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S E M I N A R
aus
Halbleiterphysik und Nanotechnologie

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"Understanding Engineering Materials in Nature"

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A main characteristic of biological structural materials is their optimisation of several, sometimes even competing properties. In the case of wood, high strength is obtained at a relatively low mass density, making wood more favourable for lightweight constructions than e. g. steel. Silk combines high extensibility with high mechanical strength. The key to those unique mechanical properties lies in the hierarchically organised micro- and nanostructure with nanocrystals embedded in a softer, disordered matrix in the fashion of a composite material. Scattering techniques using synchrotron radiation and neutrons are ideal tools for the investigation of nature's engineering materials as they cover all the relevant length and time scales. They are sensitive to the most relevant structural parameters, e. g. lattice constants (including internal stress), orientation distributions and molecular disorder.

The main constituent of the wood cell wall is crystalline cellulose. The nanocrystals, so-called microfibrils, are arranged in a helix would around the wood cell. X-ray micro- [1] and nanodiffraction [2] provided a detailed image of the layered wood cell wall. The mechanical properties and their dependence on the water content were measured *in situ* [3].

In the case of silkworm silk, new models were developed to explain how the yield mechanisms of both the fibroin nanocrystals and the disordered matrix contribute to the mechanical properties. We used a combination of high-resolution mechanical relaxation experiments [4], *in situ* neutron small-angle scattering [3] and spectroscopy [5], *in situ* X-ray microdiffraction [4] and high-pressure experiments [6]. Based on our findings, native silk fibres were functionalised with chromophores in order to make them optically switchable; again, the mechanical switching effect is readily visible in X-ray diffraction experiments [7].

References

[1] - H. Lichtenegger, M. Müller, O. Paris, C. Riekel, P. Fratzl, J. Appl. Cryst. **32**, 1127 (1999).
[2] - M. Ogurreck, H. Lichtenegger, M. Müller, J. Appl. Cryst. **43**, 256 (2010).
[3] - M. Müller, I. Krasnov, M. Ogurreck, M. Blankenburg, T. Pazera, T. Seydel, Adv. Eng. Mat. **9**, 767 (2011).
[4] - I. Krasnov, PhD Thesis, Kiel University (2013).
[5] - I. Krasnov, T. Seydel, M. Müller, *Phys. Rev. E* **91**, 042716 (2015).
[6] - C. Krywka, I. Krasnov, R. Figuli, M. Burghammer, M. Müller, Macromolecules **47**, 7187 (2014).
[7] - I. Krasnov, N. R. Krekiehn, C. Krywka, U. Jung, A. U. Zillohu, T. Strunskus, M. Elbahri, O. Magnussen, M. Müller, *Appl. Phys. Lett.* **106**, 093702 (2015).