PhD Thesis offer (2020-2023): Coupled investigation by materials science and marketing of nanocomposites based on metallic nanowires and oxide: properties, mental representations and applications

Doctoral School**: IMEP2** – Starting date**: 01/10/2020 -** Grant**: obtained**

Context:

Metallic nanowire networks have aroused a great deal of interest among scientists in recent years, in particular due to their excellent properties as transparent electrodes[1]. They are a key technological element for many devices such as solar cells, efficient lighting (LEDs, OLEDs), touchscreens, intelligent windows or transparent heaters[2]. The properties of these metallic nanowire networks (silver in particular, noted AgNW) directly affect the performance of these devices. The recurrent research objective is to obtain the best performances in terms of optical transparency and electrical conduction, without neglecting stability. Since 2012, LMGP has adopted an approach to the study of AgNW networks that is supported by experimental activity and modelling[3], activities that are now well recognized internationally. Another interesting application of these metallic nanowire networks is their antimicrobial activity. This last property has been relatively unexplored. The LMGP is currently filing a patent showing that **the antimicrobial activity of nanocomposites based on metallic nanowires and thin oxide layers can be modulated and controlled over time**. The control of this antimicrobial activity is very innovative. Further, the associated field of applications is vast: it ranges from the medical field (to fight against microbial infections), to packaging or individual protection (protective masks, contact surfaces in a public place, etc.). Now more than ever this field is particularly crucial, in the context of the ongoing health crisis. The development and optimization of antimicrobial materials and coatings that can facilitate, guarantee and accelerate the disinfection and sanitization of certain places or objects, as well as modulate and control their antimicrobial activity, is therefore a major scientific, industrial and societal challenge. This research is particularly promising; however, it is also important to understand how potential users view this technology, since this will be decisive in its subsequent adoption, and therefore in the choice of the most favourable applications of the invention. In order to make effective progress on this topic, LMGP has joined forces with the marketing team of the CERAG laboratory. For many years, this team has had expertise in research on the behaviour of the "consumer" (customer, user, patient, citizen, etc.)[4].

Thesis project:

Extensive research in materials science is required to study this type of nanocomposite (e.g. AgNW/ZnO[5]) and allow the control and modulation of antimicrobial activity. We will also seek to use low-cost deposition methods (like the Spatial Atomic Layer Deposition (SALD) method developed at LMGP by David Muñoz-Rojas), and also a very small amount of silver (~0.1 g /m^2).

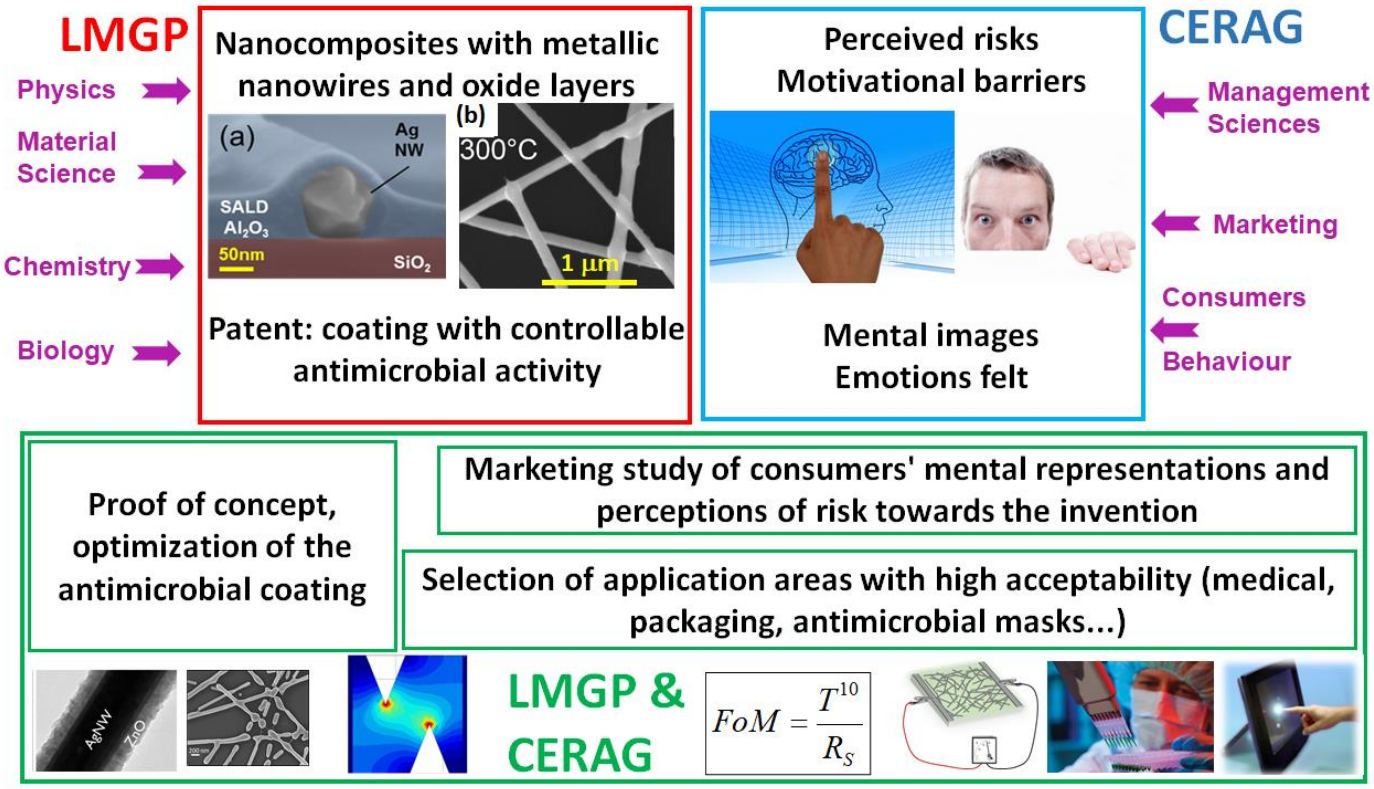
This engineering research work is based on an original idea and is supported by an expertise in silver nanowire networks which is now recognized at LMGP. This will most likely allow effective progress to be made both in the understanding of these materials and in improving their properties. This work is multidisciplinary in nature. A physicist, a chemist, a biologist and a process scientist make up the team of co-authors of the patent. However, this project requires more than just an engineering approach. Taking advantage of the closeness between engineering and management, LMGP turned to CERAG and its recognized skills in management sciences, and especially in marketing. By associating material sciences and marketing research, oriented toward "consumer behaviour", we will collectively be more efficient in choosing the relevant applications to target, i.e. the most acceptable from the point of view of the mental representations[6] and the individual motivations they generate in potential users, whether they are individuals and professionals. **The program of this thesis is therefore ambitious and innovative because of its strong coupling between research in material sciences and in management sciences.** It is based on the innovative nature of the patent in progress. Thus, the expected results will be both fundamental and applied.

