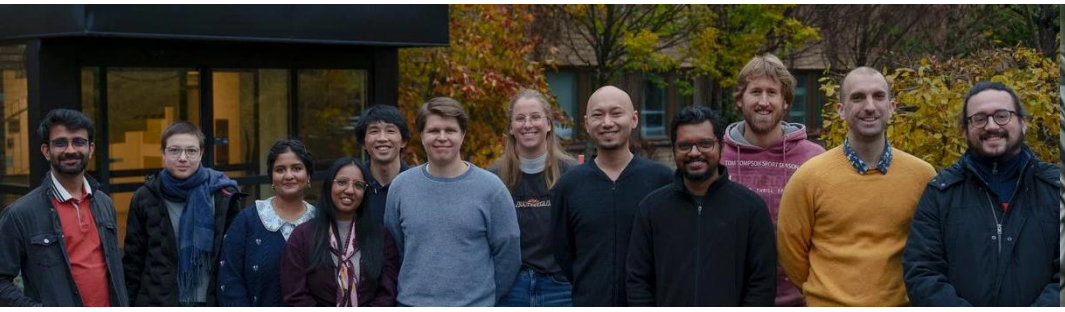
Engineering the ultrafast electronic properties of colloidal gold thin films for applications in photophysics and photochemistry

Project description

The size and shape of gold nanoparticles sensitively affect their optical and electronic response at ultrafast timescales: hot electrons can be generated more efficiently and structures comprising biocompatible and chemically stable gold nanoparticles may be engineered for hot electron injection for photocatalytic applications, for instance in photovoltaics and photothermal conversion. Such designed surfaces could potentially provide reaction efficiencies far exceeding those of current catalytic substrates.

In a recent study on disordered nanoporous gold films, we have identified a strategy to engineer the ultrafast electronic properties of nanostructured substrates for applications in photophysics and photochemistry [1]. We have developed a model predicting the electronic relaxation dynamics in colloidal metal thin films of different compositions. Preliminary findings suggest a strong dependence of the electronic population dynamics on size, shape, filling factors, and aggregation/clustering state. However, several aspects, such as the contribution of electron-surface scattering, remain not understood.

This project covers the fabrication of colloidal gold thin films, made from nanoparticle solutions at different mixing ratios, systematically varying their characteristic parameters. In a second step, ultrafast transient transmission spectroscopy will be performed to compare the behaviours of the different samples. Finally, measurement results will be compared with our numerical modelling to pinpoint how electronic relaxation pathways are affected on a microscopic scale.



Research group/environment

The Ultrafast Nanoscience Group [2] is located at the Department of Physics at Umeå University. We study a wide variety of fundamental light-matter interactions at the nanoscale, combining both experimental and theoretical studies as well as nanofabrication.

To be conducted at: Department of Physics, Ultrafast Nanoscience Group
Level: A (Master, 30/45/60 hp/ECTS depending on program)
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[1] Tapani, T. *et al. Nat Commun* **17**, 829 (2026).
[2] https://www.umu.se/en/research/groups/nicolo-maccaferri-lab/