Deposition and Characterization of Copper Indium Gallium Sulphide Thin Films Fabricated by Chemical Vapour Deposition with Metal Chloride Precursors

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Abstract

Chemical vapour deposition (CVD) is a widely used method in the optoelectronics and semiconductor industries, producing high purity thin films, in crystalline, amorphous and epitaxial phases. A variety of materials can be produced in this way although for the most part use of the technique has focussed on polysilicon, silicon dioxide, silicon nitride and metallic materials. The advantages of CVD processing, which offers offer superior quality compared to conventional methods such as sputtering or co-evaporation, include conformality, coverage, and stoichiometry control. The process should also be more economical and scalable to large substrates as it can take place at atmospheric pressure rather than under vacuum conditions.

The ORC has a long history of exploiting CVD for optoelectronic applications, initially depositing high purity silica for the achievement of some the worlds' lowest loss optical fibres. Since 2001, we have been extending our CVD technology to the chalcogenides and are now routinely depositing germanium and antimony based sulphides on a variety of substrates including glass, silicon and flexible metallic and polymide materials. Copper indium gallium sulphide/selenide (CIGS) is a new chalcogenide material which is typically deposited by vacuum-based processes which co-evaporate or co-sputter copper, gallium, and indium, followed by annealing of the resulting film with a sulphide/selenide vapour to form the final CIGS structure [2]. Other non-vacuum-based processes deposit nanoparticles of the precursor materials on substrates and then sinter them in situ [3].

We report here on efforts to extend our CVD technology to the CIGS family of materials and in doing so improving material quality and process repeatability. Our work focuses on the use metal halide precursors such as CuCl, $GaCl_3$, $InCl_3$ which are reacted in situation with processing gases such as H_2 and S_2Cl_2.

$Cu_{11}In_{26}Ga_8S_{55}$ films have been successfully fabricated by our CVD technique. The composition and surface morphology of these films have also been characterized by SEM and EDX techniques. XRD patterns of the CVD-grown CIGS film reveal two crystalline phases , $Cu(In,Ga)S_2$ and $Cu(In,Ga)_5S_8$ have been formed. The band gap of this CVD-grown CIGS film is about 0.9 eV from the transmission spectrum. The preliminary results of fabrication of CIGS films by CVD with metal halide precursors are very promising. We are now working on the improvement of film quality and adding Se into CIGS films by our CVD techniques.

References

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