Electrically-Driven Plasmon Resonances in Nanostructures: A new Tool for Biosensing

André Dathe, Uwe Hübner, Mario Ziegler, Ondrej Stranik and Wolfgang Fritzsche

Leibniz Institute of Photonic Technology (IPHT), Albert-Einstein-Str. 9, 07745 Jena, Germany

In our study, we investigated the properties of a hybridized mode of surface plasmon resonance (SPR) and its use as a sensor. This mode, i.e. gap mode (GM)[1], occurs by the placement of metallic nanoparticles onto metallic layers. The spectral characteristics of these GM are highly sensitive on the nanoparticle-substrate separation, which makes it an attractive sensing mechanism. We experimentally observed the creation of the GM for nanoparticle-substrate separation smaller than 10 nm and measured the effectivity of the excitation depending on the illumination conditions.

As a contrary to the commonly used far-field light excitation of the SPR modes, an innovative way of electrically driven excitation [2] of the GM was applied. Due to the planar geometry of the metallic layer, it was possible to extend this single metallic layer structure into metal-insulator- semiconductor (MIS) structure. The tunneling current passing through such MIS structure is accompanied by quantum shot noise that generates SPR modes, which can be then scattered by the GM. This concept was experimentally confirmed. The MIS structures with tunneling junctions were lithographically produced prior to electrical and optical characterization. We showed that the spectral emission is changed when the MIS structure also supports the GM. This was achieved by placing noble-metal nanoparticles onto the upper metallic layer.

To evaluate the spectral dependency for bioanalytical sensing, experiments involving gold nanoparticles coated with *Bovine Serum Albumin* and *monoclonal IgG*$_{2a}$ were performed.

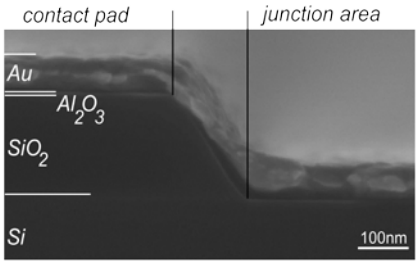

Fig.1: *Fabricated MIS stacks with SiO_2 leakage protection and Al_2O_3 tunneling oxide*

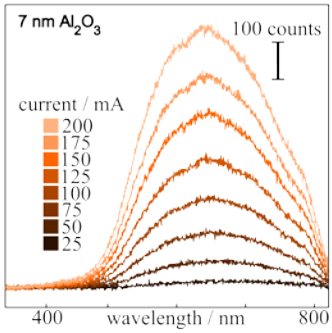

Fig.2: *Emission spectra of MIS structures for several flowing tunneling currents*

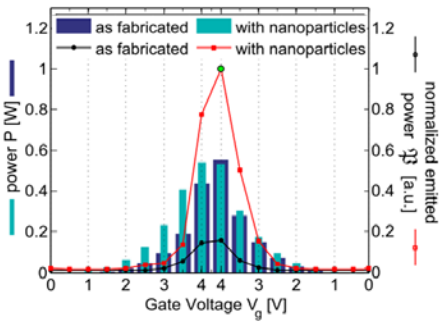

Fig.3: *Emission enhancement by deposition of nanoparticles while maintaining constant power consumption*

[1] Mock, J., Hill, R., Degiron, A., Zauscher, S., Chilkoti, A. and Smith, D. (2008). Nano letters, 8(8):2245–2252.
[2] Lambe, J. and McCarthy, S. L. (1976). Phys. Rev. Lett., 37(14):923–925.