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Properties of pulsed laser deposited CuI and characteristics of constructed dye-sensitized TiO₂|dye|CuI solid states photovoltaic solar cells

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Conversion of sunlight to electrical power has been dominated by solid states photovoltaic solar cells made of silicon. Recently, this dominance is being challenging by new type of solar cells such as dye-sensitized photo-electrochemical solar cells with considerable power conversion efficiencies were fabricated by using nano-porous metal oxide electrodes [1,2]. The photoexcited dye molecules adsorbed on the surface of a n-type (p-type) semiconductor surface inject electrons (holes) into the conduction band (valence band) if the excited level (ground level) of the dye molecule is located above the conduction (valence) band.

We have prepared micro-porous TiO₂ electrodes with a thickness of 10 μm of TiO₂ films as described in the literature [3]. Dye was coated on the TiO₂ electrodes by immersing TiO₂ electrodes in the dye solution (0.5 g/l in dry ethanol), which was maintained at 45 °C. Tris (2,2'-bipyridyl 4-4'-dicarboxylate) ruthenium (II) was used as the dye. The optically transparent and electrically conducting copper iodide (CuI) of about 100 nm thickness thin films have been deposited by excimer pulsed laser deposition technique (PLD) (NISSIN 10X, XeCl, λ = 308 nm, τ = 20 nsec, repetition rate = 2 Hz, shot number = 1200 shots, spot size = 5.5 mm², base pressure = 2 × 10⁻⁵ Torr), which is focused on the target at an incident angle of 45° to the target normal,

at room temperature using a CuI target with 99 % purity and diameter of about 10 mm that was made by pressed and sintering a CuI powder in nitrogen atmosphere at 150 °C.

In this paper, the structural and optoelectrical properties of CuI thin films and the construction of dye-sensitized TiO₂|dye|CuI solid states photovoltaic solar cells are reported.

The deposited CuI thin films were characterized by studying the absorption of the films using UV|VIS|NIR spectrometer - Jasco V570 and the X-ray diffraction from the films using X-ray diffractometer - Jeol. A modified scanning electron microscope with acceleration voltage = 5 KV and current density = 90 μA was used to measure the cathodoluminescence of the films. The incident photon to current conversion efficiency (IPCE) of the cells with wavelength was measured using a monochromator (Jasco) coupled with single phases lock amplifier (NF Instrument 5600 A), under constant photon energy illumination mode (50 μW/cm²), and current voltage characteristics of the cells were studied under 1.5 AM condition.

Figure 1 shows the X-ray diffractograms of CuI (a) pellet, and (b) film. The peak at 25.7 degree is slightly deviated from the characteristic peak for the diffraction of X rays (111) plane of CuI crystals. This deviation may be due to diffusion of iodine atoms from the unit cell. The

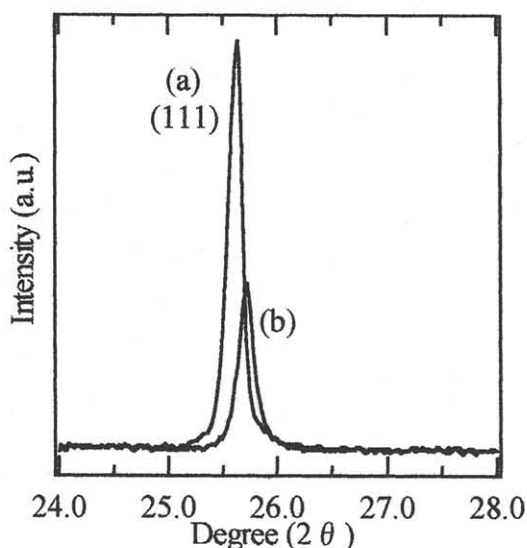


FIG. 1. X-ray diffractograms of CuI (a) pellet, and (b) film.

absorption spectrum of CuI film (Fig. 2b) is slightly shifted towards lower wavelengths compared to CuI pellet (Fig. 2a). This blue shift may be due to the existing of nano-particles in the film. The observed hump at 334 nm in the absorption spectrum (Fig. 2b) may be due to the excitation of electrons from sub bands to conduction bands. The transmittance spectrum (Fig. 2c) shows the film exhibited optical transmittance over 80 % in the wavelength region in range 400-900 nm. The cathodoluminescence spectra of the CuI pellet (Fig. 3a) and film (Fig. 3b) exhibited two emission peaks at 431, 728 and a shoulder at 808 nm, and at 431, 570, 728 and 808 nm,

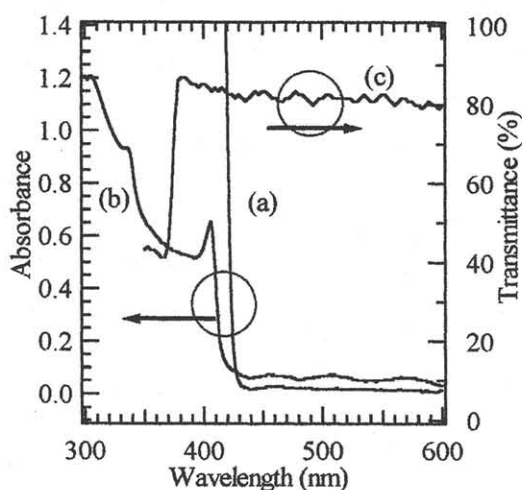


FIG. 2. Absorption spectra of CuI (a) pellet and (b) film, and (c) transmittance spectrum of CuI film.

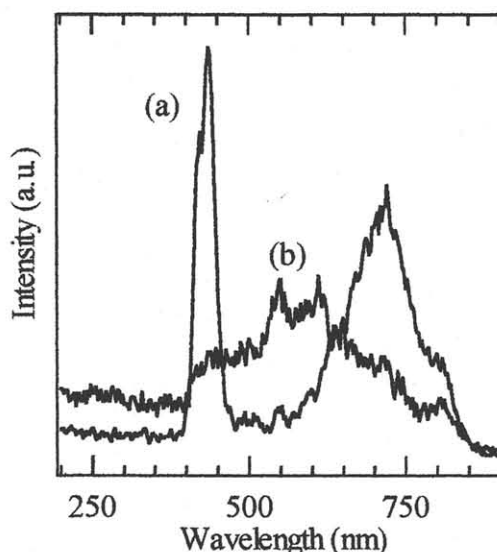


FIG. 3. Cathodoluminescence spectra of CuI (a) pellet, and (b) film.

respectively. Emission peak observed both at figure 3a and 3b may be due to the recombination of electrons and holes at Cu^{2+} and Cu^{1+} clusters. This red shift may be due to quenching of excited luminescence centers and repulsion of ions. Recombination of electrons and holes from band to impurity bands transitions might be responsible for the luminescence at 728 and 808 nm. From the current voltage characteristics, the fill factor and power conversion efficiency were about of 0.45 and 3 %, respectively. The maximum photocurrent of about 12.5 mA/cm^2 and photovoltage of 475 mV were obtained for the $\text{TiO}_2/\text{dye}/\text{CuI}$ solid states photovoltaic solar cells with good reproducibility.

Keywords: CuI; TiO_2 ; solar cell; PLD.

References

- [1] M.K. Nazeruddin, J. Am. Chem. Soc. 1613 (2001) 123.
- [2] B. O' Regan, M. Gratzel, Nature 737 (1991) 353.
- [3] P.M. Sirimanne, T. Shirata, T. Soga and T. Jimbo, J. Solid State Chem. (Submitted).

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