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Materials for Microelectronics: Introduction

Advances in a technological society place continually escalating demands on existing materials. In recent times, the tremendous diversity of material needs has created a profitable market for specialty products, often manufactured in low volume, to fill specific technological niches. No advanced technology industry is immune from the need for new, high-performance materials, a fact that has led many nonchemical companies to initiate "in-house" research and development efforts in materials research. This has led to an increasing demand for chemists, chemical engineers, and material scientists in peripheral industries whose primary business is not chemistry.

In no area is the demand for advanced materials more pressing than in the electronics industry. In this issue, we have collected a series of review articles that focus on the chemical properties and transformations of a variety of interesting microelectronic materials. This collection of articles is intended to be representative rather than comprehensive and is targeted toward materials that are transformed by reactive processing. The intent of this issue is both to stimulate interest in materials for microelectronic applications and to highlight the important role of chemistry in this field.

One key focus of the current microelectronics industry is on resist technology. Resists are materials that are used for the generation of the small, complex, high-resolution patterns that are essential for the production of electronic components such as circuit boards, memory and logic chips, recording heads, microelectrodes, sensors, displays, etc. In their article "Polymer Materials for Microlithography", Thompson and Reichmanis trace the historical development of resist materials from their early conception until modern times. The unifying theme in this evolution has been the unrelenting drive toward miniaturization. The authors touch on many aspects of modern lithography, including exposure tools, the nature and chemistry of resist materials, and new developments in image processing. Regarding the latter, the advantages and disadvantages of modern multilayer resist schemes versus the more traditional single-layer processes are discussed and material requirements are described. Resist sensitivity is discussed for both positive and negative systems and the important concept of chemical amplification is introduced.

In another article, Miller and Michl describe the chemistry, spectroscopy, and applications of a new class of radiation-sensitive polymers that contain only silicon in the polymer backbone. Soluble, substituted polysilanes constitute a class of polymeric materials with very unusual electronic properties which have recently attracted considerable attention due to potential applications as (i) thermal ceramic precursors, (ii) broad-spectrum photoinitiators, (iii) materials for microlithography, (iv) a new class of polymeric photoconductors, and (v) materials with interesting nonlinear optical properties. This article discusses the synthesis, chemistry, spectroscopy, and electronic structure of these interesting materials in considerable detail.

There are three articles in this particular issue that deal with laser-induced chemical transformations. Herman describes the laser-induced deposition of metals, semiconductors, and insulators both from the gas phase and from surface-adsorbed layers. The author discusses current experimental techniques, photoreactive materials, and spectroscopic studies of reactive intermediates. The physical and optical properties of the deposited materials are described where relevant, but are not the main focus of the review. Likewise, a number of mechanistic studies are discussed, but this area is clearly worthy of additional research in the future. Links are estalished between the decomposition of reactants and other aspects of the deposition process such as mass transport, spatial control, nucleation effects, etc.

In a complementary paper, Steinfeld focuses on the photochemical generation of neutral reactive species such as free radicals and carbenes and their reactions on the surfaces of electronically important materials such as silicon, silicon dioxide, silicon nitride, gallium arsenide, etc. Surface studies using modern analytical techniques are described in some detail and models for chemical reactivity are postulated. The relevance of these studies to the understanding of gas-phase chemical etching, a process of considerable importance in the electronics industry, is obvious.

In the third paper in this series, the ablation of organic polymer films using high-powered UV lasers is reviewed by Srinivasan. Such ablation processes are currently of considerable importance, not only in the electronics industry but also in medicine, where they are utilized for sensitive surgical procedures. Only the former applications are discussed in the review. The author describes the historical development of UV-laser polymer ablation and compares the results with those using visible and infrared radiation. The current understanding of the laser ablation process as derived from chemical and spectroscopic studies is discussed in some detail. The impressive advances that have been made in understanding UV ablation processes over a relatively short period suggest a bright future for the technique.

Finally, Bradley discusses the preparation, characterization, and properties of metal alkoxides, which are precursors to a variety of metal oxides. The latter materials are useful for optoelectronic studies and in ceramic and high-temperature superconductor research. The use of volatile metal alkoxides for gas-phase metal oxide deposition is discussed in detail. The review also

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provides a short section on the use of sol–gel techniques for the production of oxide glasses and ceramics.

Although this particular issue focuses to a large extent on materials that are transformed in processing, there is also considerable interest worldwide in stable materials with unusual physical, chemical, and electronic properties. In addition to high-temperature inorganic and organic dielectrics for insulation and packaging, the list also includes new piezoelectric, ferroelectric, and ferromagnetic materials, organic conductors and photoconductors, liquid crystalline monomers and polymers, materials for nonlinear optical applications and optical storage, etc. A unifying feature characterizing most of these materials is the ability to alter, ideally reversibly, the physical, chemical, electronic, or magnetic properties on demand in in response to a directed stimulus. While materials of this type are not discussed extensively in this issue, the topic constitutes a logical focus for a future thematic issue.

R. D. Miller
Guest Editor