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Materials Science

Materials science is currently experiencing major advances, both in basic understanding and in applications. Indeed, one of the great strengths of the field has been the close connection between the pure and applied aspects of the science. In this issue we present some exciting developments in materials science. Future issues will bring articles on areas not covered here.

Most of the topics are covered from the viewpoint of physical attributes rather than applications. In each article, however, we see a variety of applications to diverse areas ranging from structure to electronics. And, as the applications are broad, the field encompasses contributions from chemistry, solid-state physics, and electrical engineering, among others.

We start with disordered materials by Cheng and Johnson. Amorphous solids have been shown to have some remarkable properties. Active interests include synthesis of noncrystalline materials, atomic scale structural modeling, electronic structure and properties, transport and kinetic processes, and phase transitions. New conceptual developments deal with interesting aspects of the lack of long-range order. Glass describes new developments in optical materials. Display technologies have been a noteworthy area that has shown remarkable advances, but optics now appear in other areas of technology as well. These include optical devices at higher bandwidths than are possible with traditional methods, and the generation and transmission of very high energy densities (for example, in laser fusion) where spectacular advances are making new technologies viable.

Spaepen discusses recent advances in controlling the microstructure of metallic systems. Rapid solidification technology has revolutionized our ability to synthesize metals with new and important properties. In increasing order of metastability, the solidification product can be one with a finer grain size, a supersaturated solution, a metastable crystalline phase, or, if no crystallization occurs, a glass. One result has been the extraordinary discovery of icosahedral quasicrystals. Both metallic glasses as well as new crystalline materials play an important role. Ultrarapid heating and cooling techniques reveal new aspects of the kinetics of solidification.

Proceeding to more ordered materials, Baer, Hiltner, and Keith discuss hierarchical structure in polymeric materials, describing elegant new methods for controlling macroscopic properties by manipulating the chemical and physical aspects of synthesis. They focus on the molecular, nano-, micro-, and macrolevels and show how interactions at and between these levels affect each other. Semicrystalline, liquid crystalline, and amorphous polymers having flexible chains, rigid macromolecules, and multiphase components, respectively, have very different properties. From studies of biocomposites in natural polymeric systems important lessons can be learned and applied to synthetic materials.

Narayanamurti describes some exceptional examples of artificially structured materials. Molecular beam epitaxy and metal-organic chemical vapor deposition allow one to structure new materials on an atomic scale, resulting in the observation of new physical phenomena. New classes of electronic devices based on band-gap and wave function engineering arise from this work. New instrumentation plays a critical role in characterizing these materials.

Finally, Ehrenreich addresses the issue of theory in materials science. His insights into the role of theory in this strongly experimentally based science help tie together the basic science, its applications, and future developments that we may expect to see.

The diversity of the problems being attacked and solved, and the impressive progress already recorded, augurs well for more advances in this important science and technology. Helped by an also continuing advance in instrumentation and ancillary technologies, we expect continuing revelations.—JOHN I. BRAUMAN, *Department of Chemistry, Stanford University, Stanford, CA 94305*