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EDITORIAL

Methodological aspects of electrochemical science and technology: a selection of reviews

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Solid-state electrochemistry is a rapidly developing scientific field that integrates many aspects of the classical electrochemical science and engineering, solid-state chemistry and physics, materials science, heterogeneous catalysis, and other areas of physical chemistry. This field comprises, but is not limited to, electrochemistry of solid materials, thermodynamics and kinetics of electrochemical reactions involving at least one solid phase, transport of ions and electrons in solids and interactions between solid, liquid, and/or gaseous phases whenever these processes are essentially determined by properties of solids and are relevant to the electrochemical reactions, and a variety of practical applications using solid electrolytes, mixed ionic–electronic conductors, and solid-state electrochemical reactions. The range of these applications includes many types of batteries, fuel cells, capacitors and accumulators, numerous sensors and analytical appliances, electrochemical gas pumps and compressors, electrochromic and memory devices, ceramic membranes with ionic or mixed ionic–electronic conductivity, solid-state electrolyzers and electrocatalytic reactors, synthesis of new materials with improved properties, and corrosion protection. The first fundamental discoveries considered now as the foundation of solid-state electrochemistry were made in the nineteenth and first half of the twentieth centuries by M. Faraday, E. Warburg, W. Nernst, C. Tubandt, W. Schottky, C. Wagner, and other famous scientists. Their works provided background for the fast progress achieved both in the understanding of the solid-state electrochemical processes and in the applied developments during the second half of the twentieth century. Apart from the fundamental electrochemical phenomena, many experimental methods and theoretical approaches elaborated in the classical works are used in solid-state electrochemistry up to now, in combination with advanced technological and scientific facilities and, often, novel concepts and models.

As for any other area, the progress in solid-state electrochemistry leads both to new horizons and to new challenges. In particular, the increasing demands for higher performance of the electrochemical devices lead to the necessity to develop novel approaches for the nanometer-scale optimization of materials and interfaces, for analysis and modeling of highly non-ideal systems, and for overcoming numerous gaps in knowledge, which became only possible due to recent achievements in the related areas of science and technology. As for technological implementation of experimental and theoretical concepts extending from the nano to macro levels, continuous efforts are always necessary to introduce state-of-the-art electrochemical techniques to the closely related scientific areas and to adopt their advanced methods to study electrochemical systems. Moreover, the rising amount and diversity of available scientific information during the last decades increase the importance of systematization, verification, unification of terminology, and worldwide standardization of experimental and simulation techniques.

This brief introduction explains a high priority and permanent attention given by the editorial team of the *Journal of Solid State Electrochemistry* to various methodological aspects of science and technology, including interdisciplinary domains. Since its foundation in 1997, the journal publishes a

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great number of specialized reviews dealing with diverse electrochemical techniques and methodological problems, along with the research articles dedicated to specific methods and their practical implementation, and critical comments centered on limitations, perspectives, and re-examination of selected approaches. During the last years, the number of such contributions tends to increase, reflecting a growing interest on the electrochemical methods and appliances. For example, during 2009–2010, a series of reviews were presented on the electrochemical techniques for the conservation and monitoring of archeological heritage [1–3], polarization resistance approach for the corrosion studies [4], selected conceptual aspects in the developments of electrochemical sensors [5–9], (photo)electrochemical preparation and characterization of nanostructures on silicon surfaces [10–12], methods for evaluation and improvement of metal hydride electrodes [13], key theoretical issues and modeling principles of the electron transfer reactions [14], and design of hybrid materials [15] and electrodes of lithium batteries and solid oxide fuel cells [16–18]. These and other emerging topics will also be addressed in numerous works planned for publication in 2011–2012.

The present issue of the journal contains a selection of invited reviews focused on advanced methods used in research and electrochemical technologies, description of the electrochemical systems, processing of novel materials and solid-state electrochemical cells, and mechanisms relevant for their operation. Since it was impossible to cover the rich diversity of electrochemical techniques and appliances in a single issue, emphasis was centered on the recent trends and achievements related to batteries, accumulators, fuel cells, ceramic membranes, sensors, and electrolyzers. In particular, the review written by the authors from the Imperial College London and Eindhoven University of Technology discusses the isotope exchange depth profiling technique using secondary ion mass spectrometry and low-energy ion scattering, which provide very informative tools to study diffusion and interfacial exchange kinetics. Numerous in situ techniques used in the developments of Li and Mg rechargeable batteries, including X-ray absorption and diffraction, mass spectrometry, electrochemical quartz crystal microbalance, scanning probe microscopic analyses, and other methods, are briefly reviewed by the researchers from Bar-Ilan University. Continuing these discussions, the surveys presented by the scientists from Southern Federal University (Rostov-on-Don) and Eötvös Loránd University (Budapest) deal with the applications of cation exchange and electrochemical nanogravimetry. The authors from the Laboratoire d'Electrochimie, Chimie des Interfaces et Modélisation pour l'Energie (Paris) analyze important theoretical aspects and models related to the insertion processes, whereas the comprehensive review written by the researchers from the Institute of Solid State Chemistry (Ekaterinburg) covers experimental methods to study oxygen nonstoichiometry in oxide materials, primarily the coulometric titration technique. Note that, in addition to the electrochemical community, the concepts and approaches discussed in these surveys are of significant interest for specialists working in other areas such as catalysis, surface and membrane sciences, hydrogen storage and adsorption. Following the theoretical work on interpretation of dynamic processes in electrochemical cells, the reviews on the operation mechanisms of non-equilibrium sensors, deposition and characterization of thin films for solid oxide fuel cells (SOFCs), and electrode materials for SOFCs and other electrochemical devices with oxygen ion- and proton-conducting solid electrolytes are focused on the recent developments in these fields and cover a variety of relevant methodological aspects. Finally, the issue contains several research articles illustrating the practical use of selected methods and current challenges.

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