Photoluminescence spectra at low temperatures of CdS-CdTe thin films

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Common solar cells use semiconductors to convert sunlight into electricity through the conversion process known as the photovoltaic (PV) effect. Thin-film solar technology is emerging in the photovoltaic industry as a viable alternative to crystalline silicon devices. Compound semiconductor thin films are theoretically able to achieve high efficiencies, using less material because of its intrinsic properties. The properties for a high yield of solar cells include: direct band gap, high optical absorption coefficient, ease of formation to both p- or n-type, good lattice structure and electron affinity. The direct band gap is useful because it conserves energy during the PV conversion process. A high optical absorption coefficient allows the material to absorb photons rather than reflecting or transmitting them. The formation of p- or n- is useful in creating the heterojunctions for efficient charge separation. Good lattice quality and electron affinity decrease device limiting issues, such as conduction band spikes - which reduce the ability of free carriers to contribute to the electricity generation. The thin films can be deposited as polycrystalline, nanocrystals or amorphous layers of material.

Cadmium telluride (CdTe) is an II-IV compound that leads in the thin-film PV market. CdTe has a direct band gap energy of 1.45eV which is ideal for absorbing photons in the solar spectrum. It also has a high absorption coefficient of 10^4 cm^{-1}. The substantial amount of energy resulted from a large bandgap and high absorption coefficient, allows the films to require less material. For instance, an absorber layer of 2 µm can absorb nearly all (99%) of the incident photons.

Within this framework, we try to understand the factors which limit dopant incorporation, investigate the defects associated with intrinsic and extrinsic doping of CdTe and explore favorable conditions for successfully incorporating dopant through deposition and processing techniques. The films were deposited using two deposition techniques Elemental Vapor Transport (EVT) and Close Space System (CSS) under various deposition and post-deposition processing conditions. They are grouped in three general categories: (a) Stoichiometric EVT films, (b) group V doped (Sb and P) EVT films and (c) CSS-deposited and subsequently Laser Annealed films. For discussion purposes the photoluminescence (PL) spectra are divided in three regions: excitonic (1.59-1.57eV), a “shallow” 1.56-1.33eV and a “deep” transition 1.2-0.8eV. The photoluminescence (PL) measurements were performed using a SPEX 500M monochromator containing a 600 mm/groove grating. The measurements have an energetic resolution of 1meV. Temperature and intensity dependent PL measurements, along with the analysis of the results were used to trace the changes in energetic levels as they relate to defects. In addition, the effect of CdTe growing and processing techniques on the materials defect structures was studied.

Keywords: CdTe-CdS, heterojunction, exciton, photoluminescence