Capacitive and Threaded Chain Plasmons in metallic nanoparticle strings

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Nanophotonics is one of the most rapidly growing fields in Condensed Matter Physics nowadays. Recent advances in nanofabrication techniques have led to a large diversity of plasmonic nanostructures, which offer unique control of light-matter interactions. Here, we demonstrate an efficient way to exploit light for threading plasmonic nanoparticle strings, that is, creating chains of gold nanospheres conductively connected via gold threads with well-controlled dimensions. Gold nanosphere clusters are first self-assembled with use of appropriate rigid organic molecular linkers, namely cucurbiturils, which fix the interparticle gaps at precisely 0.9 nm. In such self-assemblies the excitation of collective plasmonic modes (called Capacitive Chain Plasmons, CCP) along linear and quasi-linear nanoparticle chains within the clusters leads to long-wavelength extinction resonances, accompanied by huge near-field enhancement at the interparticle gaps. This near-field enhancement is then exploited for threading, which is achieved by illuminating with ultrafast lasers whose wavelength coincides with that of the CCP mode, thus enabling non-thermal melting of gold at the gaps. This formation of plasmonic threads allows charge transfer within the entire nanoparticle strings, leading to the appearance of new, hybrid chain/rod modes in the infrared, Threaded Chain Plasmons (TCP). Nanoparticle size, chain length, and laser power offer unique control of the thread widths, which can be identified with a precision significantly exceeding that of electron microscopy by comparing experimental and simulated extinction spectra.

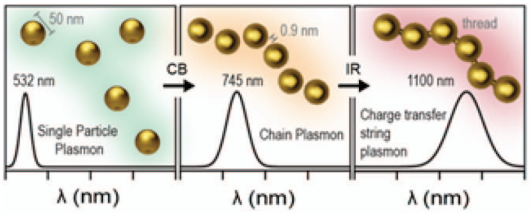

Figure 1: Schematic representation of the nanoparticle chain and string assembly, and the corresponding excitation of chain plasmons (CCP modes) and charge transfer plasmons (TCP modes), respectively

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