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New Materials: Chemistry and Physics

New materials are receiving increasing attention in the science and technology communities. High strength, new electronic behavior, and novel optical properties are among the interesting and important features of these substances. With improved theoretical understanding and much better ability to measure properties, we have now reached a threshold where new materials may soon be designed rationally, with specific properties, rather than limited by accidental discovery or by limitations of synthetic methods which give only the thermodynamically controlled or most stable products. Because materials have properties that arise both from their chemical composition as well as their physical nature, they present a set of especially interesting challenges. In this issue of *Science* we present some examples where physics and chemistry are coming together to provide new insights and new possibilities in materials research. The great achievements already here, especially in electronics, provide promise of much to come in other areas.

DiSalvo presents an overview of some aspects of solid-state chemistry. He points out the long-term challenges that currently make the design and prediction of new families of solid-state compounds difficult. He addresses, in particular, extended solids as contrasted with molecular solids. Current research directions in selected areas are discussed.

High-temperature superconductivity is an area of special importance, but theory has not yet evolved to a state which is satisfactory for complete understanding. Cava describes crystal structures of copper oxide superconductors organized by structural families. A picture is presented by which common features of all these structures can be understood. Once the basic principles are laid out, the complexities are clarified.

Dye describes a new family of chemical compounds: electrides. These are ionic materials in which electrons trapped in cavities serve as the negative counterion. Interestingly, the ability to make these compounds is a consequence of the cation solvating compounds such as crown ethers and cryptands. Electron mobilities depend on the structure of the crystal. Because of their small mass and consequent quantum effects, the trapped electrons exhibit unusual and complex interactions.

Stucky and MacDougall deal with the nanosize regime in which quantum mechanical effects can modify the electronic and optical properties of materials. They discuss the strategy of using three-dimensional crystalline surfaces such as those found in zeolites to assemble clusters of fixed arrangement and size in a periodic lattice. These issues are of importance particularly in nonlinear phenomena that are used in electrooptics and optical switching.

Nonlinear optical materials are destined to play an important role, especially in communications, because of the higher mobility of photons, as contrasted with electrons, in many materials. Greene, Orenstein, and Schmitt-Rink discuss a simple theoretical model that treats both semiconductors and organics. This provides a framework on which to base expectations for optical nonlinearities in organic and inorganic materials. This work attempts to unify the inorganic semiconductor and organic fields, showing their differences and similarities. The potential for new devices and applications is also appraised.

Diamond, remarkable for its physical properties has, until recently, not been a "workable" material. Yarbrough and Messier discuss the synthesis and characterization of diamond. They provide a critical examination of major issues and problems in the chemical vapor deposition of diamond. The physical principles involved must be understood better in order to assess possibilities for using this technique to synthesize other materials.

Ancient civilizations are characterized by the kinds of materials that were in wide use (stone, iron, and bronze). We are now in an era in which many novel materials with extraordinary properties will bring us new and exciting advances; these will change our lives in important and unexpected ways.—JOHN I. BRAUMAN