Nanocomposites and nanomaterials

Synthesis of $Cu_2ZnSnSe_4$ nanoparticles by colloidal method

O.A. Dobrozhan, A.S. Opanasyuk, S.I. Kshnyakina

Department of Electronics and Computer Technics, Sumy State University, Rymskogo-Korsakova st., 2, Sumy-40007, Ukraine.
E-mail: dobrozhan.a@gmail.com

Recently the thin films of semiconductor compound $Cu_2ZnSnSe_4$ (CZTSe) have attracted the attention of scientific community as alternative layers of $CuInSe_2$ (CIS), $CuIn_{1-x}GaxSe_2$ (CIGS) and CdTe for designing cheap thin film solar cells (SCs). This material has the optimum for conversation of solar energy into electricity band gap (E_g = 1 eV), high absorption coefficient ($\alpha > 10^5$ cm^{-1}), *p*-type conductivity and is characterized as by long lifetime so as by high mobility of charge carriers [1]. The colloidal synthesis is promising among nonvacuum chemical methods for obtaining CZTSe nanoparticles which allows synthesizing nanoparticles of a wide range of materials with the possibility of forming films using spin-coating, spray pyrolysis techniques. Also, it is important that the properties of the synthesized nanoparticles strongly depend on the shape and size. The above mentioned makes purpose of this work which is based on studying the morphological characteristics and chemical composition of nanoparticles CZTSe with different sizes and shapes synthesized by colloidal method.

Different types of phosphonic acid (propyl-, hexyl-, dodecyl- and tetradecyl-) were added to the initial solutions which were used for general synthesis for changing the size and shape of the nanoparticles. The morphology of the nanoparticles was studied by transmittance electron microscopy (TEM). Scanning electron microscopy (SEM) was performed using a ZEISS Auriga SEM with an energy dispersive X-ray spectroscopy (EDAX) detector to study composition.

It was established that the synthesized CZTSe nanoparticles were monodisperse and had small sizes (15-30 nm), their shape was like a circle, triangle, or was multifaceted, depending on the type of phosphonic acid. EDAX analysis showed that the particles were not stoichiometric with low level of zinc ions. The best results in relation to stoichiometry were obtained using the tetradecylphosphonic acid: $Cu_{1.87}Zn_{0.43}Sn_{0.99}Se_4$. These results can be used for obtaining SCs absorber layers.

1. *Opanasyuk A.S., Kurbatov D.I., Cheong H. et al.* Properties of the window layers for the CZTSe and CZTS based solar cells // J. Nano- Electron. Phys.- 2012. **- 4. -** P. 01024-1-01024-3.