Photovoltaic power generation technology is one of the most promising options for a sustainable energy future. A permanent interest, both of research and the solar cell industry, has increased the efficiency and dropped the cost of producing 1 kW. In this way, four generations of solar cells have been developed.

The majority of solar cells that exist on the market belong to the first generation of solar cells, based on silicon mono-crystalline. These products are based on silicon wafers, either single-crystalline or a lower-grade multi-crystalline wafers. The production volume is growing with the focus on improving the efficiency and reducing the cost. One of the high-efficiency technologies is based on “buried contact” solar cells. Another technology is based on high-performance silicon-on-glass.

The second generation of solar cells has the objective of reducing the production cost by using polycrystalline silicone or different semiconductors (CdTe, CuIn, Se₂) thin films. Large-scale commercialization of these products leads to a completely different manufacturing cost structure compared to the wafer-based products.

The solar cells from the third generation allow for high-efficiency, while remaining cheap (Green, 2006). There are three options of these solar cells, based on the utilization of nanotechnologies:

- The first option is based on Quantum Well Solar Cells. Keith Barnham and his co-workers from the Imperial College of Science, Technology and Medicine, London, United Kingdom, have developed such solar cells by interleaving 50 slices of InGaAs (Barnham, et al., 2001). They have demonstrated the possibility of obtaining an efficiency of 17% for concentrated solar radiation with a concentration ratio of 300.
- The second option is based on the development of Sensitized Organic Dye Solar Cells as well as Polymer Solar Cells. The best efficiency of such solar cells was 11%, reported by Michael Gratzel (O’Regan & Gratzel, 1991). These solar cells are 3-4 times cheaper than the first generation. The efficiency of the polymer solar cells is 10-11%.
- The third one is based on the Quantum Dot Solar Cells. The Martin Green Group, from the New South Wales University, Sidney, Australia, successfully developed the first solar cells of this type. This technology offers an efficiency of 20-30%. However, in order to become commercial, 10 to 15 years are still required.

The fourth generation of solar cells was launched and uses composite materials. The third and fourth generations of solar cells are potentially able to overcome the Schockley-Quiesser conversion efficiency (Shockley & Queisser, 1961) of 31% at 1-sun and 41% under concentration for...
single bandgap solar cells. The third generation systems include multi-layer, multi-junction (tandem) solar cells made of thin film Si or III-V compounds, while new developments include intermediate bands and hot carrier solar cells.

Taking into account this approach, the book, which is dedicated especially to the third generation of solar cells, is structured on five sections, namely:

- **Section 1: Basic Topics:** Chapter 1, “New Trends in Solar Cells,” and Chapter 2, “Physical Limitations of Photovoltaic Conversion”
- **Section 5: Luminescent Solar Concentrators: Prospects and Strategies for Advanced Solar Cells:** Chapter 13, “The Luminescent Solar Concentrator: Advances, Optimization, and Outlook, Chapter 14, “Prospects and Strategy of Development for Advanced Solar Cells”

The main goal of this book is to concentrate and present the main results obtained in research regarding materials, technology, modeling, and simulation of different types of advanced solar cells.

The book is targeted at experts from universities and research organizations (engineers, physicists, chemists), as well as young professionals (PhD students, master students, engineers, physicists, chemists, as well as under-graduate students from the terminal years in physics, chemistry, material sciences, optical and electrical engineering) interested in advanced solar cells. The book could be used also by specialized companies in order to consider the development trends and market opportunities for advanced solar cells.

The editors would like this book to become a building block in the progress of PV conversion of solar energy and, in this way, to a sustainable development society.

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