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Research work presented in the thesis is based on the Development and Fabrication of Laser Scribed Copper Indium Gallium Diselenide (CIGS) Thin Film Solar Cell Module. Mature commercial crystalline Silicon (Si) solar cell technology has few demerits which have been subdued by polycrystalline CIGS solar cells. Substantially CIGS technology is cost-effective in the fabrication process as well as lower material consumption. SLG/Mo/CIGS/CdS/i-ZnO/AZO. The overall performance of this kind of solar cell depends on the properties of the individual thin film layers. In this present work, an individual thin film layer is optimized on a 60 x 60 mm SLG substrate using the physical vapor deposition (PVD) technique before proceeding to the fabrication of the CIGS solar cell. The fabrication process for 50 x 50 mm CIGS solar cell module was also optimized. Monolithic interconnection P1 was carried out by 1064 nm Nd:YAG and P2 and P3 were mechanically scribed.

The ohmic back contact Mo layer, deposited by DC magnetron sputtering, were used as a metallic low sheet resistance, (of about 0.332 Ω/•), back-contact for CIGS solar cell. On Mo thin-film CIGS, an absorber layer is deposited using RF sputtering followed by RTA at 400 ^{o}C (2 mins) + 550 ^{o}C (8 mins). For depositing the CIGS layer by RF-sputtering, an in-house CIGS sputter target was fabricated by cold press followed by vacuum sintering. The effects of different annealing profiles were analyzed to optimize the phase formation of the CIGS layer. Thin-film of cadmium sulfide (CdS) is deposited using thermal evaporation, chemical bath deposition, and RF-sputtering technique on CIGS thin film. The influence of bath temperature is observed. Using RF magnetron sputtering method bi-layer of Zinc Oxide (ZnO), i. e. intrinsic and aluminum-doped ZnO, as a Transparent Conducting Oxide (TCO), front contact for CIGS based solar cells is deposited and optimized. Finally, the aluminum (Al) grid is deposited on the ZnO layer for a better collection of photo-generated electrons. Al-Finger grid of 50 µm, 100 µm, and 200 µm was deposited on the top window layer.

The development of a CIGS thin-film solar cell device fabricated under optimized conditions of the individual thin film layer were studied. Although, the performance of these fabricated devices are less compared to the standard values of commercially available solar cells. But data from all our experiments indicate the importance of the CdS layer. As the thickness of CdS gets lower, the performance of solar cells also gets demised. Lower CdS thickness is responsible for shorting the layer of ZnO and CIGS. A Higher CdS layer can protect the junction from the high-energy sputtered ions. Some of the devices become electrically shunted due to stress generation during the AZO coating at higher pressure. By varying the thickness of i-ZnO and the CdS layer the internal stress can be reduced. Therefore, we can state that, we have successfully fabricated the CIGS solar cell having a V_{oc}, I_{sc}, η, FF, Rs, and Rsh of about 479 mV, 0.25 mA, 0.73 %, 54, 747 Ω-cm^2, and 6557 Ω-cm^2 and 50 x 50 cm module having a V_{oc}, I_{sc}, FF, η, Rs, and Rsh of about 410 mV, 0.11 mA, 0.26 %, 1879 Ω-cm^2, 9062 Ω-cm^2. Our ongoing efforts to enhance the performance of CIGS solar cells will soon have better results and will update from time to time.