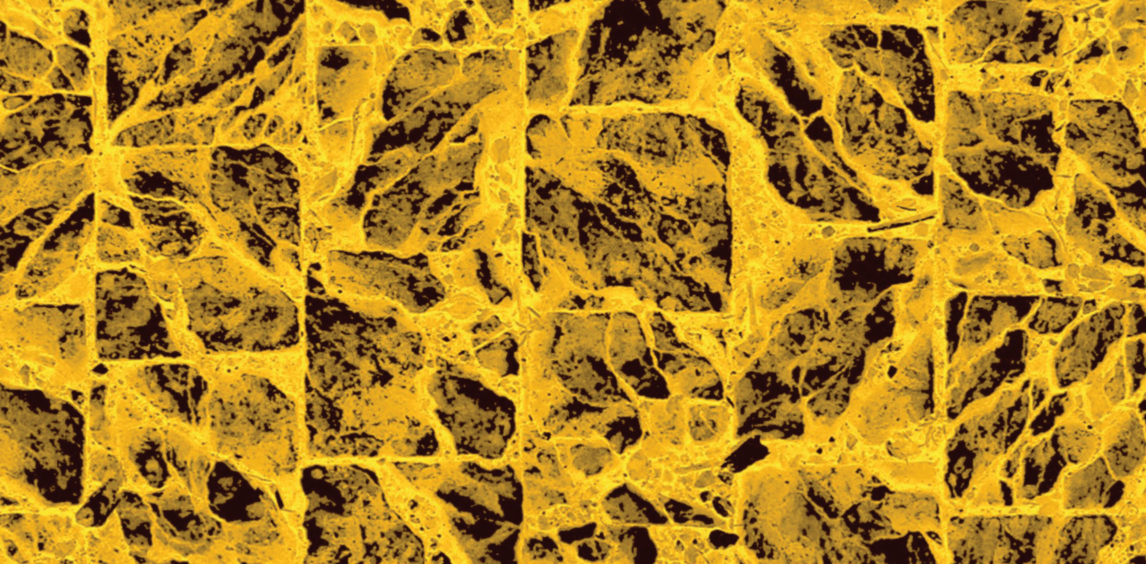

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Nanotechnology and Photovoltaic Devices

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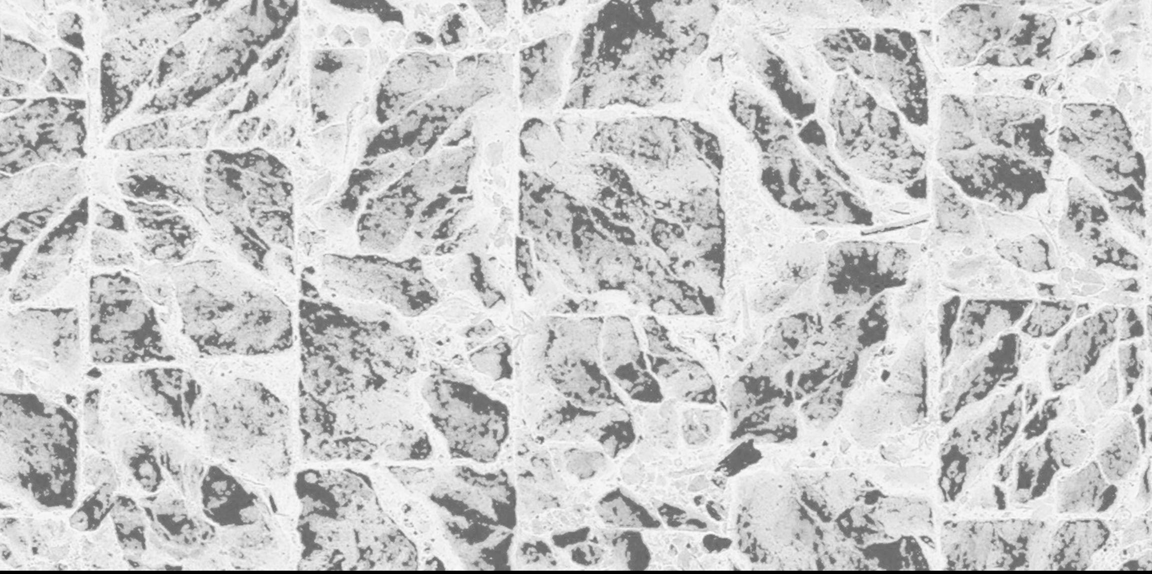

