Materials Science Colloquium of the SFB 986
Public Talk – All students, staff and interested people are warmly invited!

Prof. Tobias Kraus
INM – Leibniz Institute for New Materials
Saarbrücken

17.05.2017, 17:15h
H 009, Am Schwarzenberg-Campus 5, TUHH
Some snacks and drinks will be served from 17:00 onwards

Self-assembly of particle-based materials: Mechanisms and their application for flexible electronics

Concrete, paint, rubber, and many other important materials are prepared from mixtures of particles, polymers, solvents, and additives. Their microstructures are often heterogeneous and hard to predict; they limit the performance. This talk will discuss how self-assembly can be used to gain control over microstructure and properties of particle-based materials. We seek self-assembly mechanisms that work with relevant materials, do not require complex chemistry, and are compatible with established materials manufacturing processes such as spray coating, doctor blading, and inkjet printing.

I will discuss particle-based electronic materials that illustrate our strategy. Metal spheres, rods, and wires with characteristic dimensions between 2 nm and 50 nm and narrow size distributions were chemically synthesized and coated with organic shells of varying thickness, density, and chemical nature. We determined shape and size using electron microscopy and scattering techniques. Colloidal interactions between the hybrid particles in different solvents were systematically quantified through concentration- and temperature-dependent light and X-ray-scattering experiments. We study the onset of agglomeration, agglomeration rates, and the geometry of the agglomerates. Interfaces are used to confine the particles and template self-assembly. I will show that monolayers and multilayers of nanoparticles, supraparticles and structured nanocomposites can be deposited using the right combination of interactions and confinement.

We find that mobility and interaction at different length scales are central features of self-assembly mechanisms for particle-based materials. Their interplay affects whether the resulting materials reach equilibrium structures or are kinetically dominated. In practice, viscosity and time scales are often not freely adjustable—there are large differences, for example, between inkjet printing and 3D printing via fused deposition modeling—and rule out certain self-assembly mechanisms. I will discuss such boundary conditions on the example of transparent electrode layers that self-assemble from ultrathin gold wires.

As an outlook, I will discuss particle-based structures that can reconfigure in the material during its lifetime. First examples of “active” nanocomposites based on self-assembly and on disassembly of particles can change their properties upon stimulation. We explore such materials for a digital world where even materials are connected to networks.