Self-Assembly of Discotic Rings and Nanowires in a Liquid Crystal Confined in Nanopores

Kathrin Sentker[1]*, Arne W. Zantop[2], Arda Yildirim[3], Milena Lippmann[4], Tommy Hofmann[5], Oliver Seeck[4], Andriy V. Kityk[6], Andreas Schönhals[3], Marco G. Mazza[2], Patrick Huber[1]

[1]*Institut für Werkstoffphysik und – technologie, Technische Universität Hamburg-Harburg (DE)*
[2]*Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen (DE)*
[3]*BAM Bundesanstalt für Materialforschung und –prüfung, Berlin (DE)*
[4]*Deutsches Elektronen - Synchrotron DESY, Hamburg (DE)*
[5]*Helmholtz- Zentrum für Materialien und Energie, Berlin (DE)*
[6]*Faculty of Electrical Engineering, Czestochowa University of Technology (PL)*

Discotic Liquid Crystals (DLC) tend to stack up into linear columns creating charge carrier pathways along the stacking direction due to overlapping π-electrons. Embedding DLCs into nanoporous membranes enables the preparation of organic molecular nanowires or nanorings. Combining high-resolution optical birefringence, measuring orientational order [1,2], and synchrotron-based X-ray diffraction, measuring translational order, we found a pore size and anchoring condition dependent orientational transition from the circular (nanoring) to axial (nanowire) orientation in anodic aluminum oxide nanopores. Thereby, for nanopores smaller than 20 nm, an additional component to the pore size dependent phase transition temperature shift following the Gibbs-Thomson mechanism is found [3]. Additionally, and in combination with Monte Carlo simulations, we show that confining the same thermotropic DLC in cylindrical silica nanopores induces a quantized formation of annular layers consisting of concentric circular bent columns, unknown in the bulk state, see Fig. 1. Starting from the walls this ring self-assembly propagates layer-by-layer towards the pore center. By establishing a Gibbs free energy phase diagram the phase transition quantization is traced back to the discreteness of the layers' excess bend deformation energies in comparison to the thermal energy allowing the determination of the otherwise hard to access bend elastic constant [4].

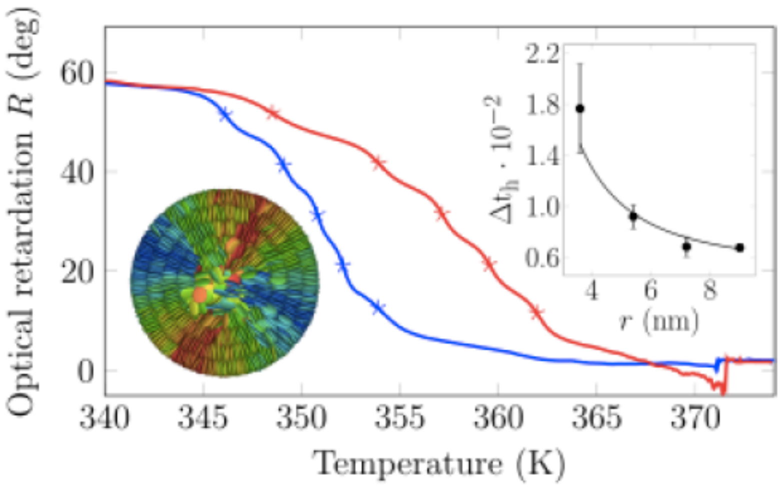

Fig. 1: Measured temperature evolution of the optical retardation R of HAT6 in confinement. Inset: Normalized supercooling temperature for the isotropic-columnar transition of each annular layer and snapshot from Monte Carlo simulations.

References

[1] S. Calus et al., Microporous and Mesoporous Materials 197 (2014).
[2] A.V. Kityk et al., Soft Matter 10 (2014).
[3] K. Sentker et al., in preparation.
[4] K. Sentker et al., submitted.

*Corresponding author e-mail: kathrin.sentker@tuhh.de