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

Grenoble INP

cnrs

2016-2017

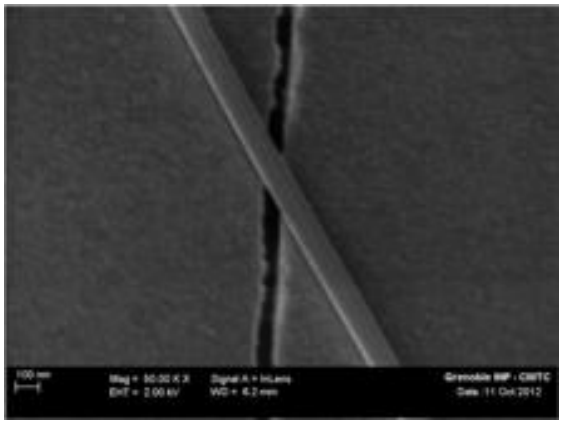
Internship proposal (Master or final project engineering school) at LMGP

Bridge percolation : 1D nano-objects as bridges over insulating gaps between conducting areas

Transparent conductive oxides (TCO) such as indium tin oxide (ITO) have been widely used as transparent electrodes in many devices including touch screens, liquid crystal displays, light-emitting diodes, transparent heaters and solar cells for decades. In all these applications the key factor in those materials is the good compromise between high electrical conductivity and optical transparency in the visible range. However, in the case of ITO, the scarcity of indium has become a major issue, leading to the rising of the fabrication cost and making this resource more and more critical. Furthermore, most TCO compounds are brittle materials. Under mechanical stress, cracks and fractures in thin films are observed, associated to vanishing conductivities. Because of those important drawbacks, alternative solutions are emerging and their development has attracted much interest over the last years.

Among all the novel transparent conductive materials (TCM), metallic nanowire networks, such as those made of high aspect ratio silver rods with sub-micrometer diameter, are certainly one of the most promising solutions [1-3]. Thanks to their mechanical flexibility, silver nanowire (AgNW) networks are suitable for applications on polymer substrates (and then compatible with flexible device and roll-to-roll technology) for low-cost transparent electrodes fabricated at low temperature. Their electrical properties fundamentally originate from a percolation phenomenon. The conductivity of the network is determined by the number and length of the electrical pathways through the network as well by the junction between nanowires in contact**.**

In this internship, we will combine AgNW networks with cracked TCO films in order to overcome the negative impact of fractures. More specifically, the goal of this work is to investigate how the electrical conductivity of fractured TCO films can be recovered by depositing a sparse AgNW network on top**.** Indeed, AgNWs can act as conductive bridges spanning over the insulating gaps represented by the cracks. **Having this recovering process in mind, we aim more generally at better understanding the mechanism of connecting separated conductive areas of TCO thin films by bridging them with 1D nano-objects such as AgNWs.** The approach will consist carrying out a detailed physical modelling of the material by performing extensive Monte Carlo simulations. The physical properties (electrical conductivity, optical transparency, mechanical properties) of these bridged percolating systems will be thoroughly studied and optimized. The LMGP houses state of the art experimental equipments to fabricate Ag nanowire networks with *in-situ* electrical resistance measurement set-up [4-6].



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) ; [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; [6] T. Sannicolo, D. Muñoz-Rojas, N.D. Nguyen, S. Moreau, C. Celle, J.-P. Simonato, Y. Bréchet, D. Bellet, ***Nano. Lett.*** (accepted).

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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