 

## BOOK REVIEW

**Solid state electrochemistry (1995) Peter G. Bruce (ed)**
Cambridge University Press, Cambridge. Printed pages xvi + 344, 11 articles; price: £ 60.00 (US $85.00). ISBN 0-521-40007-4 (hardback)

This book describes the principles of two main topics of solid state electrochemistry: solid electrolytes which conduct electricity by the motion of ions and exhibit negligible electronic transport, and intercalation electrodes which conduct both ions and electrons. The book consists of eleven chapters, written by twelve authors, with 168 figures, 9 tables, 257 mathematical formulae and 456 references. As stated in the Editor's preface, it is the textbook which is directed "towards postgraduate students and other scientists and engineers entering the field for the first time, as well as those active in the areas of batteries, fuel cells, sensors and electrochromic devices". It explains the fundamentals of the physical electrochemistry of solids, but several of its chapters have all the virtue of review papers.

A brief history of solid state electrochemistry is presented by the Editor in the introduction. The next five chapters describe crystalline, glass and polymer electrolytes, and these are followed by three chapters about intercalation electrodes and one about solid charged interfaces. In the last part, the applications of solid electrolytes are described.

A.R. West of the University of Aberdeen writes about crystalline solid electrolytes, their structures, properties and the mechanisms of ion conducting. A simple model of ion transport based on the isolated hopping of the mobile ions is presented, and the influence of interactions between mobile and immobile ions is discussed. An enhancement of conductivity by chemical doping with allovalent ions is described. The properties of numerous ion conductors are reported.

Thermodynamic aspects of ion conduction in crystalline solid electrolytes are discussed by J.B. Goodenough of the University of Texas at Austin. Ionic energies, such as intrinsic energy gaps, motional enthalpies and trapping energies of stoichiometric and doped compounds with disordered sublattices are compared. Various strategies for the design of new solid electrolytes are presented.

Ionic transport in glassy electrolytes is described by J.L. Souquet of the Institut National Polytechnique de Grenoble. The chapter deals with chemical compositions of ionically conductive glasses and with their kinetic and thermodynamic characteristics.

Polymer electrolytes are considered in two chapters written by D.F. Shriver of the Northwestern University and P.G. Bruce and F.M. Gray of the University of St. Andrews. These synthetic materials are divided in two groups: polymer-salt complexes and polyelectrolytes. The complexes are formed by the dissolution of alkali metal salts in polymers. The formation and structures of many metal complexes with various host polymers are reported. In the second group, either anions or cations of salts are covalently bound to the polymer, so that only their counterions are mobile. In both groups of electrolytes the ions are transported by the semirandom motion of short polymer segments. The methods for the electrochemical measurement of ion association and ion transport are described in detail, and the mechanisms of ionic conduction, such as free volume based models and the configurational entropy model, are discussed.

An account of insertion electrodes is given by W.R. McKinnon of the National Research Council of Canada, Ottawa. These electrodes are solid compounds consisting of host atoms providing a lattice and guest atoms which occupy sites within the lattice. The guests are mobile and can be added to or removed from the host. In alkali metal insertion compounds, the guests are ionised, donating the electrons to the host's conductive bands. Numerous examples of host compounds are presented. The thermodynamics of insertion is explained by the lattice-gas models, and the formation of separate phases is discussed.

The theory of coupled transport in the mixed ionic and electronic conductors is presented in the chapter on electrode performance, written by W. Weppner of the Christian-Albrechts University, Kiel. A certain insertion compound may act as an electrode if it exchanges ions with an electrolyte and electrons with an electronically conducting lead. Transport of ions occurs by diffusion and migration. It can be significantly enhanced by the motion of electrons, which is expressed by the Wagner factor. The methods for the measurement of kinetic and thermodynamic parameters of electrode reactions are described.

A special type of insertion electrodes is polymer electrodes, which are described by B. Scrosati of the University of Rome. These polymers contain polyanions or polycations whose charge is balanced by the counterions. Polyions are formed by the chemical or electrochemical reduction or oxidation of polymers. Polyions and counterions form mobile complexes which can diffuse through the polymer structure. The mechanism and kinetics of coupled ionic and electronic transport in the conducting polymer are discussed.

R.D. Armstrong and M. Todd of the University of Newcastle-upon-Tyne describe impedance measurements of double layers on the solid/solid interfaces. The following phase boundaries are considered: metal/polymer electrolyte, metal/crystalline electrolyte, insertion electrode/polymer electrolyte and crystalline electrolyte/crystalline electrolyte.

In the last chapter of the book, O. Yamamoto of Mie University writes about the applications of solid electrolytes and insertion electrodes. Numerous examples of commercially available solid state batteries, solid oxide fuel cells, solid electrolyte sensors, electrochromic devices and electrochemical potential memory devices are reported.

This book is an excellent introduction to solid state electrochemistry. It successfully combines descriptions of materials with discussions of thermodynamic and kinetic principles of ion transport in solids. Therefore, it can be warmly recommended to readers familiar with electrochemistry in liquid electrolytes, as well as to all chemists with a broad interest in their subject.

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