EDITORIAL

Materials Science

In this week's issue of *Science* we present one of our special issues on materials. A unifying theme of the articles is interfaces: how various materials associate with and relate to other materials. Much of the science and engineering of materials relates to interfaces within the material itself, as well as interfaces with other matter. In many cases, intrinsic properties of a material, such as its resistance to failure under working conditions or its optical properties, depend on how internal interfaces are engineering into a material or are prevented from forming. Similarly, the ways in which a material interacts with its surroundings, such as its resistance to wear or its biocompatibility, can determine its value. We present four articles, three perspectives, and a selection of research reports on materials science. In a special news section, we have three reports that examine how new materials can perform as devices.

In his article, Fréchet examines modern functional polymers. The functional groups in polymers—such as double bonds, amides, or esters—in the polymer chain or pendant to it, determine the reactivity, molecular architecture, and interfacial energy of the polymer. These reactive groups can participate in useful chemical processes without degrading the polymer chain and hence play a critical role in the interface between polymers and other surfaces. Design of new materials and new architectures depend importantly on our understanding of these interactions. In addition, the author discusses three-dimensional polymers—dendrimers—in which the reactive interfaces can be tightly controlled.

Peppas and Langer discuss creation and characterization of new biomaterials. Biomaterials are a particular challenge because critical interfaces between living tissue, including blood, can lead to rejection. Foreign materials, replacement for soft and hard tissue, adhesives, and dental materials all present interesting problems. Many conventional characterization methods, for instance, require high vacuum, yet biomaterials must be studied in a hydrated environment. Success in meeting these challenges will lead to advances in biosensor technology, surgical procedures, and drug delivery.

The interaction of bulk surfaces gives rise to adhesion. Kendall examines molecules and mechanics in adhesion at the molecular level and adhesion in engineering objects. He reminds us that macroscopic notions of glue and keyed joints need to be abandoned in the world of nanometer structures. Instead, theories should be based on reversible work and adhesion energy, including the extra energy required to restructure the interface as surfaces move. In thinking about adhesion, one must consider how surfaces jump into contact, undergo adhesive hysteresis, and then exhibit formation of adhesive strings and clusters at the surface.

The ultimate in interfaces is a monolayer film. Zasadzinski *et al.* discuss molecular order and organization in Langmuir-Blodgett (LB) films. Transfer of engineered monolayers from an air-water interface to another substrate affords a high level of control. As the authors discuss, many questions about LB films can be answered with scanning probe microscopy. Such probes reveal that thin organic films of fatty acid salts can exhibit liquid, hexatic, and crystalline order and van der Waals and strained layer epitaxy on various substrates. Sixty years after LB films were first developed, it now seems that this wide variety of structures will increasingly be used in the design of organic thin film devices.

In our Perspectives, we get views of three additional aspects of interfaces and materials. Lynden-Bell tells about fracture in computer simulations at the atomic level; in numerically "pulling apart" computer-simulated metals, for instance, we can learn much about the microscopic details of how materials fail. Marder and Perry discuss nonlinear optical materials and, in part, how their synthesis depends on the interaction with their environments; dramatic increases in our understanding of these substances open the possibility of real optical devices. Finally, Newman and Sieradzki discuss metallic corrosion, a phenomenon that erodes any industrialized nation's economy; as the authors report, new interfacial probes enable progress in characterizing and halting its effects.

New developments in materials increasingly involve conceptual scientific insights coupled with important engineering advances. This interplay between fundamental and applied science gives rise to important progress that profoundly affects our lives. It is important that the current public concern regarding the value of research be informed about the remarkably close coupling between much of fundamental science and its ultimate application.

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