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978-1-558-99693-9 - Solid State Ionics-2002

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Cambridge University Press

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MATERIALS RESEARCH SOCIETY
SYMPOSIUM PROCEEDINGS VOLUME 756

Solid State Ionics—2002

Symposium held December 2–5, 2002, Boston, Massachusetts, U.S.A.

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Materials Research Society
Warrendale, Pennsylvania

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Information on this title: www.cambridge.org/9781558996939

CODEN: MRSPDH

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ISBN 978-1-558-99693-9 Hardback

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PREFACE

This proceedings volume includes invited and contributed papers presented at Symposium EE, "Solid State Ionics," and Symposium FF, "Materials for Fuel Cells and Fuel Processors," held December 2–5 at the 2002 MRS Fall Meeting in Boston, Massachusetts. It gives an account of current developments in Solid State Ionics and highlights advances in the domains of energy storage and conversion and environmental monitoring. The largest clusters of papers are devoted to lithium batteries and fuel cell technology. This reflects the dominating relevance of these applications for fostering the modern telecommunications and information society (energy storage systems for laptops and portable telephones) and the development of environmentally friendly electric transportation and energy transformation systems, replacing traditional combustion technology. One can securely predict that fundamental and applied research in Solid State Ionics will continue to grow at a fast pace in the coming years.

Part I of the proceedings is devoted to "Theory/Inorganic Ion Conductors." The invited paper by K. Funke treats the ion dynamics in disordered solid electrolytes in the framework of the MIGRATION concept. The frequency dependence of the ionic conductivity, but also, for the first time, of the dielectric permittivity, can now be theoretically described. Several papers demonstrate the great potential of simulation techniques (Monte-Carlo, ab-initio...) for achieving an improved understanding of the mechanisms of ionic motion in solids. The new domain of "nano-ionics," i.e. ionic conduction in nanostructured materials, is also addressed. A. Tschöpe shows in an invited paper how space charge theory provides, for the first time, a quantitative description of the grain-size dependent electrical conductivity of CeO_2 . The invited paper by T.O. Mason and coworkers gives a theoretical analysis of impedance spectra of nanocrystalline electroceramics and discusses the limits of the classical brick layer model. Three papers are devoted to ion conduction properties in the $(\text{La,Li})\text{TiO}_3$ perovskite system. Furthermore, tunnel compounds, cation conducting composites with mesoporous Al_2O_3 , an unusual cation conduction mechanism in LiNaSO_4 and a new metastable fluoride ion conductor, CaSn_2F_6 , are presented.

Part II discusses "Oxide Electroceramics for Separation Membranes and Gas Sensors." The bismuth-base materials, especially the BiMeVOx system, are discussed in the invited paper by R.-N. Vannier et al. Various materials for oxygen permeation membranes are considered in contributed papers, including La-Sr-Co-Fe oxides, Ba-In oxides and oxide composites. The invited paper by E. Di Bartolomeo describes potentiometric NOx sensors based on stabilized zirconia and various oxides as auxiliary electrode. Contributed papers describe NOx sensors with other metal oxides, and oxides that could be used in resistive oxygen sensors, especially doped SrTiO_3 and pure and doped CeO_2 . A new type of resonant device, based on the high temperature piezoelectric langasite, transduces a change of the oxygen stoichiometry of a thin-film oxide into a change of the resonance frequency. This is the high temperature analogue of the well-known quartz microbalance. Finally, zeolites are investigated as new sensor materials, the preparation of TiO_2 (anatase) nanoceramics and the phase diagram of the In_2O_3 - WO_3 system, useful for electrochromics, are presented.

Part III presents "Cathode Materials for Lithium Batteries." Conventional wisdom was that only certain intercalation compounds can insert and de-insert lithium ions and can be used as anode and cathode materials. Recent experiments show, however, that simple binary compounds, hitherto neglected in the search for better cathode and anode materials, can reversibly exchange lithium ions if the particle size is sufficiently small. This is a major discovery, implying that a large number of compounds have to be checked again from this point of view. In his invited paper, G. Amatucci et al. investigate such a compound, FeF_3 , as new high performance cathode material. Several contributed papers are devoted to the "classical" cathode materials—manganese dioxide, manganese spinel and the $\text{Li}(\text{Co,Ni})\text{O}_2$ system—describing structural and chemical disorder and advanced preparation techniques. Other papers discuss transition metal phosphates as well as vanadium-oxide and

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molybdenum-oxide based cathode materials and characterization of the electrochemical cycling process by sophisticated structural techniques, such as EXAFS and XANES or Scanning Probe Microscopy.

Part IV presents "Anode Materials for Lithium Batteries and Polymer Electrolytes." A wide range of anode materials is described, ranging from nitrides, over silicon to metals, such as tin, and mesoporous silicates. Ball-milling is presented as an alternative way for anode preparation. In the context of lithium batteries and fuel cells, polymer-based nanostructured and nanocomposite solid electrolytes are an important subject. The use of functionalized oxide nanoparticles for the preparation of polymer nanocomposites for solid electrolytes and biomedical applications is described in several papers. Ionic conduction mechanisms in PEO and PEO-clay composites are investigated by Nuclear Magnetic Resonance and Neutron Scattering.

Part V treats "Proton Exchange Membrane Fuel Cells." A particular important aspect that is addressed concerns the catalytic properties of electrode materials, given the importance of *in situ* reforming for this kind of device. The invited paper by Ball and Thompson reports the development of CO-tolerant Pt-based electrode materials. Contributed papers present strategies for CO removal, other electrode materials and electrocatalysts, particularly based on composites and nanoporous carbon. Optimization of a carbon composite bipolar plate is discussed in the invited paper by Besmann and coworkers. Other topics include hydrogen separation, mechanistic investigations by x-ray absorption spectroscopy and the development of a microbial fuel cell.

Part VI is devoted to "Solid Oxide Fuel Cells" (SOFC). The reports presented at the symposium suggest that the breakthrough to commercial use is not far away, given especially impressive improvements in the mechanical properties of solid oxide membranes. The invited paper by H.-D. Wiemhöfer gives an overview on advanced electrical characterization for oxygen ion conductors, including ceria and lanthanum gallates. Contributed papers treat the preparation and properties of apatites as new solid oxygen ion conductors, Gd-doped CeO₂, Aurivillius phases, and the doped LSM system. Several articles are devoted to the classical solid electrolyte for SOFC—Y-stabilized ZrO₂ in thin-film or bulk form—and discuss the influence of interfaces on the ion conduction properties. The possibility of spurious substrate effects on thin-film conductivity is pointed out. Various other aspects of SOFC developments are also addressed, such as lanthanum cobaltite electrode materials, multilayer anodes, braze development and corrosion problems of metal interconnects. Given that the commercial application is not far away, the last paper presents a cost model for SOFC.

We acknowledge the contributions of all of the authors of this proceedings volume, which provide an excellent overview of the current status of "Solid State Ionics—2002." Financial support of the symposium by Centre National de la Recherche Scientifique, Robert Bosch AG (Stuttgart, Germany) and SETNAG (Marseille, France), is greatly appreciated.

Philippe Knauth
Jean-Marie Tarascon
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February 2003

Cambridge University Press

978-1-558-99693-9 - Solid State Ionics-2002

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