Study of Alkali (Na, K)-Doped Cu_2ZnSnS_4 Thin Films Prepared by Sol–Gel Method

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Received September 21, 2020
Revised September 21, 2020
Accepted for publication October 7, 2020

The non-doped and alkali (Na, K)-doped Cu_2ZnSnS_4 (CZTS) thin films were prepared using the sol–gel spin coating method on the glass substrate, and the changes in the structural, optical, and electrical characteristics of the films were examined and compared. The structural study results obtained showed that all the prepared samples had a kesterite structure. The scanning electron microscopy and Raman analysis showed that the samples' surface and crystalline quality were significantly changed by doping, and an appropriate amount of dopants can improve them. The optical study showed that the energy gap values for the CZTS layers were in the range of 1.40–1.61 eV, which is desirable for solar cells. Moreover, good optical conductivity values (10^{12} to $10^{15}\,S^{-1}$) and high absorption coefficients (up to $1.8 \cdot 10^5\,cm^{-1}$ in the visible region) were obtained for the CZTS thin films. Investigation of the sample's electrical properties indicated that non-doped and doped CZTS was *p*-type, and therefore doping did not change the type of the charter of thin films. Moreover, the carrier concentration of the samples significantly increased up to $8.00 \cdot 10^{19}\,cm^{-3}$ (one order of magnitude increase) with the doping. The samples' photovoltaic properties showed that the fabricated ZnS|CZTS hetero-junction exhibited good rectifying behavior and the doped layers had better diode parameters. Overall, the results showed that the CZTS thin films doped with an appropriate amount of dopants (1% Na and 1.5% K) had better structural, optical, and electrical properties. The photo-electrical study of the samples showed that for all samples, photocurrent under light illumination significantly increased (especially for Na-doped CZTS thin films), indicating that the CZTS thin films are suitable for solar energy conversion.

Keywords: sol–gel, Cu_2ZnSnS_4 (CZTS) thin films, alkali dopants, photodiodes, solar cell.

Full text of the paper will appear in journal SEMICONDUCTORS.