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An Investigation on the Suitability of Dual Ion Beam Sputtered GMZO Thin Films: For All Sputtered Buffer-Less Solar Cells

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Abstract : CuInGaSe (CIGSe) is the dominant thin film solar cell technology. The band alignment of Buffer/CIGSe interface is one of the most crucial parameters for solar cell performance. In this article, the valence band offset (VBOff) and conduction band offset (CBOff) values of Cu(In0.70Ga0.30)Se/ 1 at.% Ga: Mg0.25Zn0.75O (GMZO) heterojunction, grown by dual ion beam sputtering system (DIBS), are calculated to understand the carrier transport mechanism at the heterojunction for the realization of all sputtered buffer-less solar cells. To determine the valence band offset (VBOff), ΔE_V at GMZO/CIGSe heterojunction interface, the standard method based on core-level photoemission is utilized. The value of ΔE_V can be evaluated by considering common core-level peaks. In our study, the values of (Valence band onset)VBOn, obtained by linear extrapolation method for GMZO and CIGSe films are calculated to be 2.86 and 0.76 eV. In the UPS spectra peak positions of Se 3d is observed in UPS spectra at 54.82 and 54.7 eV for CIGSe film and GMZO/CIGSe interface respectively, while the peak position of Mg 2p is observed at 50.09 and 50.12 eV for GMZO and GMZO/CIGSe interface respectively. The optical band gap of CIGSe and GMZO are obtained from absorption spectra procured from spectroscopic ellipsometry are 1.26 and 3.84 eV respectively. The calculated average values of ΔE_v and ΔE_C are estimated to be 2.37 and 0.21 eV, respectively, at room temperature. The calculated positive conduction band offset termed as a spike at the absorber junction is the required criterion for the high-efficiency solar cells for the efficient charge extraction from the junction. So we can conclude that the above study confirms GMZO thin films grown by the dual ion beam sputtering system are the suitable candidate for the CIGSe thin films based ultra-thin buffer-less solar cells. We investigated the band-offset properties at the GMZO/CIGSe heterojunction to verify the suitability of the GMZO for the realization of the buffer-less solar cells. The calculated average values of ΔE_V and ΔE_C are estimated to be 2.37 and 0.21 eV, respectively, at room temperature. The calculated positive conduction band offset termed as a spike at the absorber junction is the required criterion for the high-efficiency solar cells for the efficient charge extraction from the junction. So we can conclude that the above study confirms GMZO thin films grown by the dual ion beam sputtering system are the suitable candidate for the CIGSe thin films based ultra-thin buffer-less solar cells. Acknowledgment: We are thankful to DIBS, EDX, and XRD facility equipped at Sophisticated Instrument Centre (SIC) at IIT Indore. The authors B.S.S and A.K acknowledge CSIR and V.G acknowledge UGC, India for their fellowships. B.S.S is thankful to DST and IUSSTF for BASE Internship Award. Prof. Shaibal Mukherjee is thankful to DST and IUSSTF for BASE Fellowship and MEITY YFRF award. This work is partially supported by DAE BRNS, DST CERI, and DST-RFBR Project under India-Russia Programme of Cooperation in Science and Technology. We are thankful to Mukul Gupta for SIMS facility equipped at UGC-DAE Indore.

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