2026-2027 M2 Internship proposal at LMGP – NEEL

AgNW/graphene hybrid transparent electrodes: mechanical properties and electrical stability

Context

Transparent electrodes are essential components of most optoelectronic devices, and are today dominated by indium tin oxide (ITO). ITO has, however, two important limitations: indium is a scarce and critical raw material, and ITO itself is brittle, which makes it poorly suited to the flexible and stretchable devices now being developed. Silver nanowire (AgNW) networks and graphene are promising alternatives, combining high conductivity and transparency with good mechanical flexibility and reduced material use.

Project description

Combined into a hybrid electrode, AgNW and graphene reach low sheet resistance at high transparency, while the graphene layer also protects the nanowires against ageing. Most existing studies, however, focus on how the electrode performs, typically the change in resistance under bending, while the mechanisms that govern its mechanical response and stability under deformation are not fully understood. This project takes a fundamental approach, aiming to understand these deformation and failure mechanisms in AgNW and AgNW/graphene electrodes, and how the structure of the nanowire network influences this behavior.

The hybrid films will be prepared by spray-coating the nanowire networks (LMGP) and transferring CVD graphene (NEEL), first on silicon and glass as well-controlled reference surfaces, then on flexible and stretchable polymers such as PET and PDMS, where the electro-mechanical behavior becomes the core of the study. The synthetized hybrid materials will be characterized by structural, optical and electrical methods, and above all through bending and stretching tests coupled with in situ electrical measurements, so that the electrical stability can be followed directly during deformation.

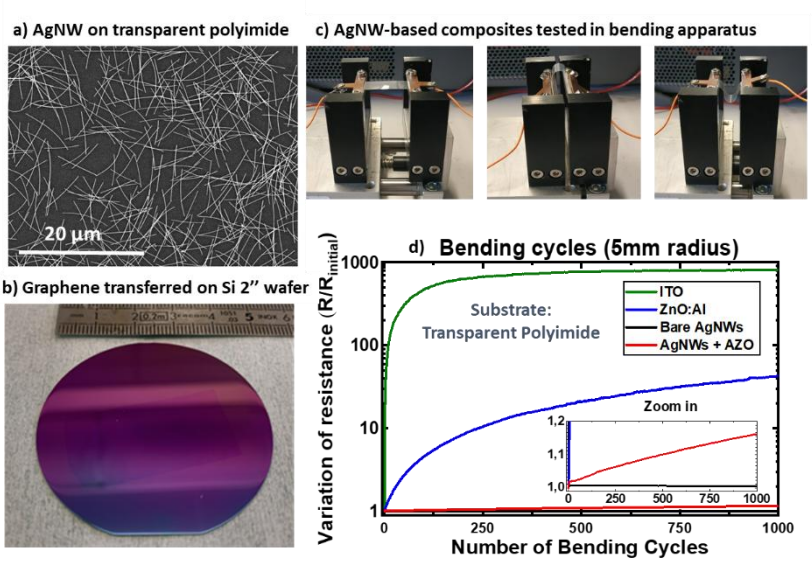

Figure 1: a) SEM image of AgNW network deposited on polyimide, b) Photo of Graphene transferred on Si 2'' wafer, c) Photos of bending apparatus with a flexible AgNW-based electrode tested, d) Electrical resistance variation measured in situ during bending cycles for different transparent electrodes.

Scientific environment

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 at LMGP has developed expertise on the fabrication of AgNW networks by spray-coating on a wide range of substrates and devices, together with in situ electrical characterization benches with heating and mechanical tests and other techniques. Institut Néel (NEEL), a CNRS laboratory of fundamental research in condensed matter physics, has a strong expertise in the field of high-quality graphene growth by chemical vapor deposition (CVD) and the transfer of graphene layers on foreign substrates, including semiconductors, ceramics and polymers, with large size up to 100 mm semiconductor silicon wafers.

Profile & requested skills

Master 2 student in Materials Science, Physics, Chemistry, … This internship will be essentially experimental: graphene transfer processes, AgNW deposition, and characterizations (SEM, electrical, mechanical, Raman spectroscopy, …). Work in chemistry and clean rooms.

Contacts

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Gratification ~600 €/month (M2 internship financed by LabEx MateriAlps)