DocMASE Project Proposal 2013-01

Project Title	ZnO-based thin films for electronics and plasmonics through High Power Impulse Magnetron Sputtering (HIPIMS)
Main University and Advisor	Université de Lorraine / Dr. David Horwat
Second University and Advisor	Linköping University / Prof. Ulf Helmersson
Associated Partner(s) (if applicable)	
Project Description (with **image**, if applicable)	n-type doped zinc oxide ZnO is a transparent conducting material that can be used as electrodes in transparent electronics. ZnO is also suggested for applications in the field of plasmonics as it exhibits low losses in the near-IR where many high performance plasmonic devices can be developed [1]. Magnetron sputtering is a method of choice for the deposition of n-type ZnO at the laboratory and industrial scale but can introduce defects in the structure of ZnO degrading the conductivity and perturbing the plasmon resonance [2]. Noble metal particles exhibit a specific absorption of light at a frequency usually in the visible range and depending noticeably on the surrounding medium, size and shape of the particles [3]. The motivation of this project is two-fold: • improving the efficiency of the doping of ZnO thin films for transparent electronics • Explore the potentialities of metal/ZnO nanocomposite films for plasmonics High Power Impulse Magnetron Sputtering (HIPIMS) has recently emerged [4] as a development of magnetron sputtering. It allows forming an ionized vapor of high velocity ions [5]. Therefore, energetic condensation is enabled and can be used to tailor the structure and microstructure of thin films. ZnO-based thin films will be deposited with HIPIMS and their properties analyzed with X-ray diffraction and absorption methods, high resolution transmission electron microscopy, photoluminescence, Raman spectroscopy, spectrophotometry, and Hall-effect measurements.
Previous Publications	• V. Kouznetsov, K. Maca´k, J. M. Schneider, U. Helmersson, and I. Petrov, A novel pulsed magnetron sputter technique utilizing very high target power densities, Surf. Coat. Technol. 122, 290 (1999). • J.T. Gudmundsson, N. Brenning, D. Lundin, High power impulse magnetron sputtering discharge, Journal of Vacuum Science and Technology A: Vacuum, Surfaces and Films, 30 (2012) 030801. • 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. • D. Horwat, A. Anders, Compression and strong rarefaction in high power impulse magnetron sputtering discharges, J. Appl. Phys. 108 (2010) 123306. • U. Helmersson, D. Söderström, I. Pilch, S. Pillay, N. Benning, A novel pulsed high-density plasma process for nanoparticle synthesis, Technical Proceedings of the 2012 NSTI Nanotechnology Conference and Expo, NSTI-Nanotech 2012, p 368-370, 2012.
References	[1] G. V. Naik, J. Kim, A. Boltasseva. Oxides and nitrides as alternative plasmonic materials in the optical range, Optical Materials Express 1 (2011) 1090. [2] M. Jullien, D. Horwat, F. Manzeh , R. Escobar Galindo, Ph. Bauer, J.F. Pierson, J.L. Endrino, Influence of the nanoscale structural features on the properties and electronic structure of Al-doped ZnO thin films: An X-ray absorption study, Solar Energy Materials & Solar Cells 95 (2011) 2341. [3] T. Klar, M. Perner, S. Grosse, G. von Plessen, W. Spirkl, J. Feldmann, Surface-Plasmon Resonances in Single Metallic Nanoparticles, Physical Review Letters 80 (1998) 4249 [4] V. Kouznetsov, K. Maca´k, J. M. Schneider, U. Helmersson, and I. Petrov, Surf. Coat. Technol. 122, 290 (1999). [5] D. Horwat, A. Anders, Ion acceleration and cooling in gasless self-sputtering, Applied Physics Letters 97 (2010) 221501.
Requirements of the candidates / Requirements during the doctoral programme (courses, seminars, etc.)	Fluency in English, knowledge of French (optional), background in materials and /or plasma science. PhD duration should be 3 to 4 years, depending on achievements. 90 ECTS credits to be completed during the programme among which: 30 ECTS (minimum requirement within DocMASE); 30 ECTS can be accounted for by courses taken during the Master studies on advanced level if the supervisor agrees on the relevance; about 10 ECTS can be accounted for seminar series, about 20 ECTS additional courses.