SCIENCE

28 FEBRUARY 1992
VOLUME 255
NUMBER 5048

Frontiers in Materials Science

Materials and materials science and engineering play a major role in science because these areas play a major role in our lives. Materials are critical in satisfying human needs as well as human desires. In this issue of *Science*, we explore some advances in the science and technology of materials, in part because of the broad, interdisciplinary aspects of the field but also because of its relevance.

A recurring theme in these articles is rational synthesis and process control. The ability to make molecules and materials with well-defined properties, under controlled conditions, is one of the important characteristics of modern molecular science. Significant progress in understanding chemistry and physics has enabled us to develop new reactions and processes and thus make new materials and improve the properties of older materials. The era of "shake and bake" in synthesis is behind us.

Aircraft engines represent one of the most extreme tests of materials. Backman and Williams discuss advanced materials for aircraft engines. Turbine disks and blades are among the most demanding applications. High temperature and stress can lead to fatigue, corrosion, oxidation, and erosion. Currently, superalloys can be used at temperatures greater than 1200°C. The future will bring new intermetallic and composite materials that will make even lighter weight, stronger, and safer materials possible.

At the other extreme of applications are electronic materials. Synthesis in this area requires a detailed understanding of the physics and chemistry involved in depositing extremely small amounts of matter in precise physical arrangements and locations. Metiu, Lu, and Zhang describe computer simulations of the kinetics of epitaxial growth and the formation of aggregates during deposition of atoms on semiconductor surfaces. A qualitative understanding can be gained of processes such as aluminum segregation during the growth of AlGaAs coherent tilted superlattices and formation of islands during the deposition of silicon on Si(100) surfaces. These simulations become even more relevant as new experimental techniques allow us to examine atomic "clusters" as they are formed.

Wiley and Kaner discuss rapid solid-state precursor synthesis. Solid-state reactions often require long reaction times at elevated temperatures, in part because of the limited intimate contact between solid reactants and long diffusion path lengths. Metathesis (exchange) pathways can be used to initiate extremely rapid reactions at or near room temperature. These methodologies can be used to control particle size and to make high-quality ionic solid solutions.

Nature is a wonderful source of materials, and there is much to learn from the structure of natural materials and the way in which they are made. For example, living systems construct structural ceramic composites from readily available materials. Heuer *et al.* describe materials-processing strategies based on biomimetic approaches. Mother-of-pearl, dentin, enamel, cartilage, bone, and eggshell are bioceramics synthesized under low-temperature aqueous conditions. We even use some of these, such as Portland cement, for our own structural purposes. The biosynthetic rates range from very slow to quite fast. We need to adopt the best of what nature has to offer.

Finally, Allcock describes rational design and synthesis of new polymeric materials. The interest here is in using polymers in hybrid materials which are designed at the interface of ceramics, metals, and electroactive or electro-optic materials. Many materials have intrinsic advantages that naturally lead to some corresponding disadvantage, for example, strength versus brittleness. Hybrid materials may help to overcome some of the problems in this area.

In these special issues that present broad overviews we can see an indication of how well we, as scientists, are doing in our respective areas. Materials science is particularly interesting because of the close coupling between basic knowledge and applications. It is easy to make the case that our investment in this activity is a good one, as is obviously true in many other fields. It is also true for areas that appear initially to have fewer applications. However, the articles in this issue show how strongly fields of science are coupled together and how basic research in one area impacts on work in others. The dividends from support of science are spectacular and remain one of our best investments.—JOHN I. BRAUMAN