Magnetron sputtering of Cu_2O thin films for photovoltaics

D.A. Kudryashov[1], A.S. Gudovskikh[1], A.A. Lazarenko[1]

[1] St Petersburg Academic University of RAS, St.-Petersburg, Russia

Currently, new types of solar cells (SC) are actively developing. In parallel, new materials for solar cells are investigating. The choice of materials for the next generation solar cell must meet such requirements as high chemical stability, low toxicity, and scalability at the industrial scale. Copper oxide (I) - one of the most interesting material in terms of photovoltaic semiconductor materials because of its availability, non-toxicity, and having a low cost of production. On the other hand Cu_2O is a direct-gap p-type semiconductor with a band gap of 2.2 eV and having a high optical absorption coefficient [1]. Calculated by Shockley-Queisser limit of efficiency for solar cells based on Cu_2O is about 20% [2]. However, the state of the art of recent values for the efficiency of these SC does not exceed 5.38% [3].

In this work we present experimental results for rf-magnetron sputtering of Cu_2O thin films for photovoltaic application.

Cu_2O films were deposited at room temperature on Si(100)-wafers and glass substrates by rf-magnetron sputtering techniques (BOC Edwards Auto 500 RF) using 99.9% Cu_2O 3" targets supplied by Testbourne Ltd. High purity argon gas was introduced at rate of 10-15 sccm. No oxygen was added during deposition. The working pressure was changed from 10^{-4}-10^{-3} mbar and rf power was varied from 50 to 125W. Film thickness was measured with a profiler AMBiOS XP-1. The microstructure of the samples was analyzed using a scanning electron microscope (SUPRA 25-30-63). The optical transmittance of was measured using spectrophotometer based on Solar Laser Systems M266 monochromator. Spectral refractive index of Cu_2O film was measured using Horiba UVISEL2 ellipsometer. The PL spectra were measured using an instrument from Accent Optical Technologies at the room temperature.

SEM images of all samples show smooth surface with sharp substrate/Cu_2O interface. Increasing sputtering power results in changing morphology of thin films. The PL spectra measured at room temperature shows a small photoresponse with two peaks: sharp peak at 625 nm corresponding to band-to-band transitions and broad peak at 705 nm related to growth defects. Adsorption coefficient and band gap energy of Cu_2O (1.98 eV) were calculated from transmittance spectra being in accordance to other reports [4] and measured PL data.

The reported study was partially supported by RFBR, research project No15-08-06645-A

References:

1. Sven Ruhle et al. All-Oxide Photovoltaics // J. Phys. Chem. Lett.2012, 3, 3755-3764

2. Lee, Yun Seog et al. // Applied Physics Letters 98.19 (2011): 192115.

3. T. Minami, T. Miyata, Y. Nishi // Solar Energy, V. 105, 2014, P.206–217

4. Sivasankar R, A Venkata et al // Mater. Lett 60 1617 (2006)