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NEWS

Book reviews

Electroless Nickel Plating by Wolfgang Riedel, (Stevenage, UK, Finishing Publications Ltd, 1991; ASM International, USA)
ISBN 0 904477 12 6, 320 pp, £60

This book, an authorized translation of *Functionelle Chemische Vernicklung* (Leuze Verlag, Germany) by A. T. Kuhn, provides a timely contribution to the literature on surface finishing. Although the field is specialized, nickel is the major metal deposited by electroless deposition; it is widely used, particularly in wear- and corrosion-resistant engineering applications.

My own interests in electroless nickel date back to 1974 when a range of novel Ni-based composite coatings were under development in Kees Helle's Electroplating Laboratory at AKZO Research BV, Arnhem. Since those early days, the technology has matured and has become an accepted, if specialized, coating technique. The last two decades have witnessed almost one-thousand research and technical papers on electroless nickel plating. There are, however, few detailed compilations of data and methodology for the practitioner.

This contribution should, therefore, be welcomed as a readable and useful treatment of electroless nickel technology. As indicated in the Preface, the emphasis of the book is on the properties of the deposits rather than on the chemistry of the deposition process. Consequently, electrochemists may be disappointed at the absence of detailed information on the mechanism of electroless deposition or the incorporation of 'alloying' species such as phosphorous or dispersed particles into the growing deposit. On the other hand, the text provides extensive data on the physical and materials properties of the deposits as evidenced by the following chapter headings: Metal deposition from aqueous solution; Electroless nickel baths; The practice of electroless nickel plating; Atomic structure and microstructure of electroless nickel deposits; The properties of electroless nickel deposits; Measurement methods and quality control; The effect of electroless nickel deposits on the substrate material and the properties of coated components; Pretreatment of various substrate materials; Posttreatment of electroless nickel deposition; Stripping electroless nickel coatings; Effluent treatment and disposal of electroless nickel baths; Plant design and construction; Electroless nickel deposition of nickel-based alloys and composites; Standards and specifications; Applications; and Costs of electroless nickel deposition.

It will also be clear from the above list that the coverage of electroless nickel deposition is usually wide; pretreatment, posttreatment, disposal/recycling, process control and costing are all considered. A strong feature is the extensive bibliography containing 739 references, many of these reflecting the German origins of this text. A recent updating of these references is evidenced by the appearance of many 1989–1991 citations, despite the 1989 date on the author's preface.

In a practically-based text, it is essential to provide a strong coverage of the application areas. The author accomplishes this, in part, by photographs of industrial engineering components. A closer comparison with competitive coating technologies would, I believe, have strengthened the book. Having spent several years developing and troubleshooting on dispersion composite coatings, I was disappointed to see only a concise mention of these finishes. Although their 'tonnage' use is low, coatings such as Ni-PTFE, NI-SiC, Ni-diamond and Ni-graphite provide unique properties and are being increasingly exploited.

Certainly this work is worthy of a place in both an institutional library as well as on a personal book shelf. It provides a useful contribution to the field of surface finishing and deserves a place in most metal finishing libraries. It is well-illustrated and the publishers deserve congratulations for making such specialist texts available. Any future edition might advantageously incorporate more electrochemistry in order to widen the readership.

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Polymer Electrolyte Reviews, No. 2, edited by J. R. MacCallum and C. A. Vincent, (London: Elsevier Science, 1989)
ISBN 185 166 3487, 338 pp, £55

The trouble with the new field of polymer electrolytes is that the relevant papers crop up all over the place – the electrochemical literature, the polymer literature, specialized application journals – even the physicists throw their hats into this ring. The detail illustrates the reason for the greatest success of this review series, which organizes most of the significant developments into self-contained chapters, including the rudiments necessary to guide the reader through the many associated disciplines.

Volume 1, published in 1987, covered the early work which began in the 1970s on poly(ethylene oxide) (PEO). A similar volume of material produced

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in the following two years testifies to the rapid growth of the field that has been promoted by the technological significance of very thin layers of plastic electrolytes.

The present volume is introduced by physicists, starting with a heavyweight description on the information which may be gathered from light scattering. Apart from Raman scattering, which may be more familiar to chemists as a technique for elucidating the state of ionic association, we can read about Brillouin scattering, that probes intrachain motion of the polymer backbone and gives an insight into the microscopic processes which determine the mobility of ions within the structure. Next, there is a chapter on dielectric properties; this examines charge transport in the solvent polymers before going on to discuss the effect of adding salts.

