Theoretical investigation of field enhancement at plasmonic near-field probes

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For a detailed understanding of near-field optical probes theoretical investigations of the electro-magnetic phenomena in the nanometer regime are required. We use Finite Element Method (FEM - Comsol Multiphysics) to model structured tips. This results in the lateral field distribution at the foremost site of the particle. The particle's shape can be modified and thus we obtain results for different potential near-field tip geometries. Our probes are made of silver islands evaporated on commercial Atomic Force Microscopy (AFM) probes (Fig. 1) which are used for Tip-enhanced Raman spectroscopy (TERS) [1]. Recent TERS results point to a lateral resolution below 1 nm on samples like proteins or DNA. Similar results were shown by Zhang et al. under low temperature and high vacuum conditions [2]. As such results can hardly be explained by the classical electromagnetic theory using the typical "tip or particle diameters" it is necessary to relate theory with current experimental results.
In a first study we simulate the particle formation in the apex region. Furthermore we investigate how the geometry affects the field enhancement (Fig. 2).

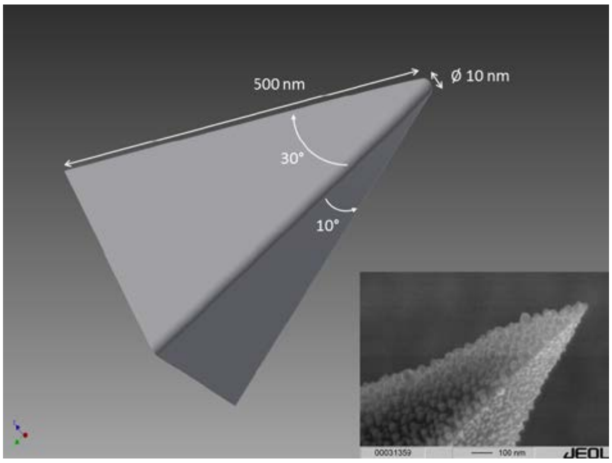

Fig. 1: *AFM tip without nanoparticles as modeled (big image) and a Scanning Electron Microscopy image of a TERS probe (small image)*

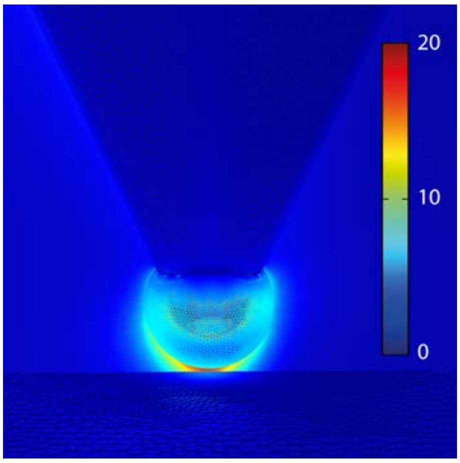

Fig. 2: *Field enhancement at the AFM tip (Fig.1) with a spherical 20nm silver nanoparticle at the apex caused by an incident evanescent field (532 nm).*

[1] R. M. Stöckle, Y. D. Suh, V. Deckert, and R. Zenobi, "Nanoscale chemical analysis by tip-enhanced Raman spectroscopy," Chem. Phys. Lett., vol. 318, no. 1–3, pp. 131–136, 2000.
[2] R. Zhang, Y. Zhang, Z. C. Dong, S. Jiang, C. Zhang, L. G. Chen, L. Zhang, Y. Liao, J. Aizpurua, Y. Luo, J. L. Yang, and J. G. Hou, "Chemical mapping of a single molecule by plasmon-enhanced Raman scattering," Nature, vol. 498, no. 7452, pp. 82–86, 2013.