Seminar

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Institute for Plasma Research

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Title: Development of SERS substrate based on self-organized nanoparticles for molecular sensing applications

Speaker: Mr. Sebin Augustine

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Date: 13th December 2023 (Wednesday)

Time: 10:00 AM

Venue: Seminar Hall, IPR

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Abstract

Surface Enhanced Raman Spectroscopy (SERS) is a widely used sensing method in chemistry, forensics, food, agriculture, and the biological field for detecting trace quantity of molecules. Researchers all over the world are constantly working on improving the sensitivity and uniformity of this technique. Ion-induced ripple nanopatterns have shown great potential as SERS templates. The ion irradiation parameters offer the ability to adjust the ripple wavelength at nanoscale, which affects the growth of nanoparticles and help to produce compact nanoparticle arrays. Our work presents a two-stage process for growing nanoparticles on nano-rippled templates. Initially, low-energy ion beam irradiation is used to fabricate self-organized ripple patterns on Si and glass surfaces. In the next step, metal nanoparticles were grown at glancing angles using PVD, resulting in aligned nanoparticles arrays. The wavelength of the ripple patterns determines the shape and interparticle gap of the deposited nanoparticles. The Localized Surface Plasmon Resonance (LSPR) response of Ag grown on these nanoscale ripple patterns are studied to develop an optimized substrate for 532 nm laser excitation. To demonstrate the SERS properties of the produced substrate, we used $10^{6\text{-}10}$ M concentrated crystal violet dye molecules for detection. We have successfully detected the Dichlorvos pesticide at concentrations as low as 1 ppm, which is below its recommended level [1].

For making the substrate sensitive to border excitation region (532 nm and 785 nm) self-organized bimetal Au/Ag nanoparticles were produced. Systematic investigation was conducted to study the effect of Au nanocapping layers on the morphological and optical properties of Ag nanoparticles. The experimental results were compared with FDTD simulations, to explore interparticle gap and Au/Ag layer thicknesses effect on the LSPR position and SERS enhancement [2]. It was demonstrated that the addition of Au capping layer to Ag nanoparticles contributed to a redshift of the LSPR wavelength. SERS properties of the developed substrate were investigated and found that the growth of Au/Ag nanoparticles allowed for the detection of analyte molecules using both 532 nm and 785 nm laser excitation wavelength.

To make the SERS substrate more sensitive and economical, the possibility of making low amplitude ripples on the glass was investigated. It has been found that ripples having amplitude similar to Si with

higher wavelength can be produced using low energy ion beam irradiation [3]. The template is a low cost alternative to growing self-organized ordered nanoparticles. The SERS and LSPR properties of the Ordered Ag nanoparticles grown on the glass substrate were investigated and shows better SERS sensitivity. The substrate utilized for detecting food adulterant Metanil yellow from the turmeric solution. The produced SERS substrate is then utilized for classifying the cancerous patient saliva from saliva of tobacco habitué. PCA-LDA based multivariate analysis of saliva sample demonstrates the potential applicability of such substrate in the detection of cancer [4]. Overall, this study can be useful in the SERS-based detection of ultralow concentrations of analytes molecules.

Reference :

[1] Sebin Augustine, K.P. Sooraj, Vivek Pachchigar, C. Murali Krishna, Mukesh Ranjan *Applied Surface Science* 544 (**2021**) 148878.

[2] Sebin Augustine, Mahesh Saini, Sooraj K.P., Sukriti Hans, Vivek Pachchigar, Mukesh Ranjan *Optical Materials* 135 (**2023**) 113319.

[3] Sebin Augustine, Sooraj K.P., Mahesh Saini, Sukriti Hans, Vivek Pachchigar, Mukesh Ranjan, *Photonics and Nanostructures - Fundamentals and Applications* 56 (**2023**) 101166.

[4] Sebin Augustine, Arti Hole, Sooraj K P, Mahesh Saini, Mukesh Ranjan, C. Murali Krishna *Vibrational Spectroscopy* (**2023**, Under Review)