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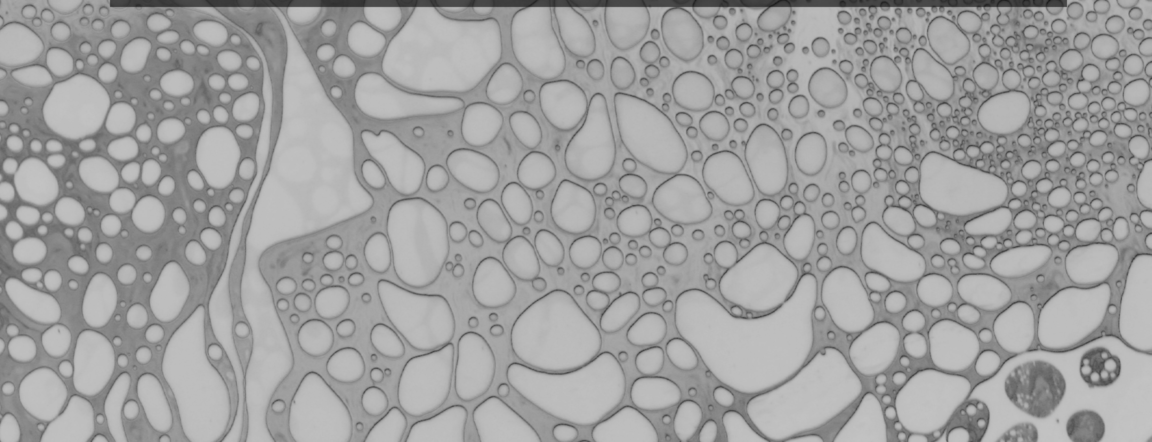

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Contents

Preface

The increasing energy demand of humankind on the Earth cannot be reasonably sustained by prolonged exploitation of fossil fuels. Therefore we have to turn toward efficient usage of the most abundant renewable supply of energy—it means the Sun. When considering Photovoltaics' aim, the direct transformation of solar photon flux into electrical energy, the most practical materials for this transformation are semiconductors whose absorption matches quite well solar photons' energy and whose conductivity can be adjusted so that photogenerated charge carriers are separated and directed to make useful work in an external circuit. Fortunately, some of these materials are very abundant, especially silicon, but other elements from group IV of the periodic table of elements are also extremely interesting. However, the maximum efficiency in energy conversion of the solar spectrum by a single semiconductor material is limited, as described by the famous Shockley–Queisser limit. To overcome this constraint, most of the proposed ideas, commonly labeled as third-generation Photovoltaics, are based on Nanotechnology employing materials whose energy scheme is more complex and variable. There are such materials, namely, semiconductor nanostructures, that enable us to tune their energy levels, density of electronic states, transition probabilities, etc., with large potential benefits for light energy conversion.

The purpose of this book is to summarize the knowledge and current advances of group IV semiconductor nanostructures potentially applicable in the next generations of solar cells. Considering the increasing research efforts devoted to nanostructure applications in Photovoltaics, our intention was to provide a clear background to students and newcomer researchers as well as to point out some open questions and promising directions of future development.

The book presents a broad overview on group IV nanostructures in Photovoltaics, beginning with a theoretical background, presentation of main solar cell principles, technological aspects, and nanostructure characterization techniques and finishing with the design and testing of prototype devices. The limited space of one book did not allow us to include some special nanostructure-related subjects, such as nanocrystal-sensitized solar cells (Grätzel cells or polymer cells), microcrystalline and amorphous silicon materials, rare-earth-doped nanostructures, plasmonic structures, etc. It is not intended to be just a review of the most up-to-date literature, but the contributing authors' ambition was to provide an educative background of the field. In view of the harsh economic competition in the solar cell business it might be that nanostructures will never be a commonly used material in Photovoltaics' massive production; still the solid background knowledge gained by researchers and summarized in this book will help in applying nanostructures to this and other fields.

The idea to compile this book was born in 2012 within the framework of a successful European research project (NASCEnT, Silicon nanodots for solar cell tandem, 2010–2013, 7FP project contract 245997), and in fact, many authors of the book participated in that project. Therefore we shall thank the European Commission for the support and Pan Stanford Publishing for its effort and helpful cooperation. The main acknowledgment goes to all chapter authors, who invested a lot of time and effort into the success of this book.

Jan Valenta and Salvo Mirabella
Prague and Catania
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