where macroscopic softening sets in, but at a much higher critical temperature.

"This means that there is a temperature range, extending over almost 200°C, where the atoms still move exclusively like in a solid by local hopping over thermal barriers, although macroscopically the system already behaves like a viscous liquid. As in the glassy state, this hopping involves the coordinated motion of many atoms," said Faupel.

Faupel said that the critical temperature was found to be exactly located at the temperature T_c where the so-called mode-coupling theory predicts the freezing-in of liquidlike motion upon cooling. The T_c was obtained from quasi-elastic neutron scattering by A. Meyer at the Munich University of Technology.

"Moreover, our isotope-effect measurements, which are the first measurements of this kind near T_c in any material, demonstrate that even in the equilibrium melt of the novel bulk-glass-forming alloys, the atomic dynamics are highly coordinated and far away from the hydrodynamic limit of uncorrelated binary collisions," Faupel said. "This seems to be a prerequisite of the exceptional glass-forming abilities."

Nature Designs Hard and Tough Materials at the Nanoscale

The nanoscale size of mineral particles in bone, teeth, and other biological materials may have evolved to ensure optimum strength and maximize tolerance of flaws, according to a research team from the Max Planck Institute for Metals Research (MPI), the Austrian Academy of Sciences, and the University of Leoben. While it is clear that the composite character of biological materials plays an important role in determining their strength, little is known about the role of the nanometer scale of mineral particles. The research team reports in the May 13 issue of the *Proceedings of the National Academy of Sciences* that there exists a critical nanometer size at which the particles found in biocomposites become insensitive to flaws: They maintain strength equivalent to a perfect crystal despite inherent defects. This phenomenon also suggests that the engineering concept of stress concentration at flaws is no longer valid for nanoscale design.

Biomaterials like bone are molecular composites of proteins and biominerals. While the stiffness of biocomposites is similar to that of the mineral, their fracture energy can be several orders of magnitude higher than the mineral. For example, the composite shell of nacre shows a fracture strength that is 3000 times higher than its mineral constituent $CaCO_3$. Despite the complicated hierarchical structures of biocomposites, the smallest building blocks in biological materials are generally on the nanometer length scale and aligned in a generic structure of mineral platelets staggered in a protein matrix.

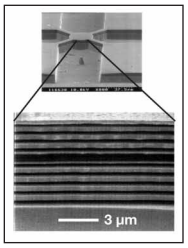
H. Gao of MPI, I.L. Jäger of the Academy and the University of Leoben, and coworkers have found that this generic nanostructure of biomaterials may be the key to the high fracture strength of these materials. Their analysis demonstrates that the mineral crystals carry the tensile load while the protein matrix transfers the load between mineral crystals by shear. The mineral crystals have large aspect ratios in order to compensate for the large differences in stiffness between mineral and protein. In order to ensure integrity and strength of the composite structure, the mineral crystals must be able to sustain large tensile stress without fracture. The tensile strength of mineral crystals is the key to the composite strength.

Using a simple model, the scientists illustrated that cracked mineral crystals below a critical nanometer size, estimated at 30 nm, have fracture strength identical to that of a perfect, defect-free crystal. They further developed a finite element method to demonstrate that the stress field near a growing crack becomes more and more uniform as the thickness of the structure decreases, eventually reaching the theoretical strength at the critical size. A particle smaller than this size becomes insensitive to cracklike flaws. The findings may explain why bone, which has particles a few nanometers thick, is stronger than shell, which has particles a few hundred nanometers thick. The scientists suggest that because materials become insensitive to flaws at this critical nanometer size, the engineering concept of stress concentration at flaws is no longer valid for nanoscale design. □

Corrections

An article in the February 2003 issue of *MRS Bulletin*, "Cosmic-Ray Neutrons on the Ground and in the Atmosphere," by P. Goldhagen, contained two incorrect entries in Table I: Cosmic-Ray Neutron Fluence Rates Measured at Various Locations (p. 134). In the column under "$E > 10$ MeV Fluence Rate (cm^{-2} s^{-1})," the correct entries for the second and third rows are 2.5 and 2.3, respectively, not 6.9 and 6.2.

On the cover of the May 2003 issue of *MRS Bulletin* on Photonic Materials for Optical Communications, an incorrect scale was included in the micrograph of the photon wave resonator (right bottom image on the cover). The correct version is reproduced here. See LETTERS TO THE EDITOR in this issue for a detailed explanation from H. Hillmer, guest editor of the May 2003 issue, of the parallel between quantum electronics and quantum photonics as represented on the cover of the issue.



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