MM 60: Topical session (Symposium EPS and MM): Mechanical Properties at Small Scales

Functional Mechanics

Time: Thursday 15:45–16:45 Location: H 0106

MM 60.1 Thu 15:45 H 0106

Interpenetrating-phase metal-polymer composites mimicking mechanical behavior of bone — •Ilya Okulov[1], Artem Okulov[1,2], Jörg Weissmüller[1,3], and Jürgen Markmann[1,3] — [1]Helmholtz-Zentrum Geesthacht,Geesthacht, Germany — [2]Institute of Metal Physics of the Ural Branch of the Russian Academy of Sciences, Ekaterinburg, Russia — [3]Hamburg University of Technology, Hamburg, Germany

The close match of stiffness between an orthopedic implant material and cortical bone is critically important to ensure fast healing of injured tissues. However, due to its complex composite microstructure, bone exhibits quite a unique mechanical response. In order to mimic bone's mechanical properties, we developed interpenetrating-phase metal-polymer composites. The composites were fabricated by impregnation of epoxy resin into biocompatible open porous metallic scaffolds. The metallic scaffolds were synthesized by liquid metal dealloying - a metallurgical process for synthesis of porous materials by means of selective corrosion in a liquid metal [1,2]. The yield strength of the composites exceeds that of cortical bone while its stiffness remains in a range of that for cortical bone. Moreover, the composites exhibit high strain rate sensitivity similar to bone. These findings suggest advantages for biomedical applications of the current composites, e.g. as materials for orthopedic implants.

[1] T. Wada, K. Yubuta, A. Inoue and H. Kato, Materials Letters 65, 1076-1078 (2011). [2] I.V. Okulov, J. Weissmüller and J. Markmann, Scientific Reports 7, 20 (2017).

MM 60.2 Thu 16:00 H 0106

Structural investigations of spider attachment hairs — •Silja Flenner[1], Imke Greving[1], Emanuel Larsson[1], Clemens Schaber[2], Christina Krywka[1], Stanislav N. Gorb[2], Martin Rosenthal[3], Manfred Burghammer[3], and Martin Müller[1] — [1]Institute of Materials Research, Helmholtz-Zentrum Geesthacht, Germany — [2]Institute of Zoology, Kiel University, Germany — [3]ESRF, Grenoble, France

The hairy attachment system of spiders enables these animals to walk upside-down on rough and smooth surfaces without the use of glue. These outstanding biological structures comprise of pads including hundreds to thousands of specially designed hairs that are made of composite materials consisting of proteins and reinforcing chitin fibres.

The goal of our study is to gain an in-depth understanding of the structure-function mechanism of the attachment and detachment processes of single hairs to a surface. X-ray Tomographic Microscopy and Scanning X-ray nanobeam diffraction are ideal tools to reveal the inner structure of the spider hairs and allow to determine the gradient of the mechanical properties which is essential for the attachment process.

With both techniques we found that the shaft of the attachment hair is hollow. Wide Angle X-ray scattering of the shaft revealed, that in contrast to the tip region, oriented α-chitin was present, indicating the presence of chitin crystals in the shaft region. These results suggest that the tube-shaped hollow part of the hair in combination with the presence of chitin crystals along the tube is needed to withstand the strong forces which occur during attachment/detachment process.

MM 60.3 Thu 16:15 H 0106

Influence of flexoelectricity on nanomechanical properties of ferroelectrics — •Gustau Catalan[1], Kumara Cordero-Edwards[2], Fabian Vasquez-Sanchez[2], Amir Abdollahi[3], and Neus Domingo[2] — [1]ICREA-Institucio Catalana de Recerca i Estudis Avançats, Barcelona, Catalonia — [2]ICN2-Institut Catala de Nanociencia i Nanotecnologia, Barcelona, Catalonia — [3]Universitat Politecnica de Catalunya (UPC), Barcelona, Catalonia

Flexoelectricty is a coupling between strain gradients (inhomogeneous deformations) and electric polarization. It is allowed by symmetry in all materials, but it is strongest in those with high dielectric constants, such as ferroelectrics. Because of flexoelectricity, the electrostatic energy cost of very inhomogeneous deformations, such as those that can be induced at the nanoscale due to e.g. nanoindentation or cracking, can be enormous. Flexoelectricity thus has a strong impact on the mechanical response of materials (and particularly ferroelectrics) at the nanoscale.

Here I will present results that have profound implications for our understanding of solid state mechanics and fracture physics. Specifically, due to flexoelectricity the indentation response and also the fracture propagation in ferroelectrics can be asymmetric: cracks travelling parallel to the ferroelectric polarization become much longer than tose travelling against it. This discovery challenges the general notion that mechanical properties of matter are symmetric with respect to space inversion. Some implications and possible applications of this discovery will be discussed.