One of the originators of the field, Peter Wright, follows with a very substantial chapter on the crystalline complexes. Here, the complex structures and morphologies encountered are described along with an important new calculation of lattice energies to explain the phase transformations which take place with temperature and salt concentration. Almost as an afterthought, the author presents a final section on the possibility of electronic conduction in organized polymer electrolyte lattices – an important new concept which does not arise in the case of liquid electrolytes.

Phase equilibria are summarized and rationalized for nonelectrolytes; then specific examples are taken from the PEO/salt systems, showing how the fraction of the conducting, but mechanically weak, amorphous phase varies with temperature and composition. In the following chapter, amorphous phases at low molecular mass – i.e. liquid analogues of polymer electrolytes – are reviewed as model systems reflecting many of the properties of the elastomeric high polymers. Here, properties such as conductivity, viscosity and transference number can be researched much more quickly and reliably than for the elastomer/crystal composites. From a study of NaSCN solutions it comes as a relevation that Na^+ is practically immobile and its transport is probably via ion pair diffusion (very controversial and sure to promote arguments in volume 3!).

In the next review, substitution of quaternary nitrogen for the oxygen in polyethers leads to the class of electrolytes named ionenes (ionic amines). These are of special interest because the cations are incorporated in the polymer backbone and therefore immobilized. Conductivities are disappointingly small, but the authors do point out that there is much scope for improvement.

Returning to PEO, Colin Booth and his colleagues analyse the possibilities of supressing crystallinity by modifying the polymer backbone. They show that the most efficient depression of melting point occurs in linked copolymers; in this way small changes in the overall composition can result in polymers which are fully amorphous at room temperature. This approach retains the low glass transition temperature and excellent solvating properties of PEO itself, resulting in one of the best conductivity systems found without the aid of small molecule additives.

Next we have a study of electrolytes containing divalent cations. Michel Armand showed, in volume 1, that most of the periodic table can be put into PEO given a suitable counter-ion. Taking concentration and temperature as additional variables, the ensuing volume of data could keep several new journals going for decades. That horrendous scenario is avoided by this type of review, whereby the authors summarize their own new data along with results collected from other laboratories. Although useful as an up-to-date reference, the review is perhaps a little premature because many of transference data are unreliable, so that it does not yet seem possible to organize the results coherently under a simple theory.

Finally, a detailed account is given of the most extensively researched application: the solid polymer electrolyte lithium battery. Although room temperature cells employing amorphous electrolytes are suggested for small scale applications, the most impressive demonstration is for a system operating at about 80° C; a projection of laboratory results shows this system to be a serious contender for the powering of future electric vehicles.

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Microbial Corrosion – 1 edited by C. A. C. Sequeira and A. K. Tiller (Amsterdam: Elsevier, 1988)
ISBN 1 85166 299 5, 461 pp, £60

This book contains the 38 papers presented at the First European Federation on Corrosion Workshop on Microbial Corrosion. This brought academic, government and industrial researchers together to discuss three main topics of microbial corrosion: mechanisms, laboratory and field testing methods, and prevention and control. The use of camera-ready manuscripts will have shortened publication time and decreased costs, however, a subject index should have been included.

The expression 'microbial corrosion' refers to the biodeterioration of many kinds of engineering materials such as concretes, plastics, wood and cotton, not just metals, which are the principle concern of this book. Microbial corrosion has been responsible for many catastrophic failures, especially in the petroleum and paper industries and in industrial cooling water circuits, often with considerable economic and ecological consequences. Indeed, such failures are so common that when a corrosion problem is encoun-

tered, one of the first questions that should be asked is "Are bacteria involved?"

The study of microbial corrosion requires collaboration between corrosion scientists and engineers, metallurgists, microbiologists and biochemists, all of whom use rather specialized language, techniques and methodology. Hence, few individuals can master all of the knowledge needed to study or solve a microbial corrosion problem. With this in mind, some of the papers in the book provide very useful reviews: for example, A. K. Tiller's "The impact of microbially-induced corrosion on engineering alloys", C. A. C. Sequeira's "Electrochemical techniques for studying microbial corrosion" and P. F. Sanders "Monitoring and control of sessile microbes: cost effective ways to reduce microbial corrosion". Other papers concentrate on particular topics for the benefit of readers already involved in similar research; also microbial stimulation of dangerous forms of corrosion, such as corrosion fatigue, crack growth propagation and hydrogen embrittlement, is highlighted in the book.

Due to the complexity and number of factors affecting microbial corrosion, general solutions to the problems it engenders are rarely available; each system must be treated independently due to differences in the environment, bacterial types, fouling characteristics and system conditions. For example, adding chemicals to a system to kill or prevent growth of microbes is a popular method to control microbial corrosion; however, a biocide selected for one specific application may be totally inappropriate for another. The contents of this book will help engineers to solve microbial corrosion problems by the correct application of a variety of techniques, such as using an appropriate biocide, applying cathodic protection, choosing suitable materials, or by monitoring and analysing the system using a variety of rapid techniques for the detection of corrosion-inducing microorganisms.

