Preface

The hydrogen energy covers all aspects of the production, transportation, storage, and end use of hydrogen. Hydrogen is not in and of itself an energy source, because it is not naturally occurring as a fuel. It is, however, widely regarded as an ideal energy carrier or energy storage medium, due to the ease with which electric power can convert water into its hydrogen and oxygen components through electrolysis. Hydrogen can be produced on a large scale through raw materials and processes which are economically profitable. Water electrolysis is one of the most utilizable industrial processes for hydrogen production today, and is expected to become even more important in the future. Although water electrolysis is not the least expensive method of hydrogen production, it supplies hydrogen of a very high purity and is nonpolluting. The best electrocatalysts for hydrogen evolution are noble metals, however, they cannot be used directly as solid metals for industrial processes because of their high cost. Hence, a principal focus of modern electrochemistry in hydrogen production by electrolysis is to develop novel electrode materials which should possess long-time stability, be capable of electrocatalytically reducing the energy barrier of the hydrogen evolution reaction, and be immune to the current interruptions and short circuit i.e., exposition in the solution under the open circuit conditions. Industrial hydrogen evolution was initially carried out on mild steel and nickel electrodes. Newer active electrode materials have been gradually developed and introduced, however, lack of proper scale-up practice is one of the primary drawbacks of the present hydrogen technologies.

This special topic volume deals with the development of novel solid state electrocatalysts of a high performance to enhance the rates of the hydrogen or oxygen evolution. It contains a description of various types of metals, alloys and composites which have been obtained using electrodeposition in aqueous solutions that has been identified to be a technologically feasible and economically superior technique for the production of the porous electrodes. Two ways for improvement of the electrode performace have been reported: use of electrode materials characterized by higher intrinsic activity i.e., higher exchange current density, and use of electrode materials characterized by large real surface area. Among electrodeposited composite electrocatalysts of particular importance were coatings containing oxides or metal powders of micron or nanometer size, which cannot be directly codeposited in a metallic form from aqueous solutions. Such multicomponent and multiphase composite electrocatalysts with modified structure become more popular as they exhibit higher electrochemical activity in comparison with pure metals. In the presented papers, composite electrocoatings belonging to the specific type of modified electrode materials consisted of a crystalline or amorphous matrix and the other solid

phase dispersed within it, have been investigated. It was found that the kind of a metallic matrix used (Ni, Ni-P, Ni-Mo, Ni-W, Ni-Co) and the type of embedded solid particles (Mo, Co, Cr, W, Ti, Al, NiAl, MoO_2, TiO_2, NiO, Cr_2O_3, MoS_2, Si, PTFE) determined the properties of the obtained composite materials. Due to the interaction between the matrix and dispersed substance a complex with properties different from the component's features is created. This is a reason for the occurence of synergetic effect of the substrate in the course of hydrogen or oxygen electroevolution. The mechanism of H_2 and O_2 evolution on these electrodes was studied in alkaline solutions, and the kinetic parameters were determined using steady-state polarization and electrochemical impedance spectroscopy methods. Scanning probe electrochemistry techniques were used as a highly sensitive tool for studies of metal-hydrogen interactions and localized corrosion research of the electrocatalysts. These techniques are of central importance to nanoscience and nanotechnology. They allow characterization of the local structure and properties of surfaces and interfaces as well as corrosion and localized electrochemical events on the micro- to subnanometer scale, opening up the possibility to perform physical and chemical experiments on individual nanoscale objects.

The goal was to produce papers that would be useful to both the novice and the expert in hydrogen technologies. This volume is intended to be useful to the materials scientist or electrochemist, student or profesional, who is planning studies of solid state electrocatalysts and who may have had little previous experience with electrochemical measurements. Such a reader will find an outline of basic theory and a discussion of experimental techniques and data analysis, with examples and appropriate references. It is hoped that the more advanced reader will also find this volume valuable as a review and summary of the literature up to the time of writing, with a discussion of current theoretical and experimental issues of research activity in the field of hydrogen energy.

This volume is dedicated to Professor Andrzej Lasia (Université de Sherbrooke, Québec, Canada) on the occasion of his retirement with warm thanks from the Institute of Materials Science (University of Silesia, Poland) for multiannual and valuable cooperation in the field of electrochemistry in the areas of new materials for water electrolysis and the studies of the mechanism and kinetics of hydrogen adsorption, absorption and evolution using electrochemical impedance spectroscopy techniques.

Bożena Łosiewicz