Morphology of Copper Tin Sulfide Films Grown by Pulsed Laser Deposition at 248 and 355 nm

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SnS-enriched Cu$_2$SnS$_3$ films also available, such as ternary Cu–Sn–S systems, i.e. Cu$_2$SnS$_3$ (CTS) [2].

Thin films solar cells based on Cu$_2$ZnSnS$_4$ (CZTS) as absorber layer have seen a rapid development leading to a world record of 8.8% [1].

Sn and S losses are commonly observed in CTS films, thus a SnS-enriched CTS system is also studied here.

- Its composition needs be accurately controlled
- Reduced complexity compared to CZTS.

To best of our knowledge, we were the first group to report on CTS thin films by Pulsed Laser Deposition (PLD) [5].

**Motivation and aim**

First CTS solar cell prepared by Pulsed Laser Deposition have reached an efficiency of 0.82%. [4]

Ablation of CTS at 355 nm results in large droplets and rough surfaces and the aim of the study is to reduce their size and distribution.

Here we study the influence of the laser wavelength on the size and density of the droplets using:

1. Two different wavelengths, i.e. 355 nm (Nd:YAG laser, third harmonic of 248 nm (KrF excimer laser).
2. Two different targets, i.e. CTS and SnS enriched-CTS to compensate for losses of Sn and S in the CTS films.

**Deposition rate measurements**

- Wavelength dependence on the deposition rate
- Composition dependence of the deposition rate

**Surface morphology**

- 355 nm
- 248 nm

**Annealing of CTS and SnS enriched-CTS**

**Discussion and conclusion**

- SEM images reveal that CTS and SnS-enriched CTS absorber layers have droplets ranging from hundreds of nanometers up to several micrometers.
- A lower irradiation wavelength (higher photon energy) does not reduce the density or size of the droplets.
- Droplets are generally Sn and S-poor suggesting losses of volatile elements during re-crystallization of the molten agglomerates arising from the ablation process.
- Annealing reduces considerably the size and distribution of droplets; however, local non-uniformity composition may be retained in the annealed films.
- Bubbles are present on the surface of the annealed films, most probably resulting from evaporation of SnS.
- Further studies will be carried out to understand the influence of droplets on the performance of the solar cells but also to reduce their density by optimization of the PLD process.

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**References**


