Master Project Proposal

Rheological Characterisation of Screen-Printing Conductive Inks

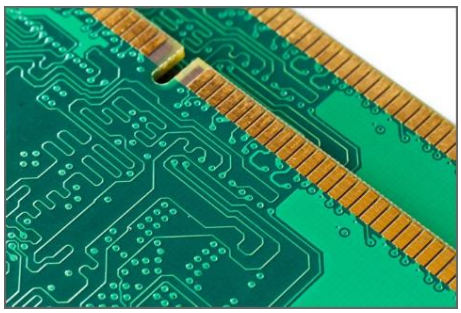

Fig. 1: Electronic circuit printed on a plastic substrate (www.electronics-lab.com)

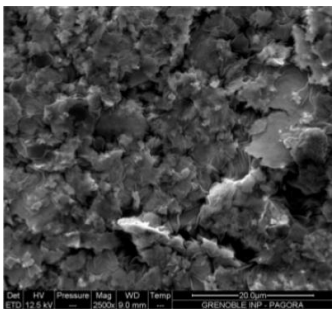

Fig. 2: SEM micrograph of a silver-based conductive ink (photo LGP2)

Printed electronics represents a very promising approach to produce electronic devices with reduced consumption of energy, solvents, and resources compared to microelectronic processes (Fig. 1). These processes widely use screen-printing conductive inks. These inks are generally composed of metallic particles with broad size spectrum (from tens of nm to tens of µm), dispersed into a vehicle composed of solvents and additives. To improve the process sustainability, biosourced solvents are also more and more proposed.

From a mechanical standpoint, screen-printing inks must fulfil the double requirement of being set into flow under mechanical forcing through the mesh of the screen, and returning to a solidlike state when this forcing ceases. While all screen-printing inks are thick viscoelastic fluids, the practical answers to this double requirement are not universal: some inks are thixotropic and/or shear-thinning and solidified *ex-post* by thermal or UV curing, others feature a yield stress and can therefore be directly printed on a three-dimensional substrate.

The influence of the inks' composition on the structural and functional properties of the final prints is however poorly understood, one of the difficulties residing in the lack of knowledge of the formulation choices in commercial inks. Yet, depending on the size, shape, nature, surface properties of the particles (Fig. 2), depending on their affinity with the vehicle, biosourced or not, a wide variety of physico-chemical mechanisms can lead to a given rheological response.

In this project, which could extend through a PhD project, we aim at identifying the mechanisms driving the rheological behaviour of commercial inks. The internship will include two instrumental phases:

- Characterising the rheological properties of several inks, at rest and if possible under forcing conditions approaching those encountered in screen printing. These measurements will rely on rheological tools available in the lab.
- Characterising the physical and physico-chemical properties of these inks, especially the particular phase: size, size distribution, particle morphology, surface charge… Depending on the scales analysed, these measurements will be performed with particular analysis instruments (granulometry, dynamic light scattering) and imaging (optical and electron microscopies).

These characterisations will feed the development of model systems (fluids and setup) of the screen-printing process, which will further allow a more formal investigation of the structural responses of inks during printing.

The project will be carried out in the LGP2 (Process Engineering Laboratory for Biorefinery, Bio-based Materials and Functional Printing), associated with the CNRS (French public agency for scientific research) and hosted within Grenoble INP-Pagora (graduate school of engineering in paper & print sciences), in the university campus of Grenoble, France. The laboratory develops, among others, expertise in characterisation and formulation of functional inks, possesses the relevant instrumentation, and benefits from the exceptional scientific and natural environment of the University of Grenoble (among the top research universities in France, nested at the heart of the French Alps).
Projected dates: from February to June 2025.

We seek for an engineering or applied physical sciences student (MSc or equivalent) with good background in physico-chemistry or complex fluids, and taste for instrumental techniques. Other profiles with relevant skills and good references may be considered as well.

To apply, please send your resume, cover letter and 1-2 contacts for reference to:
Matthieu Robert de Saint Vincent, matthieu.robert@grenoble-inp.fr
Nadège Reverdy-Bruas, nadege.reverdy@grenoble-inp.fr
Céline Martin, celine.martin@grenoble-inp.fr
Application deadline is Monday December 9th 2024.