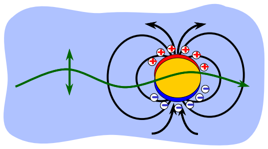
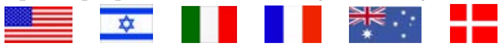
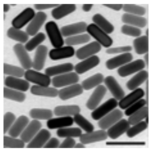
Scientific profile

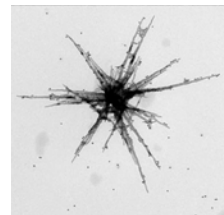


The primary focus of the **nano-bio-technology group** of **Prof. Dr. Carsten Sönnichsen** at the University of Mainz is exploring new properties arising in nanostructured materials. The properties of nanostructured materials differ significantly from bulk due to a variety of effects, including quantum-confinement, electrodynamic resonances and are determined to a large extend by surface effects (most atoms in nanoparticles are at the surface). Even though our main focus are optical properties, we also study thermodynamic, electrical, mechanical and magnetic effects.

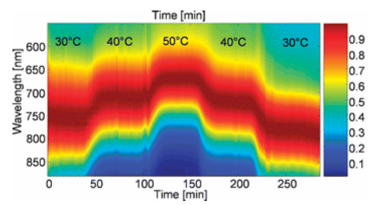


Our approach is to integrate our research project 'vertically', starting from the production of particles, their characterization and assembly to designed structures, the physical investigation of such structures and the modeling and understanding of the results. Obviously we work in close collaboration with a large number of partners on campus, within Germany and internationally. These collaborations vary in depth from discussing ideas, exchanging samples to applying for common funding and sharing students.

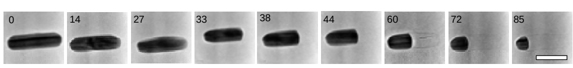




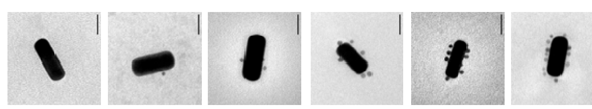
We focus on nanoparticles made by wet-chemical synthesis. The main material systems we use are noble metals (gold and silver) and semiconductors (cadmium telluride). To make the desired particles, we need a deep understanding of the synthesis process – and a large part of our research effort is dedicated at getting such insight. The main tools used to study nanoparticle growth are light scattering / absorption and transmission electron microscopy. We make particles for our own applications as well as provide particles for many other projects, including medical applications, fundamental research in physics, biophysical and biochemical research.



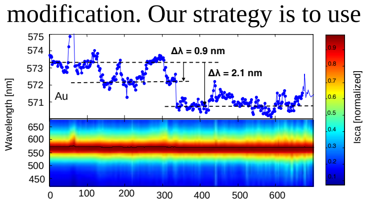
In order to produce particles reliably, efficiently and with consistent quality, we developed a continuous flow synthesis. This method allows us not only to make particles with specific shapes and sizes, but also to explore new points in parameter space due to the access to unusual combinations of temperature and pressure, rapid mixing and fast cooling/heating times. Future directions include segmented flow and real time monitoring.



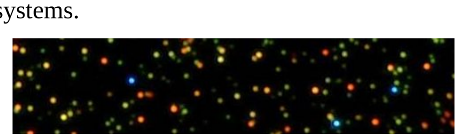
We study fundamental properties of nanoparticles we produce and their growth process with the aim of obtaining a better control over their synthesis. For example, we have conducted an *in-situ* melting experiment on gold and silver nanorods (in collaboration with the group of Prof. Dr. Florian Banhart). Surprising differences in melting behavior between gold and silver were observed which might explain the different synthesis behavior observed earlier. We use X-ray scattering, dynamic light scattering, size and charge selective separation techniques, atomic force and scanning tunneling microscopy to investigate further particle properties.



To use nanoparticles as label in single molecule studies of biomolecules, in electro-optical devices like solar cells or LEDs, as components in new material systems or as biomedical contrast agent (and in most other applications), the surface of those nanoparticles has to be chemically modified or functionalized. This functionalization allows the controlled self-assembled buildup of hetero-structures of different nanoparticles or inorganic-organic hybrid materials. The challenge lies in simultaneously protecting the nanoparticles against aggregation and unspecific attachment to surfaces while providing chemical anchor points for further chemical modification. Our strategy is to use long-chain polymers with mono- and bi-functional end groups.



The main application for our functionalized particles we have in mind is their use as optical label for single molecule microscopy of biological molecules. Metal particles provide stable and efficient optical labels giving both orientation and intramolecular distance information and can be used as nanosensor probing volumes as small as attoliters. We have investigated DNA hybridization dynamics on single DNA molecules and are currently studying a number of additional systems.



To visualize and investigate single metallic nanoparticles in an optical microscope we use the dark-field contrast mechanism, where the sample is illuminated in a way that allows only light scattered by the particles to enter the detection path. Quantitative information is obtained by spectrally investigating individual particles using a spatially resolved spectrometer. Recently we improved the detection speed by several orders of magnitude by employing a novel detection scheme (patent pending). This improved detection method will allow us to investigate large amounts of particles in a quick and convenient form and obtain good statistics, which allows us to study rare events.