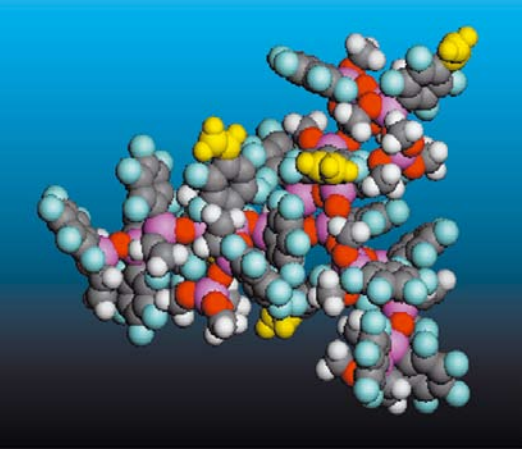

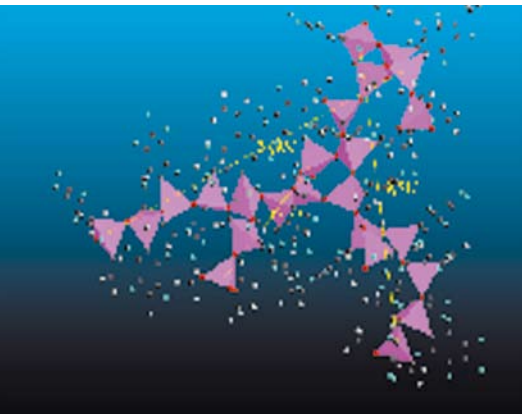

Nanoscaled hybrid inorganic-organic polymer structures for optical waveguides based on Si-O-Si-networks (shown in violett) according to molecular modelling (ISC)

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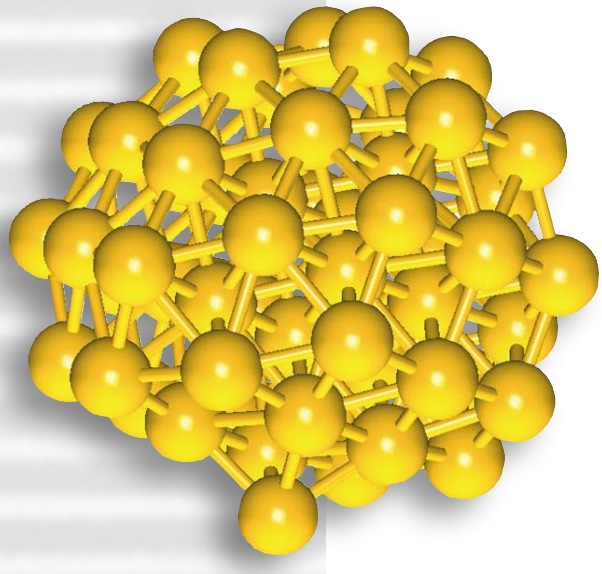
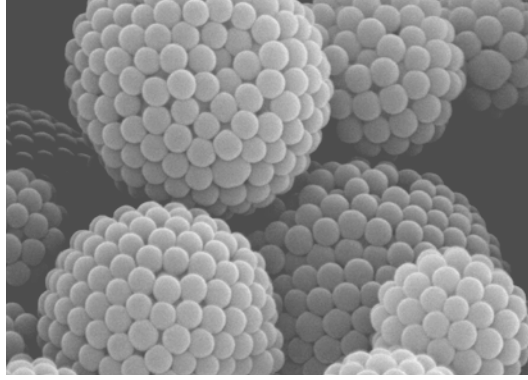
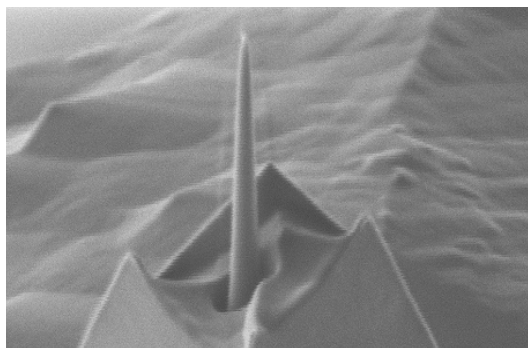






Fraunhofer Nano-technology Alliance

Making small things effective

NANO

Fraunhofer Verbund Nanotechnologie

Fraunhofer R&D:
serving the nanotech community and industry

Transparent aluminium-oxide ceramics based on nanoparticles (IKTS)

Antifungal façade coating using Ag-nanoparticles; top picture without Nano-Ag (ICT)

Description of figures on cover page:

Left:
Molecular modelling of Au nanoparticle structures (IWM)

Left background:
Multilayers for reflective optical layers (IWS)

Right top:
Redispersable silica particles by spray-drying (ISC)

Right below:
Tip of an AFM modified by ion beams (IISB)

What is nanotechnology?

Materials and systems with critical dimensions below about 100 nm change their behaviour due to increasing importance of surface effects and the occurence of special optical, electrical and quantum size effects. Techniques to synthesize these systems and to use the effects in products are summarized under the term nanotechnology. Materials and applications of nanotechnology cover a wide range of branches like electronics and optics, biotechnology, polymers and surface refinement.

Material synthesis

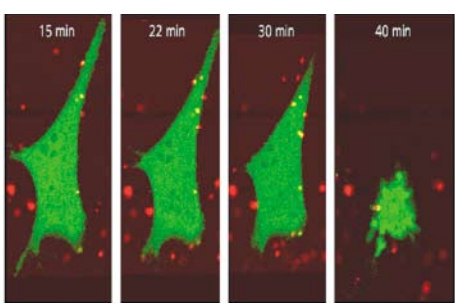
The synthesis routes are generally divided into two groups: Top-down and bottom-up. The top-down approach starts with materials of macroscopic sizes and makes them smaller (milling or lithography). The bottom-up approach starts with atoms and molecules and uses chemical processes or self-assembling.

