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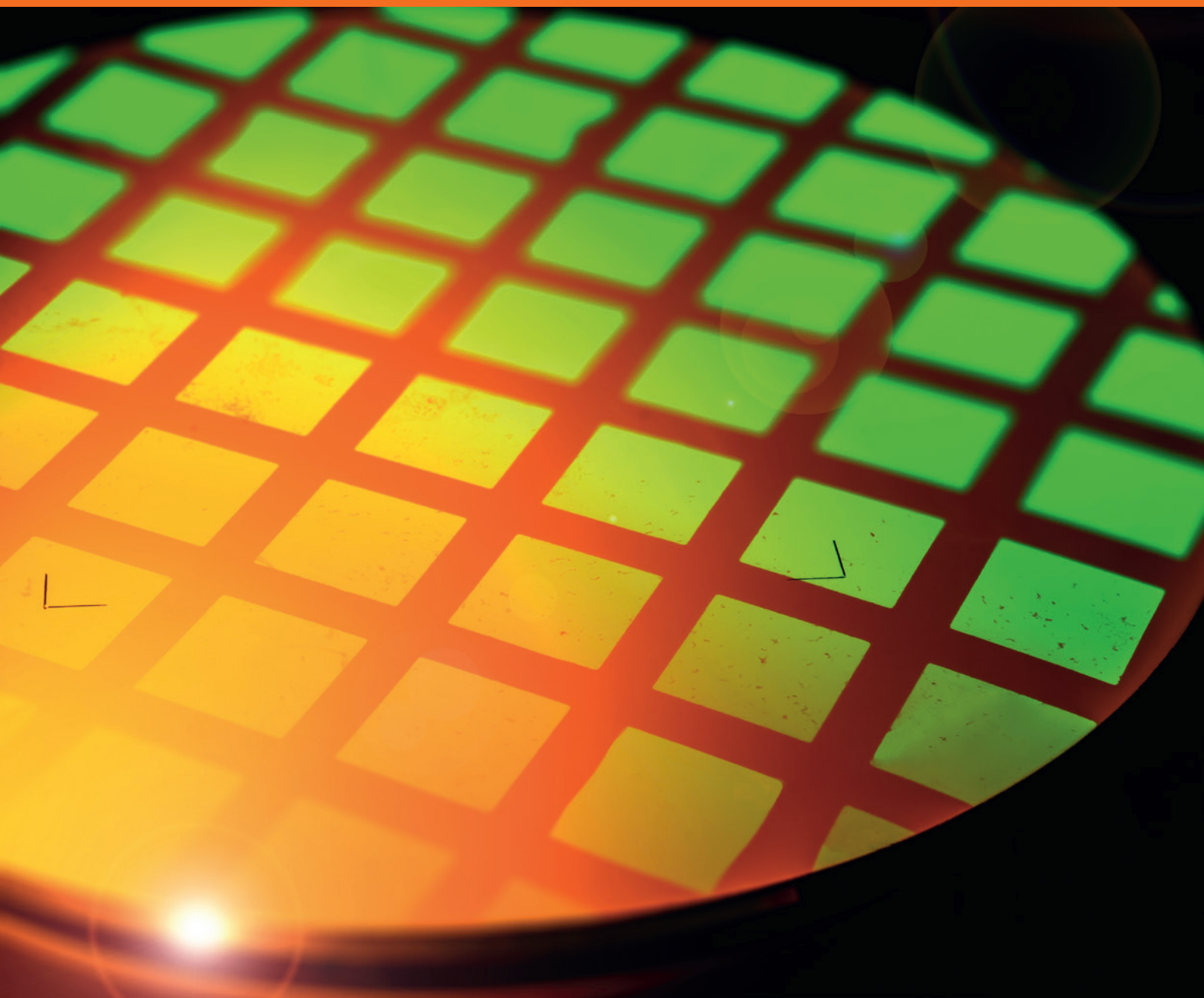
FRAUNHOFER INSTITUTE FOR CHEMICAL TECHNOLOGY ICT, BRANCH ICT-IMM

NANOPARTICLE TECHNOLOGIES



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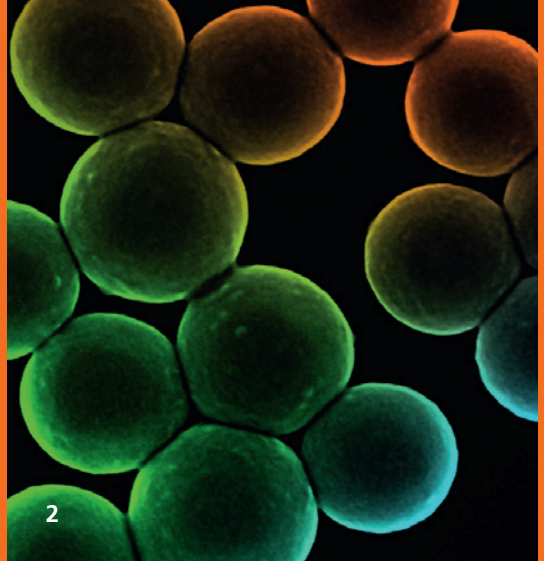

