Thin Film Solar Cells

Thick film photovoltaics offers the potential for ultra-low cost processing of solar modules in comparison to current Silicon technologies. One area of thin-film photovoltaic materials, known as chalco-genesides, are based on the II-VI semiconductor CdTe, with Cu(In,Ga)Se₂ (CIGS) and Cu₂ZnSn(Se, S)₄ (CZTS) created to prevent the use of toxic or rare elements. CIGS and CZTS are processed by selenizing of a tri-metal precursor, made either via electrodeposition or low pressure thermal deposition.

Contamination in Quartz Tube Furnace

When using the Quartz tube furnace, photoluminescence spectra showed a strong response at 1000nm rather than the expected peak at 1240nm, indicating some kind of high band gap secondary phase contaminant. EDX analysis indicated the presence of zinc and tin selenide due to low copper content in the films. By placing part of the sample holder in the cold trap, volatile contaminants were drawn away from the sample, giving consistently good results.

Stoichiometry Variation

Increasing the copper content of the metal tri-layer lead to increased performance of the final device. This suggests a different standard tri-layer is required for Quartz tube furnace selenizations.

Selenization Temperature & Time Variation

For both stoichiometries, selenizations at 500-560°C for 15 minutes were tested, as were 10-20 minute selenization times at 520°C. Temperatures below 520°C gave lower efficiencies, but the film delaminated during selenization at 560°C. Increased selenization time leads to longer carrier lifetimes in the material. Both temperature and time effects are small.

Titanium Nitride Barrier Layer

Titanium Nitride (TiN) was successfully used as a barrier layer to prevent formation of Molybdenum Selenide.

Conclusion

Thin-film chalco-genesides show great potential as materials for low-cost solar cells. Zinc has a beneficial effect on CIGS cells. The quartz tube furnace requires careful positioning of the boat to prevent contamination, and a higher copper content in the trilayer stacks than the RTP oven. Increased temperatures and times during selenization increase the performance of the cell but a high bias dependent photocurrent prevents a clear trend being seen. Poor adhesion prevents TiN from being an effective barrier layer.