OPTICAL FIELD ENHANCEMENT AT COATED METAL SPHEROIDS

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Abstract: Subject of this contribution is the theoretical investigation of the optical properties, especially the field enhancement characteristics, of coated metallic nano-sized ellipsoids using the Multiple Multipole Program (MMP).

Collective electron oscillations at metal surfaces as well as in small particles play an important role in 'near-field optics' [1]. The resonant excitation of these so-called Surface Plasmons (SP) results in localised and confined electromagnetic fields at pointed metallic structures. Detecting the near field in Scanning Near-field Optical Microscopy (SNOM) makes it possible to obtain information about optical features much smaller than the wavelength of the light.

Raman spectroscopy with a minimum amount of a sample concentration can be performed by using the strongly enhanced near field at nano-particles to get a reasonable scattering signal, which is well known for Surface Enhanced Raman Spectroscopy (SERS). Furthermore, a metal tip that acts as such a nano-particle can be scanned in close proximity to a sample to measure topography and spectral data simultaneously with nanometre resolution [2,3,4]. The development towards single molecule spectroscopy combined with high spatial resolution imaging of the involved structures and reaction sites demands a good understanding of the associated processes and physical mechanisms.

In this presentation, a numerical method is used to investigate the localised and enhanced near fields at metal spheroids theoretically [5]. Idealising a scattering probe as a spheroid allows to obtain fundamental knowledge about the near field but requires only reasonable effort in terms of modelling and computational time. The semianalytical multiple multipole technique is chosen here to solve the Maxwell equations according to the specified boundary conditions[6,7].

Centre of interest is the near-field behaviour of silver coated ellipsoids illuminated by light and the differences compared to the pure metal particle of the same shape and size. The field enhancement at the very end of the spheroid is determined and plotted over the wavelength of the excitation light. The core ellipsoid is changed in size and shape whereas the outline of the entire particle is maintained.

Furthermore, the influence on the frequency of the plasmon resonance is studied if the silver layer is deposited on different core materials like glass, silicon nitride and silicon. This is related to real Tip Enhanced Raman Scattering (TERS) experiments where silver coated probes made of those materials can be used.

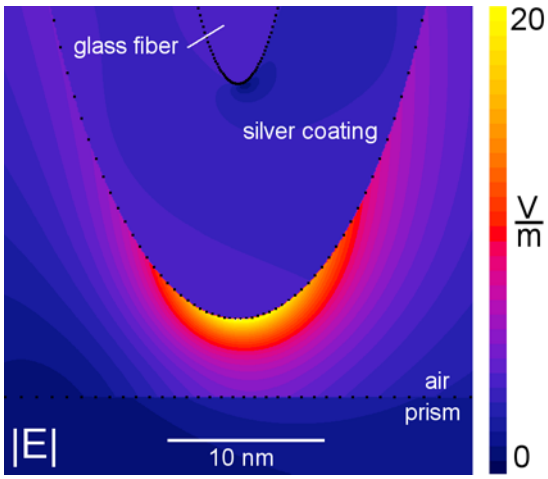

Fig.1: Plot of the electric field around a silver coated glass fibre positioned in the evanescent field over a prism surface. The strong, highly confined field at the particles end reduces the interaction volume.

Direct excitation of the ellipsoid by plane waves polarised along the major axis of the particle is compared with a set-up where the particle is positioned a few nanometres above a glass prism and experiences the evanescent field generated by total internal reflection at the prism-surface (Figure 1).

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