LMGP
Laboratoire des matériaux et du génie physique
une vision des matériaux

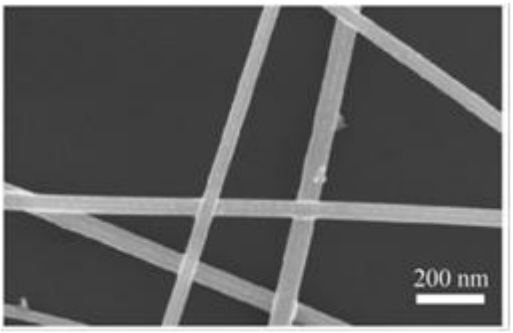
2015-2016

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

Transparent heaters based on Ag nanowire networks: from fundamental aspects to integration in devices

Transparent electrodes are of the utmost importance in many applications such as solar cells, flat panel displays, efficient lighting or transparent heaters. Over the past few years, the demand for such products has led to a considerable amount of research devoted to nanostructured transparent conducting materials. Among these applications, which all require a good compromise between high electrical conductivity and optical transparency in the visible, transparent heaters constitute an interesting applied domain. This concerns for instance applications such as defrosting (allowing airplanes to fly at high altitude) or heating in a simple way an object which should be transparent such as a helmet visor (avoiding then defogging) or a glass substrate or any polymeric substrates or devices. It has been recently shown (see [1] for a review) that random Ag nanowire networks result in good compromise between electrical and optical properties, and therefore can be used as a transparent heater [2]. They are also suitable for applications on polymer substrates (and then compatible with flexible device) for low-cost transparent electrodes and fabricated at low temperature. The goal of this internship is to work within a team aiming at better understanding and optimizing the physical properties of such transparent heaters and to incorporate and test their performance in devices.

The physical properties (electrical conductivity, optical transparency, mechanical properties) of these networks will be thoroughly studied and optimized. The LMGP houses state of the art experimental equipment to fabricate Ag nanowire networks with *in-situ* electrical resistance measurement set-up [3,4]. A special attention will also be devoted to the stability of the obtained transparent electrodes and the integration of these transparent heaters will be performed. Finally as the electrical resistivity of metals increases linearly with temperature, the resistance measurement leads to the temperature measurement: this is then a **transparent thermometer !**



Simple models as well as numerical simulations (based on stick percolation for instance) will be used to better understand 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, as well as integration into real devices.

Related references: [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; [3] D.P. Langley, M. Lagrange, G. Giusti, C. Jimenez, Y. Bréchet, N.D. Nguyen, D. Bellet, ***Nanoscale*** 6 (2014) 16535; [4] M. Lagrange, D.P. Langley, G. Giusti, C. Jimenez, Y. Bréchet, D. Bellet, ***Nanoscale*** 7 (2015) 17410-17423.

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 several scientists of LMGP.

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

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 (554€/month)

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