Main objectives of the Thesis:

The two main topics of this thesis concern antimicrobial coatings with controlled and modular activity (materials science), and understanding mental representations and motivational barriers (management science)[4]. The main objectives of the thesis aim to:

1/ Understand in order to optimize the antimicrobial activity of nanocomposites based on silver nanowires and oxide layers, but also the mechanisms behind the control of this activity.

2/ Understand the mental associations, internal representations but also emotional response that various categories of individuals (individuals vs. professionals, young vs. elderly, healthy patients vs. sick patients, etc.) are likely to have regarding the invention and its possible applications[7].



Profile and requested skills: The two essential themes of the thesis are material sciences (primarily), and management sciences (secondarily). The candidate must be a graduate of an engineering school and/or of a Master 2R, with a background mainly focused on materials science, physics, chemistry or a related field. We are looking for a highly motivated candidate whose interpersonal skills, dynamism, rigour and teamwork abilities will be appreciated. **His/her open-mindedness is crucial in order to be interested and involved in the two components that constitute the two axes of the thesis.** Written and oral mastery of English is essential (level C1).

Websites of the laboratories:

http://www.lmgp.grenoble-inp.fr/ and https://www.cerag.org/

Salary: Gross Annual Salary: 21,200 € ; net monthly salary: 1,400 €

Supervisors (To apply please send all supervisors an e-mail ASAP with CV, letter and contact details of two referees)

Daniel Bellet (LMGP): daniel.bellet@grenoble-inp.fr
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Bibliography :

1. Sannicolo, T. *et al.* Metallic Nanowire-Based Transparent Electrodes for Next Generation Flexible Devices: a Review. *Small* **12**, 6052–6075 (2016).
2. Papanastasiou, D. T. *et al.* Transparent Heaters: A Review. *Adv. Funct. Mater.* 1910225 (2020) doi:10.1002/adfm.201910225.
3. Langley, D. P., Lagrange, M., Nguyen, N. D. & Bellet, D. Percolation in networks of 1-dimensional objects: comparison between Monte Carlo simulations and experimental observations. *Nanoscale Horizons* **3**, 545–550 (2018).
4. Reydet, S. & Carsana, L. The effect of digital design in retail banking on customers' commitment and loyalty: The mediating role of positive affect. *Journal of Retailing and Consumer Services* **37**, 132–138 (2017).
5. Nguyen, V. H. *et al.* Low-cost fabrication of flexible transparent electrodes based on Al doped ZnO and silver nanowire nanocomposites: impact of the network density. *Nanoscale* **11**, 12097–12107 (2019).
6. Vellera, C. & Gavard-Perret, M.-L. A better understanding of the role and underlying mechanism of stimulating mental imagery in improving the creativity of "ordinary" users. *Recherche et Applications en Marketing (English Edition)* **31**, 111–130 (2016).
7. Mignot, A. *et al.* Behavior of nurses and nurse aides toward influenza vaccine: the impact of the perception of occupational working conditions. *Human Vaccines & Immunotherapeutics* **16**, 1125–1131 (2020).