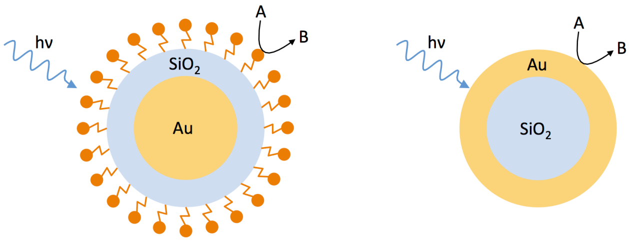
Synthesis of plasmonic core@shell nanoparticles for catalytic applications

Metal nanoparticles are used in a wide range of applications, from catalysis, to advanced solar cells, photo-thermal cancer therapy, and medical imaging [1]. One of the most striking features of metal nanoparticles is their unique interaction with light, leading to strong absorption and reflection in the visible range. Such strong interaction is responsible for a variety of interesting effects, from the generation of non-equilibrium charge carriers to the localized heating of the nanoparticle surrounding. For example, irradiating metal nanoparticles with spectrally tuned light can give rise to temperature gradients of tens of degrees within few nanometers of the particle's surface. In the group of Nanomaterials for Energy Applications (NEA) at DIFFER we explore such light-induced effects to control a variety of chemical reactions at the surface of metal nanostructures, from catalytic conversions, to sol-gel and colloidal syntheses.



An important aspect of the application of metal nanoparticles is their surface reactivity, which can be modified by changing their surface chemical composition. For example, it is known that several organic and catalytic molecules bind strongly to silica (SiO_2). Coating gold nanoparticles with a thin layer of SiO_2 can therefore be used to combine the optical properties of gold, to the chemical and catalytic properties of functional organic molecules [2].

A similar control of the structure-function relationship can be achieved by synthesizing SiO_2 nanoparticles coated with a thin Au shell. Such plasmonic "nanoshells" have easily tunable and strong resonances, making them ideal candidates as sources of heat and hot charge carriers for synthetic, therapeutic, and catalytic purposes [3].

The aim of this project is to synthesize size- and shape-controlled hierarchical plasmonic nanostructures, such as Au@SiO_2 and SiO_2@Au nanoparticles. The student will learn to synthesize and purify metal and semiconductor nanoparticles using a variety of colloidal and sol-gel methods and to characterize their optical and structural properties using UV-Vis-NIR spectroscopy and scanning electron microscopy. The synthesized particles will then be tested as catalysts in a variety of model chemical reactions, from the reduction of p-nitrophenol to p-aminophenol to the fluorogenic formation of resorufin, both in ensemble and single-particle experiments.

[1] A. Naldoni et al., *Applying plasmonics to a sustainable future*, **Science** 356, 908–909 (2017)
[2] J. Lee et al., *A Nanoreactor Framework of a Au@SiO2 Yolk/Shell Structure for Catalytic Reduction of p-Nitrophenol*, **Advanced Materials** 20, 1523-1528 (2008)
[3] L. R. Hirsch et al., *Nanoshell-mediated near-infrared thermal therapy of tumors under magnetic resonance guidance*, **PNAS** 100, 13549–13554 (2003)

The project will be carried out at DIFFER, which is located inside the TU/e campus, under the supervision of dr. Andrea Baldi. For further information please contact:

Andrea Baldi
a.baldi@differ.nl
Nanomaterials for Energy Applications
De Zaale 20, 5612 AJ Eindhoven
+31 (0)40 3334925