERS sensing applications was investigated.

The morphology of the generated nanoisland arrangements was investigated with SEM and was compared to their sensing properties.

Larger nanoparticles, which are closer to each other lead to higher LSPR bulk refractive index sensitivities which are strongly connected to the increased island sizes and smaller gap distances.
SERS measurements performed on the AuNPs and AgNPs gave similar results.

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