Processing

The synthesis of nanoscaled building blocks is the first step. However, in order to create a macroscopic system or product, these building blocks have to be assembled in a reproducible way. Therefore, the processing is a critical step for nanosystems. Fraunhofer offers various techniques to generate nanosystems like bulk materials, coatings, fibers and composites, either by physical or chemical means.

Analysis, characterization tools and modelling

The development of nanotechnology was fostered by new analytical tools like the atomic force microscope. Due to the atomic resolution of these devices the nanoscale systems can be analyzed and even processed on an atomic scale. Ultrasonic AFM modes have been developed to image and measure local material properties. Advanced modeling tools are used in order to predict material properties in the range between atomic or molecular and macroscopic scale. Basic research is also conducted on macroscopic properties of nanostructured layers and substrates e.g. with micro-force testing devices.

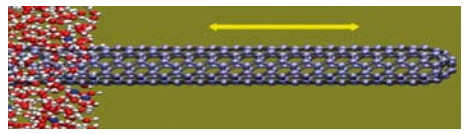


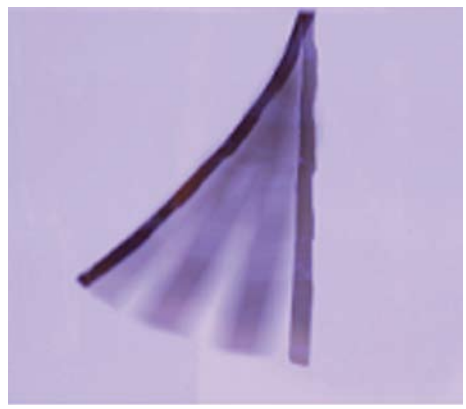
Modified nanoparticles can interact with living systems which is useful for biosensing and, finally, therapeutic applications. (Reaction of cells after addition of TNF-modified silica nanoparticles (in red), IGB)

Applications

Nanoscale systems as thin films, nanocomposites or nanoparticles cover a wide range of applications in electronics, optics, biotechnology, surface refinement and catalysis. Some examples are shown in the following.

Structuring of surfaces in the submicron and nanometer regime is often used in electronics and optics for different applications. Generating photonic crystals or antireflective coatings for polymers and glass surfaces are active areas of research.





Carbon nanotube (CNT) based actuators are also an area of active research within Fraunhofer (top: modeling of the reversible extension of CNT in an electric field in the presence of an electrolyte (IWM); bottom: macroscopic motion of CNT bucky paper, TEG, ISC)

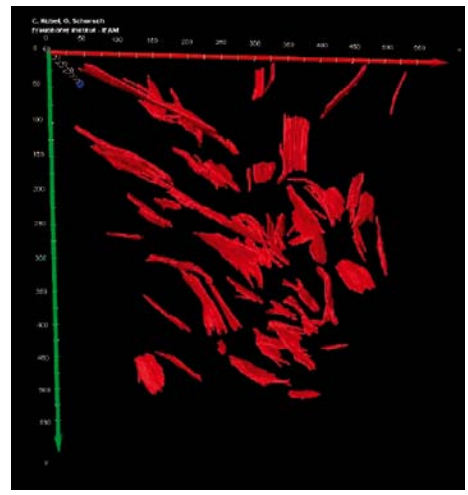
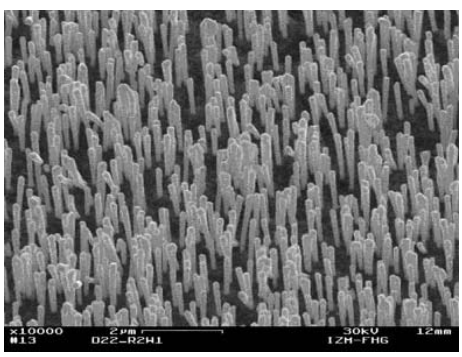


Plate-like nanoclays are particularly useful in polymer composites in order to increase flame retardancy, diffusion barrier properties and thermal resistance. Here the dispersion and exfoliation are the most critical process steps in order to generate true nanoscale systems. (3D-TEM picture of nanoclay composite based on organically modified bentonite, IFAM)

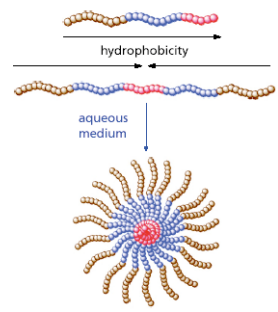


Carbon nanotubes and other nanowire systems are a very promising basis for bio-interfaces and electronic applications. Here the synthesis/processing on-site, e. g. on the surface of electronic devices, is important. Special analytical tools allow quality assurance on the nanoscale.(Metallic nanowire structures for microelectronic packaging, IZM)

Our offer

Fraunhofer offers services for all aspects of nanotechnology from the basic idea up to the industrial relevant product:

- molecular modelling of nanoscaled systems, optical and electronic devices
- synthesis by physical and chemical means (PVD, CVD, laser, lithography, sol-gel processing)
- processing of coatings, nanoparticles, fibres, composites and bulk materials
- specialized analytical tools
- structuring of surfaces by embossing, lithography and self-assembly



Modern polymer chemistry can generate nanoscaled copolymers of different chemical compositions for applications as in coatings, latices and biotechnology. The polymerization process as chemical tool determines the nanoscale architecture. (Grafted copolymers for multicompartment micelles, IAP)

New solar cell architectures use nanoparticles and organic compounds (Dye solar cell, ISE).