2015-2016

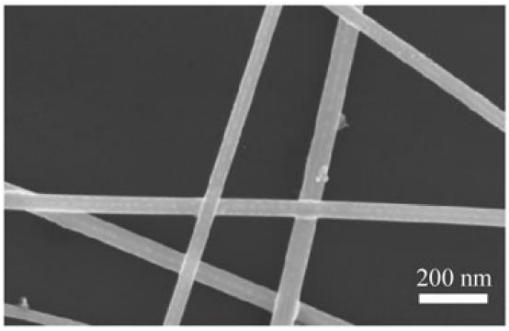
Internship proposal (Master or final project engineering school) at LMGP & IMEP-LAHC

Innovative Transparent Electromagnetic Shielding & Antennas based on silver nanowire networks

Project description: Electromagnetic (EM) waves are present everywhere and are used in many devices for industrial as well as in everyday life applications. Applications concerning shielding for military purposes, data protection from spying for companies, wearable systems for detecting human motions and health monitoring, mobile phone, Wi-Fi, TV / computer/ Box connection, Bluetooth, Alarms, RFID Identification/Authentication, NFC contactless payment, and always new contactless communications standards and bandwidth exploitation (up to TeraHertz) show continuing technological and economical growths. Research should be dedicated to the antennas which constitute the key component [1]. Cost and low optical transparency are clearly the limiting factors to integrate antennas into transparent windows, touchscreens or windscreens; the same occurs as well for selective shielding. Fabricating flexible antennas or shielding devices would also open new applications fields.

Antennas are usually fabricated by printing or etching metal patterns on rigid or conformable substrates. In majority of EM devices, the standard material to be used as metallic electrode is based on silver particles. Due to the ink opacity, applications are limited to wallpaper and cannot be extended to windows.

Replacing Ag (silver) nanoparticles by a percolating network of Ag nanowires (AgNW) would be very beneficial since the necessary amount of metal would be much smaller, decreasing the cost. For instance, a factor of 500 of silver mass can be gained since an AgNW network with a real mass density of 100 mg/m^2 is enough for applications. Moreover, thanks to the empty spaces between NWs (see Figure), **the metallic electrode is transparent** in the visible. Indeed AgNW networks have lately been much studied as transparent electrodes for many applications such as solar cells, transparent heaters, etc., [2] but only few works were devoted to antennas or electromagnetic shielding even though proof of concept has been reported [3].



Scanning Electron Microscopic image of silver nanowires (AgNW).

The goal of this internship is to work within a team aiming at better understanding and optimizing the physical properties of such nanomaterial networks deposited on large area (5-100 cm^2) glass or polymer substrates and compatible with applications within many EM applications which should pave ways to innovations either in everyday life devices, for industrial or medical purposes and for strategic fields. Indeed, AgNW networks exhibit several advantages such as low cost, flexibility, transparency and high electrical conductivity. Therefore intensive research is devoted to the study of AgNW networks in order to improve their properties and achieve better integration into devices such as transparent electrodes in solar cells, transparent heaters or radio frequency (RF) antennas. In spite of dynamic efforts towards the integration of AgNW networks in many devices, it appears that the EM field is still in its infancy.

The LMGP & IMEP-LAHC house state of the art experimental equipment for studying such properties. Both experimental and modelling approaches will be considered. The first one will focus on the spray deposition of Ag nanowire networks designed antennas at LMGP and their electromagnetism characterization at IMEP-LAHC. The modelling approach will concern 3D electromagnetic software to design antennas as well as physical properties of silver nanowire networks. A special attention will be devoted to the optical transparency, electromagnetic properties and stability of the obtained antennas. The flexibility might be tested as well. Finally the integration of these layers into simple devices might also be considered.

References: ; [1] F. De Barros, G. Eymin-petot-Tourtollet, P. Lemaitre-Auger,T. P. Vuong, “Surface for filtering a plurality of frequency bands”, 2011" WO Patent WO/2011/135,224; [2] D.P. Langley, G. Giusti, C. Mayousse, C. Celle,

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D. Bellet, J.-P. Simonato, Nanotechnology 24 (2013) 452001; [3] L. Song, A. C. Myers, J. J. Adams, and Y. Zhu, ACS Appl. Mater. Interfaces 6 (2014) 4248.

Scientific environment: Located in the heart of an exceptional scientific environment, the LMGP & IMEP-LAHC offer the applicant a rewarding place to work. The applicant will be integrated within a close collaboration between one team of each Laboratory.

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

Profile: Looking for a highly motivated student interested to work in an inter-disciplinary project. Interpersonal skills, dynamism, rigor and teamwork abilities are appreciated. Candidates can be fluent 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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