Functional plasmonic nanostructures obtained from helium droplet synthesis

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Nano-sized metal structures composed of bimetallic nanoparticles are attracting increasing interest due their tailorable properties, thereby opening new prospects for plasmonics and catalysis. We introduce the helium nanodroplet synthesis approach as a novel and versatile method for the production of functional nanostructures, assembled by the deposition of nanoparticles formed in the inert low-temperature helium environment.

For Ag@Au core@shell nanoparticles [1] deposited on fused silica substrates we present an investigation of the dependence of the localized surface plasmon resonance (LSPR) on the relative Ag:Au ratio using UV-vis absorption spectroscopy. The obtained spectra reveal a shift of the plasmon resonance from blue to red with increasing Au doping level, which can be conveniently controlled. [2]

Furthermore, we show that the nanostructures formed by the deposition of Ag@Au particles can be employed for surface enhanced Raman spectroscopy (SERS). Raman spectra for Ag@Au nanoparticles functionalized with 4-Methylbenzenethiol have been recorded, the enhancement for three different Raman laser wavelengths agrees well with the observed position of the LSPR peak and decreases with increasing Au content. Intriguingly, the structure of the Raman mode at 1595 cm^{-1} encodes information on the binding of the molecule to the nanoparticle surface, revealing that even at the lowest employed Au doping level the particle surface is covered by a thin layer of Au.

The strength of the method lies in the unprecedented variety of constituents that can be combined with each other inside the helium droplets as well as their subsequent deposition under soft-landing conditions on any desired substrate. [1,2,3] Hence, our current efforts are geared towards the use of the developed helium droplet approach for the formation and deposition of novel nanoparticles in the sub-10 nm size regime. Recent examples encompass the production of Ni@Au and Co@Au particles [3] as well as Ag@ZnO nanoparticles and their subsequent deposition on fused silica and hexagonal boron nitride substrates.

References:
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