PhD at IM2NP (AMU CNRS, Marseille) in collaboration with ST Microelectronics (Rousset and Crolles)

Subject: Study of the amorphous-crystal phase transition in Ge-rich GST alloys by means of *in situ* transmission electron microscopy

Description: Among the emerging technologies for future non-volatile memories, PCRAMs (Phase Change Random Access Memory) are a favourite. Indeed, this technology allows a fast reading associated with a reliability on many writing cycles. The operating principle is based on the use of a material for which the reversible transition from the amorphous to the crystalline state is accompanied by distinct physical properties. In nanodevices, the phase transition between the two states is controlled by applying an electrical current to the active cell, while the reading of the stored bit rests on the different electrical resistivities of the amorphous and crystalline phases at low voltages.

The $Ge_2Sb_2Te_5$ (GST) alloy exhibits very fast heat-induced phase transition that makes it a very good candidate for PCRAMs devices. For automotive applications which impose strong temperature stability requirements, ST Microelectronics has recently developed a new generation of PCRAMs based on a Ge-rich GST (GGST) alloy offering a better thermal stability than conventional GST material for high-temperature working environment applications. The reduction in the size of memory cells and the increase in their density in embedded-memory devices also require considering the thermomechanical effects linked to the confinement of the material, and the influence of chemical segregation and interdiffusion mechanisms at the interfaces that may occur during the very fast phase transition processes occurring in operating devices.
A deep understanding of the segregation and crystallization mechanisms with a nanometre-scale resolution is thus critical for insuring the reliability of the devices, but requires challenging characterization experiments to be performed.

In this PhD thesis, advanced characterisation techniques will be carried out on thin films of GGST and confined structures to address this problematic. Compositional analyses of the amorphous and crystalline phases will be performed using spectroscopic techniques with a nanometre-scale resolution: energy dispersive X ray spectroscopy and electron energy loss spectroscopy will notably be performed in scanning and transmission electron microscopes. Fast thermal annealing (ms) and biasing experiments of test devices will also be performed *in situ* in high resolution transmission microscopes to investigate the influence of confinement and kinetic effects on the demixing and phase sequence formation, during the amorphous-crystal phase transition of the GGST alloy in realistic conditions of memory devices.
This work will rest on very ambitious experiments and will be conducted in close correlation with other approaches already developed in our group, which mainly make use of X ray diffraction.
In addition, Finite Element Method based simulations of thermal transport will be performed on Ge-rich GST, both for thin film stacks and confined structures, in order to support the interpretation of experimental results.

Candidate profile: The candidate must have an engineering degree, a Master's degree in Materials Science or an equivalent qualification. He/she will have a solid knowledge of condensed matter physics, and a basic knowledge of electron microscopy techniques. Good teamwork and scientific communication in English abilities are expected. Skills in Python coding would also be appreciated.

Starting year: 2023
PhD supervision: Michaël TEXIER (academic supervisor), Solène DASSONNEVILLE (academic co-supervisor)
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Industry: close collaboration with ST Microelectronics, Crolles/Rousset (www.st.com)
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Location: IM2NP, Marseille

Applications including a CV and a letter of motivation should be sent to michael.texier@univ-amu.fr and solene.dassonneville@univ-amu.fr