Recent Advances In CIGS Solar Cells

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Current trends suggest solar energy will play an important role in future energy production.[1] Silicon has been and remains the traditional solar cell material of choice. While silicon is a highly abundant material, it requires an energy intensive process to purify and crystalize. Furthermore, installations of silicon cells require heavy glass protection plates, which reduces residential applications.[2]

Recently commercial interest is beginning to shift towards thin film cells.[3] Material, manufacturing time and weight savings are driving the increase in thin films. Copper indium gallium selenide (CIGS) solar cells have the highest production among thin film technologies. Advances in preparation and efficiency have allowed these cells to be produced rapidly and are approaching market values for carbon based energy production.[4]

Thin film CIGS cells have two main advantages for space applications. They offer specific power of up to 919 W/Kg, the highest of any solar cell.[5] CIGS cells are also superior to GaAs cells in radiation hardness.[2] Moreover, the flexibility of these cells allows for novel storage and deployment options.[5]

The typical method for CIGS synthesis employs vacuum based deposition.[6] First a substrate is sputter coated with molybdenum, forming the back contact. Then the CIGS absorption layer is vapor deposited over the back contact. The general formula for the CIGS adsorption layer is $CuIn_{1-x}Ga_xSe_2$. Next a chemical bath deposits cadmium sulfide forming a heterojunction with the adsorption layer. Finally, zinc oxide and indium tin oxide are sputter coated on to form a clear window and the contact grid is e-beam-evaporated on top.[7] This standard structure of a CIGS cell is illustrated in Figure 1. This method created the record setting cell M2992, with an efficiency of 19.9%.[8]

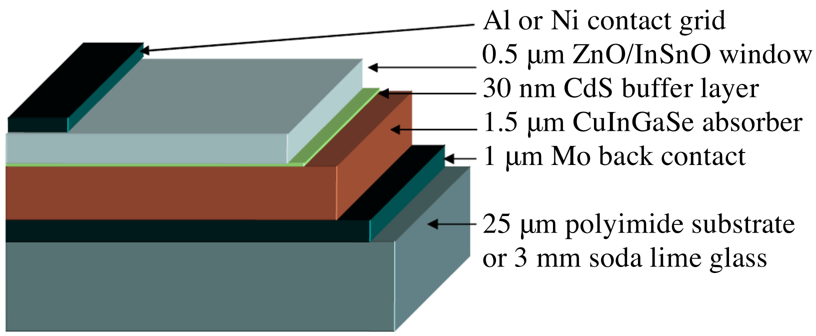

Figure 1

While the above method produces record efficiency cells, other CIGS synthesis processes exist that are faster and more energy efficient. One such method involves the deposition of CIGS absorber from individual component hydrazine solutions. This method allows for simple preparation of precursor solutions and efficient utilization of material. While efficiencies only reach 10.3%, since process temperatures are lower, this method has potential flexible cell production.[9,10]

Flexible cells have been steadily gaining efficiency, they still lag 5 to 9% behind soda lime glass supported modules. One of the key elements for efficiency is surface defects in the substrate. A large surface roughness decreases the grain size within the film. Larger grains give higher efficiencies because electron-hole charge recombination is most prevalent at grain boundaries. A possible answer is deposition of NaF on the polymer substrate, which smoothes the surface and reduces the series resistance.[11]

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