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NANOPARTICLE SYNTHESIS – FROM BATCH TO CONTINUOUS

The importance and unique advantages of nano- and microparticles made from different types of inorganic and organic/polymeric materials has been demonstrated in diverse material and life science applications. Our core focus is in multidisciplinary research areas that are of potential interest to the following industrial sectors: coatings, adhesives, polymers, catalysis, paper, packaging, textiles, food, cosmetics and pharmaceuticals.

Functional macromolecules

The research is centered around the design and continuous synthesis of innovative materials (polymers and block copolymers) by the combination of several techniques including step-growth polymerization, RAFT and "click" chemistry. Particular attention is paid to the development of (bio-)macromolecules with enhanced performance and functionalities tailored to the specific requirements of each application.

Polymer-based particles

Well-defined micro- and nanoparticles (capsules) with adjustable properties, such as size, shape, chemical composition, morphology and surface functionalization are formulated from a broad spectrum of synthetic/natural monomers and polymers by utilizing different engineering approaches. Our special expertise lies in the development of new polymeric materials and concepts for designing particles that react to external stimuli and are able to release the encapsulated payload in a controlled way.
It is our ambition to provide economical high-throughput synthetic strategies enabling excellent product quality in continuous production processes.

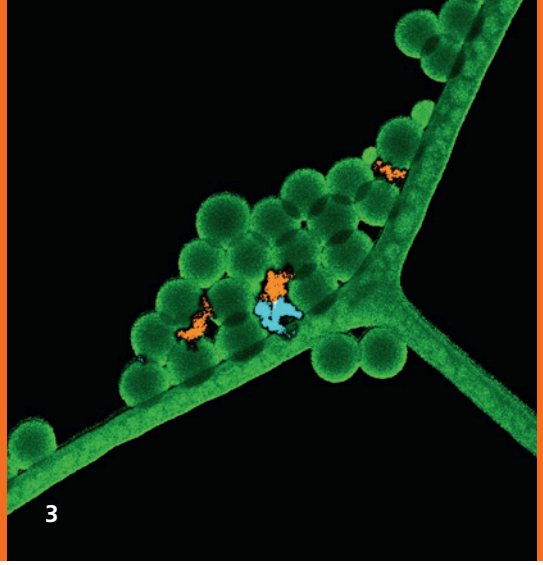
Inorganic nanoparticles

Activities are focused on the continuous production of engineered silica, metallic and semiconductor nanoparticles as well as their alloys with controlled size, composition and shape.

MATERIAL PROPERTIES OVERVIEW

- Particle size between 2 nm (inorganic particles) and several µm
- Stimuli-responsive
- Long shelf-life
- Conductive
- Morphology: solid, porous or gel-like
- Fluorescent
- Magnetic
- Catalytic
- Antifouling
- Temperature-, moisture-, fire-, light-, etc. resistant
- Antimicrobial
- Protein repelling
- Biocompatible
- Biodegradable
- Molecule-, ion-, or gas-selective

1 *CdSe quantum dots*
2 *Polylactide composite nanoparticles*
3 *Nanoparticle mixture (TEM/EELS)*
4 *Topology of polystyrene nanoparticles (AFM)*
5 *Osteosynthesis plate on finger bone*
6 *Plasma chamber*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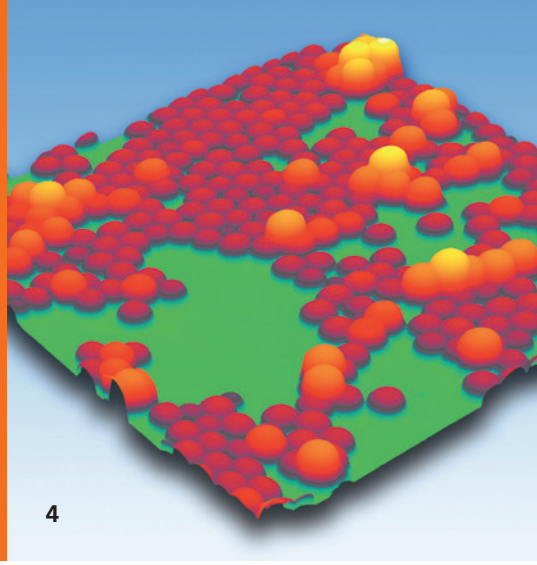
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NANO ANALYTICS

We are specialized in bulk and on-line analysis of nanomaterials. This includes nanoparticles of different materials under various conditions, e.g. colloids in organic solvents, aqueous solutions, physiological environment or embedded in solid matrices. Our expertise in nanomaterials enables us to carry out comprehensive studies using a variety of techniques to provide tailored solutions for specific characterization needs.

