## Nanocomposites and nanomaterials

# Optical properties of CZTS films obtained from nanoink deposition by spray pyrolysis technique

**O.A. Dobrozhan[1], A.O. Salohub[1], P.N. Danylchenko[1], A.S. Opanasyuk[1]**

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

$Cu_2ZnSnS_4$ (CZTS) is *p*-type semiconductor compound, having both an optimal band gap ($E_g$ = 1.0-1.5 eV) for the effective absorption of solar spectrum and the high absorption coefficients ($\alpha \approx 10^4$-$10^5$ $cm^{-1}$), is considered as the promising alternative to the traditional absorber layers, such as Si, CdTe, $Cu(In,Ga)(S,Se)_2$, in 3rd generation thin-film solar cells.

One of the low-cost and non-vacuum techniques for the CZTS film deposition onto different kinds of substrates is the spraying of previously synthesized colloidal nanocrystals (NCs) in nanoink form by using the pneumatic pulsed spray pyrolysis. During this process, the film's properties can be controlled by either changing NCs or solvent characteristics. Thus, the main goal of this work is to investigate the optical properties of CZTS NCs and films deposited by spraying of colloidal nanocrystal solution dispersed in hexane (synthetic procedure is described in [1]) by using spray-pyrolysis technique at the different physical-chemical deposition and annealing conditions (substrate temperature $T_s$ = 523 K; annealing temperature $T_a$ = (523-723) K; step change $\Delta$ = 50 K; annealing time $t_a$ = (2-10) min). The optical properties of films were studied by a spectrophotometer LI-722 at the wavelength range $\lambda$ = (320-1000) nm. The absorption spectra of NCs and films were derived from transmission coefficients ($T(\lambda)$), absorbance ($D$), and film's thickness ($d$).

It was shown, that the material of freshly synthesized CZTS NCs had a band gap of $E_g$ = 1.58 eV. The increase of annealing time $t_a$ at the constant temperature ($T_a$ = 723 K) led to the slight increase in $E_g$ = (1.42-1.65) eV. The same changing tendency of $E_g$ = (1.42-1.67) eV was observed with increasing of $T_a$ at the constant $t_a$ = 3 min. This may be due to the increase of grain's size in the nanocrystalline films with increase of $T_a$ and $t_a$ values

1. Yang Y., Que W., Zhang X., Yin X., et al. *Appl. Catal. B* 200 (2017) 402-411.