Abstract of PhD Thesis

Improved Light Management and Photogenerated Carrier Collections Concepts for Third Generation Solar Cells (Koncepcje na poprawę zarządzania światłem oraz zbierania fotowzbudzonych nośników ładunku w ogniwach słonecznych trzeciej generacji)

Maciej Krajewski

This thesis is dedicated to research aimed at the performance enhancement of solar cells by optimization of photon and electron management within the photovoltaic system. It particularly focuses on a crucial component of the solar cell, namely the transparent electrode, which is designed to let as much light as possible into the active layer, where free carriers are generated, and to efficiently collect these charges. Solar cells are currently a dynamically developing source of renewable energy, which in the future may account for the majority of generated electrical energy worldwide. Therefore, research to improve their efficiency is crucial for the development and widespread implementation of this technology.

The thesis introduces concepts aimed at improving the properties of the upper layer of the solar cell, both electrically and optically. The work consists of three main chapters covering various approaches to those materials and systems.

The thesis presents research on the deposition of atomic layers of co-doped zinc oxide, used as a planar conducting electrode. The obtained material exhibits excellent optoelectrical properties, surpassing the results achieved by the commonly used aluminium-doped zinc oxide. This section also focuses on the proposed composite electrode, composed of a multilayer structure of oxide-metal-oxide, as the promising approach towards the operation of transparent electrodes.

This work demonstrates also a structured anti-reflective layer placed on top of the solar cell, using the nanoimprint technique. This scalable solution, applicable in the current industrial production chain, visibly improves performance results, especially the generated current.

Another part of the thesis introduces a model of a structured electrode utilizing a submicron mesh embedded in a planar oxide electrode. The presented model illustrates trends to consider when choosing the mesh geometry and allows for its adaptation to the selected active layer. The impact on the optical properties of such a composite material is also determined, providing a basis for experimental verification of numerical studies in the future.

This doctoral thesis contains new information enabling the design and fabrication of solar cells incorporating the proposed concepts. The author hopes that the research presented herein will contribute to improving the efficiency of solar cells on a large scale and accelerate the implementation of the latest solutions and architectures. I believe that this thesis can be useful for young students and researchers looking for reliable information source about solar cells, the photovoltaic market and new concepts emerging in this field.