EDITORIAL

Thin Films

Electronic devices, coatings, displays, sensors, optical equipment, and numerous other technologies all depend on the deposition of thin films. Even when well-established methods exist for the production of high-quality films, there is still considerable interest in alternative methods that may be less expensive, more reliable, or capable of producing films with novel or improved properties. In this special issue, we focus on some areas in which new technologies are challenging established routes to making thin films.

Inorganic light-emitting diodes (LEDs) are well established, but developers of organic devices have made considerable strides. The familiar gallium arsenide LED of home electronics will be joined by newly developed organic pixel displays. Sheats *et al.* survey the potential advantages of organic and polymer LEDs—such as low cost and full-color capabilities—as well as technical issues that must be addressed—such as efficiency and lifetime—before commercial applications are possible.

Hard inorganic coatings were originally developed for cutting tools, but now metal carbides, nitrides, and oxides are used on wearing elements such as bearings and even as decorative or protective coatings on doorknobs and pens. Sproul reviews methods for making hard superlattices, in which the properties of individual materials are greatly improved by the deposition of thin alternating layers of a second material (such as niobium nitride and titanium nitride). He also discusses the use of pulsed dc power for the rapid deposition of hard oxide films.

Nature also takes advantage of thin-film approaches: For example, seashells are built up through the complex chemistry in solution of inorganic and organic components at an interface. Aksay *et al.* discuss low-temperature biomimetic routes in which directed nucleation and growth of inorganics at self-assembled organic templates produce continuum films of single-phase ceramics. Low-temperature solution routes to inorganic films are desirable because of their technological simplicity (beakers and dip-coating). Lange reviews approaches that lead to epitaxial inorganic films of oxides, in which precursor films deposited on single-crystal substrates are converted through heating into polycrystalline and even single-crystalline films.

The vapor-phase growth of complex inorganic materials, especially layered compounds such as perovskite high-temperature superconductors, requires precise control of deposition conditions. Pulsed laser deposition, in which a laser beam ablates a material for deposition on a substrate, has progressed considerably. Lowndes *et al.* review some of the advantages of pulsed laser deposition, including use under reactive conditions and in cluster deposition, and discuss approaches for overcoming some of its potential drawbacks, such as the deposition of nonuniform films.

Thin films of nematic liquid crystals have long been harnessed for use in display technologies. Recent efforts to improve this technology have included work on ferroelectric liquid crystalline polymers, which take advantage of the greater inherent ordering of smectic liquid crystals. Blackwood reviews the progress and challenges of using these materials in displays and sensors.

Polymer thin films are perhaps the most typical organic thin film, but further miniaturization in device technology will require the use of ultrathin films less than 1000 angstroms thick, a distance on the order of the radius of gyration of the polymer chain. Frank *et al.* discuss the structural issues that arise as thin films move to the ultrathin limit and how such information may improve applications, such as minimizing pinhole defects and substrate mismatch.

The field of thin films is now so broad that not all of the important approaches—such as molecular beam epitaxy, Langmuir-Blodgett films, and self-assembled monolayers—could be included as the focus of a specific article. In our News section, we look at advances in superconductors, giant magnetoresistance, and organic devices.

Progress in thin film research is a remarkable example of the interplay between basic studies and practical applications. The demands for improved methods and properties have helped to drive new discoveries, which, in turn, have opened even more opportunities for applications.

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