Overall, *Microbial Corrosion* can be recommended as a very informative book, both for academics studying the subject and for industrialists wishing to control microbial corrosion.

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Second International Symposium on Polymer Electrolytes edited by B. Scrosati (London: Elsevier Applied Science, 1990)
ISBN 1 85166 473 4, xv + 482 pp, £75

A number of publications have provided extensive accounts of the academic and industrial research effort which followed upon the first demonstration of ionic conductivity in poly(oxyethylene)-salt mixtures [1] and the realization of its potential for construction of solid state devices [2]. The two volumes of *Polymer Electrolyte Reviews* [3, 4] allow ready access to the field, but more direct reports of research can be found in the proceeding of the International Symposia devoted to the topic. Papers from the first of these, held in St. Andrews in 1987, were published in a special edition of the *British Polymer Journal* [5]. Forty-one papers from the second, held in Sienna in 1989, are the subject of this review.

The poly(oxyethylene) chain remains the basis for useful polymer electrolytes, and the majority of papers are concerned with this polymer, or with atactic poly(oxypropylene) which provides a non-crystallizable, though somewhat inferior, analogue. The underlying problem in the development of poly(oxyethylene) electrolytes is the crystallizability of the high molecular weight polymer. Modified non-crystallizable 'poly(oxyethylene)s' have been available for some time, notably polymers in which short oxyethylene sequences are incorporated into high molecular weight linear, branched or crosslinked structures. Several papers report studies of these or similar modified polymers, including comb-branch polysiloxanes with novel pendant groups, comb-branch polystyrenes, and end-capped polyethylene glycols. Poly(amido-amino acid)s and polyvinyls with amine or carboxylic acid functionalities and silica sol-gels with amine functionalities provide new protonic systems. Papers on secondary battery and electrochromic display applications involve comb-branch polymers as well as plasticized poly(oxyethylene). Novel salts with plasticizing properties, e.g. lithium bis(trifluoromethanesulphone)imide, $LiN(CF_3SO_2)_2$, are also described and applied.

Some ten or so papers are concerned with salts with polyvalent cations, including trivalent Nd(III), La(III) and Eu(III). Interest is focused on morphology and complex formation and, particularly, anionic mobility. Of course, the fundamental properties of polymer electrolytes of greatest interest are the type, concentration and mobility of the charge carriers, allied to the segmental mobility of the polymeric solvent. The general line of study, well represented in the book, is direct investigation of conductivity and transport paralleled by spectroscopic studies of the state of the solute and its interaction with the polymeric solvent, all as functions of salt concentration and temperature. Raman spectroscopy and near-edge X-ray absorption fine structure (NEXAFS) probe the state of the solute, while Brillouin scattering dielectric relaxation, and electron-spin resonance (ESR) probe the mobility of the polymer segments and, as a secondary effect, the charge carriers. Unfortunately, studies by solid state NMR are not reported. The correspondence between segmental mobility and conductivity is confirmed, but the relationship between ionic association/solvation and conductivity remains unclear.

Overall the book presents a valuable account of most aspects of 'polymer electrolytes' as understood

in 1989. The problems posed then remain today, and the reports of original work are both informative and stimulating. The presentation, including indexing, is very satisfactory. It will be read with pleasure by all those with an interest in the field and should be on the shelf of any institutional library anxious to keep abreast of topics of contemporary importance.

References

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Comprehensive Chemical Kinetics, Vol. 29, *New Techniques for the Study of Electrodes and their Reactions* edited by R. G. Compton and A. Hamnett (Amsterdam: Elsevier, 1989)

The present volume in this series is intended to complement the two recent volumes on electrode kinetics (Vol. 26, *Electrode Kinetics: Principles and Methodology*, and Vol. 27, *Electrode Kinetics: Reactions*). It covers a variety of techniques for the study of electrode surfaces and electrode reactions.

In an attempt to obtain a better understanding of electrode reactions, electrochemists have probed the electrode/electrolyte interface with radiation of various wavelengths and using a variety of experimental configurations. The present volume describes a number of these, with chapters on *in situ* infrared, Raman, ESR, ellipsometry, electroreflectance and photocurrent spectroscopy, as well as *ex situ* UHV studies. A further concern in the study of electrode reactions is the control of the mass transport of reactants to the electrode surface; this field is represented by chapters on microelectrodes, new hydrodynamic methods, and channel electrodes. Finally, the use of computers to accumulate and process electrochemical data is also described.

