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Erasmus Mundus

DocMASE Project Proposal 2014-04

Project Title	**Rare earth-doped Gold/aluminun nitride nanocomposite films for optical applications**
Main University and Advisor	University of Lorraine (France) Ass. Prof. David Horwat
Second University and Advisor	Saarland University (Germany) Prof. Frank Mücklich
Project Description (with **image**, if applicable)	Aluminum nitride (AlN) is a wide bandgap semiconductor with a hexagonal wurtzite structure. It offers high optical transparency in the UV and visible range which makes it an interesting candidate for building transparent devices for photonics and transparent electronics. It has been shown in our group that (i) the growth parameters using magnetron sputtering can control the microstructure of AlN in a large extent and (ii) that small addition of optically active elements such as Erbium stimulate the photoluminescence in the infrared region [1-3]. This PhD thesis project proposes first to extend this principle to emissions in the visible range by doping AlN with the appropriate rare earth and by controlling its placement in the microstructure. In a second step rare earth-doped AlN embedding gold nanoparticles could be produced in order to investigate the nature of the interaction between optical emissions by the dopant and localized surface plasmon resonance by the gold nanoparticles. The enhancement of optical emissions in the visible range has been correlated to the development of a localized surface plasmon resonance in metal/oxide nanocomposite systems [4, 5] but the mechanisms responsible of such effects have not been clearly identified to date. Indeed, this project aims for connecting the local microstructure and chemical states of the synthesized layers to their optical response. The synthesis will be conducted in a deposition chamber equipped with 3 magnetron sputtering guns and 3 evaporation guns. It is also equipped with ellipsometry, cathodoluminescence and photoluminescence detectors to follow the optical properties *in situ*. In parallel, an approach combining high resolution transmission electron microscopy and spectroscopy (electron energy loss spectroscopy-EELS) with atom probe tomography will be applied. This will allow us to track microstructural, structural and chemical informations down to the atomic scale.
Previous Publications	[1] P. Pigeat, T. Easwarakhanthan, J.L. Briançon, H. Rinnert, Thin Solid Films 519 (2011), pp. 8003-8007. [2] S.S. Hussain, V. Brien, H. Rinnert, P. Pigeat. Physica Status Solidi (C) Current Topics in Solid State Physics 7 (1) (2010) 72-75. [3] V .Brien, P. Miska, H. Rinnert, D. Geneve, P. Pigeat, Materials Science and Engineering B: Solid-State Materials for Advanced Technology 146 (2008), pp. 200-203. ➢ Publications in the topic of functional nanocomposite films J.F. Pierson, D. Horwat, Applied Surface Science 253 18 (2007) 7522-7526 J. L. Endrino, et al., Solid State Sciences 10 (2009) 1742-1746 J.L. Endrino, et al., Plasma Processes and Polymers S438-S443 (2009) ➢ Publications in the field of transmission electron microscopy S. Bruyère, et al., Surface and Coatings Technology 227, 15-18 (2013) S. Bruyère, et al., Thin Solid Films 517(24), 6565-6568 (2009)
References	[4] P. Cheng, D. Li, Z. Yuan, P. Chen, D Yang, Appl. Phys. Lett. 92, 041119 (2008) [5] K. Saravanan, B. K. Panigrahi, R. Krishnan, and K. G. M. NairJ. Appl. Phys. 113, 033512 (2013)
Requirements of the candidates / Requirements during the doctoral programme (courses, seminars, etc.)	You must hold a master degree with a strong background in physics. Knowledge in inorganic chemistry and thin films synthesis will be appreciated but not compulsory. A good knowledge of written and spoken English is required Knowledge of French will be appreciated but not compulsory. The general requirements for the DocMASE program regarding courses, seminars, summer schools, etc must be fulfilled. Particulraly, 30 ECTS of lectures have to be validated at the end of the PhD and you are expected to publish the results of your studies in international peer-reviewed journals.