Effect of Varying the Cu Content on Cu(In,Ga)Se2 Solar Cells

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Abstract

$Cu(In,Ga)Se_2$ (CIGS) based thin film solar cells are the most efficiency polycrystalline solar cells, performing even at an higher electrical performance than multi-crystalline solar cells. Furthermore, CIGS is still not a mature technology with significant potential gains yet to be achieved. There is still a significant amount of knowledge that needs to be understood since CIGS is a self-doped semiconductor and its opto-electric are closely related with its preparations means. For instance the ratio [Cu]/([Ga]+[In]) (CGI) has a profound influence on the opto-electronic, on the structural properties of these and on the electrical performance of resulting thin film solar cells [1,2,3,4]. Most of the fundamental studies found in the literature are based in CIGS layers that present a [Ga]/([Ga]+[In]) depth profile and/or Cu-rich to Cu-poor transitions during the different growth stages. To understand in detail the effect of variations in the Cu content, it is necessary to isolate this effect from the variation of other elements and to avoid Cu-transitions during its growth. Hence, in this work, we prepared a set of CIGS samples using flat evaporation rates which produced films with a constant value of [Ga]/([Ga]+[In]) (GGI) in depth and without any Cu-transitions. The CGI contents studied were 0.53 (10.5 % power conversion efficiency), 0.71 (13.8% efficiency), 0.85 (15.1% efficiency) and 0.98 (14.5% efficiency) with a fixed GGI of 0.3. For low CGI values, the electrical performance lowers together with a lowering of the crystal quality and an increase of the effect of fluctuating potentials, as observed by photoluminescence (Fig.1). External quantum efficiency measurements show that between CGI values of 0.53 and 0.85, the bandgap energy increases with increasing Cu content. A relation between the electrical performance and the morphological and opto-electronic properties for multi-crystalline samples with depth-flat Ga ratios and no Cu-transitions is demonstrated.

References

[1] J.-F. Guillemoles, L. Kronik, D. Cahen, U. Rau, A. Jasenek, H.-W. Schock, J. Phys. Chem. B, **104** (2000), 4849.
[2] I. Dirnstorfer, M. Wagner, D. M. Hofmann, M. D. Lampert, F. Karg, and B. K. Meyer, Phys. Status Solidi A **168** (1998), 163.
[3] J. P. Teixeira, R. A. Sousa, M. G. Sousa, A. F. da Cunha, P. A. Fernandes, P. M. P. Salomé, J. P. Leitão, Physical Review B, 90 (2014) 235202.
[4] J.P. Teixeira, R.A. Sousa, M.G.Sousa, A.F. da Cunha, P.A. Fernandes, P. M.P. Salomé, J.C. González, J.P. Leitão, Appl. Phys. Lett., 105 (2014) 163901.

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