Electrical Properties of Anisotype ZnO:Al/ZnSe/*p*-CdTe Heterostructures

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Solar cells based on CdTe, fabricated in the form of ITO/CdS/CdTe heterostructures, achieved an efficiency of more than 22% when the buffer layer from the CdS compound was replaced by a wide-gap MgZnO solid solution. The wider band gap of zinc selenide (2.7 eV), higher transparency, and a small difference in electron affinities (0.19 eV) contribute to the use of ZnSe as an alternative to CdS buffer layer in these solar cells to increase their efficiency [1].

The investigated ZnO:Al/ZnSe/*p*-CdTe heterostructures were produced by sequentially deposition of ZnSe and ZnO:Al thin films by high-frequency magnetron sputtering on the surface of freshly cleaved plates from the crystalline parts of a CdTe ingot. Cadmium telluride crystals were grown by the vertical Bridgman method with a low pressure of cadmium vapor in an ampoule to form acceptor defects of cadmium vacancies (V_{Cd}^{-}, V_{Cd}^{-2}), which determine the hole conductivity of the semiconductor. The kinetic parameters of *p*-CdTe at T= 295 K were: specific electrical conductivity $\sigma = 3\cdot10^{-3}\ \Omega^{-1}\cdot cm^{-1}$, hole concentration and mobility p= $3.5\cdot10^{14}$ cm^{-3} and μ_H = 56.0 cm$^2\cdot$V$^{-1}\cdot$s^{-1}, respectively. The problem of making ohmic contacts to *p*-CdTe was solved by creating a p^+-region in the near-surface layer of the semiconductor when irradiated with ruby laser pulses (wavelength l = 0.694 μm, absorption coefficient $a = 6\cdot10^4$ cm^{-1}).

The rectifying properties of ZnO:Al/ZnSe/*p*-CdTe heterojunctions are determined by a potential barrier of ~1.0 eV formed in the near-contact region of *p*-CdTe. Current rectification coefficient: ~10^2. The *I-V*–characteristics of the structures are well explained within the framework of the theory of currents limited by the space charge (which is caused by the formation of an inverse layer in the near-surface region of *p*-CdTe), both in the region of small forward biases ($3kT/q < V < 0.45$ V) and in the region reverse biases (-0.6 V $< V <$ $-3kT/q$). As the forward voltage increases, the main mechanism of current transfer is electron tunneling through a thin potential barrier from the conduction band of the film to the conduction band of *p*-CdTe. In the region of higher reverse biases ($V <$ -0.6 V), the current is formed by the tunneling of electrons from deep energy levels ΔE = 0.5 eV located in the band gap of cadmium telluride in the region of the inversion layer.

The *C-V*–characteristics of ZnO:Al/ZnSe/*p*-CdTe heterojunctions in the region of reverse biases at high frequencies (f = 600 – 1000 kHz) correspond to sharp surface-barrier structures. The dependence of the capacitance on the frequency of the alternating signal observed at low frequencies (f = 10 – 100 kHz) is explained by the influence of the charge of deep surface levels at the ZnSe/*p*-CdTe interface.

The constructed energy diagram of the ZnO:Al/ZnSe/*p*-CdTe heterostructure (taking into account the energy parameters of the materials) well explains the obtained experimental results.

[1] A. A. Khurram, M. Imran, Nawazish A. Khan, M. Nasir Mehmood, *J. Semiconductors* **38**, 093001 (2017)