

## CPP 8: Focus Session: Photonic Structures from Polymer and Colloidal Self-Assembly

organized by Ilja Gunkel (University of Fribourg) and Bodo Wilts (University of Salzburg)

Time: Monday 15:00–17:15

Location: H38

**Invited Talk** CPP 8.1 Mon 15:00 H38  
**Stimuli-Responsive Opal Films based on Core-Shell Particle Self-Assembly** — ●MARKUS GALLEI — Lehrstuhl für Polymerchemie, Universität des Saarlandes, Campus C4 2, Saarbrücken

In the last decade stimuli-responsive polymers have proven their feasibility for a wide range of important applications. These polymers are capable of changing their conformation, solubility, or they can even break or form covalent bonds upon a change of temperature or pH, light irradiation or by electrochemical stimuli, or combinations thereof. The presentation will focus on materials, which contain at least one selectively addressable segment, either chemically or physically. Functional porous nanostructures based on inverse opal films obtained after shear-induced particle self-assembly will be highlighted and discussed in more detail. In the case of soft colloidal crystal and their inverted structures, external triggers additionally lead to a remarkably fast and reversible change of their intriguing optical properties. Moreover, such opal structures can be used for the design of smart catch and release systems based on responsive moieties, but also as soft templates for ceramic materials. The talk will give some recent examples for the rational design of functional organic as well as hybrid porous materials with hierarchical architectures. Some of the highlighted polymer or polymer-templated structures can be advantageously used for direct conversion into ordered ceramic or carbonaceous materials. Herein presented preparation strategies will pave the way for a manifold of applications in the field of sensing and robust membrane technologies.

CPP 8.2 Mon 15:30 H38  
**Strategies for increased colour saturation in colloidal photonic crystals** — ●GUDRUN BLEYER<sup>1</sup>, CARINA BITTNER<sup>1</sup>, LUKAS ROEMLING<sup>1</sup>, NICO NEES<sup>2</sup>, ERIC GOERLITZER<sup>1</sup>, and NICOLAS VOGEL<sup>1</sup> — <sup>1</sup>Institute of Particle Technology (LFG), FAU, Erlangen, Germany — <sup>2</sup>Chair of Applied Mathematics, FAU, Erlangen, Germany

Monodisperse polystyrene nanoparticles are easily synthesized using surfactant free emulsion polymerization, making them ideal accessible building block for photonic crystals via self-assembly.

However, structures made only with polystyrene display a whitish hue of colour as incoherent scattering at defects in the crystal structure overlaps with the photonic stop band from constructive interference. We investigate how the colour saturation in colloidal photonic crystals depends on the local and global ordering of the particles and the absorptive properties of additive materials.

First, we assemble photonic crystals using two methods resulting in structures displaying different defect characteristics. We then correlate the photonic properties as a function of these defects using correlative microscopy connecting optical imaging, reflectance spectra and SEM measurements to establish the structure-property relationship.

Secondly, we introduce absorbing material at defined positions within the colloidal photonic crystal with the goal to optimize not only the amount but the absorber position as well, allowing for an optimized colour saturation.

**Invited Talk** CPP 8.3 Mon 15:45 H38  
**Self-assembled photonic pigments from bottlebrush block copolymers** — ●RICHARD PARKER, TIANHENG ZHAO, ZHEN WANG, CLEMENT CHAN, and SILVIA VIGNOLINI — Yusuf Hamied Department of Chemistry, University of Cambridge, United Kingdom

The self-assembly of bottlebrush block copolymers (BBCPs) into photonic materials has drawn significant attention due to the flexibility and diversity of the building blocks that can be synthesised. In this talk we will introduce a robust strategy for the fabrication of hierarchical photonic pigments via the confined self-assembly of BBCPs within emulsified microdroplets. By utilising an amphiphilic BBCP and optimising the emulsification conditions, we will demonstrate the formation of structurally coloured particles with a correlated disor-

dered structure (i.e. a photonic glass) and compare them to particles with a highly-ordered concentric lamellar structure (i.e. a 1D photonic crystal). The mechanisms behind these two different architectures will be proposed and methods to tune the reflected colour of the respective systems considered. Finally, the strengths and weaknesses of the two approaches will be summarised in terms of the optical properties of the particles, the scalability of the approach and their viability as real-world colorants.

CPP 8.4 Mon 16:15 H38  
**Elucidating the chiral self-assembly of cellulose nanocrystals for photonic films** — ●THOMAS PARTON, RICHARD PARKER, GEVA VAN DE KERKHOF, AURIMAS NARKEVICIUS, JOHANNES HAATAJA, BRUNO FRKA-PETESIC, and SILVIA VIGNOLINI — Department of Chemistry, University of Cambridge, United Kingdom

Cellulose nanocrystals (CNCs) are naturally-sourced elongated nanoparticles that form a cholesteric colloidal liquid crystal phase in suspension. Interestingly, this helicoidal arrangement can be preserved upon drying to create films with vibrant structural colour. However, while CNCs have drawn significant attention as a way to produce sustainable photonic materials, the underlying mechanism by which chirality arises in the mesophase remains unclear. Although the morphology of individual CNCs is believed to play an important role, most particles are not strongly twisted, and the suspensions exhibit considerable polydispersity in both particle size and shape.

In this study, we performed an in-depth morphological analysis of CNCs observed using transmission electron microscopy (TEM) and atomic force microscopy (AFM). We sequentially tuned the size and shape of the CNCs using ultrasonication and correlated the morphology of individual nanoparticles with their ensemble liquid crystalline behaviour and photonic response. This analysis revealed that a sub-population of CNC “bundles” (i.e. clusters of laterally-bound elementary crystallites) act as chiral dopants, analogous to those used for molecular liquid crystals, and are therefore essential for the formation of the cholesteric phase.

**15 min. break**

**Invited Talk** CPP 8.5 Mon 16:45 H38  
**Hierarchically structured mechanochromic deformation-sensing pigments** — ●JESSICA CLOUGH<sup>1</sup>, CÉDRIC KILCHOER<sup>1</sup>, BODO WILTS<sup>1,2</sup>, and CHRIS WEDER<sup>1</sup> — <sup>1</sup>Adolphe Merkle Institute, University of Fribourg, Chemin des Verdiers 4, Fribourg 1700, Switzerland — <sup>2</sup>Chemistry and Physics of Materials, University of Salzburg, Jakob-Haringer-Str. 2a, 5020 Salzburg, Austria.

Mechanochromic materials can change their colour in response to mechanical force and are useful for fundamental studies as well as practical applications. A versatile platform with extended sensing capabilities would be valuable for monitoring complex mechanical behaviours and failure events. Here, we report that this is possible by combining photonic structures, which alter their reflection upon deformation, and covalent mechanophores, whose absorption changes upon mechanically induced bond scission, in hierarchically structured assemblies. This was achieved by synthesising microspheres of an elastic polymer with spiropyran-based cross-links and incorporating non-close-packed silica nanoparticles into this matrix. The shift of the reflection band produced by the silica is noticeable at less than 1% strain, while the conversion of the spiropyran can require strains exceeding 50%. The two responses can be tailored via the silica content and the cross-link density. The mechano-sensing pigments can readily be incorporated into different materials of interest and probe local deformations from within. This was demonstrated by monitoring high-strain deformation of poly(dimethyl siloxane) in compression and local strain field variations caused by the necking of semicrystalline polyethylene.