Optimization of ZnO-Si photovoltaic cells

Author: Katarzyna Gwóźdź

Supervisor: prof. dr hab. Ewa Popko
Second supervisor: dr inż. Eunika Zielony

Abstract

Photovoltaics is being one of the most developed branch of renewable energies technologies. Nowadays, research focuses not only on increasing the efficiency of the solar cells, but also decreasing the cost of the production of the solar panels. Combining low-cost, non-toxic and easily accessible zinc oxide with cheap silicon substrates lead to fabrication of inorganic solar cells, which technological process is economical and scalable. However, the efficiency of those solar cells is still too low to compete with commonly used silicon cells.

The goal of this work is optimization of ZnO/Si heterojunction solar cells leading to the increase of their efficiency. To achieve the assumed goal, two different research paths were chosen. The first one, includes increasing the absorption of the solar cells using plasmonic effects in metallic nanoparticles. The method is widely used in different kind of solar cells leading to the increase of efficiency. The second one involves determination of the quality of the layers and junction by investigating the defects by the means of electrical methods. Knowledge about the parameters and origin of the defects will allow to eliminate them during the technological process.

Nanoparticles of different sizes made of gold and silver were deposited. on top of the ZnO/Si solar cells. Optical and photovoltaic properties were investigated to establish the influence of the nanoparticle on the solar cells performance. In each case the increase of external quantum efficiency was observed in comparison to the reference sample without the nanoparticles. The highest relative increase of efficiency (167%) was achieved for solar cells with silver nanoparticles of sizes around 10 nm. Whereas, the highest efficiency observed (5,8%) was for solar cells with gold nanoparticles of sizes smaller than 10 nm.

Silicon substrates of p- and n-type were investigated by the means of deep level transient spectroscopy (DLTS) and Laplace deep level transient spectroscopy (LDLTS). It allowed to describe traps associated with defects originating from the presence of carbon-oxygen-hydrogen complexes (COH), gold-hydrogen complexes (AuH) and iron atoms in silicon crystal. Based on mentioned measurements, the quality of the used silicon substrate was estimated. By means of the DLTS method defects in the ZnO layer and at the ZnO/Si interface were investigated. In ZnO typical defect related with oxygen vacancy was observed. At the same time, different concentration of surface defects were found at the interface.

Innovative studies performed within this work will allow the optimization of the ZnO/Si solar cells. Nevertheless, this research will also influence on the development of wide range of scientific areas, concerning silicon technologies, photovoltaics and nanostructures.