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Photoswitching of spin-crossover nanoparticles in an ultrafast electron microscope

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Ultrafast transmission electron microscopy (UTEM) allows time-resolved studies of materials by combining sub-nanometer spatial resolution with femto- to nanosecond temporal resolution. This pump-probe technique, where a laser pulse is used as the pump and an electron pulse as the probe, allows us to gain detailed information about photon-driven structural transformations at the nanoscale in a TEM. Reversible [1] as well as irreversible [2, 3] transitions can be studied.

We used the ultrafast TEM at the IPCMS in Strasbourg to study shape changes in individual spin-crossover (SCO) nanoparticles. Anisotropic length changes can be induced under heating which is achieved in IR laser pulses. This allows fast laser-driven mechanical switching of SCO. To speed up the heat transfer, gold nanorods were embedded in the SCO particles so that plasmon dissipation around the Au cores leads to efficient local heating. Nanoparticles of $[Fe(Htrz)_2trz](BF_4)$ were synthesized, some of them encapsulating Au nanorods, and deposited on graphene layers for imaging in the TEM. The experiments were carried out with IR laser pulses and electron pulses, both with 7 ns duration. Since the laser-driven shape changes of SCO are reversible, a stroboscopic approach was used.

Figure 1 shows TEM images of SCO particles encapsulating Au rods before (a) and 20 ns after (b) a laser pulse. The shape change is shown in the length profile (c). The expansion of SCO particles with different numbers of embedded Au rods is shown as a function of time in (d). The plasmonic heating effect, which increases with the number of Au rods, is obvious. The presentation will compare results on pure and Au-loaded SCO particles and show the potentials and limits of these nanocomposites for fast mechanical switching.

[1] K. Bücker et al., Ultramicroscopy **171**, 8 (2016)
[2] M. Picher et al.,Ultramicroscopy **188**, 41 (2018)
[3] S. K. Sinha et al., Nature Comm. **10**, 3648 (2019)
[4] M. Palluel et al., Adv. Funct. Mater. **30**, 2000447 (2020)

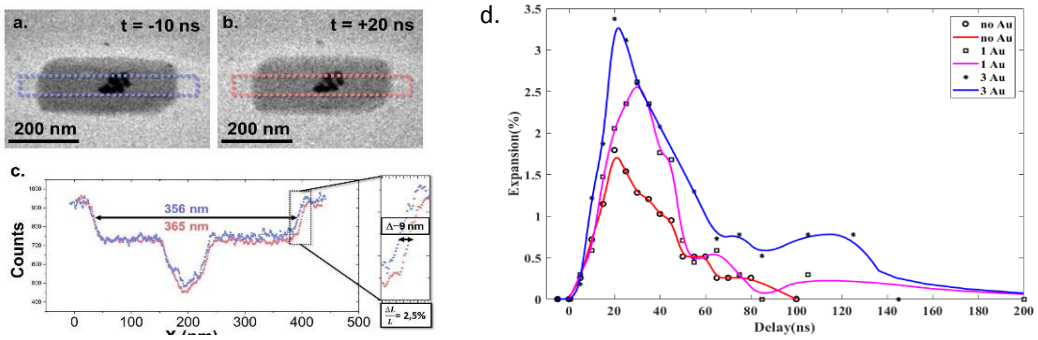

Figure 1 : SCO nanoparticles with embedded Au nanorods before (a) and after (b) an IR laser pulse with the corresponding contrast profiles (c). The temporal evolution of the expansion is shown in (d).