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

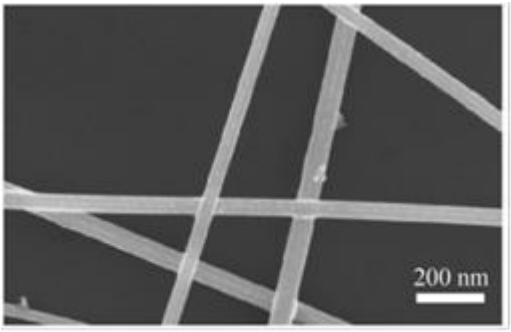
2016-2017

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

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

Transparent electrodes (TE) are of the utmost importance in many applications such as solar cells, flat panel displays, efficient lighting or transparent heaters. All of these applications require transparent electrodes which exhibit a good compromise between high electrical conductivity and optical transparency in the visible. Therefore a considerable amount of research has been lately devoted to nanostructured TE. It has been recently shown (see [1-2] for a review) that random Ag nanowire networks result in good compromise between electrical and optical properties [3], and therefore can be used as TE in these different applications [2]. These networks are also suitable for applications on polymer substrates (and then compatible with flexible device and roll-to-roll technology) 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 electrodes and to test their performance in devices.** The approach could be, depending on the skills/wishes of the trainee, based on fundamental aspects (Monte Carlo or Comsol simulations, physical modelling), on experimental approach (deposition by spray of AgNWs, post-deposition treatments; structural, electrical and optical characterization) and as well on integration into devices. The latter concern for instance transparent heaters, with the aim 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 (defogging) or a glass slab used for optical microscopy observations. Since electrical resistivity of metals increases linearly with temperature, the resistance measurement leads to the temperature measurement: this is then a **transparent thermometer** that we are integrating for in-situ biological analysis. As well we work with academic or industries to integrate AgNW networks in solar cells or in cold electron emission (for miniaturizing X-ray production).

The physical properties (electrical conductivity, optical transparency, mechanical properties) of these networks (see on the right a typical image of such a network) 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 [4,5]. A special attention will also be devoted to the stability of the obtained transparent electrodes and the integration of these transparent electrodes will be performed. Simple models as well as numerical simulations (based on stick percolation for instance) will be used to better understand the physical properties.




**Related references:** [1] D.P. Langley, G. Giusti, C. Mayousse, C. Celle, D. Bellet, J.-P. Simonato, ***Nanotechnology*** 24 (2013) 452001; [2] T. Sannicolo, M. Lagrange, A. Cabos, C. Celle, J.-P. Simonato, D. Bellet, **Small** (accepted, in press) ; [3] S. Sorel, D. Bellet, J. N. Coleman ***ACS Nano*** 8 (2014) 4805; [4] D.P. Langley, M. Lagrange, G. Giusti, C. Jimenez, Y. Bréchet, N.D. Nguyen, D. Bellet, ***Nanoscale*** 6 (2014) 16535; [5] 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 and/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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