Energy Harvesting—Recent Advances in Materials, Devices and Applications

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Energy Harvesting—Recent Advances in Materials, Devices and Applications

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PREFACE

The need for renewable energy, energy efficiency, and energy harvesting is motivating the discovery of new materials and design of novel devices and systems. At the 2011 MRS Spring Meeting, in San Francisco, California, April 25-29, Symposium E, "Energy Harvesting—Recent Advances in Materials, Devices and Applications" addressed the Energy Harvesting topic area with several innovative research topics and in particular, emphasized the fact that nano-structured materials are becoming increasingly attractive for such applications. This MRS symposium represents the third in a series, including those held in Spring 2008 and Fall 2009. The present proceedings volume captures some 25 papers out of over 100 presentations made during the Spring 2011 symposium, and highlights the increasing importance and interest in the field of energy harvesting.

The proceedings volume, with its section on Thermoelectric Energy Harvesting, contains a number of papers on emerging thermoelectric materials and devices as well as applications in automotive waste heat recovery and in some military systems. There have been a number of published reports describing the enhancement of the figure of merit (ZT) of thermoelectric materials during the last decade. A set of papers in this proceedings volume outline the progress in thin-film materials, bulk materials and device design. The papers discuss the vision and necessity of energy harvesting to reduce the use of fossil fuels, with some cutting-edge research on advanced nanostructured thermoelectric materials with high ZT and also advanced lightweight photovoltaic technologies for portable power and light-energy harvesting. Thermal-to-electric energy harvesting efficiency not only depends on thermoelectric material ZT but also on device-level architecture. The section on Heat Transfer and Storage for Harvesting discusses new design of system components, storage and understanding of thermal interfaces.

The section on Photovoltaic and Light Energy Harvesting discusses ideas from the fundamental science of photon processes to the technology of broadband anti-reflective coatings and multi-functional fiber solar cells. The lighting/PV multifunctional device appears to have the advantage of high efficiency light usage. There is also a discussion of concentration cells for small scale Energy Harvesting based on reverse electro-dialysis.

The section on Mechanical Energy Harvesting spans the wide range of topics which this type of energy harvesting encompasses. Piezoelectrics are involved in devices which harvest wind at the larger scale and potentially could harvest energy from human motion at the smaller scale. New devices which combine piezoelectric with other energy harvesting modes such as magnetic harvesting are expected to play increasingly important roles in the future. As the use of piezoelectrics continues to rise rapidly, the role of Pb-free materials will also rise in importance, as illustrated by one of the papers in this section. The harvesting of mechanical energy has merged with new composite design, involving multi-functional materials and energy transfer. Computer simulations have continued to enhance our understanding of the behavior of piezoelectric-based materials and their properties as a component in a matrix. The efficiency of these devices is continuously improving through a combination of simulation and experiments.

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The role of new materials in energy harvesting cuts across all the sub-fields represented here. The group of papers we have placed under Materials Characterization illustrates the crucial role of understanding the basic material properties. The need for this enhanced understanding will grow increasingly important as the role of nano-structered materials increases within materials for energy harvesting.

The final section on Heat Transfer and Storage for Harvesting represents a new link with traditional energy harvesting sub-fields. This topic was not specifically called out in the first two MRS Symposia on the topic. However, this volume contains papers that discuss the importance of thermal issues in thermoelectric and mechanical systems as well as novel high energy density thermal storage materials.

This symposium proceedings volume emphasizes the importance of considering energy harvesting as a cross-cutting and multi-disciplinary activity, and addresses the importance of each of the sub-fields, represented by the topic headings, to understand and incorporate advances across the field as a whole. We hope the proceedings volume will undoubtedly indicate that the materials development for energy harvesting is heating up, revving up, and lighting new pathways for a bright future in energy efficient systems!

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