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Physik neuer Materialien

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Topic for a Master's / Bachelor's Thesis

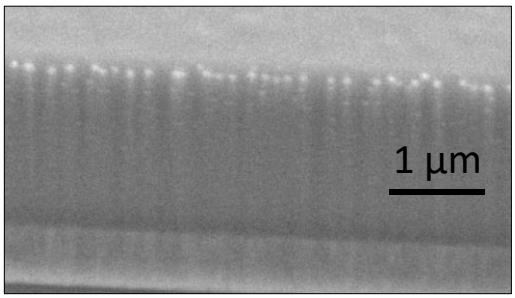
„Stress measurements in Cu(In,Ga)Se_2 thin films for solar cells applications"

INTRODUCTION…This project aims at understanding how the stress evolves in thin films like Cu(In,Ga)Se_2 (CIGS) as a function of temperature, this would help in a better understanding of the growth of CIGS grains and abilities on controlling them. Solar cells are devices that convert light energy into electricity, this conversion is carried out in three steps: i) Generation of electron-hole pair using light, ii) their separation by the p-n junction and iii) their collection through an external circuit. The above processes hence require an absorber material of band gap 1-2 eV completed by a window layer. CIGS is one of the most suited materials as their band gap can be tuned from 1 eV to 1.7 eV according to the In/Ga elemental ratio in the material. The sample can be pure **$CuInSe_2$**, pure **$CuGaSe_2$** or in between keeping In+Ga constant to make it **Cu(In,Ga)Se_2**. CIGS (2 µm thick) holds also the record for the highest conversion efficiency (23.4%) among other stable thin-film solar cells because of its very large absorption coefficient.[1] Hence, the stress measurements would provide new insights about the growth of the thin film and possibly paves the direction to reduce these stresses which might result in better crystallinity and efficiency of the solar cell device.

THESIS DETAILS… Cu(In,Ga)Se_2 (CIGS) thin-film solar cells present very high efficiency and is one of the most suitable candidates for future solar cells. Understanding the evolution of stress inside the films upon annealing would help in a better understanding of the growth of crystals and in optimizing their deposition conditions.

The goal of this project is to measure the stress development upon annealing of CIGS using the multi optical stress setup (MOSS).[2] The initial work of the thesis would be the deposition of CIGS layer on Si substrates using the co-sputtering of $CuSe_2$ and InSe/GaSe targets already installed in the sputter system. Thin-film of approximately 2 µm would be deposited on Si at room temperature. The deposited layer would be amorphous (Figure 1a), as CIGS crystallizes above 450°C. The sample is then transferred to the MOSS[2] (multi optical stress setup) setup, where the sample is positioned appropriately and heated under vacuum for 2-4 hours recording the curvature changes in the thin films which correspond to and translates to stress developed in the film. Figure 1(b) is the sample after annealing showing the grown grains/crystallites separated by grain boundaries. The aim is to measure the stress causing the formation of grains. Initial experiments would be to measure the stress of pure $CuInSe_2$ and see the evolution of stress upon the addition of Ga (and In removal) until the sample reaches pure $CuGaSe_2$. Future possible experiments can be deposition on different substrates and the addition of S.

(a) Before annealing



(b) After annealing

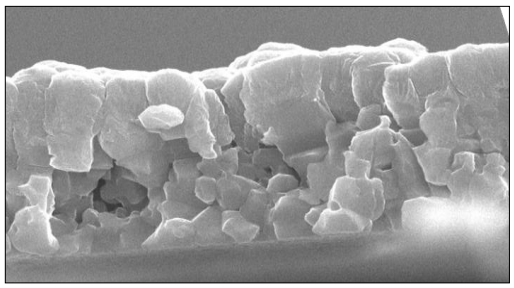


Figure 1. Cross section SEM images: (a) As deposited CIGS using RF sputtering shows uniform and smooth deposition. (b) Upon annealing at 500°C for 1 hour.

The project mainly involves the deposition of thin films, their stress measurement and characterization of thin films using SEM and XRD. The student will obtain the opportunity to work individually on scientific instruments like Sputtering machine, MOSS, SEM, EDX and XRD.

References

[1] Nakamura, et al in 46th IEEE Photovoltaic Specialist Conference, IEEE, Chicago 2019.
[2] https://www.k-space.com/products/mos/

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