Laser-induced crystallization of Ge-rich GST thin films studied *in situ* with synchrotron X-Ray Diffraction

Thomas Fernandes[1,2], Michael Texier[1], Philipp Hans[3], Solène Dassonneville[1], Simon Jeannot[2], Celine Mariette[4], Yannick le Friec[2], Roberto Simola[5], Olivier Thomas[1].

1- Aix Marseille Univ, Université de Toulon, CNRS, IM2NP, Marseille, France
2- STMicroelectronics, Crolles, France
3- Synchrotron-Light for Experimental Science and Applications in the Middle East (SESAME), P.O Box 7, Allan, 19252, Jordan
4- European Synchrotron Radiation Facility, Grenoble F-38034, France
5- STMicroelectronics, Rousset, France

Phase Change Materials (PCM) are very promising candidates for future non-volatile memory applications [1]. The contrast between two phases (amorphous and crystalline) and the differences in their physical properties (resistivity, optical reflectivity …) allows modifying and reading the state of the memory. The most studied PCM is $Ge_2Sb_2Te_5$ (GST), with a crystallization temperature within the 150-170°C range. However, this temperature is too low for data retention for automotive applications but Ge-rich GST (GGST) with a crystallization temperature of 350°C [2] is fully suitable for this purpose. While *in situ* furnace-annealings of GGST have been recently performed at low heating rates (few °C/min) evidencing a sequential crystallization of the Ge and $Ge_2Sb_2Te_5$ phases [3], real memories are switched at the ns timescale. In the aim of performing time-resolved investigations of the phase transformations in GGST and reproducing the crystallisation dynamics of operating memory devices, we have started performing *in situ* laser irradiation experiments at ID09 beamline at ESRF. 800 nm – 100 ps laser pulses with laser fluences between 14 and 219 $mJ \cdot cm^{-2}$ and a focused pink (14.5 keV, $\Delta E/E \sim 1.5$ %, size ~ 25 µm (V) × 49 µm (H)) X-ray beam have been used for probing the sample response at an incidence of 1° with high enough flux (~10^8 photons/ 100 ps pulse). Ge and GST crystallizations have been evidenced. The diffraction peaks are fitted with a Gaussian plus a background. The evolution of integrated intensity, integral breadth and peak position for Ge 111 and GST 200 as a function of laser fluence and number of laser pulses will be presented and discussed. These experiments open the possibility of future time-resolved pump-probe experiments that will allow probing the sub-ns dynamics of these materials.

1. H.S.P. Wong *et al.*, *Proc. IEEE 98* (2010) 2201.
2. P. Zuliani *et al.*, *Solid State Electron. 111* (2015) 27.
3. O. Thomas *et al.*, *Microelectronic Engineering 244-246* (2021) 111573