Size and morphology

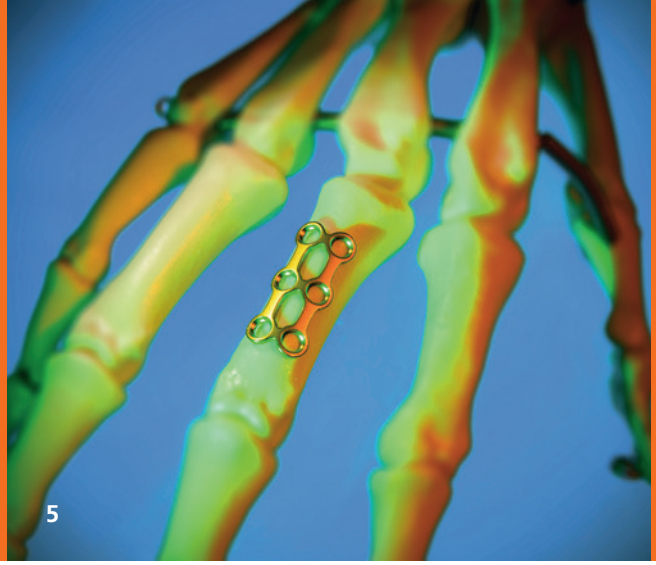
Particle size is one of the basic parameters in nanoparticle analysis. In addition to average particle size, knowledge of the size distribution, morphology, and physicochemical properties are essential for understanding the characteristics and behavior of a nanoscale material – this knowledge can be applied to the improvement of specific properties of products, for example surface area or dissolution kinetics. Whether it be a rough overview of sample morphology or a more detailed analysis with regards to specific properties, we offer tailored services for the desired needs of our customers.

Completing the picture

Through the use of different, complementary techniques we and our clients can gain a comprehensive picture of the sample. To achieve this, we can perform not only characterization of particle size, size distribution and morphology, but also elemental analysis by EDX and EELS, as well as investigation of surface potentials and magnetic properties by KPFM and MFM. We have access to a wide variety of additional techniques via collaborations with other research facilities.

ANALYTICAL METHODS

- Scanning electron microscopy (SEM, cryo-SEM), with energy-dispersive X-ray spectroscopy (EDX)
- Dynamic light scattering (DLS)
- Transmission electron microscopy (TEM, cryo-TEM), with electron energy-loss spectroscopy (EELS)
- Optical spectroscopy
- Analytical centrifugation
- Field flow fractionation (FFF)
- Surface charge detection (zeta potential)
- Size exclusion chromatography (SEC)
- Atomic force microscopy (AFM), Kelvin probe force microscopy (KPFM), magnetic force microscopy (MFM)



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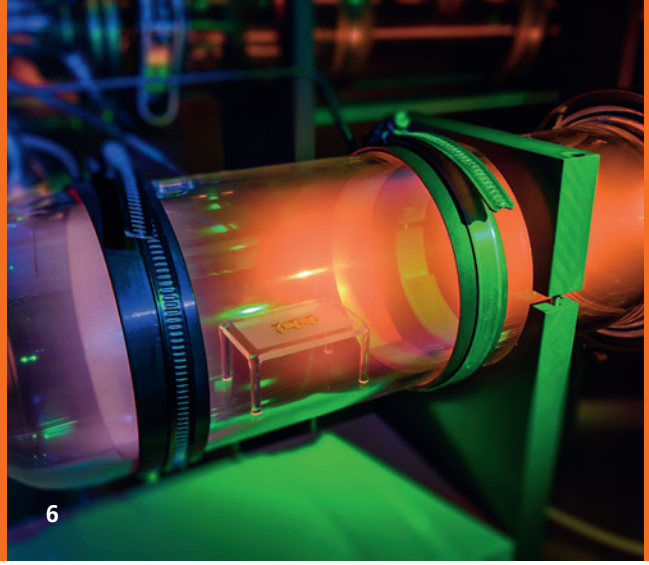

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BIO-NANO-INTERFACES

The detailed understanding of interfacial reactions occurring between man-made materials and biological molecules, fluids, cells and living tissue are the basis for innovative technological developments in areas such as health, filtration, sensors, hygiene and food packaging.

