Seminar

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Institute for Plasma Research

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Title: Low-energy ion beam modification of tungsten oxide nanorods for SERS sensing application

Speaker: Dr. Shyamapada Patra
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Date: 19th December, 2025 (Friday)

Time: 11:00 AM

Venue: Seminar Hall, IPR

Abstract

The development of efficient and reliable substrates for surface-enhanced Raman scattering (SERS) is critical for ultrasensitive molecular detection. In this work, tungsten oxide (WO_3) nanorods were synthesized via a hydrothermal route and subsequently irradiated with low-energy argon ion beams in the range of 300–1000 eV to tailor their surface morphology and electronic structure. Ion beam irradiation induced nanoscale surface roughness, oxygen vacancies, and defect sites that significantly enhanced the surface reactivity and plasmonic interactions. Post-irradiation, silver (Ag) nanoparticles were deposited onto the surface-modified WO_3 nanorods through a physical vapor deposition process to create hybrid WO_3–Ag nanostructures. The synergistic effect of defect engineering and Ag nanoparticle decoration led to a substantial improvement in the SERS activity of the composite. Crystal Violet (CV), a standard Raman probe dye, was used to evaluate the SERS performance. Raman measurements of the CV dye revealed a distinct enhancement of characteristic vibrational modes, even at low concentrations (10^{-11} M), confirming the improved sensitivity of the irradiated substrates. Detailed spectral analysis confirmed that the observed enhancement originated from both electromagnetic enhancement due to Ag plasmonic hotspots and chemical enhancement via charge transfer between WO_3 and the analyte facilitated by defect states. This study reveals that low-energy ion irradiation is a powerful tool for tuning the physicochemical properties of metal oxide nanostructures to achieve high-performance SERS platforms. The strategy demonstrated here opens up new avenues for designing cost-effective, stable, and highly sensitive SERS substrates for detecting trace amounts of molecules in environmental and biomedical applications.

Reference

1. Nidhi Pathak, Ritu Kumari Pilani, Kandathil Parambil Sooraj, Mukesh Ranjan, Charu Lata Dube, Journal of Alloys and Compounds 2024, 1004, 175887.
2. Jian Huang, Dayan Ma, Feng Chen, Dongzhen Chen, Min Bai, Kewei Xu, and Yongxi Zhao, ACS Appl. Mater. Interfaces 2017, 9, 7436−7446.
