OPTO-ELECTRONIC CHARACTERISATION OF LARGE AREA SOLAR CELLS

By

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(O.S. SASTRY)

ABSTRACT

Large area high efficiency solar cells are necessary for fabricating efficient panels for terrestrial solar energy applications. However, upscaling of the fabrication processes to large areas lowers the efficiency by introducing spatial defects and inhomogeneities. The work reported here investigates these defects and inhomogeneities and proposes methods to improve efficiencies. Studies have been performed on three photovoltaic systems: Polycrystalline silicon, CdS/Cu_2S and SnO_2/SiO_x /n-Si.

Scanning beam techniques have been developed using a laser beam or an electron beam, for indentifying and analysing these defects. A laser beam induced current system has been developed using a logic module or a micro - computer for a detailed analysis of the cell. A facility for electron beam induced current measurements has been incorporated in a Scanning Auger Microprobe (SAM,PHI, 590A) system for simultaneous study of EBIC and elemental analysis.

Capacitance transient techniques such as deep level transient spectrescopy (DLTS), thermal stimulated capacitance have been used to study the deep level defects present in the solar cells. The DLTS system uses micro-computer box-car for fast analysis of the defect parameters in a single temperature scan.

Studies on polycrystalline silicon solar cells reveal that the grain boundaries are the most prominent defects decreasing the efficiency. Impurities (Fe,Cr,and Ti) segregation enhances recombination property of the grain boundary. Apart from grain boundaries, localised regions of poor response formed because of the precipitation of impurities decreases the efficiency. Defects due to damages are also observed to lower the performance of the cells. Hydrogen treatment passivated the grain boundaries and improved the efficiencies.

Analysis on CdS /Cu_2S cells prepared using solution spray pyrolysis techniques shows inhomogeneities in Cu_2S and CdS layers. In Cu_2S , the inhomogeneities arise due to stoichiometry variations and thick CuO formation. CdS layer shows region of varying base resistivity and microstructure . Diffusion of Cu into CdS base degrades the cell efficiency by lowering Cu_2S stoichiometry. Also oxidation of top Cu_2S surface to form CuO increases the series resistance decreasing the efficiency. It has been shown that the hydrazine hydrate treatment and subsequent Cu refilling improve the efficiency in these cells.

SnO_2 /SiO_x /n-Si (SIS junction) cells fabricated using spray pyrolysis process are analysed. The analysis

shows that the inhomogeneities in these cells arise because of the interfacial oxide thickness variation and SnO_2 thickness variations. Inhomogeneous etching of the wafer introduces high density of surface states and surface charges, reducing the V_{oc} in these cells. Annealing the cells in O_2 or air improved the efficiencies.

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