Towards new hard materials by structuring soft matter

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Introduction

The properties of materials are often determined by their mesoscopic structuring. Phase separation processes are used already in the field of polymers to tailor the microstructure. However, in the ceramic world comparably inadequate methods (for instance blowing gas into a melt or introducing additives which are burned after mixing) are still used to produce porous materials.

Aim and Strategy

Our aim is to induce a structure in a material based on physical phenomena in colloidal systems. Colloids are particles of mesoscopic size that can assemble into a variety of structures - for instance they can form crystals, gels and glasses. With these possibilities pore size distribution and specific surface area can be tuned.

Phase separation

Inducing weak attractive interactions between colloids can produce a phase separation similar to a spinodal demixing. A weak depletion interaction can be obtained if a non adsorbing linear polymer is added to the background fluid (Fig.1). This depletion pushes the colloids together, creating an arrested structure with well defined features at the macroscopic level (Fig. 2).

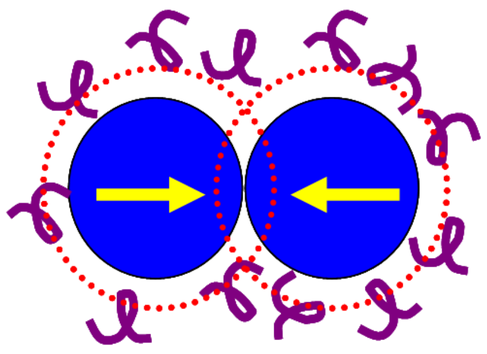

Fig. 1: Depletion interaction due to an unbalanced osmotic pressure

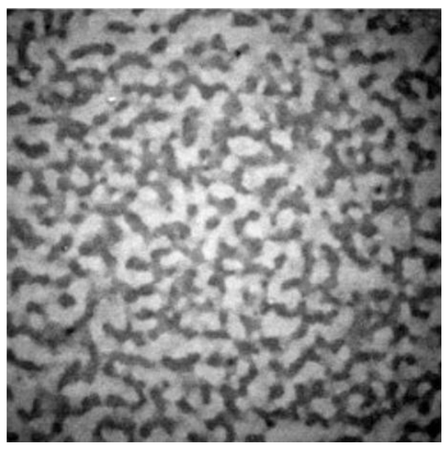

Fig. 2: Structures induced by phase separation proven by CARS microscopy images

Static and dynamic information

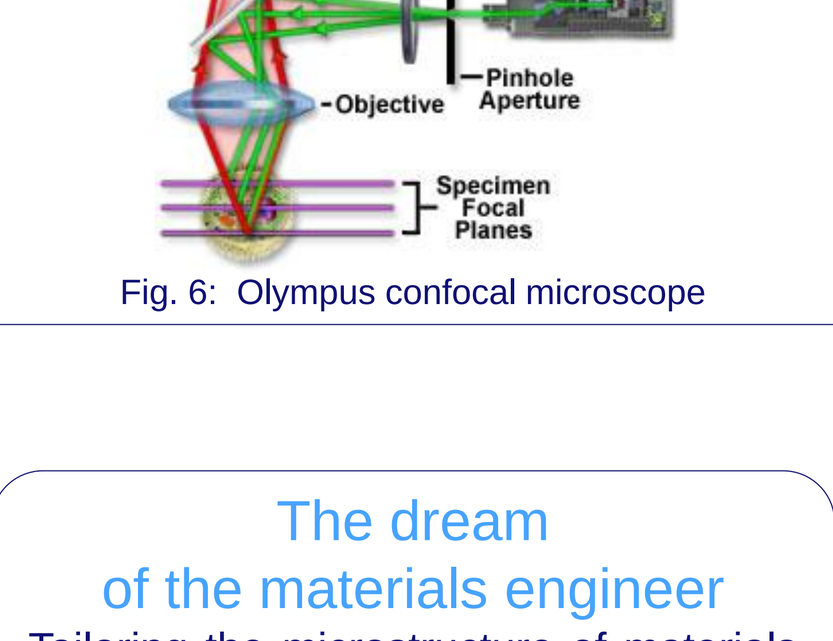

Fig. 5: Static and dynamic light scattering setups

Structure information

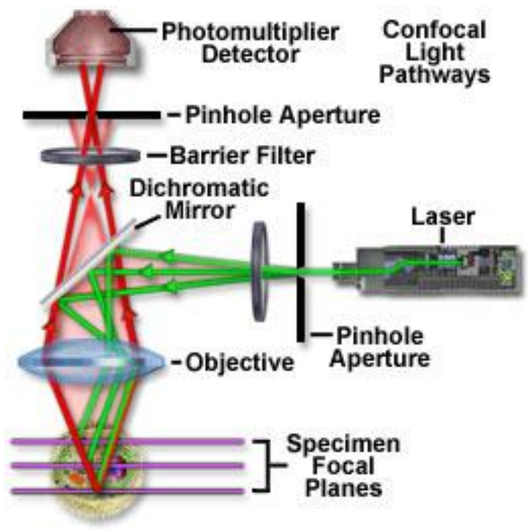

Fig. 6: Olympus confocal microscope

Convection

Using the setup presented in Fig. 3 and by heating the bottom plate an unstable density gradient is created in the suspension. Depending on the conditions, different morphologies can be obtained (Fig. 4). After creating the patterns, different ”freeze-in” mechanisms will be applied by inducing strong interactions between the particles. This will create a well defined colloidal gel network.

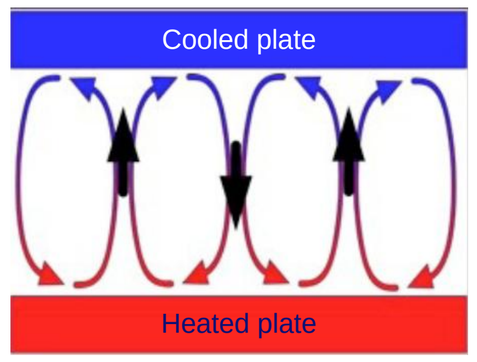

Fig. 3: Schematic representation of Rayleigh-Bénard convection

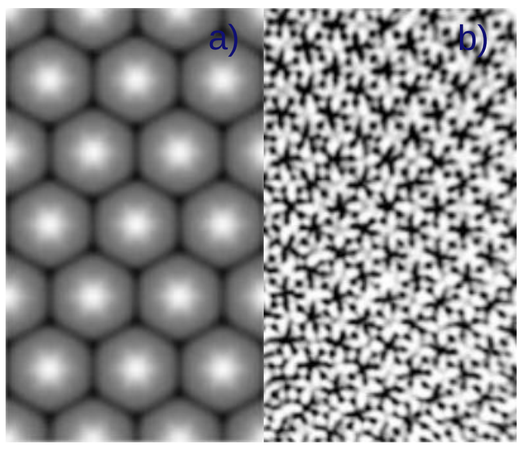

Fig. 4: a) Hexagonal patterns
b) Complex patterns

The dream of the materials engineer

Tailoring the microstructure of materials without limitation by the chemical composition.