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Cold Plasma-Enhanced Nanostructures for Next-Generation Biomedical Plasmonic Sensors

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ABSTRACT

Introduction: Low-cost, portable surface-enhanced Raman scattering (SERS)-nanoplasmonic biosensors enable early, molecular-level diagnostics in precision medicine. Treatment with atmospheric-pressure plasma treatment enhances surface properties, allowing for highly sensitive, non-destructive Raman detection of biomolecules such as lysine at concentrations as low as 10^{-14} M. The effects of plasma exposure parameters on sensor performance were also evaluated.

Materials and Methods: Silver nanostructure-based SERS plasmonic biosensors were fabricated on plasma-treated silicon via electroless deposition. The sensors were further modified by atmospheric-pressure plasma treatment (power: 35 W, output gas rate: 6 Lit/min, treatment time: 8 min).

Results and Discussion: At low concentrations, the Raman signal of lysine is often obscured by fluorescence. However, applying 3 µL of 10^{-4} M lysine solution to the nanoplasmonic SERS sensor allows detection even at this concentration, enabling identification of lysine, which is a biomolecule implicated associated with metabolic disorders.

Conclusion: Optimized argon plasma treatment of silver nanostructures enhances sensor performance by increasing surface energy, introducing nanoscale defects and roughness, and promoting denser nanodendritic growth that generates more active hotspots. Additionally, increased hydrophilicity facilitates better adsorption of target molecule, thereby improving the efficiency of plasmonic biosensors.

Keywords: Ag nanostructures, Argon atmospheric plasma jet, SERS plasmonic biosensor

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