

## PREFACE

Interest in photovoltaics has grown rapidly during the last half of the current century. The importance of alternative energy sources has increased in significance both for energy supply and ecological conservation reasons. In spite of limitations due to short-term economic considerations, research and development of photovoltaic solar cells has increased and is playing an increasingly practical role all over the world.

The performance of photovoltaic solar cells is intimately related to the properties of the materials from which they are made, and many materials science problems are encountered in the understanding of existing solar cells and the development of more efficient, less costly and more stable cells.

Every semiconducting material in a suitable electronic environment is capable of exhibiting properties that might properly be called "photovoltaic", i.e. the generation of an electric current and potential difference under absorbed illumination. What may be considered surprising, therefore, is that so few materials are known that are able to form photovoltaic devices with sufficient efficiency to make them of potential interest for practical applications. Allowing for the additional existence of a number of solid solution compounds based on this small number, it is still noteworthy that only the following materials have exhibited a solar efficiency in excess of ten percent: silicon, gallium arsenide, indium phosphide, cadmium telluride, copper indium diselenide, and cuprous sulfide. Of these the most versatile is silicon, which can be used to produce efficient cells in single crystal, polycrystalline or amorphous form.

It is the purpose of this book to describe the properties of these materials that play an important role in their photovoltaic applications, and to discuss the experimental and theoretical developments that have led to the leading contenders among photovoltaic cells for practical applications today. In conjunction with this is included (where appropriate) a briefer discussion of other systems that have been tested but have been found to exhibit major problems primarily in the areas of low efficiency or poor stability under operating conditions, as well as systems that are considered exploratory today but may develop into devices of interest in the future. It is not the purpose of the book to attempt an exhaustive history of the rapidly expanding field of photovoltaic materials, but to concentrate instead, primarily on developments in the last decade.

The book starts with a summary of the major properties of the semiconductor junctions that are involved in conventional photovoltaic devices, together with the typical quantitative relationships that describe electrical transport in these junctions. The major purpose of this summary is to provide a common framework for the discussions to follow, and it is assumed that the reader has a basic grounding in semiconductor electronics. It is anticipated that the book will be used in a teaching or research environment.

The focus of the book is on the materials properties important for photovoltaic applications, and does not deal in detail with device design or systems considerations, except where these are essential to the discussion. It is based on over twenty-five years of research experience, which has touched at one time or another on properties relevant to photovoltaic applications of all of the major materials.

The book covers research done by a wide variety of investigators in many countries. I am grateful for the assistance that has been given to me by many colleagues from all over the world in acquiring reprints of key research papers.

In my own program at Stanford University, thirty-one students have completed their Ph.D. research on photovoltaic materials and have added many significant memories in the process. I gratefully acknowledge support for that research from the Air Force Materials Laboratory at Wright-Patterson Air Force Base, the NASA Lewis Research Center, the National Science Foundation — Research Aimed at National Needs (NSF-RANN), ERDA, the Division of Basic Energy Science (BES) of the Department of Energy, the Solar Energy Research Institute (SERI), the Electric Power Research Institute (EPRI), ARCO Solar, and the National Renewable Energy Laboratory (NREL). The research benefited throughout from facilities made available to Stanford University by the National Science Foundation through the Center for Materials Research at Stanford University.

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