Seminar

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Institute for Plasma Research

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Title: Ti-TiO_2-Ag assembly grown on Si and Soda-lime glass for SERS applications

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Date: 01st August 2025 (Friday)

Time: 03:30 PM

Venue: Seminar Hall, IPR

Abstract

Molecular sensing utilizing Surface Enhanced Raman Spectroscopy (SERS) has demonstrated the capability to detect trace quantities of molecules[1]. The metal-metal oxide-metal (MOM) plasmonic assembly is gaining prominence due to its distinctive optical properties and applications across various fields, including dye degradation, water splitting, and SERS applications. The Ti-TiO_2-Ag nanoparticle system is particularly noteworthy due to its significant SERS enhancement[2]. Research has shown that arrays of Ag nanoparticles developed on ion beam-fabricated nano-ripple structures on silicon and soda-lime glass function as superior SERS substrates compared to those with randomly ordered nanoparticles[3–5]. Therefore, combing the MOM with ion beam produced nanostructure may improves the SERS efficiency further.

This study initially investigates the growth of Ag nanoparticles on faceted glass structures. Ag nanoparticles were deposited on the glass substrate employing both magnetron sputtering and electron beam evaporation techniques. SERS analysis indicated that the amplitude of the glass surface enhances growth of additional nanoparticles within a defined area, thereby enhancing SERS performance. This SERS substrate used for getting the Saliva Raman spectra, for improving the classification of SERS spectra of oral cancer patient and healthy volunteer (70% sensitivity and 67% specificity).

To optimize the Ti-TiO_2-Ag layered structure, Ti was deposited on glass and Si by magnetron sputtering, followed by the reactive sputtering of titanium in an oxygen environment to yield TiO_2. Spectroscopic ellipsometry was employed to assess the optical properties of the resulting structure. Subsequently, Ag deposition was carried out using both magnetron sputtering and electron beam evaporation methods. The spectroscopic ellipsometry analysis revealed the plasmonic characteristics of the produced substrate. Finite-Difference Time-Domain (FDTD) analysis was executed to evaluate the influence of TiO_2 thickness on the plasmonic properties of the Ti-TiO_2-Ag system which confirms the experimental results. SERS analysis conducted using Crystal Violet dye (CV) indicated that the Ti-TiO_2-Ag system achieves a tenfold enhancement compared to the Ag/Si or Ag/soda-lime glass systems.

To capitalize on the benefits of the Ti-TiO_2-Ag assembly and ion beam nanopatterning, titanium was grown on rippled silicon and faceted soda-lime glass substrates. The optical analysis revealed angle-dependent reflection and plasmonic properties. The optimized substrate demonstrated superior SERS efficiency compared to the Ti-TiO_2-Ag structures grown on flat silicon and glass, as well as Ag deposited on rippled silicon and glass substrates.

References:

1. Kneipp, J., Kneipp, H. & Kneipp, K. SERS—a single-molecule and nanoscale tool for bioanalytics. *Chem Soc Rev* **37**, 1052–1060 (2008).
2. Li, C. *et al.* Towards practical and sustainable SERS: a review of recent developments in the construction of multifunctional enhancing substrates. *J Mater Chem C Mater* **9**, 11517–11552 (2021).
3. Augustine, S. *et al.* SERS sensing of Metanil yellow in turmeric solution using self-organized nanoparticle arrays grown on Ion beam patterned soda-lime glass. *Photonics Nanostruct* **56**, 101166 (2023).
4. Augustine, S. *et al.* Au/Ag SERS active substrate for broader wavelength excitation. *Opt Mater (Amst)* **135**, 113319 (2023).
5. Augustine, S. *et al.* Ion beam-induced nanoripples patterns for SERS based saliva analysis to detect oral cavity cancer. *Radiation Effects and Defects in Solids* **179**, 1644–1655 (2024).