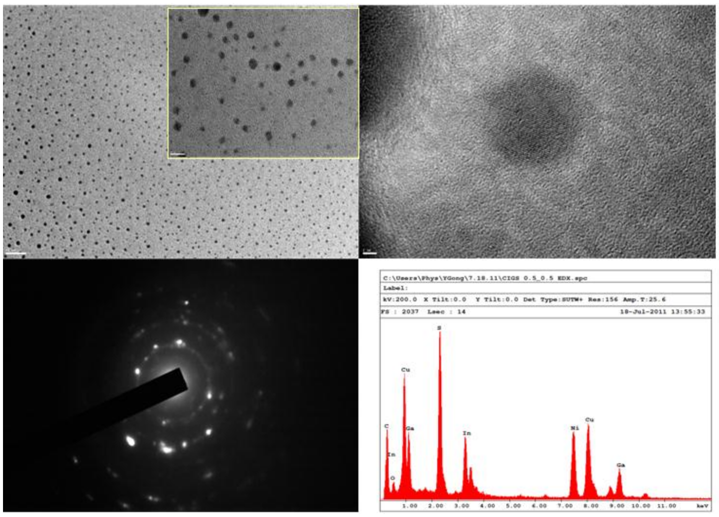
Research Project

Non-Vacuum Fabrication of $Cu(InGa)(Se,S)_2$ Thin Film Photovoltaic Absorbers

Polycrystalline thin films of $CuInSe_2$ and its alloys with gallium and sulphur (CIGS) have proven to be good candidates as absorber layer in high-efficiency solar cells. CIGS is a direct band gap semiconductor and it has an exceptionally high absorption coefficient of more than 10^5/cm for 1.5 eV and higher energy photons. According to the recent report from the ZSW, CIGS solar cell has reached efficiency of 20.4%, which is the record to date for any thin film solar cells. The vacuum-based processes including co-evaporation and sputtering have been used for preparing the CIGS absorber layers. However, the methods have drawbacks such as the complexity in process, production costs and difficulty in scaling up, which are to be solved before the commercialization of the CIGS solar cells. Our research in CIGS solar cells focuses on low-cost fabrication of CIGS nanoparticles and lower-cost deposition methods as an alternative to expensive vacuum processes.

