Electrodeless dielectrophoretic filtration

The separation of suspended particles smaller than 1 µm according to their electrical properties, size and shape is an unresolved task especially at a high throughput. For industrial applications a high throughput is particularly relevant. Electrodeless dielectrophoretic (DEP) filtration is an enabling technology that allows for highly selective particle separation. Possible technology fields range from processing of valuable sludges to innovative semiconductor manufacturing. The mechanism of the DEP filter is based on the polarization of the target particles in their suspension which depends on both the medium's and particle's dielectric properties. The combination with a non-uniform electric field, which is induced by insulating posts, gives rise to a dielectrophoretic force that selectively retards particles. Multidimensional separation of particles can be achieved by adjusting the field frequency and field strength considering both the deposition and the subsequent remobilization of the particles. Depending on the particle size, shape, and material, the dielectrophoretic force has a different magnitude which allows for selective retention.

In this project, we model a switchable selective filter through a geometrically defined microfluidic channel with an array of insulating posts which is superimposed by an alternating electric field. Perspectively, fibreglass membranes can substitute the function of the insulating posts. Using this structure in experimental investigations with a homogeneous particle fraction, we expect to understand the retention dynamics with respect to particle size, shape, and conductivity. Additionally, we want to investigate the possibility to achieve high separation rates with particles smaller than 100 nm. Understanding the influence of geometry and process parameters should enable a prospective upscaling.

In the first project phase, monodisperse particle suspensions will be investigated. In addition to model particles different size made of polystyrene, gold particles of various shapes (spheres, platelets, and rods) and particles of zirconium dioxide, silica, and cellulose derivatives will be used. The selectivity regarding particle size, shape, conductivity, and polarization will be analyzed by mixing these particles. Moreover, suspensions from nano grinding processes will be investigated.

The particles are labeled with different fluorescence dyes and can be detected using standard fluorescence microscopy. Therefore, particle flux into and out of the post array can be observed and used for calculating the separation efficiency. The selectivity can further be investigated using scanning transmission electron microscopy (STEM). The particle size, shape and material can also be analyzed by scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), or in the case of organic compounds by chemical oxygen demand (COD) measurements.