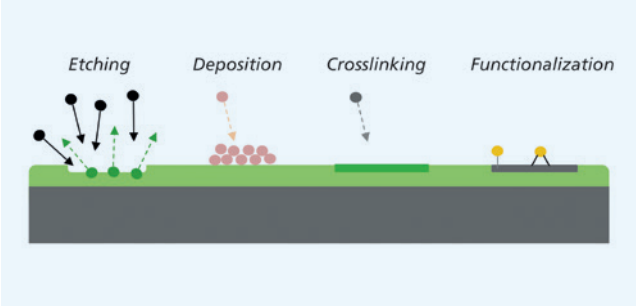
Nanoscale surface interactions

The interactions and reactions of man-made materials with biological matter are largely influenced by:

- Philic/phobic surface behavior
- Adhesive and non-adhesive effects
- Surface chemistry and composition
- Surface morphology

Plasma surface treatment

Specific surface interactions can be influenced by modifications to the outermost molecular level of a material. We achieve these using solvent-free plasma processes, which enable surface modification without affecting bulk properties by etching, deposition, crosslinking or functionalization.

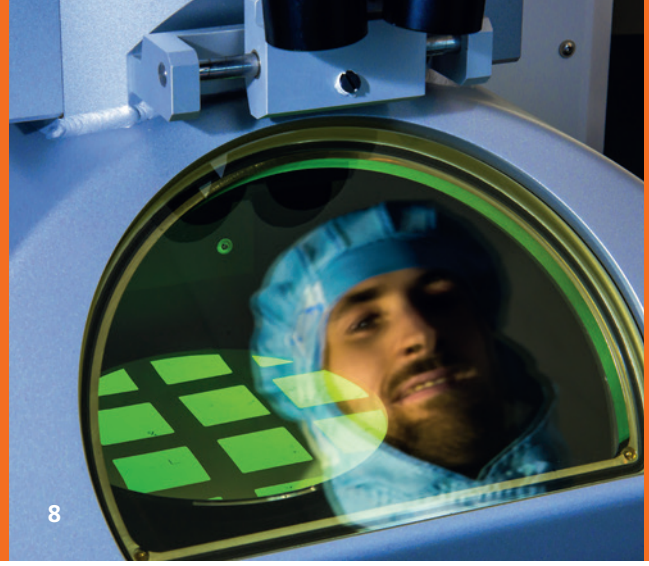


Multiple functionality

Long term expertise in design of experiment and surface properties allows us to tailor surfaces to exhibit multiple properties suitable for biomedical applications. The surfaces may exhibit one or more of the following: drug release, antimicrobial activity, antifouling, biocompatibility and biointegration.

Application examples

- Diagnostic and therapeutic thin films for wound healing and implants
- Antiadhesive coatings for implants
- Antifouling coatings for sensor design
- Barrier coatings in complex structures
- Multifunctional coatings involving nanoparticles and capsules



7 *4-fold concentrical micromixer*
8 *TEM fluorescence screen*

EXPERTISE AND SERVICE

Our particular focus lies on developing continuous processes for the synthesis of functional materials to include polymers tailored to a specific application such as drug delivery and organic or inorganic nanoparticles of a wide range of materials. Generally, continuous methods enable scalable production with constant and often unmatched product quality. Together with our customers, we transfer existing batch processes to continuous methods and develop prototype systems including process control and online analytics for quality control.

With our long term experience in research and development, customers can benefit from our competence with the following service offers:

Particles and interfaces

- Customized synthesis and process validation for the production of:
  - Polymers (linear or branched macromolecules)
  - Inorganic nanoparticles
  - Polymer-based particles
- Particle/capsule/polymersome formulations:
  - Encapsulation of active components for on-demand release
  - Therapeutic drugs as payloads
  - Functionalization for improved specificity and efficacy in targeted delivery
- Transfer of existing batch syntheses to continuous processes, scale-up
- Development of innovative plasma-based surface treatments and coatings from lab to industrially relevant scales
- Pinhole-free coatings with high precision on the nanometer scale
- Plasma coating/treatment of 2D objects like membranes and foils or 3D objects such as screws, scaffolds and non-woven

Analytics

- Characterization of nanoparticle samples in different media:
  - Liquid (organic or inorganic)
  - Air (as dry powders)
  - Solid (as composites)
- Development of protocols for material characterization, handling and processing
- Consultation, evaluation and feasibility studies for the establishment of new characterization techniques customized for specific customer needs

Contact

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