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Electrohydrodynamic Patterning for Surface Enhanced Raman Scattering for Point-of-Care Diagnostics

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Abstract : Medical diagnostics, environmental monitoring, homeland security and forensics increasingly demand specific and field-deployable analytical technologies for quick point-of-care diagnostics. Although technological advancements have made optical methods well-suited for miniaturization, a highly-sensitive detection technique for minute sample volumes is required. Raman spectroscopy is a well-known analytical tool, but has very weak signals and hence is unsuitable for trace level analysis. Enhancement via localized optical fields (surface plasmons resonances) on nanoscale metallic materials generates huge signals in surface-enhanced Raman scattering (SERS), enabling single molecule detection. This enhancement can be tuned by manipulation of the surface roughness and architecture at the sub-micron level. Nevertheless, the development and application of SERS has been inhibited by the irreproducibility and complexity of fabrication routes. The ability to generate straightforward, cost-effective, multiplex-able and addressable SERS substrates with high enhancements is of profound interest for SERS-based sensing devices. While most SERS substrates are manufactured by conventional lithographic methods, the development of a cost-effective approach to create nanostructured surfaces is a much sought-after goal in the SERS community. Here, a method is established to create controlled, self-organized, hierarchical nanostructures using electrohydrodynamic (HEHD) instabilities. The created structures are readily fine-tuned, which is an important requirement for optimizing SERS to obtain the highest enhancements. HEHD pattern formation enables the fabrication of multiscale 3D structured arrays as SERS-active platforms. Importantly, each of the HEHD-patterned individual structural units yield a considerable SERS enhancement. This enables each single unit to function as an isolated sensor. Each of the formed structures can be effectively tuned and tailored to provide high SERS enhancement, while arising from different HEHD morphologies. The HEHD fabrication of sub-micrometer architectures is straightforward and robust, providing an elegant route for high-throughput biological and chemical sensing. The superior detection properties and the ability to fabricate SERS substrates on the miniaturized scale, will facilitate the development of advanced and novel opto-fluidic devices, such as portable detection systems, and will offer numerous applications in biomedical diagnostics, forensics, ecological warfare and homeland security.

Keywords : hierarchical electrohydrodynamic patterning, medical diagnostics, point-of care devices, SERS
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