Study of Plasmonic Nano-array for the Development of Cost-effective SERS Substrate

Due to its excellent signal uniformity and reproducibility, well-ordered plasmonic nano-arrays demonstrate great potential as practical SERS probe for real-time in-situ analysis of molecules. A basic study of SERS mechanism was carried out to elucidate relevant factors that can affect SERS enhancement. The results revealed that the rarely discussed scattering cross-section can have substantial influence on SERS enhancement and should be considered for a complete understanding and optimization of the performance of SERS substrates. Two commonly used metallization techniques, DC sputtering and electron-beam (E-beam) evaporation, was investigated to quantify their effect on SERS performance. It was found that the E-beam evaporation technique produces inherently roughened gold film which serve as additional EM hotspots favourable for SERS. A hybrid metal deposition approach to exploit the advantages of both the sputtering and E-beam technique is proposed and verified. Two well-ordered and cost-effective SERS substrates were proposed and investigated. The first is a Au-SiO_2 nano-pillar substrate fabricated by performing an additional plasma enhanced chemical vapour deposition of SiO_2 on nano-sphere-lithorgraphy fabricated Si pillars to tune the plasmonic resonance of the nano-structures. The optimized Au-SiO_2 nano-pillar exhibits comparable SERS performance as the well-established gold-film-over-nano-sphere substrate and has the added advantage of better stability and reusability due to its inherently rigid structure. The second SERS substrate developed in this work comprises non-lithographic anodized aluminium oxide (AAO)-based nano-fibres (ANF) that are fabricated by optimizing the second anodization and incorporating an additional chemical wet-etching step. The optimized ANF substrate exhibits better sensitivity, signal-to-noise ratio, signal uniformity and stability than those of conventional substrates. The fabrication process of the ANF SERS substrate is also highly reproducible and scalable. Label-free detection of two DNA and RNA nucleobases are also demonstrated with the ANF SERS substrate.