A Grenoble, au centre des Alpes, le LETI est un institut de recherche appliquée en micro et nano technologies, technologies de l'information et de la santé.
Interface privilégiée du monde industriel et de la recherche académique, il assure chaque année le développement et le transfert de technologies innovantes dans des secteurs variés via des programmes de recherche utilisant nos plateformes technologiques.

Research fields: chalcogenide, photonics, neuromorphic, phase-change, materials

Post-doctoral fellowship on chalcogenide materials for photonic and neuromorphic applications: innovative materials, from integration to photonic devices

Chalcogenides are a family of materials offering a **wide variety of applications in the field of micro and nanotechnologies**. In particular, chalcogenide thin films have enabled a revolution in the non-volatile memory market by opening the way to the fabrication of 3D resistive memories, as demonstrated very recently by INTEL with the Optane™ technology. Moreover, the exploitation of the optical non-linearity of chalcogenide glasses could offer a new range of applications in the field of MIR optics. Phase-Change Materials (PCM), which have been successfully used in optical data storage devices (DVD-RAM, CD-RW ...), are also at the origin of this revolution in the non-volatile resistive memory market. **The exploitation of the unique contrast of electronic properties between the amorphous and crystalline phases of PCMs allows to consider a wide range of new applications in the field of photonics or for neuromorphic computing on silicon platform.**

The integration and elaboration on Si of chalcogenide materials (GeSe, GeSbSe, GeSeTe...) is already known because they have been and still are widely used for non-volatile resistive memory applications (CBRAM or PCRAM and OTS selectors). This offers the **opportunity to develop innovative integrated devices based on chalcogenides** while benefiting from the maturity of planar technologies in the silicon industry. In this context, LETI has a longstanding expertise in the elaboration and characterization of such materials in CMOS technology and photonics. Recently, we were able to **demonstrate the exceptional potential of these Ge-Sb-Se-Te-based chalcogenide materials for MIR optics applications** with for example optical nonlinearities superior by more than 2 orders of magnitude compared to the current reference which is SiN in thin film. Beyond their high non-linearities, these chalcogenide thin films have the advantage of being perfectly compatible with the CMOS and BEOL integration (Tmax~400-450°C) of microelectronics. However, **the integration of these materials in photonic devices such as waveguides is a challenge**. Indeed, the etching of these films proved to be complex and the obtained structures present optical losses that will have to be finely controlled in order to allow their integration in photonic and neuromorphic devices.

The **objective of this 2 years post-doctorate** is to participate and **manage the integration processes to fabricate innovative photonic devices dedicated to the targeted photonic applications** (phase shifters, tunable interferometers, absorbers, optical switches ...). For this purpose, different etching chemistries will be available according to the nature of the chalcogenide materials and the quality of the processes will be evaluated by measuring the optical losses in etched waveguide type structures. Indeed, the impact of the etching edges plays a major role in the optical transmission and thus represents the main limiting factor for the future use of these materials in devices with high surface/volume ratio. The characterization of the structural, morphological, electronic and optical properties of these chalcogenide thin films subjected to etching (AFM3D, XPS, XRR, ellipsometry, FTIR, WDXRF, SEM/TEM...) will be carried out both in a clean room on the industrial equipment of the LETI's Si platform (http://www.leti-cea.com/cea-tech/leti/english/Pages/Applied-Research/Facilities/research-facilities.aspx) and on the PFNC the nano characterization platform (http://www.leti-cea.com/cea-tech/leti/english/Pages/Applied-Research/Facilities/nanocharacterization-platform.aspx). The optical characterization of the properties and the dimensioning of integrated photonic structures based on these chalcogenide materials will be carried out in close collaboration with the photonic teams of LETI and our partners **in frame of OCTANE project recently funded by ANR, the French Research Agency (2021-2025)**. The Graal of this work will be to succeed in the integration in Si technologies of such materials in thin films for, for example, the first demonstration of photonic neuromorphic circuits or the generation of super continuum in the MIR in integrated device. The results of this work should allow to demonstrate new innovative applications based on chalcogenide materials in integrated photonics on silicon and be the subject of patents and publications in international journals and conferences of first rank.

Laboratoire d'accueil: LETI/DPFT/SDEP
Advanced Thin films and Nanomaterials Laboratory
Adresse: 17 avenue des martyrs
38054 GRENOBLE cedex 9
Contact : pierre.noe@cea.fr

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Durée: 12+12 months
Date démarrage: 2022