2014-2015 - Internship proposal (Master or final project engineering school) at LMGP

Transparent conductive electrodes based on Ag nanowire networks: Optimization of their physical properties for energy applications

Context

Transparent electrodes are of the utmost importance in many applications such as solar cells, flat panel displays and efficient lighting. Over the past few years, the demand for such products has led to a significant increase in transparent electrodes use. Typically, these electrodes are based on oxide thin films commonly known as Transparent Conducting Oxides (TCO). So far, Indium Tin Oxide (ITO), Fluorine-doped Tin Oxide (FTO) and Aluminium-doped Zinc Oxide (AZO) are the most encountered TCO thin films for both laboratory researches and industrial applications. These three oxides give a good (or even very good) compromise between electrical and optical properties in the visible range but nonetheless exhibit some drawbacks such as cost, the common use of vacuum or high temperature in fabrication and their incompatibility with flexible devices.

However, it has been recently shown (see [1] for a review) that well-designed and structured Ag nanowire networks result in electro-optical properties as good as those of TCO thin films. They are also suitable for applications on polymer substrates for low-cost transparent electrodes and fabricated at low temperature. Moreover the required quantity of silver is very low (about 0.1 g/m^2) and thus still remains a low cost transparent conductive material.

Objectives

The goal of this internship is to work within a team aiming at better understand and optimize the physical properties of such nanomaterial networks deposited on glass or polymer substrates on large areas (5-100 cm^2) and compatible with applications such as solar cells, touch screens or transparent heaters (more precisely for defrosting of motorbike helmets). The physical properties (electrical conductivity, optical transparency, mechanical properties) of these networks will be thoroughly investigated and optimized as well by using appropriate thermal annealing. The LMGP houses state of the art experimental equipment for investigating such properties. X-Ray diffraction (XRD), spectrophotometry, electron microscopy and *in-situ* electrical resistance measurements will be routinely used to get a better understanding of the relationships between microstructure and physical properties for as-deposited and thermally treated networks. A special attention will also be devoted to the stability of the obtained transparent electrodes. Finally the integration of these layers into solar cells or other devices could be performed through collaborations with other laboratories.

Simple models as well numerical simulations (based on stick percolation for instance) help in better understanding the physical properties. The subject of the training will be developed with the student, depending on his/her own interests and preferences between more experimental or theoretical approaches.

<u>References:</u> ; [1] D.P. Langley, G. Giusti, C. Mayousse, C. Celle, D. Bellet, J.-P. Simonato, Nanotechnology 24 (2013) 452001; [2] S. Sorel, D. Bellet, J. N. Coleman, ACS Nano 8 (2014) 4805.

Scientific environment: Located in the heart of an exceptional scientific environment, the LMGP offers the applicant a rewarding place to work. The applicant will be integrated within a close collaboration between on team of each Laboratory.

Laboratory website: http://www.lmgp.grenoble-inp.EN/

Profile: We are looking for a highly motivated student who is interested to work in an inter-disciplinary project. Interpersonal skills, dynamism, rigor and teamwork abilities will be appreciated. Candidates can be fluent either in English or in French

Subject could be continued with a PhD thesis : Yes/~~No~~.

Stipend: an internship stipend will be provided.

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