**ABSTRACT**

The use of dimethylformamide (DMF) as a solvent in vapor annealing processing has been previously shown to improve the device performance of bismuth triiodide (BiI₃) photovoltaics. An extension of this work is to integrate dimethlysulfoxide (DMSO) as a solvent in the vapor annealing processing to further improve BiI₃ thin film morphology. The use of DMSO led to larger grain sizes compared to DMF, however, voids in the film at the expense of larger grains led to a decrease in the J_{SC} of BiI₃ photovoltaics (PVs). A 1:1 mixture of DMF and DMSO was found to improve the J_{SC} of BiI₃ PV devices.

**BACKGROUND**

BiI₃ has recently gained interest as a nontoxic alternative to lead-based hybrid perovskite photovoltaics. The material has a bandgap of ~1.8 eV making it suitable for use in a single junction solar cell, or as the top layer of a tandem solar cell. Recently, Hamdeh et al. demonstrated a BiI₃ PV device with greater than 1% efficiency utilizing solvent vapor annealing techniques to improve grain size and film morphology to improve charge carrier mobility.

**RESULTS & GRAPHICS/CHARTS**

- Fig.1 SEM images of BiI₃ thin films processed with DMF and DMSO solvent vapor annealing
- Fig.2 J-V sweeps of BiI₃ PVs processed with DMF and DMSO solvent vapor annealing
- Fig.3 The effect of the percentage of DMSO in the solvent on the J_{SC} and V_{OC} of BiI₃ PV devices

**METHODS**

1) Spin coat BiI₃ into a glass substrate with TiO₂
2) Place spin coated BiI₃ onto a preheated (160 °C) aluminum block (160 °C) for 30 seconds
3) 10 µL of solvent (DMF and/or DMSO) was placed on the aluminum next to the BiI₃ and both were covered with a petri dish for 10 minutes
4) The petri dish was removed, and the BiI₃ was thermally annealed for 20 minutes

**DISCUSSION**

Solvent vapor annealing (SVA) has been a widely used strategy to improve film quality, increase grain size, and enhance carrier transport. Solvent vapor annealing with DMSO was found to significantly improve the crystal grain size of BiI₃ thin films compared to using DMF. The increase in crystal grain size was at the expense of voids formed in the thin film resulting in a decrease in BiI₃ PV device performance. Voids in the film lead to poor charge transport in the BiI₃ PV devices, specifically seen as a decrease in J_{SC} shown in Figure 3. A 1:1 mixture of DMF and DMSO results in both an increase in BiI₃ crystal grain size, and in uniform film coverage – alleviating the issue with voids in the thin film increasing charge transport. However this processing condition also led to the lowest V_{OC} of all PV devices tested. Figure 2 shows the current-voltage characteristics of BiI₃ PVs. Low fill factors are a result of decreased shunt resistance which arises from SVA processing.

**REFERENCES**


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