Conducting Polymers and Their Applications

by Peter J. Hesketh and Durga Misra

Typically conventional polymers such as plastics, rubbers, etc., offer significant resistance to electrical conduction and are either dielectrics or insulators. With the invention of conductive polyacetylene in the 1970s, conducting polymers have received significant attention from both science and engineering communities. This culminated in 2000 when the Nobel Prize was awarded to Alan J. Heeger, Alan G. MacDiarmid, and Hideki Shirakawa for their discovery and development of electrically conductive polymers. Since then applications such as polymer-based electronics and biosensors have provided further impetus for the growth of this R&D community. With the advances in stability of the materials, and improved control of properties, a growing number of other applications are also currently being explored.

The properties that make these conductors attractive include a wide range of electrical conductivity, which can be achieved with various doping levels, while maintaining mechanical flexibility and high thermal stability. Even for rugged applications including LED lighting and electrical supercapacitors, conducting polymers have advantages over other materials candidates such as conductive metal oxides. In this special issue of *Interface*, conducting polymers and their applications are featured.

The article by Seiichi Takamatsu and Toshihiro Itoh describes novel MEMS devices based on conducting polymers. The article describes the processing and fabrication of flexible large-area conducting polymer-based MEMS devices. They describe a Parylene peel-off process and subsequently used this process to fabricate touch sensors, electrochromic pixel displays, and biochemical sensors. They also demonstrate the feasibility of these human interface devices at the several-centimeter scale. Secondly, for the scale-up of conducting polymer-based MEMS devices a new manufacturing process is described that includes a continuous reel-to-reel die-coating process for fiber substrates with organic electronic materials and a large area integration system that weaves the resultant functional fiber substrates. The article also presents meter-scale touch-senstitive sensors and demonstrates them with keyboard input. These conducting polymer-based MEMS devices are believed to lead to flexible and large-area sensor applications for human information input and output.

The paper by Ajit Koshla describes nanoparticle-doped electrically conducting polymers for flexible nano-micro systems. In particular, techniques for nanoparticle dispersion in polymers films for integration into functional materials are described. The use of electrically-conducting, nanocomposite polymers and the hybrid fabrication process alleviates problems with materials mismatch between flexible nonconductive polymers and metals/alloys or less flexible conductive polymers for soft (polymer) (N)-M-EMS and flexible lab-on-chip systems. The high degree of biocompatibility of conducting polymers also makes them particularly interesting materials for biosensing and implantable electrodes.

The third article by Amir H. Saheb, Michelle Leon, and Mira Josowicz presents a label-free detection scheme for a short GSTP1-related DNA sequence (27-mer) based on modified polypyrrole (PPy) films deposited at a microelectrode surface. The direct application of this electrochemical DNA hybridization probe on clinical samples offers great promise for its translational use in early prostate cancer diagnosis, prognostic assessment of tumor behavior, as well as monitoring response to therapeutic agents.

The feature articles in this special issue signal that the first period (roughly spanning the 1970s, 80s, and 90s) of frenetic activity in gaining a fundamental understanding of conducting polymers has now given way to opening up exciting and new application possibilities for these materials. By the same token, the articles presented here can provide a status snapshot for new researchers interested in conducting polymers, their synthesis, and applications. Certainly the future looks bright for conducting polymers.

About the Guest Editors

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