Plasmonic Nanoislands on Glass: Formation and Properties

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 Optical properties of metal nanoparticles arise from their localized surface-plasmon resonances (LSPRs). These resonances give rise to strongly enhanced local fields near the metal-dielectric interfaces, which are advantageous for, e.g., catalytic activity, optical absorption and emission, as well as for Raman scattering and other nonlinear optical phenomena. We performed the studies of silver and gold nanoisland films (NFs) and isolated nanoislands (INs), including the structures covered with dielectric layers of different thickness.

The silver NFs and INs were formed on the surface of glass substrates subjected to silver-sodium ion exchange via out-diffusion of silver atoms reduced in hydrogen processing of the samples. In the case of the INs, thermal poling of the ion-exchanged glasses with structured anodic electrodes before silver reduction allowed the growth of one, two or several INs in the prescribed positions. Depending on the processing mode, nanoislands from 10-15 nm up to 200 nm in diameter were grown. The theory of the nanoislands growth was constructed. The gold NFs were formed from gold films deposited on the surface of glasses in the course of their self-arrangement under a thermal treatment. Atomic layer deposition (ALD) technique was used to cover the NFs and INs with dielectric TiO2 layers. Linear optical properties of the metal core - dielectric shell nanoislands and virgin metal nanoislands were analytically and numerically modeled.

After the characterization of the size, morphology and LSPRs, the NFs and INs were tried in microRaman and the second harmonic generation (SHG) studies. The NFs and INs showed their applicability in Surface Enhanced Raman Scattering (SERS), with the efficiency comparable with one of commercial SERS substrates. Additionally, the NFs demonstrated a high temporal stability, and the INs allowed for high locality of SERS measurements. In nonlinear optical experiments, it was found that the TiO2 cover provided ~50 times increase in the SHG efficiency [1]. A theory explaining this phenomenon was developed.

References

1. S. Chervinskii, K. Koskinen, S. Scherbak, et al, Phys. Rev. Lett. 120, 113902 (2018)