Sample-uniform Reproducible Surface Enhanced Raman Spectroscopy

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We propose a method to produce a field strength enhancement factor of 10^{13} reliably for surface enhanced Raman spectroscopy (SERS) applications by combining the field enhancement effects of photonic crystal and coupled metallic nano-particles (MNP) in a self-assembled arrangement.

SERS is a powerful technique for chemical and biological sensing, but there is still a great need to improve sensitivity or reduce the laser power requirement. Standard SERS using single MNP produces a field enhancement factor of 10^6. Recently, it was discovered that, occasionally, an anomalous enhancement factor of 10^8 is possible. This is because when two MNPs are close together, the field from each MNP adds coherently producing an additional enhancement factor of 16 for a two-particle system. Reproducibility is also an issue in most reported SERS experiments because the MNPs are placed randomly, particle sizes are non-uniform, and packing density varies. Our approach guarantees the reproducibility by using state-of-the-art self-assembly techniques for arrays of mono-disperse MNPs packed in high density configuration (Sandia-AML).

In a close pack configuration, each particle has four nearest neighbors producing an enhancement factor of 256 higher than the single particle case. In addition, when this array is placed in a photonic crystal, it is possible to increase the field enhancement factor by another 10^3-10^4. This method also lends itself with ease to standard methods of functionalization of MNPs for chemical and biological sensing applications. This integrated approach to as SERS sensor package will achieve a total enhancement factor of 10^{11}-10^{12} which is 10^3-10^4 higher than the present state-of-the-art SERS, thereby reaching a significant milestone toward single molecule detection where 10^{14} is needed.