Researchers produce insulation with lowest thermal conductivity ever

December 14 2006

A new insulation material with the lowest thermal conductivity ever measured for a fully dense solid has been created at the University of Oregon and tested by researchers at three other U.S. institutions. While far from having immediate application, the principles involved, once understood, could lead to improved insulation for a wide variety of uses, the scientists say.

In a paper published online Dec. 14 on *Science Express*, in advance of regular publication in the journal Science, the scientists describe how they used a novel approach to synthesize various thicknesses of tungsten diselenide. This effort resulted in a random stacking of tungsten-diselenide planes (WSe_2), possibly leading to a localization of lattice vibrations.

The resulting synthesized material, they report, resulted in thermal conductivity -- the rate at which heat flows through a material -- 30 times smaller than that for single-crystal WSe_2 and a factor six smaller that the minimum level predicted by theoretical computations for the cross-plane thin films used in the experiments.

Surprisingly, creating a fully disordered structure by bombarding the films with ions to destroy the order in the two-dimensional planes actually increases thermal conductivity, said David C. Johnson, a professor of chemistry at the University of Oregon and member of the UO Materials Science Institute.

"The reason for the extraordinarily low thermal conductivity that we've now achieved is an unusual structure which is crystalline in two directions but has a subtle rotational disorder in the direction of low-heat conduction," Johnson said.

The material prepared in Johnson’s lab "is the closest thing that anyone has found to making a dense solid into a perfect thermal insulator," said co-author and corresponding investigator David G. Cahill, a professor of materials science and engineering at the University of Illinois at Urbana-Champaign. "This material would not be practical for insulating a refrigerator, the wall of a house or parts inside a turbine engine, but the new physical properties displayed by this material might some day point the way toward methods of creating more effective practical insulations."

The approach is a new alternative to one described by Cahill and others in separate journals in the last two years in which researchers reduced minimum thermal conductivity by manipulating thin films of metals and oxides by adjusting interfaces of the materials by only a few nanometers.

"Thermal conductivity is an important property in both conserving energy and in converting between forms of energy," Johnson said. "Obtaining low thermal conductivity in a thermoelectric material, which converts temperature gradients into electrical energy, increases efficiency."

The properties of Johnson's material were measured in Cahill's Illinois laboratory. The structure was analyzed at the Argonne National Laboratory in Argonne, Ill. Computational simulations and molecular modeling of the layered crystals was carried out by researchers at Rensselaer Polytechnic Institute (RPI) in Troy, N.Y.

Source: University of Oregon