High Temperature Materials for Energy Conversion

by Jeffrey W. Fergus

The High Temperature Materials Division (HTM) of The Electrochemical Society was initially established in 1922 as the Electrothermics Division, and in 1982 took its current name to better reflect the research interests of its members. These research interests include the properties, processing, and application of materials at high temperatures and encompass a broad range of materials types and applications. High temperatures are often needed in processing materials through sintering, casting, and other heat treatments and are encountered in applications such high-speed aircraft and energy-conversion technologies.

The HTM Division sponsors several recurring symposia including Solid Oxide Fuel Cells, Solid Ionic Devices, Ionic and Mixed Conducting Ceramics, and High Temperature Corrosion and Materials Chemistry, each of which has been offered at least eight times. In addition, new symposia are developed to address emerging technology areas, such as Electrochemical Synthesis of Fuels and Electrochemical Utilization of Solid Fuel, which will be offered for the second time at the San Francisco and Orlando meetings, respectively. Other new symposia to be offered in the upcoming year include High Temperature Experimental Techniques and Measurements and Mechanical-Electrochemical Coupling in Energy Related Materials and Devices.

The trend in topic areas has led to discussions about another change in the name of the Division to reflect two common aspects of papers in HTM symposia: device/process design and energy applications. Some papers in HTM symposia focus on materials properties, but others focus on design of the process or device, and the name High Temperature Materials may imply a materials focus. The other is that many papers focus on energy applications. Both of these aspects, especially the latter, are reflected in the focus of this issue.

The articles in this issue highlight the importance of high temperature materials in energy conversion technologies. One of the advantages of high temperatures is that reaction kinetics increase with increasing temperature. This advantage is evident in solid oxide fuel cells, which do not require costly platinum catalysts and can be used with a wider variety of fuels as compared to low temperature fuel cells. The high temperature provides an added advantage of increased efficiency. These advantages and other aspects of solid oxide fuel cells are discussed in the first article of this issue, which summarizes a recent NSF-sponsored workshop entitled Solid Oxide Fuel Cells: Promise, Progress and Priorities. The second article is related and discusses reversible solid oxide fuels cells, which can be used for both power generation and for fuel production.

The third article is also related to fuel production, but on a topic not typically associated with high temperature materials—solar energy conversion. In particular, the article discusses the use of metal-oxide reduction-oxidation for the production of carbon monoxide and hydrogen fuels using solar energy by solar thermochemical fuel production (STFP). Such carbon-neutral fuel production is critical to meet the growing demands for fuels in transportation and other sectors.

The fourth article is on a topic that is applicable to most, if not all, high temperature applications—corrosion. As noted above, one of the advantages of high temperature operation is the accelerated chemical reaction rates. This is an advantage for desired reactions, but a disadvantage for undesired reactions. The importance of corrosion in a variety of energy conversion technologies, including Rankine and Brayton cycles, nuclear power, solid oxide fuel cells, thermoelectric energy conversion, and concentrated solar power, is discussed.

The articles in this issue provide a few examples of the application of high temperature materials in energy conversion technologies. It is worth noting that this is not the only area where high temperature materials are used, but the topic of energy conversion has assumed increasing importance due to growth in worldwide energy demands and the threat of climate change resulting from the accumulation of greenhouse gases.

About the Author

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