Direct Observation of Plasmon Band Formation and Delocalization in Quasi-Infinite Nanoparticle Chains

Johannes Schultz[1], Martin Mayer[2,3], Pavel L. Potapov[1,6], Darius Pohl[1,3,4], Anja Maria Steiner[2,3], Bernd Rellinghaus[1,3,4], Axel Lubk[1], Tobias A.F. König[2,3], and Andreas Fery[2,3,5]

[1] *Leibniz-Institut für Festkörper- und Werkstoffforschung, Dresden, Germany*
[2] *Leibniz-Institut für Polymerforschung Dresden e.V., Dresden, Germany*
[3] *Cluster of Excellence Center for Advancing Electronics Dresden (cfaed), TU Dresden, Dresden, Germany*
[4] *Dresden Center for Nanoanalysis, TU Dresden, Dresden, Germany*
[5] *Department of Physical Chemistry of Polymeric Materials, TU Dresden, Dresden, Germany*
[6] *Department of Physics, TU, Dresden, Dresden, Germany*

Chains of metallic nanoparticles (NP) sustain strongly confined surface plasmons with relatively low dielectric losses. To exploit these properties in applications, such as waveguides, the fabrication of long highly-ordered chains and a thorough understanding of their plasmon mode properties such as dispersion relations, are indispensable.

We use a wrinkled template for directed self-assembly of gold NP chains. With this up-scalable method, chain lengths from two (140 nm) to 20 particles (1,500 nm), and beyond, can be fabricated.

Spatially resolved Electron Energy-loss Spectroscopy (EELS) in the Transmission Electron Microscope [1] reveals the evolution of plasmonic waveguide modes from degenerated single particle modes towards the formation of a band (Fig. 1). In striking difference to plasmonic rod like structures, the plasmon band is confined in excitation energy, which allows light manipulations below the diffraction limit. The non-degenerated surface plasmon modes show suppressed radiative losses for efficient energy propagation over a distance of 1,500 nm.

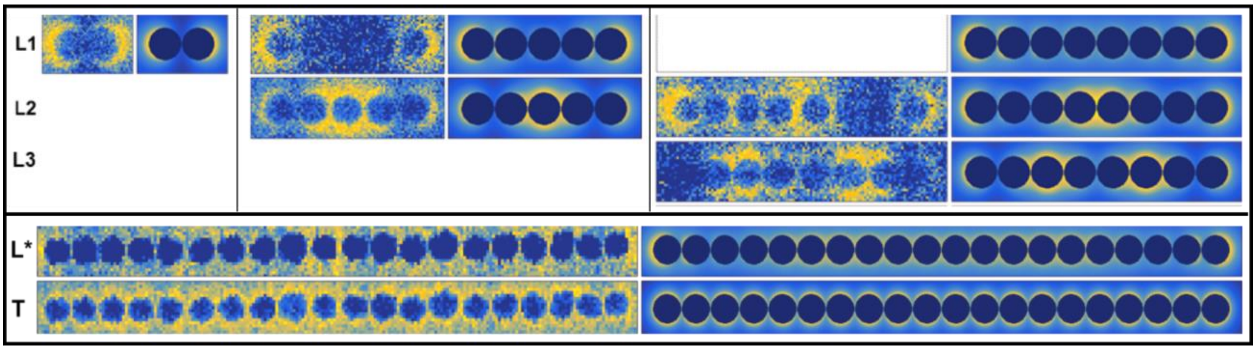

Figure 1. Surface Plasmon hybridization and band formation for assemblies of 2 (top left), 5 (top middle), 8 (top right) and 20 (bottom) NPs, comparison of experimental results (left) and simulation (right): Individual NP (diameter: 70 nm) modes hybridize and split up in energy due to interparticle interaction. Accordingly longitudinal modes (Ln) with different node numbers form as demonstrated by EELS maps and simulations.

[1] J. Nelayah et al., *Nature Physics* **3**, 348-353 (2007).

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