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# Comparing photoluminescence and structural properties of electrochemically deposited $Cu_2Sn_1S_3$ thin films

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## 1. Introduction

Quaternary $Cu_2Zn_1Sn_1S_4$ (CZTS) is known as a potential thin-film material in solar cells due to its earth abundant and environmentally friendly constituents.[1] However, few works have been reported on ternary CTS compounds. This study compared the optical and structural properties of CTS thin-film absorbers that were prepared by electroplating Cu/Sn layers onto glass/Mo substrates and sulfurization. Particularly, alloying of Cu/Sn layers was performed in low temperature before a high temperature sulfurization. The alloying was conducted at 170-220 °C for 60-90 min in vacuum. The sulfurization was conducted at 560 °C for 30-60 min in a tubular furnace that was filled with sulfur vapor and $N_2$ gas.

The crystal and optical properties of CTS thin-film absorbers that were prepared by various sulfurization processes were compared (Table 1). The structural study was performed using x-ray diffraction. The morphology and the composition of the CTS thin films were characterized by scanning electron microscopy and energy dispersive spectroscopy. Photoluminescence (PL) was performed at room-temperature using a 325 nm He-Cd laser.

The result revealed that the secondary phases appeared in the surface when the alloying time was longer than the sulfurization time (case CTS_001 and CTS_003). Furthermore, the optimized morphology of CTS absorbed layers were alloyed at 220 °C-60 min and sulfurized at 560 °C-60 min (CTS_004). Figure 3 shows the PL spectrum of the CTS film. A broad peak centered at 1.5 eV was observed.

## 2. General Instructions

Table 1. Four post-annealing cases and atomic ratios for CTS thin-film absorbed layer.

| Sample | Alloy temperature (°C) | Alloy time (min) | Sulfurization temperature (°C) | Sulfurization time (min) | [Cu]/[Sn] |
|---|---|---|---|---|---|
| CTS_001 | 170 | 90 | 560 | 30 | 2.1 |
| CTS_002 | 170 | 60 | 560 | 60 | 2.2 |
| CTS_003 | 220 | 90 | 560 | 30 | 2.0 |
| CTS_004 | 220 | 60 | 560 | 60 | 1.9 |

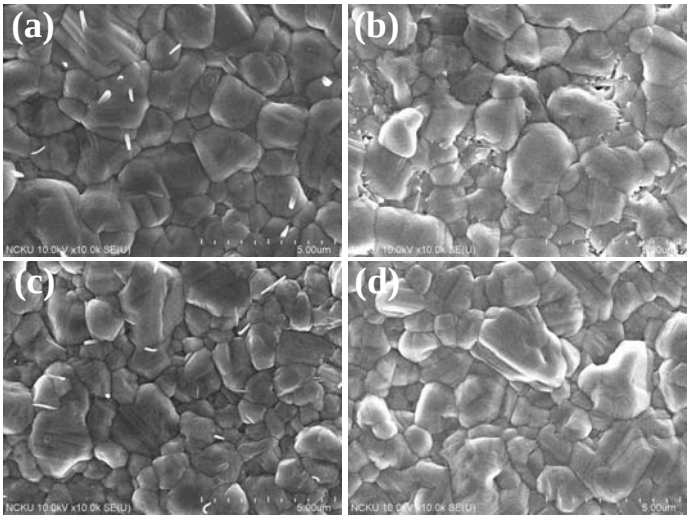


Fig. 2. SEM micrographs of the sulfurized films: (a) CTS_001, (b) CTS_002, (c) CTS_003 and (d) CTS_004.

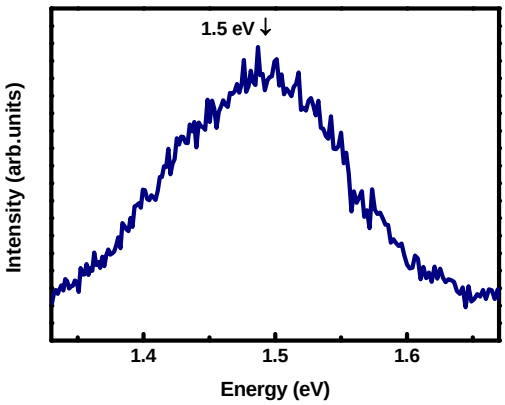


Fig. 3. PL spectra of CTS samples annealed at 220°C-60min and sulfurized at 560°C-60min.

## 3. Conclusions

Optical and structural properties of CTS thin-film absorbers that were prepared by various sulfurization processes were compared. The secondary phases appeared if the alloying time was longer than the sulfurization time. The optimized morphology of CTS films were alloyed at 220°C-60min and sulfurized at 560°C-60min without voids. The PL spectrum of the CTS film showed the broad peak centered at 1.5 eV.

## References

[1] J. P. Leitao and et. al., Thin Solid Films. **519** (2011) 7390.