From plasmonic film to edge modes

Franz-Philipp Schmidt[1,2], Harald Ditlbacher[1], Ulrich Hohenester[1], Andreas Hohenau[1], Ferdinand Hofer[2] and Joachim R. Krenn[1]

1. Department of Physics - University of Graz
2. Institute for Electron Microscopy and Nanoanalysis (FELMI) - Graz University of Technology

Surface plasmons are density waves of collectively oscillating electrons, which are propagating at a metal-dielectric interface. They are generated at optical frequencies and show confinement into areas much smaller than the wavelength of light, which causes a strong increase of the electric field intensities. This enhancement is especially pronounced in case of nanometer sized metal particles. Various applications, ranging from novel light sources, photovoltaics to sensor devices take advantage of the extraordinary optical properties of such metallic nanoparticles.

We studied different nanostructures from disks and triangles to rectangles using the STEM-EELS method in a monochromated scanning transmission electron microscope (Tecnai F 20) [1], [2]. The electron energy-loss was measured in order to get spatially resolved spectral information from the near-infrared, the visible and the UV range. These nanoparticles of different shapes were designed using electron beam lithography, a technique suitable of creating thousands of nanostructures in just a few minutes.

In this study we show that the multitude of observed localized modes can be reduced to two main excitations, so called film and edge plasmons, which follow different dispersion relations.

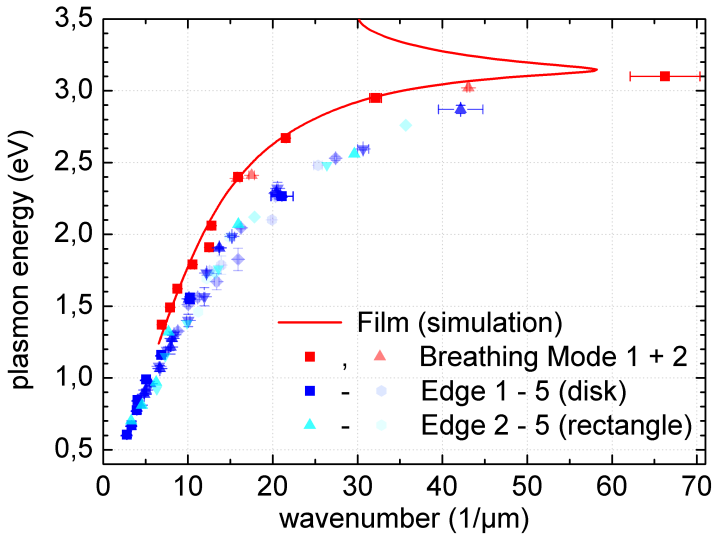

Figure 1. *Dispersion relation of surface plasmons: Breathing modes (red symbols), which are propagating across the particle, follow the dispersion of a surface plasmon on an extended film (red line), while localized surface plasmons along the particle's edge lie on a dispersion relation shifted to lower energies (blue symbols), but behave similar for different geometries.*

References

[1] J. Nelayah *et al*, Nature Physics **3**(2007), 348.
[2] F.P. Schmidt *et al*, Nano Letters **11** (2012), 5780.
[3] The authors gratefully acknowledge funding from the Austrian Science Fund under grant number P21800-N20 and the Graz Centre for Electron Microscopy.