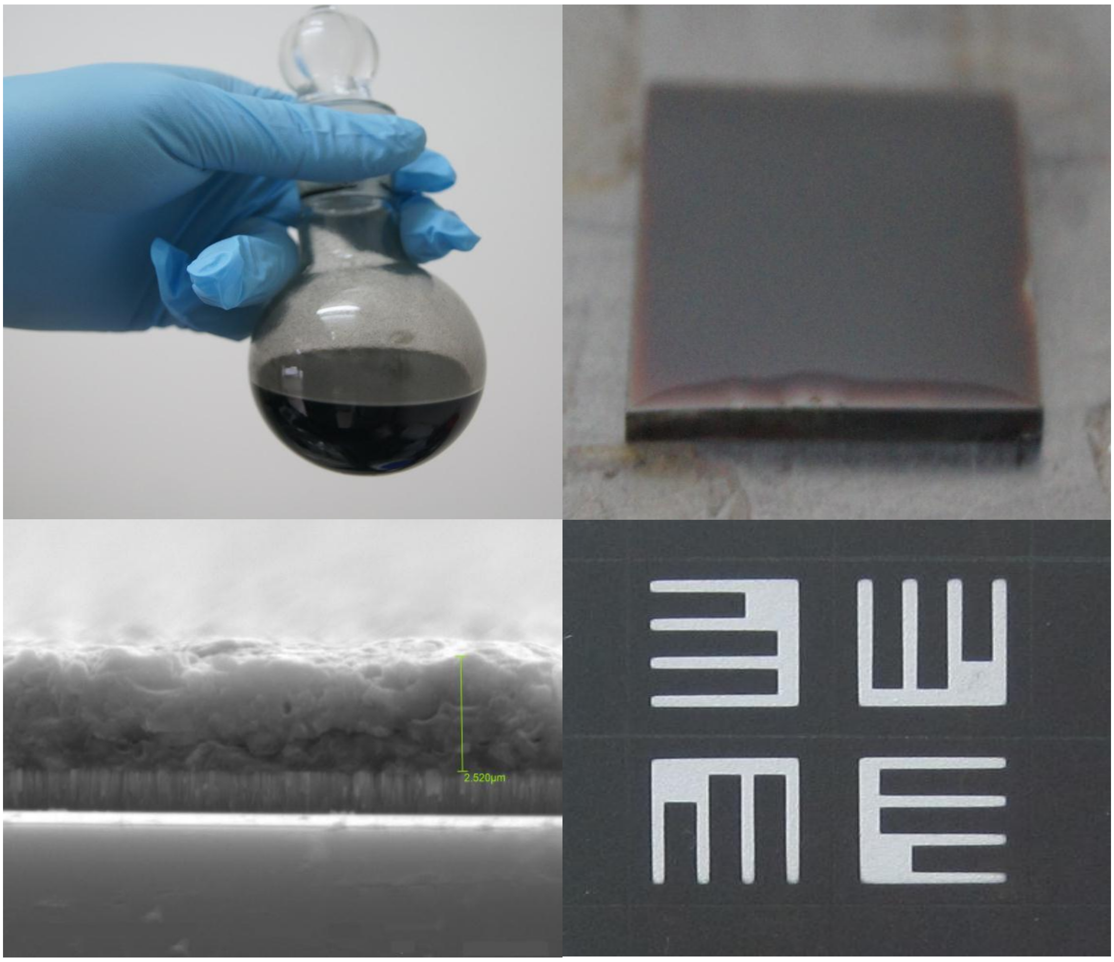
1. One-pot synthesis and characterization of $Cu(InGa)(Se,S)_2$ nanoparticles



We synthesized Chalcopyrite $CuInS_2$ (CIS) and $Cu(InGa)S_2$ (CIGS) nanoparticles from molecular single source precursors (SSPs) by a one-pot reaction in a high boiling solvent using NaCl as heat transfer agent via conventional convective heating method. We can control the nanoparticles sizes from 1.8 nm to 5.2 nm by varying the reaction temperatures (from 150 ℃ to 190 ℃), reaction time, and precursor concentrations. The method is easily scalable to achieve ultra-large volume production of CIS/CIGS nanoparticles with very high-yield (> 94%).

2. Synthesis of CIGS nanoparticles by an atmospheric solution recipe:

We have also synthesized metastable CIGS nanoparticles using our proprietary low-cost solution route under atmospheric conditions. The approach is simpler and cheaper than any other non-vacuum methods with the following advantages: (1) Normal atmosphere fabrication. No need to have inert gas protection; (2) Short reaction time. The whole synthesis process may only take up to 5 minutes; (3) Formation of amorphous nanoparticles. The nanoparticles can be deposited on various substrates and turn into uniform thin films at low temperature (<300 ^{o}C); (4) Low cost and easy to scale-up. The amorphous CIGS nanoparticles fabricated in our research melt under low temperature (even below 180℃) and crystallize to various sizes of nanoparticles with increasing temperature (above 200℃). We observe such dynamical changes by the color of CIGS nanoparticle solutions: with increasing temperature, the color changes from white to red, then to yellow, finally black. We deposit the nanoparticle-based precursor on the Moly-coated substrate to form a smooth precursor layer. After typical selenization process, we obtain a high quality CIGS film (Fig. 2). So far, we have achieved CIGS solar cells with efficiencies of above 10%, based on this approach.



More Details:

Chivin Sun, Paifeng Luo, Piao Liu, Kai Shum, and Yuhang Ren, "One-pot synthesis and characterization of Chalcopyrite $CuInS_2$ nanoparticles", (to be submitted)
Paifeng Luo, Chivin Sun, Bo Gao, Kai Shum, Yuhang Ren, "Solution-based deposition of high quality CIGS absorber layer". (to be submitted)