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Deep traps in the ZnO nanorods/Si solar cells

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Electric measurements were performed on solar cells composed of n-type ZnO nanorods grown by the hydrothermal method on p-type silicon substrate. The nanorods were covered with silver nanoparticles of sizes 20-30 nm and 50-60 nm. The diameters and density of the nanorods and nanoparticles were determined from scanning electron microscopy (SEM) and atomic force microscopy (AFM) images. On top of the structures the ZnO:Al (AZO) layer was deposited as a transparent electrode using the atomic layer deposition (ALD) method. The efficiency of the cells was found to be ~3.4%, however the sample with larger nanoparticles exhibit better performance. The analysis of the current-voltage (I-V) measurements vs illumination intensity let us conclude that the surface recombination deteriorates their performance. The measurements of capacitance-voltage (C-V) characteristics allowed us to determine the concentration of donors in ZnO and built-in voltage at the ZnO/Si interface. The deep level transient spectroscopy (DLTS) measurements confirmed the presence of defects at the surface as well as deeper in the ZnO nanorods. Obtained results compared with the data reported elsewhere let us conclude that the defect density is much less than in the case of similar heterojunction ZnO/Si solar cells made by other technological methods.

I. INTRODUCTION

Zinc oxide is an attractive semiconductor material due to its wide band gap (3.37 eV at 300 K) and large exciton binding energy (60 meV) [1] for many applications such as photodetectors [2-4], light emitters [5, 6] and gas sensors [7, 8]. Its possible application in optoelectronics is limited because of problems with growing stable p-type zinc oxide due to the presence of oxygen vacancies and zinc interstitials [9]. The knowledge of the defects occurring in ZnO, which is necessary for technological optimization, is not accomplished yet, despite the intense efforts [10-12]. Concerning applications in photovoltaics, ZnO can be used as an n-type partner to a p-type Si [13, 14], GaN [15, 16] and Cu_2O [17] in heterojunctions.