Nanoscale physics

Temperature induced spin-state switching in hybrid spin-crossover nanoparticles coupled to graphene electrodes

A. Holovchenko[1], J. Dugay[1], M. Giménez-Marqués[2], E. Coronado[2] and H.S.J. van der Zant[1]

[1] Kavli Institute of Nanoscience, Delft University of Technology, Lorentzweg 1, 2628 CJ Delft, The Netherlands.
E-mail: a.holovchenko@tudelft.nl

[2] Instituto de Ciencia Molecular, Unversidad de Valencia, Catedrático José Beltrán 2, 46980 Paterna, Spain.

Spin-crossover compounds of $3d^4$-$3d^7$ transition-metal ions are known for their bistability between high- and low-spin states near room temperature. External stimuli, such as temperature, light irradiation, magnetic field or pressure can induce this change in for instance nanoparticles. This has been evidenced both in bulk and on a single-nanoparticle level by conductance measurements. However, the mechanisms behind the conductance change is not understood yet.

In this work we investigate the electrical spin-state switching in individual hybrid spin-crossover nanoparticle (NP) that consists of a [Fe(trz)(H-trz)2](BF4) core stabilized by a silica shell. Single-layer graphene nanoelectrodes were used for contacting the nanoparticle. Dimensions of the electrodes have been changed, in order to observe a dimensionality effect on the conductance. Nanoparticles were placed between the electrodes by means of a dielectrophoresis technique. Electrical characterization as well as scanning-electron microscopy was conducted on the devices before and after deposition to verify the presence of nanoparticles in the gap. Subsequently, temperature-dependent conductance measurements were performed. While heating and cooling the system between 300 K and 385 K hysteretic behavior of the conductance as a function of temperature was observed. Importantly, thermal hysteresis was observed in three samples with different electrode dimensions. The width of the hysteresis loop tends to vary depending on the electrode dimensions (it scales down with the electrode's length). This conductance change is attributed to changes in the electronic configuration of the nanoparticle and points at a hopping mechanism for charge transport at distance > 100 nm.

Acknowledgement:
This work was supported by advanced ERC grant (Mols@Mols).