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BOOK REVIEW

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X.G. Zhang, Electrochemistry of silicon and its oxides

Kluwer/Plenum, New York, 2001, 522 pp (ISBN 0-306-46541-8) €132.25/US$115.00

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Silicon as a material is of central importance in the current age of technology; some people have even claimed that we are living in the silicon age. This by itself is certainly not a justification to prepare such a rich book on this element and its oxide. Silicon has attracted the attention of electrochemists presumably for three major reasons:

1. Silicon can be machined/treated/manipulated with a variety of electrochemical methods.
2. Silicon may be a central component in photoelectrochemical systems for energy conversion.
3. Silicon is a fascinating subject for investigations of structures and dynamics at semiconductor/electrolyte solution interfaces.

The first aspect has certainly stimulated the interest of semiconductor manufacturers in methods like electrochemical etching of silicon or metal deposition on semiconductors, whereas the last aspect has been of interest since the pioneering work of Heinz Gerischer and his group on semiconductor electrochemistry. The general interest in devices for the conversion of solar energy and the still considerable number of research groups interested in semiconductor electrochemistry have resulted in a large number of papers and in contributions towards books and series, whereas a general overview and a sufficiently broad general coverage of the electrochemistry of silicon and its oxide seems to be missing. The present book provides a rich attempt to close this gap.

Taking into account his experience with a successful previous publication (Corrosion and electrochemistry of zinc, Plenum, New York, 1996), the author provides a systematic overview instead of compiling a distillation of reports and reviews only. He starts with an introductory chapter on the basic theories of semiconductor electrochemistry. For those familiar with the metal/solution interface, the detailed description of the differences between these interfaces and the semiconductor/solution interface pertaining to structure and dynamics, the changes in charge transfer processes and particularly photoeffects will be especially welcome. As the author sometimes deviates a little from IUPAC standards, this introduction is particularly useful. The second chapter is devoted to silicon/solution interfaces. Starting with the basic properties of silicon, the chemical processes occurring upon immersion of pure silicon into water are considered first. The influence of various additives, metal ions, etc., on these processes and upon the formed interfacial layers is treated in detail. Corrosion of silicon – certainly a major aspect both in many experimental investigations and practical applications – is treated thoroughly. Silicon oxide in both forms – crystalline quartz and amorphous vitreous silicon dioxide – can be generated simply by exposure of silicon to air, by chemical vapor deposition, by thermal and by anodic oxidation. Although the electrochemist is certainly interested most in the last possibility (which is in the focus of this section), this chapter deals with all processes and in particular with electrochemical properties of the obtained oxide layers. Etching of silicon oxides is treated in a short chapter 4. In this chapter the relationship to electrochemistry is less obvious. As pointed out by the author, chemical etching is closely related to the anodic behavior of silicon. This certainly justifies inclusion of this section.

The anodic behavior of silicon is of considerable importance for both fundamental and applied aspects, ranging from electropolishing to formation of porous silicon. Current-potential relationships, the influence of various solution additives, the mechanism of anodic processes, passivation, current oscillations and photoeffects are among the subjects of chapter 5. The following chapter 6 deals with cathodic processes, including hydrogen evolution and metal deposition. Somewhat arbitrarily, the behavior of silicon in the presence of dissolved redox couples is also reviewed in this chapter.

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Both organic and inorganic systems potentially interesting for solar energy conversion and etching processes are treated. Etching of silicon – technologically certainly one of the important steps in semiconductor manufacturing – is reviewed extensively in chapter 7. Although at first glance this chapter does not seem to have any relationship with the book's subject, it makes fascinating reading and is certainly of relevance for understanding other electrochemical processes occurring at the silicon/solution interface (see above). Anodic dissolution of silicon in hydrogen fluoride solution results in extremely rough surfaces and the formation of porous silicon. The material's properties are considerably different from those of nonporous silicon. Consequently, the electrochemical formation, the materials properties and various aspects of the formation process as well as applied aspects are reviewed and discussed extensively in chapter 8. In a brief, concluding final chapter, some general aspects as well as trends and further direction of research and development are outlined. A list of about 1200 references provides access to the sources of information used by the author; a carefully prepared detailed index enables location of information pertaining to any aspect of particular interest.

This volume collects an almost overwhelming amount of data and information on silicon and its oxides. Not every detail is obviously and directly related to structures and electrochemical processes at the solid/solution interface. Nevertheless, this systematic and broad approach is certainly justified and necessary in order to provide a complete overview which does not leave gaps of information the reader has to close himself.

There are some minor inaccuracies, presumably printing errors. On p. 6 the Nernst equation is formulated rather uncommonly as: $\varphi_{\mathrm{redox}} = \varphi^0_{\mathrm{redox}} + kT\ln(a_{\mathrm{ox}}/a_{\mathrm{red}})$, whereas a standard redox potential $\omega^0_{\mathrm{redox}}$ is subsequently mentioned. Somehow, chemical and electrochemical potentials seem to be mixed up.

This book is a must for every laboratory where semiconductor electrochemistry is actively pursued. It is a welcome and recommended addition to every library of an institution where electrochemistry is a subject of active research.