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Characterization of Cu_2ZnSnS_4 (CZTS) by Two-wavelength excited Photoluminescence Spectroscopy

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Introduction: Indium (In) and Gallium (Ga) free, earth abundant and low cost solar cell absorber Cu_2ZnSnS_4 (CZTS) has received considerable attention as a promising material in place of Copper indium gallium (di) selenide (CIGS). To date the highest power conversion efficiency 12.6% has been reported for the CZTSSe solar cell. To improve the efficiency of solar cells, a better understanding of the physics involved in these materials is needed. By Transient Photo-capacitance Technique (TPC), Miller et al observed deep defect level centered roughly near at 0.8 eV for CZTSSe like CIGS. In this study, for CZTS samples we have investigated a defect at 0.8 eV from the valence band, by using the two-wavelength excited photoluminescence (PL) method.

Experimental: PL measurements were carried out at room temperature with a confocal laser scanning microscope using a 635 nm diode laser (Scientex OPG-3300) for excitation and a CCD is used for the detection. During the PL measurements, a 0.8 eV (1550 nm) laser beam corresponding to the defect level was irradiated simultaneously together with the 635 nm diode laser.

Result and Discussion: Figure 1 shows the schematic diagram showing the principle of the two-wavelength excited PL. The electron distribution and its possible recombination processes under the normal excitation (635 nm Laser) and two-wavelength excitation (635 nm + 1550 nm) are shown in Fig 1(a) and 1 (b), respectively. By the two-wavelength excited PL, both above gap excitation and below gap excitation which enables to saturate the 0.8 eV defect level were carried out to examine recombination properties of the 0.8 eV defect.

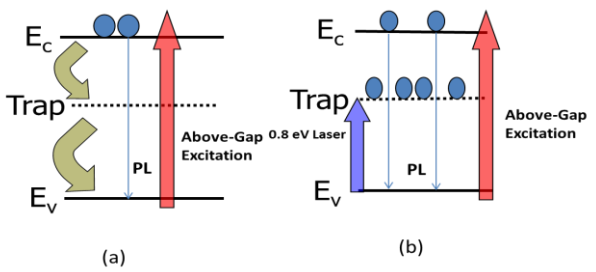

Figure 1 Principle of the Two-wavelength Excited PL

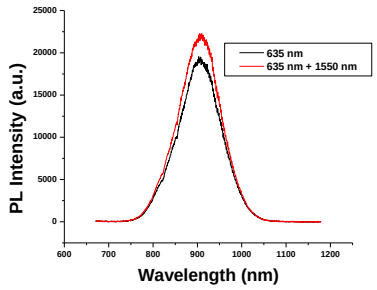

Figure 2 Two-wavelength Excited PL and normal PL spectra of CZTS (Cu/Sn = 1.75)

Figure 2 shows PL spectra of CZTS with Cu/Sn ratio of 1.75 measured under normal (635 nm laser) excitation and both 1550 nm and 635 nm laser irradiation. If we consider 0.8 eV defect level as a trap center then the PL intensity should be same under normal and two-wavelength excitation. There is clear increase in the PL intensity under 1550 nm laser irradiation which indicates a reduction in the non-radiative recombination by filling electrons at the 0.8 eV defect level that is the 0.8 eV defect level works as a recombination center at room temperature.