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Different natures of sub-gap states in 135-CIGS / 112-CIGS and 112-CIGS / 135-CIGS heterostructures investigated by photoluminescence technique

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$CuIn_{1-x}Ga_xSe_2$ (112-CIGS) has been proposed as a material for high efficiency thin film solar cells with reliably applicable photovoltaic properties. Higher efficiency devices can be achieved by various surface treatments and are believed to have Cu deficiency at the surface. One of the possible techniques is to have a very thin Cu-depleted surface, e.g. $Cu(In_{1-x}Ga_x)_3Se_5$ (135-CIGS) layer on top of 112-CIGS layer, thus the heterostructure of 135-CIGS / 112-CIGS is formed. Our previous work show that the photoluminescence (PL) spectra of 135-CIGS with various thicknesses on 112-CIGS (135-CIGS / 112-CIGS) heterostructure are identified as donor-to-acceptor pairs (DAPs) and free (conduction band) -to-bound (acceptor) transitions and show the temperature and excitation power dependence on the PL spectra. On the contrary, when the thin 112-CIGS layer is deposited on top of 135-CIGS (112-CIGS / 135-CIGS), the PL spectra show more pronounced and resolved peaks which are surprisingly independent of temperature and excitation power and significantly distinguishable in its natures observed in those broad emissions of 135-CIGS / 112-CIGS heterostructures.When the thickness of 112-CIGS on 135-CIGS is increased, the red shift in the order of ten meV is noticed in both emission lines of 112-CIGS and 135-CIGS. These results suggest that the strains play more important roles in thinner capping layer and freeze out the temperature and excitation power dependence in the 112-CIGS / 135-CIGS rather than the 135-CIGS / 112-CIGS heterostructures.

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