I. Physikalisches Institut (IA)
Physik neuer Materialien

RWTH AACHEN UNIVERSITY

I. Institute Of Physics (IA)
Nanocharacterization for advanced functional materials Group
Dr. Mohit Raghuwanshi

Topic for a Master's Thesis

„Fabrication, optimization and characterization of CuO thin film solar cells"

INTRODUCTION…This project aims at fabrication, optimization and characterization of p-type CuO (copper oxide) thin film absorber layer for solar cell, which is then completed by deposition of n-type ZnO. Cu and Zn are two of the most abundant elements on earth and constructed devices with reasonable efficiency could produce stable inexpensive solar cells. Solar cells are devices which 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 p-n junction and iii) their collection through external circuit. Above processes hence require an absorber material of band gap 1-2 eV completed by a window layer. Here we make use of CuO, which is p-type material with 1.5eV band gap[1] (which is close to optimum band gap of 1.4 eV) and would be completed by deposition of n-type ZnO window layer. CuO is not among the most commonly used materials for solar cells because of its low conversion efficiency and majority of research about this material for photovoltaics remains unexplored. However, features like inexpensive raw materials, non-toxicity and high absorption coefficient makes it one of the most favorable candidates for future modules. Theoretical prediction made in 1998 [2] anticipated a conversion efficiency of 18 %. Although there is no contemporary report of its efficiency more than 0.5%[3] which indicates an ample scope of improvement [4].

THESIS DETAILS… Solar cells based on copper oxides (CuO and Cu_2O) already exists onthe laboratoryy scale and to date no one has achieved efficiency higher than even 2%, as compared to traditionally used solar cells whose efficiency have reached higher than 22%. Their low efficiency is mainly attributed to their poor crystallinity and increase in their crystalline nature is expected to improve its optoelectronic properties.

The goal of this projectis to be able to fabricate CuO/ZnO thin film solar cells using sputtering. Primary and core part of the thesis would be to improve the crystallinity of CuO thin films and its optoelectronic properties. Thin film of Cu would be deposited on ITO conductive substrate utilizing RF/DC sputtering, followed by air annealing at elevated temperatures (>300°C). This should oxidize Cu into CuO and convert it from metal to a p-type semiconductor. P-N junction is then formed by deposition of ZnO using RF sputtering. Deposition parameters of ZnO are already optimized for $Cu(In,Ga)Se_2$ solar cells in our lab and hence optimization of ZnO for CuO solar cells would be the secondary/optional part of the thesis. Obtaining a decent efficiency value in itself would produce high impact results and would provide new insights in these unexplored materials for solar cells.

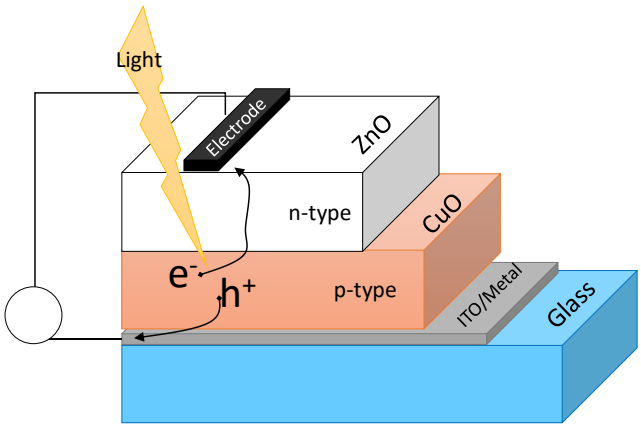

Figure: Schematic diagram of a completed CuO/ZnO thin film solar cell

The figure shows the schematic representation of different layers involved in completion of a typical CuO solar cell. This work is particularly targeted towards obtaining a well-defined crystalline layer of CuO. The project involves optimization of deposition parameters, annealing conditions and basic characterization of thin films. Student will obtain the opportunity to work individually on scientific instruments like Sputtering machine, SEM, EDX and XRD.

References:

[1] H. Kidowaki, T. Oku, T. Akiyama, *J. Phys.: Conf. Ser.* **2012**, *352*, 12022.
[2] A. O. Musa, T. Akomolafe, M. J. Carter, *Solar Energy Materials and Solar Cells* **1998**, *51*, 305.
[3] F. Gao, X.-J. Liu, J.-S. Zhang, M.-Z. Song, N. Li, *Journal of Applied Physics* **2012**, *111*, 84507.
[4] Y. Alajlani, F. Placido, H. O. Chu, R. De Bold, L. Fleming, D. Gibson, *Thin Solid Films* **2017**, *642*, 45.

Dr. Mohit Raghuwanshi
raghuwanshi@physik.rwth-aachen.de
MB2 002 0241/8020271