Project A2: Ordering of nanoparticles at surfaces patterned with polymer brushes

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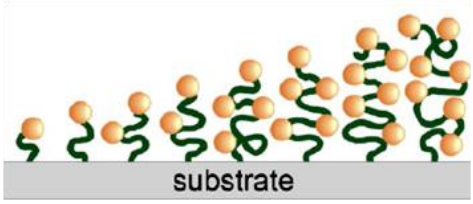
US partner: **Genzer (NCSU)**

Outline. The challenge of the project is the ordering of particles at a controlled distance in two and three dimensions. Soft stimuli responsive polymer particles show a tendency of such an ordering. Layers of close-packed hard particles on silicon wafers can be produced, but a controlled distance could not be achieved so far. The project addresses the lateral and vertical distribution of inorganic particles in polymer brushes which are grafted from planar surfaces. The motivation is at least two-fold: 1) The silica particles (diameter: 50–500 nm) serve as templates for fabricating a two- polymer system, which could be interesting e.g. for photovoltaics. 2) Using gold particles (diameter: 10–30 nm) would give interesting optical properties of the polymer system. Preliminary experiments on polymer brushes showed that they are promising candidates for the ordering of soft particles. It will be studied how the softness of the brushes influence the ordering of the particles and how the particles affect the structural and dynamic properties of the brushes.



*Nanoparticles adsorbed in a polymer brush with a gradient in molecular weight (from Bhat et al., Nanotechnology **14**, 1145 (2003).*

Research within the German group. The formations of 2D crystals of solid particles of a diameter of several 10s to several 100s of nm on solid substrates will be studied and controlled. It is assumed that the 2D crystals can be formed via electrostatic repulsion forces between the particles. In addition the interaction between the particles and the substrates play an important role. Therefore different parameters, like charge density of the particles and the substrate and ionic strength will be studied. In order to change the properties of the substrate, it will be modified by adsorption of polyelectrolytes. Silica or latex particles of positive or negative charge will be deposited at polymer brushes with different outer charge and elasticity. Short brushes are promising to induce a 2D ordering. If they are long enough with respect to the particle diameter, they serve also as a matrix for 3D ordering (see figure). Either Au nanoparticles or silica particles will be adsorbed within the brushes. The question is how the ratio between particle diameter, length and grafting density of the polymer brushes correlate with the number density of adsorbed latex or silica particles. AFM, X-ray and neutron reflectometry will be used to characterize the lateral and vertical distribution against vapor and solvent.

Longer-term perspective. A long-term goal will be to control the mutual effect in mobility of particles and polymer matrix and the directed motion of the particles. For mobility studies the project brush polymers, which are responsive to external stimuli like pH (e.g., poly(dimethylaminoethyl methylacrylate)), or temperature (e.g., poly(N-isopropylacrylamide)) will be used.

Complementary work in US partner group. Genzer has a lot of experience in modification of surfaces by depositing polymer brushes. The deposition of particles would be also of interest for his group, since it would bring his systems to a higher dimension in complexity.

Status of the project. A close collaboration is planned with project C5 (Klapp) which addresses the self-assembly at solid interfaces in the presence of external electromagnetic fields. For nucleation studies in project A4 (Riegler) this project delivers different polymer coatings. Substrates endowed with gradients are central to the research in project A1 (Schoen). We offer scattering techniques (neutron and X-ray) at surfaces, especially to the group of Zauscher (DU).