Joined PhD between STMicroelectronics (Crolles and Rousset), CEA LETI and IM2NP (AMU CNRS Marseille)

Subject: Characterization and Modeling of Phase-Change Materials for Advanced Embedded Memory Applications

Description:
As it was recently demonstrated by the INTEL OPTANE™ memory technology, Phase-Change Materials (PCM) are the most promising materials for new generations of Non-Volatile Memories (NVM). This is the result of their ultra-high scalability and short programming times lying in between volatile DRAM and Flash non-volatile memories. As a result, PCMs offer the opportunity to achieve Storage Class Memory which are at the forefront in order to achieve innovative brain-inspired computing devices and neuromorphic circuits. The principle of operation of PCM memories is to switch reversibly the PCM between an amorphous and a crystalline phase by means of electrical pulses application. Reading the state (amorphous or crystalline) is based on the very large and unique resistivity contrast between the two phases. Nowadays, the most promising PCM to target embedded applications (mobiles, automotive, micro controllers…), i.e. requiring high stability under thermal stress, are multi-phased complex composition alloys $Ge_xSb_yTe_z$. The latter raise critical issues on the interplay between interfaces, composition, stresses or confinement and crystallization kinetics. This PhD work will investigate *in situ* the structural change of these materials during heat treatment using various advanced X-ray scattering techniques (laboratory or synchrotron radiation facilities). These advanced experiments and their modeling by finite element-based methods will bring invaluable information on the physical mechanisms at work during crystallization (nucleation and growth of crystalline phases, stress development and relaxation…). The work will start with simple thin film samples and will continue with prototypical patterned structures of various aspect-ratios in order to mimic as closely as possible memory devices architecture. This will allow for a fundamental understanding of the influence of geometry, interface and volume confinement on the crystallization mechanisms including mechanical stresses. All these results will be used to understand and predict what happens during programming the memory cells as well as addressing some related reliability issues (cycling, drift, data retention …). Aside from X-ray scattering additional input will be obtained from complementary techniques available from the partners (IM2NP/STM/CEA-LETI) involved in the PhD project such as transmission electron microscopy, Raman/FTIR/X-Ray Photoelectron spectroscopy, resistivity/reflectivity/ellipsometry vs temperature…). Thanks to the high penetrating power of x-rays dedicated devices will, in the longer term, be developed for *operando* real time investigations of memory cells during operations like set and reset at synchrotrons or XFELs. These unique experiments will allow for a detailed understanding of the behavior of GST material in its full environment as well as giving unique clues to improve PCM in order to improve further memory devices performance.
The PhD work will be performed in strong partnership between STMicroelectronics, CEA LETI and IM2NP.

Candidate profile:
The ideal candidate holds a master's degree in Material Sciences (or equivalent), has a solid background in physics, good communication skills and is proficient in written and spoken English. Knowledge of solid mechanics and programming skills will be appreciated.
Deadline: June 30th, 2019
Starting year: 2019
PhD Advisor: Prof. Olivier Thomas
Laboratory: IM2NP (http://www.im2np.fr/)
Industry: STMicroelectronics, Crolles/Rousset – France (http://www.st.com)
Funding: CIFRE (3 years)
Location: IM2NP-Marseille (60%), STM-Crolles/Rousset (20%) and CEA-LETI-Grenoble (20%)

Applications including a CV and letter of motivation should be sent by email to Prof. Olivier THOMAS (olivier.thomas@im2np.fr) and Philippe Boivin (philippe.boivin@st.com).