SENSING HYDROGEN WITH (SINGLE) NANOPARTICLES

Christoph Langhammer

Department of Physics, Chalmers University of Technology, SE-41296 Göteborg, Sweden

e-mail: clangham@chalmers.se

Using particles as signal transducers in a hydrogen sensor offers the ultimate miniaturization limit of the single nanoparticle. At the same time, at nanoscopic length scales, metallic nanoparticles exhibit localized surface plasmon resonance (LSPR), which provides unique opportunities for optical sensing. In this talk, I will discuss the concept of (single nanoparticle) nanoplasmonic hydrogen sensing [1] on two examples:

I. A plasmonic optical hydrogen sensor using Pd–Au alloy nanoparticles [2,3], which enables hysteresis-free hydrogen detection with a sensor uncertainty < 5% throughout the studied hydrogen pressure range and, by engineering the sensor nanoparticle size, sub-second sensor response time. Due to the wavelength-independence of the response, it also allows single-wavelength hydrogen sensing and therefore promises the use of low-cost optical components for implementation in real devices. As a first step in this direction, I will report on the integration of our plasmonic nanostructures in a fiber optic sensor prototype.

II. Single nanoparticle plasmonic gas sensing based on our recent study of the metal-hydrogen interactions of individual Pd nanocrystals with different size and shape [4]. Using this approach, we find that hydride formation enthalpies and entropies are nearly independent of nanocrystal size and shape. At the same time, the hysteresis observed is significantly wider than for bulk, with details depending on the specifics of individual nanoparticles. Hysteresis also becomes size-dependent for particles smaller than 30 nm, consistent with a coherent phase transition during hydride formation, influenced kinetically by the specifics of nucleation.

References

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3. Nugroho, F. A. A., *et al.* ACS Nano **2016**, 10, (2), 2871-2879.
4. Syrenova, S., *et al.* Nature Materials **2015**, 14, 1236–1244

Associate professor Christoph Langhammer is the principal investigator of an experimental research group at the Department of Physics at Chalmers University of Technology in Göteborg Sweden. His research is situated at the interface between materials science, nanoscience, plasmonics and catalysis, with focus on sustainable energy-related nanomaterials and related physical and chemical processes, such as metal-hydrogen interactions in nanomaterials. He has recently been awarded an ERC Starting Grant (2015) and is co-founder and CSO of Insplorion AB, a spin-off company that markets nanoplasmonics-based research instrumentation and sensor system solutions.