E·U·S·M·A·T

DocMASE

Education and Culture
Erasmus Mundus

DocMASE Project Proposal 2015-03

Project Title	**Microstructure, chemistry and interaction of n-ZnO / p-Cu_2O films for solar energy harvesting**
Main University and Advisor	Université de Lorraine / Ass. Prof. David Horwat
Second University and Advisor	Saarland University / Prof. FranK Mücklich
Project Description (with **image**, if applicable)	Doped zinc oxide ZnO and copper oxide Cu_2O are n-type and p-type semiconductors, respectively, promising for the fabrication of transparent pn junctions as building blocks for transparent electronics and electro-optical devices including the emerging ZnO/Cu_2O solar cells [1]. While the theoretical limit to the conversion efficiency of such solar cells is close to 20%, the efficiency of state of the art solar cells is close to 5% showing that substantial progress is possible. Given the abundance and low toxicity of the cell constituents relative to other types of solar cells, this represents an important challenge in materials science and engineering. Several approaches can be employed to improve the cell performance including the control of the point defects and morphology of the junctions. Our recent studies showed the importance of the vapor energetics and initial growth conditions to control the dopant activation in ZnO [2] and optical properties and crystal orientation of Cu_2O [3, 4] using magnetron sputtering. Hence, a detailed study of the growth conditions on the film and junction performances is required in view to enhance the conversion efficiency of the cells. For this, pulsed laser deposition (PLD) will be employed to synthesize doped and intrinsic ZnO films of various microstructures (from epitaxial films to nanorods) to serve as a support for the growth of Cu_2O layers. The film performance-structure and performance-chemistry relationships will be studied in situ using cathode-luminescence, reflexion high energy electron diffraction (RHEED) and X-ray photoelectron spectroscopy (XPS). Further ex-situ analyses will be performed with high resolution transmission electron microscopy (HR-TEM) and atom probe (APT) to track down the local chemistry and atom distribution at the interface between both oxide layers. The junction and cell performances will be evaluated depending on the achievements.
Previous Publications	D. Horwat, M. Jullien, F. Capon, J-F Pierson, J. Andersson and J-L. Endrino, On the deactivation of the dopant and electronic structure in reactively sputtered transparent Al-doped ZnO thin films, J. Phys. D : Appl. Phys. 43 (2010) 132003
References	[1] S.S. Jeong, A. Mittiga, E. Salza, A. Masci, S. Passerini, Electrochimica Acta 53 (2008) 2226–2231 [2] M. Jullien, D. Horwat, F. Manzeh , R. Escobar Galindo, Ph. Bauer, J.F. Pierson, J.L. Endrino, Solar Energy Materials & Solar Cells 95 (2011) 2341 [3] Y. Wang, P. Miska, D. Pilloud, D. Horwat, F. Mücklich, and J. F. Pierson Transmittance enhancement and optical band gap widening of Cu2O thin films after air annealing, J. Appl. Phys. 115 (2014) 073505 [4] Y. Wang, J. Ghanbaja, F. Soldera, P. Boulet, D. Horwat, F. Mücklich, J.F. Pierson, Controlling the preferred orientation in sputter-deposited Cu2O thin films: Influence of the initial growth stage and homoepitaxial growth mechanism, Acta Materialia 76 (2014) 207–212.
Requirements	Fluency in English, knowledge of French (optional), background in materials and/r plasma science and/or physics. Responsible design and conduction of experiments. Dedicated and independent working attitude. A PhD duration of 3 years will be sought. 30 ECTS (requirement within the DocMASE program).