As will all multi-author texts the level of presentation varies from chapter to chapter, with some chapters providing in depth reviews of the field while others concentrate on summaries of the authors' own contributions. Nevertheless, in this volume the standard is consistently high. The two chapters which particularly stand out are the chapter on *in situ* infrared studies (by Christensen and Hamnett) and the chapter on the use of the channel electrode (by Unwin and Compton). The latter might almost convince one to make/buy a channel electrode, provided of course that you have reasonably large amounts of electroactive material to study. In both cases the authors have provided comprehensive and authoritative reviews of their subject written in an extremely readable manner. These two chapters alone would be sufficient to recommend this volume. However, there is much more on offer with excellent material in the other chapters.

The channel electrode makes a second appearance in the chapter on *in situ* ESR (Waller and Compton) along with the various other ingenious electrode geometries which electrochemists have used in order to place a metal electrode into an ESR cavity without absorbing all the microwave radiation. The chapters on *in situ* Raman studies (Hester), *ex situ* UHV studies (Parsons), microelectrodes (Robinson), and ellipsometry (Greef) all provide good introductions to the different fields and would be a good starting point for anyone contemplating the application of one or other of these techniques to a particular problem. Developments in the Albery school using rotating disc, rotating ring-disc, and wall-jet electrodes are documented in the chapter on new hydrodynamic methods (Albery, Jones and Mount). Progress in Newcastle towards the automation of electrochemistry (after the 'paperless office', and given current demographic trends, perhaps the 1990s will bring the 'post-graduateless laboratory') is nicely described in the chapter on computing strategy for on-line accumulation and processing of experimental data (Harrison). One should not under estimate the sheer magnitude of this task, in the chapter the author estimates that worthwhile computerization of measurements in electrochemistry requires 20 programmers for up to 3 years (thus replacing the post-graduate electrochemist by the computer programmer).

Finally two chapters describe techniques applicable to semi-conductor electrodes or semi-conductor films. The use of photocurrent spectroscopy to characterize thin semi-conducting films on metal electrodes is described by Peter in a chapter which demonstrates the abilities of the approach to both identify and quantify such films *in situ* and to follow the dynamic effects of potential cycling on film properties. Elec-

troreflectance is not for the faint hearted. It is clear that there is information to be had using this technique the problem has been in the interpretation. The chapter on electroreflectance at semi-conductors (Hamnett, Lane, Trevellick and Dennison) gives an up to date view of the field and provides a clear exposition of the present state of theory in this area.

In all volume 29 is an excellent addition to the 'Comprehensive Chemical Kinetics' series and one which I am sure will be of much use to electrochemists.

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Modern Chlor-Alkali Technology, Vol. 3, edited by K. Wall (Chichester UK: Ellis Horwood, 1986) ISBN 0 853128650, 450 pp, £57.50

This book has been compiled from all the lectures presented at the Fourth International Chlorine Symposium held in London during June 1985. The period covered by the book is 1982 to 1985 but the two previous volumes go back to 1979. The contributions come from nine different countries spread around the world, ensuring that the book also has an international flavour to it. There are thirty separate chapters that have been divided into six main sections. A useful index has also been put together to help locate required subjects of interest.

The opening section gives an outline of the world chlor-alkali business scene in 1985. This introduction not only gives a useful general background on the market, but also has a look at some of the pressures put on it by other influences such as governments, environmentalists and energy costs. The next section takes note of the wide variety of hazards associated with chlorine. This is given some emphasis by having five chapters covering the toxicity and detection of chlorine, corrosion, general design and the UK example of a procedure for chlorine emergencies.

The largest section is concerned with developments in the field of ion-exchange membrane cell technology. The nine chapters here describe the continuing growth of this technology. There are now many more plants in production and a considerable amount of experience has been gained in their operation. This is reflected in several chapters. Data and photographs for some of the plants are presented, and some problems that have been encountered are outlined. Related to the development of these cells, the next section describes some aspects of the electrodes for chlor-alkali electrodes. These four chapters cover the reduction of energy costs by electrode design and over voltage, as well as the purity of the chlorine product.

The text then moves onto the more general aspects of chlorine plant design and operation chapters describing several different topics such as sulphate removal, modular plant design, shunt currents and computerized data collection. The final section is on hypochlorite and chlorate production, with chapters covering the chemistry of this process and the design of optimized electrolytic cells.

This brief outline shows that a very wide variety of subjects have been covered, and this makes the book a very useful one to have. It will be of interest to anyone involved with electrochemical technology, and taken with its two predecessors it forms a good base for reference and learning.

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