TITLE

Plasmonics for chemistry: sensing and driving chemical reactions using plasmons

ABSTRACT

Metal nanoparticles can sustain localized surface plasmon resonances, which are light-driven resonant oscillations of their free electrons. Thanks to their strong spectral dependence on the nanoparticle size, shape, composition, and dielectric environment these resonances can be used as nanoscale probes for a large range of chemical and physical processes. Furthermore, their non-radiative decay into "hot" charge carriers and heat can be exploited to accelerate and modify chemical reactions at the metal nanoparticle surface. Here, I will first show how we use plasmon resonances to study hydrogen absorption in individual metal nanocrystals in an environmental transmission electron microscope. Such single-particle approach offers unprecedented insight into the phase transition of nanomaterials used for energy storage [1–4]. Additionally, I will present how we use localized surface plasmon resonances to probe charge equilibration reactions in metal@semiconductor core@shell nanoparticles. Detailed characterization of the plasmon resonance peaks allows us to challenge the established understanding of charge equilibration in hybrid metal@semiconductor nanostructures [5]. Finally, I will demonstrate how plasmon resonances can be exploited to drive the synthesis of hierarchical nanostructures in solution and discuss the relative contributions of photo-thermal heating versus non-thermal processes such as near-field effects and hot charge carriers [6].

[1] Baldi et al., Nature Materials 13, 1143-1148 (2014)
[2] Narayan et al., Nature Materials 15, 768–774 (2016)
[3] Narayan et al., Nature Commun. 8, 14020 (2017)
[4] Hayee et al., Nature Commun. 9, 1775 (2018)
[5] Parente et al., J. Phys. Chem. C 122, 23631-23638 (2018)
[6] Kamarudheen et al., ACS Nano 12, 8447-8455 (2018).

BIO

Andrea Baldi received his Master in Chemistry from the University of Rome "La Sapienza" and his PhD in Condensed Matter Physics from the VU University Amsterdam. During his PhD he studied the properties of metal hydride thin films for hydrogen storage and smart windows applications. In 2011 he won the Young Energy Scientist Fellowship from the Dutch physics institute (FOM), which funded his tenure as a postdoctoral scholar at Stanford University. Here, he developed imaging and spectroscopic techniques in an environmental TEM to study phase transitions in nanomaterials for energy storage. Since 2015 he has returned to the Netherlands as a tenure-track senior scientist at the Dutch Institute For Fundamental Energy Research (DIFFER) in Eindhoven, where he leads his research group on Nanomaterials for Energy Applications. In 2017 he won a Vidi grant from the Dutch Research Organisation (NWO) to study plasmon-activated catalysis.