SYBM 1: Symposium Bioinspired Materials

Time: Thursday 9:30–12:15 Location: H1

Invited Talk SYBM 1.1 Thu 9:30 H1

Using Ice to Mimic Nacre: From Structural Materials to Artificial Bone — •A. P. Tomsia, S. Deville, and E. Saiz — Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

Despite extensive efforts in the development of fabrication methods to prepare porous ceramic scaffolds for osseous tissue regeneration, all porous materials have a fundamental limitation - the inherent lack of strength associated with porosity. Shells (nacre), tooth and bone are frequently used as examples for how nature achieves strong and tough materials made out of weak components. So, the unresolved engineering dilemma is how to create a scaffold that is both porous and strong. The objective of this study was to mimic the architecture of natural materials in order to create a new generation of strong hydroxyapatite-based porous scaffolds. The porous inorganic scaffolds were fabricated by the controlled freezing of water-based hydroxyapatite (HA) slurries. The scaffolds obtained by this process have an ordered and homogeneous lamellar architecture that exhibits striking similarities with the meso- and micro- structure of the inorganic component of nacre. Compressive strengths of 20 to 60 MPa were measured for lamellar scaffolds with densities of 32 to 45%, significantly better than for the HA with random porosity. In addition, the lamellar materials exhibit gradual fracture unlike conventional porous HA scaffolds. These biomimetic scaffolds could be the basis for a new generation of porous and composite biomaterials.

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Invited Talk SYBM 1.2 Thu 10:00 H1

On the structure of biogenic $CaCO_3$ — •B. Pokroy — Department of Materials Engineering, Technion Israel Institute of Technology, Technion City, Haifa 32000 (Israel)

Organisms produce a large number of minerals in the course of biomineralization. These biogenic minerals have been extensively studied because of their fascinating mechanical, optical and magnetic characteristics and their capability to effectively control the polymorph selection and crystal morphology. Calcium carbonate, $CaCO_3$, is by far the most abundant biogenic mineral and it exists in different structural forms (listed in the order of descending thermodynamic stability at normal conditions): calcite, aragonite, vaterite and amorphous calcium carbonate.

By performing accurate structural measurements by high-resolution x-ray powder diffraction on a synchrotron beam line the unit cell parameters of biogenic $CaCO_3$ crystals were found to be slightly distorted as compared to that of their geological counterparts. Moreover, neutron diffraction revealed that the atomic bonds of these biogenic crystals are also distorted.

I will show that these structural distinctions are caused by intra-crystalline organic molecules.

Theses results imply that organisms can control biogenic crystals on the nm scale.

Invited Talk SYBM 1.3 Thu 10:30 H1

Bio-Inspired Hybrid Materials from Block Copolymer Assemblies and Nanoparticle Co-assemblies — •U. Wiesner — Department of Materials Science & Engineering, Cornell University, Ithaca, NY 14853-1501, USA

The study of bio-inspired block copolymer based self-assembly (bottom-up) approaches to multifunctional polymer-inorganic hybrid materials is an exciting emerging research area interfacing solid state and soft materials and offering enormous scientific and technological promise. By choice of the appropriate synthetic polymer blocks as well as nanoparticles unprecedented morphology control down to the nanoscale is obtained. Tailoring of the polymer-inorganic interface is of key importance. The structures generated on the nanoscale are a result of a fine balance of competing interactions, a typical feature of complex biological systems. The potential for new multifunctional materials lies in the versatility of the polymer chemistry as well as that of the inorganic chemistry that can be exploited in the materials synthesis. In the present contribution the synthesis and characterization of nanostructued hybrid materials will be presented with potential applications ranging from microelectronics to nanobiotechnology. In all cases cooperative self-assembly of organic and inorganic species is induced by amphiphilic macromolecules, either block copolymers or extended amphiphilic dendrons, which are blocked species with one block being highly branched. Besides amorphous and crystalline oxide materials novel systems toward high temperature SiCN and SiC structures are introduced.

15 min break

Invited Talk SYBM 1.4 Thu 11:15 H1

Bio-Inspired Organic-inorganic Hybrid Materials — •U. Steiner — University of Cambridge, Department of Physics, Cavendish Laboratory, Madingley Road, Cambridge CB3 0HE (UK)

Pattern formation in physics and chemistry is a consequence of non-linear processes, which are of fundamental interest. Recently, pattern formation by self-assembly or by instabilities in liquids were also employed in soft-lithographic methods. Patterns occurring in living organisms, on the other hand are formed under stick biological control and serve a specific purpose for the organism. Since the relationship between the pattern and its function was optimised by evolution, patterns occurring in nature are an interesting repository for physical effects that can be achieved by controlling physico-chemical pattern formation processes.

My presentation will discuss three examples of this biomimetic approach: (i) optical effects in structured films (anti-reflection and structural colours), (ii) structured super-hydrophobic surfaces, and (iii) structured bio-mimetic minerals.

Invited Talk SYBM 1.5 Thu 11:45 H1

Structural, Nanomechanical, and Nanotribological Characterization of Human Hair Using Atomic Force Microscopy and Nanoindentation — •Bharat Bhushan — The Ohio State University, Columbus, Ohio 43210 USA

Maintaining the health, feel, shine, color, softness, and overall aesthetics of the hair is highly desired. Hair care products such as shampoos and conditioners, along with damaging processes such as chemical dyeing and permanent wave treatments, affect the maintenance and grooming process and are important to study because they alter many hair properties. Nanoscale characterization of the cellular structure, mechanical properties, and morphological, frictional, and adhesive properties of hair are essential to evaluate and develop better cosmetic products, and to advance the understanding of biological and cosmetic science. Another property of interest is surface charge of hair which has a significant effect on manageability, feel, and appearance. Controlling charge buildup to improve these factors is an important issue in the commercial hair care industry. The atomic/friction force microscope (AFM/FFM) and nanoindenter have recently become important tools for studying the micro/nanoscale properties of human hair. In this talk, we present a comprehensive review of structural, mechanical, and tribological properties of various hair and skin as a function of ethnicity, damage, conditioning treatment, and various environments.