mineral, pyrochlore, results when the size of the cation pairs differs so much that they cannot easily trade places. A structure more similar to that of the purple mineral, fluorite, occurs when the pairs are close in size. In this case, the cations switch places readily, creating a poorly ordered pattern.

In the past, scientists held that the materials with the brown pyrochlore structure were promising candidates for use in waste containment because they would be chemically compatible with the waste constituents. Whether such storage materials would withstand the long-term effects of radiation, however, has been unclear.

Radiation-induced defects would cause more commotion in the rigid crystal structure of the pyrochlore group.

"If a material wants to be highly ordered, and the defects are putting atoms where the material doesn't want them, that raises the energy in the structure. Ultimately, the material may have so much energy that it will suffer unwanted structural change," said Kurt Sickafus of Los Alamos National Laboratory in New Mexico.

As reported in the August 4 issue of *Science*, Sickafus and his colleagues have used computer simulations in determining that in these materials, atoms can shift around to accommodate the defects with little effort.

The researchers performed some preliminary experiments, irradiating one crystal with a pyrochlore structure, and another with a fluorite structure. As the team had predicted, the highly ordered atoms in the pyrochlore structure changed into an amorphous jumble, while the fluorite structure remained intact.

Both the pyrochlore- and fluorite-type complex oxides are crystalline materials, meaning they consist of units of atoms that, overall, are regularly spaced. Sickafus and his colleagues suspect that other crystalline materials with relatively disordered structures may be resistant to radiation damage as well.

Phage-Display Libraries Allow Identification, Development, and Amplification of Binding between Organic Peptides and Inorganic Semiconductors

Living systems can be used to produce microscopically small components of uniform size that potentially can be used to build electronic devices, according to researchers at The University of Texas at Austin. By combining proteins from viruses with inorganic elements commonly used as semiconductors, the research team produced hybrid materials called electronic biocomposite materials. By extending the processes that result in naturally occurring biocomposites to substances commonly used in construction of electronic components, the scientists said they are paving the way for development of potential building blocks for transistors, wires, connectors, sensors, and computer chips far smaller than devices manufactured so far.

As reported in the June 8 issue of *Nature*, Angela M. Belcher, an assistant professor in the Department of Chemistry and Biochemistry, and her graduate student Sandra R. Whaley have been isolating viruses containing proteins that can recognize and combine with gallium arsenide, silicon, indium phosphides, and zinc selenide. Belcher and her team have identified proteins at the ends of viruses that can tell the difference between similar semiconductor alloys and bind to the ones the scientists prefer.

When the living proteins bind to the inorganic particles chosen by the scientists, the particles eventually will be "assembled" by the proteins into desired patterns. In effect, the living organisms "grow" uniform components at the nanoscale.

Belcher said her team went through 100 million viruses before slowly determining which ones worked best with certain materials. She said various virus and semiconductor combinations were tried. Only proteins that bound themselves tightly to the semiconductor survived the experiment and were cloned by Whaley.

In a commentary on this topic published in the same issue of *Nature*, Chad A. Mirkin and T. Andrew Taton of the Center for Nanofabrication and Molecular Self-Assembly at Northwestern University said that the approach used by Belcher and her colleagues can be applied to all materials; in essence, they "may have discovered a way of directly interfacing biomolecules with any inorganic structure."

"Moreover," they said, "different parts of the same biomolecule could be designed to selectively recognize and organize multiple, inorganic building blocks, creating structures with even greater spatial control." □

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