Using ultrashort laser pulses to weld, melt, and reshape plasmonic nanoparticles

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The optical response of plasmonic nanoparticles can be engineered for an incredibly large number of useful applications, but it requires a complex balance between the competing requirements of the application, optics, and fabrication. Hence, new strategies are sorely needed to attain a better control over the nanoparticles' optical response. Femtosecond laser irradiation allows an extreme control over the modification of plasmonic nanoparticles, producing structures with an improved optical response. In this talk, I will expose some of our recent works, related to the use of ultrashort laser pulses to modify plasmonic nanoparticles.

For example, irradiation of nanorod colloids with fs laser pulses can produce a controlled reshaping, yielding colloids with unprecedentedly narrow plasmon bands [1]. The process is characterized by a gentle multi-shot reduction of the aspect ratio, whereas the rod shape and volume are barely affected. This perfection process provides a simple, fast, reproducible, and scalable route toward nanorods with an optical response of exceptional quality, near the theoretical limit. Moreover, irradiation of rod-sphere assemblies produces structures hard to obtain by other methods [2]. Judicious selection of the wavelength and fluence of the laser pulses allows a fine control over the changes produced: the particles can be melted, welded and/or the organic links cleaved. In this way, it is possible to generate structures "à la carte" with a degree of control unmatched by other synthetic protocols.

Finally, we have synthesized bimetallic and alloyed nanocrystals through the irradiation of colloidal Au@Ag core-shell nanorods [3]. Different morphologies and degrees of alloying are obtained, depending on the energy deposited on the rods (Figure 1). The ample array of bimetallic species obtained highlights the potential of combining synthetic colloidal methods with laser irradiation for the fabrication of unique nanoparticles. The resulting control over size and composition raises promising prospects for its applications.

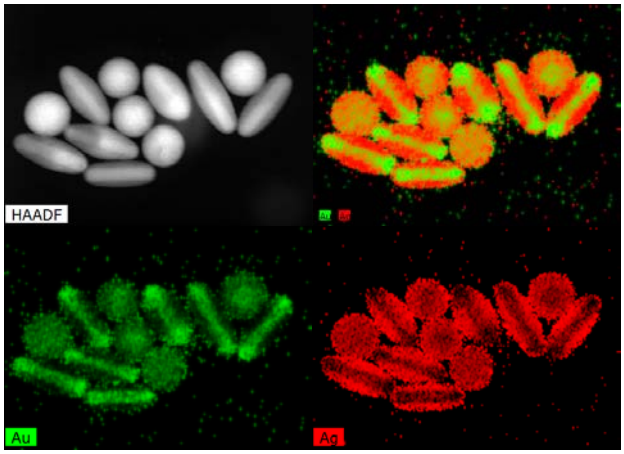

Figure 1: *Morphology of Au@Ag rods after irradiation with fs laser pulses, and characterization of the distribution of Au and Ag.*

Index Terms: plasmonic nanoparticles, fs laser pulses, nanoparticle modification.

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[2] P. Díaz-Núñez *et al.*, "Rod-sphere cluster irradiation with femtosecond laser pulses: Cut and paste at the nanoscale," *Nanophotonics*, vol. 10, no. 12, pp. 3153–3159, Sep. 2021, doi: 10.1515/nanoph-2021-0240.
[3] G. González-Rubio *et al.*, "Controlled alloying of Au@Ag core-shell nanorods induced by femtosecond laser irradiation," *Adv. Opt. Mater.*, vol. 9, no. 10, p. 2002134, May 2021, doi: 10.1002/adom.202002134.