2026-2027 M2 Internship proposal at LMGP – SYMMES

Flexible photodiodes based on lead-free quantum dots and silver nanowire networks

Context & project description

Photodetection in the SWIR range (1-2.5 µm) is used in many fields, such as plastic sorting, biological imaging, machine vision, agriculture and horticulture. However, the wider adoption of this technology is hindered by the high cost of current SWIR sensors, based on InGaAs photodiodes, mounted on rigid substrates. Semiconductor nanocrystals (quantum dots, QDs) represent an innovative class of materials, whose absorbance can be tuned with particle size, and which are processable from solution at low temperature. However, the QDs most widely studied in the SWIR range contain toxic elements such as lead and mercury. Previous work at SyMMES laboratory has established efficient synthesis routes for highly promising alternative materials (Figure 1).[1]

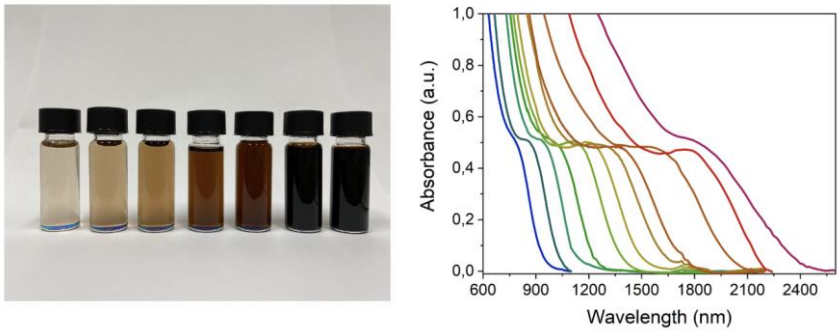

Figure 1: SWIR QDs developed at SyMMES (left: photo of colloidal solutions, right: absorption spectra).

The goal of this internship is a first demonstration of a SWIR photodiode based on non-toxic QDs, fabricated by solution processing on a flexible substrate. In this context, the other layers of the device stack, in particularly the electrodes, must also be mechanically flexible and deposited by compatible methods. Transparent flexible electrodes based on silver nanowire (AgNW) networks, developed at LMGP by spray coating, will be used for this purpose.[2] Deposited on flexible and stretchable substrates, AgNW networks are a promising replacement for conventional materials such as indium tin oxide (ITO), which is brittle and relies on critical raw materials (Figure 2).[3] The main targets are to optimize the deposition of QDs layers and the integration of AgNW networks as bottom and/or top electrodes. Both laboratories provide a wide variety of structural, electro-optical and mechanical characterization methods (EQE, I-V, UV-Vis-NIR transmittance, SEM, AFM, bending tests).

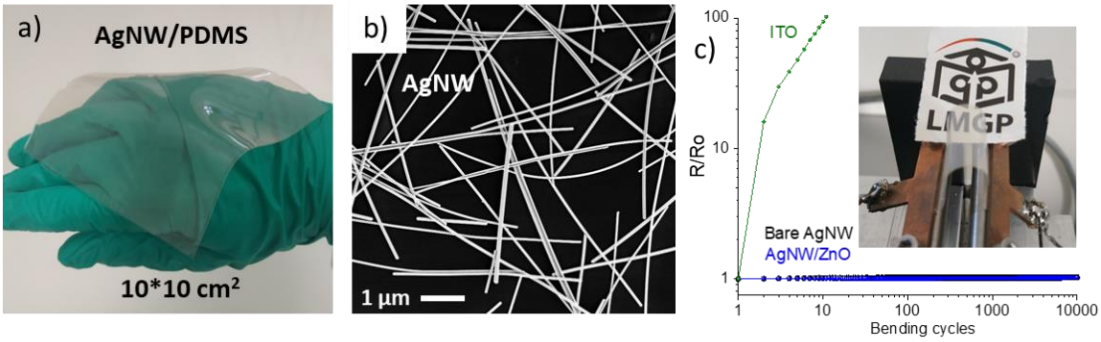

Figure 2: a) Photo of AgNW network deposited on PDMS, b) SEM image of AgNW network, c) Flexibility tests (r= 5 mm) with in situ electrical resistance measurement for ITO, AgNW, AgNW/ZnO transparent electrodes.

References

(1) Kwon, Y.; Yeromina, O.; Cavallo, M.; Silly, M. G.; Pierucci, D.; Lhuillier, E.; Aldakov, D.; Hyot, B.; Reiss, P. Synthesis of NIR/SWIR Absorbing InSb Nanocrystals Using Indium(I) Halide and Aminostibine Precursors. *Adv. Funct. Mater.* **2024**, *34* (40), 2403912. https://doi.org/10.1002/adfm.202403912

(2) Papanastasiou, D. T.; Mantoux, A.; Crisci, A.; Ribeiro, H.; Sekkat, A.; Roussel, H.; Weber, M.; Rapenne, L.; Jiménez, C.; Fivel, M.; Bellet, D.; Blanquet, E.; Muñoz-Rojas, D. Silver Nanowire Networks Coated with a Few Nanometer Thick Aluminum Nitride Films for Ultra-Transparent and Robust Heating Applications. *ACS Appl. Nano Mater.* **2024**, *7* (11), 12312–12322. https://doi.org/10.1021/acsanm.4c00044

(3) Papanastasiou, D. T.; Sekkat, A.; Nguyen, V. H.; Jiménez, C.; Muñoz-Rojas, D.; Bruckert, F.; Bellet, D. Stable Flexible Transparent Electrodes for Localized Heating of Lab-on-a-Chip Devices. *Adv. Mater. Technol.* **2023**, *8* (1), 2200563. https://doi.org/https://doi.org/10.1002/admt.202200563

Scientific environment

SyMMES (Molecular Systems and nanoMaterials for Energy and Health) is a joint research unit (UMR 5819 CEA-CNRS-UGA-Grenoble INP) located on the campus of CEA Grenoble. The QD team (www.g-qdlab.com) focuses on the development of non-toxic and sustainable quantum dots for applications ranging from optoelectronics over energy conversion to biological imaging and detection.

LMGP (Laboratory of Materials and Physical Engineering, http://www.lmgp.grenoble-inp.fr/) is a joint research unit (UMR 5628) of CNRS and Grenoble INP within Université Grenoble Alpes, located at the Minatec site in the PHELMA (Physics, Electronics, Materials) engineering school buildings. The AgNW group has developed expertise on the fabrication of AgNW-based nanocomposites, together with in situ electrical characterization benches with heating and mechanical tests.

Profile & requested skills

We are looking for a highly motivated M2 student in Materials Science, Chemistry, Physics, or Nanoscience, who is interested to work in an inter-disciplinary project. Candidates should be fluent in English.

Contacts

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Starting date ≈ February 2027 – Duration: 6 months.

Gratification ~600 €/month