L.6: Large area, densely packed monolayer films of Au nanoparticles of different shapes

Noble metal (Au and Ag) nanoparticles exhibiting plasmon response have become the mainstay for surface-enhanced Raman scattering (SERS) applications. In the presence of these nanoparticles, manifold enhancement of Raman signal facilitates trace molecule detection of various analytes. Uniform and densely packed nanoparticle films are advantageous for producing large enhancements in SERS signal with better reproducibility, which is well reported in literature. Depending on the nature of the analyte, SERS experiments are performed at different excitation wavelengths, and accordingly the plasmon response of nanoparticles is tuned by varying their size and shapes. In this respect, colloidal synthesis methods are advantageous for producing size and shape tunable nanoparticles at a significantly low cost as compared to physical vapor deposition or lithography methods. However, drop-casting of colloids result in aggregated nanoparticles in the form of an annular ring, known as the coffee ring effect. Strong SERS signal occurs from these aggregated nanoparticles, but with poor spatial signal uniformity.

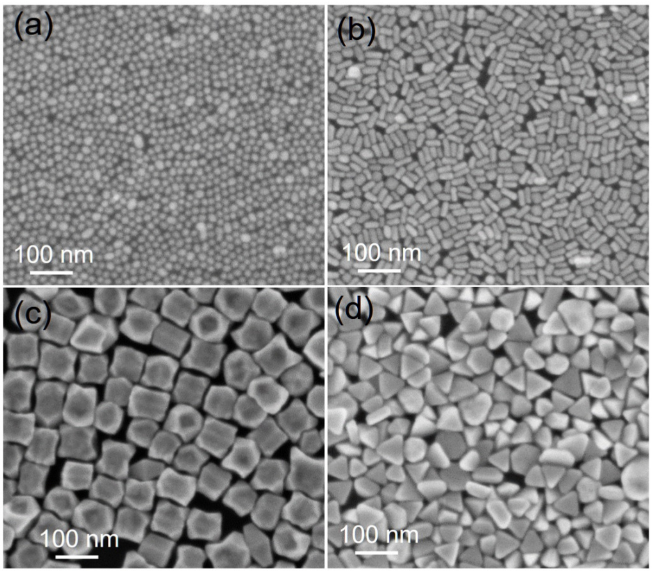

Fig. L.6.1: Magnified views of monolayer films of colloidal Au nanoparticles of various shapes: (a) spherical, (b) rod, (c) cubic, and (d) prism.

In this regard, synthesis of uniform, densely packed monolayer of metal nanoparticles of different shapes through colloidal route is an important step towards realization of in-expensive and highly reliable SERS substrates.

In order to fulfill this requirement large area, monolayer Au nanoparticle films of different shapes were synthesized through chemical methods (Figure L.6.1).

The shape and size control has been achieved by controlling process kinetics through optimization of various parameters. Shape control of nanoparticles allows tuning of localized surface plasmon resonance (LSPR) wavelength and bandwidth across significantly large wavelength regions. Other shapes like multi-cornered urchin and octahedron Au nanoparticles films are also shown in Figure L.6.2. In all the cases, by precise tuning of nanoparticle growth conditions along with film deposition conditions, few centimeter area films with significantly narrow size and shape dispersion were obtained. As a result, these films exhibited spatial uniformity of LSPR response, which was confirmed by optical characterizations, including UV-Visible spectroscopy and spectroscopic ellipsometry. Further, these monolayer films were deposited on various substrates like glass, metal foils, nanostructured silicon and flexible polymer supports.

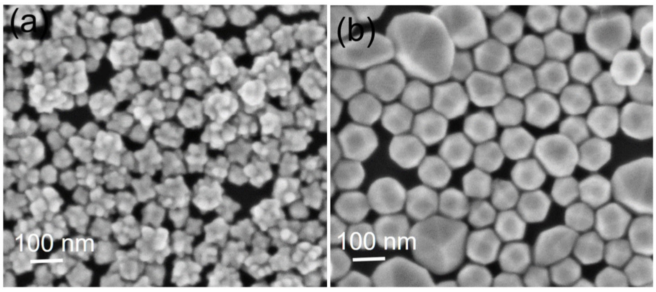

Fig. L.6.2: Magnified views of monolayer films of colloidal Au nanoparticles of (a) urchin, and (b) octahedral shapes.

Notable advantages of these films include significantly low production cost, efficient SERS substrates for multiple excitation wavelengths and uniformly distributed hot-spots (localized regions of the high electric field in between the nanoparticles), which is an essential requirement for SERS based quantification studies. The colloidal synthesis process is easily adaptable for large scale production for commercial use. These nanoparticle films can be produced from liquid solution as per the requirement, thereby overcoming shelf-life limitation of SERS substrates. These low cost SERS substrates are promising substitute for imported ones towards trace detection of pesticides, food colorants for food safety, narcotics, explosives etc. Apart from SERS application, these films are also attractive candidates for other applications including catalysis, optical filters, coatings for broadband solar light absorption etc.

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