Investigating the crystallization behavior of Ge-rich GST PCMs with in-situ synchrotron XRD

P. Hans[1], C. Guichet[1], C. Mocuta[2], MI Richard[1,3], D. Benoit[4], P. Boivin[5], Y. Le-Friec[4], R. Simola[5], O. Thomas[1]

[1]Aix-Marseille Université, CNRS, IM2NP UMR 7334, Marseille, France, [2]Synchrotron SOLEIL, Saint-Aubin, France, [3]ID01/ESRF, The European Synchrotron, 71 rue des Martyrs, 38043, Grenoble, France, [4]STMicroelectronics, 850 rue Jean Monnet, 38920 Crolles, France, [5]STMicroelectronics, 190 Ave Coq, 13106 Rousset, France

philipp.hans@univ-amu.fr

The demand for fast and reliable data storage is strongly rising, with the IoT and Cloud Computing sectors being big drivers. This is reflected by the estimated global next-generation data storage market size in 2018 was 53.1 billion USD with an expected compound annual growth rate of 12.5% until 2025 [1]. Coming to automotive applications (elevated temperatures), the current state of the art for non-volatile data storage employing *flash technology* (e.g. in SSDs), is reaching fundamental limits because of its physical principle. Owing to their properties, p*hase change materials* (PCMs) can solve the problem. PCMs can be *reversibly switched* between an *amorphous* and a *crystalline phase* through controlled (local) heating, e,g, by lasers or by *an electrical current*. Thus, PCMs open the path to Phase Change Random Access Memories (PCRAM), a very promising alternative to replace flash technology [2]. In this contribution investigations on the PCM *GST-theta* a Ge-rich material within the Ge-Sb-Te ternary system are presented. GST-theta reaches *crystallization temperatures above 350°C*, which is needed in *automotive applications* [3]. In a previous study on 50 nm thick films of GST-theta [4], we have shown that the crystallization of that PCM proceeds in two steps (fig 1). Ge crystallization precedes the crystallization of $Ge_2Sb_2Te_5$, a cubic, metastable phase [5]. In the present work we aim at investigating the effects of N-doping and H_2-treatment on the structural evolution of GST-theta (crystallization temperatures, evolution of grain sizes, elastic strains). Therefore, a series of annealing experiments was performed and followed by in-situ X-ray diffraction at the DiffAbs beamline of SOLEIL synchrotron. All samples are annealed up to 500°C under N_2-atmosphere using an Anton Paar® heating stage mounted on the six-circle diffractometer. The diffraction patterns were recorded with an XPAD hybrid pixel detector and corrected and transformed into 1D patterns following previously developed procedures [6]. The 1D patterns are then indexed and diffraction peaks are fitted. A fitting procedure was developed in-house to find and handle also very weak peaks on a strong background. We will discuss here the influence of H_2-treatment, N doping and lateral confinement on the crystallization and microstructure development in GST-theta thin films and nanostructures. It is worth mentioning that some investigated samples are very close to final products (several metallization layers on top), which demonstrate the capability of synchrotron X-ray diffraction to investigate the PCM in its "real" environment.

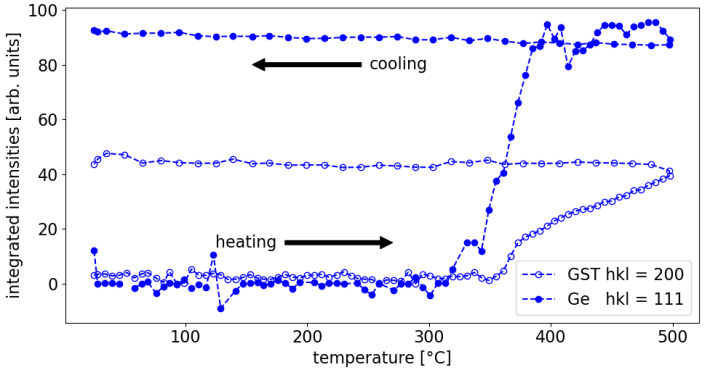

Fig 1. areas of the Ge 111 and $Ge_2Sb_2Te_5$ 200 reflections upon heating of an amorphous film show a phase separation

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Keywords: chalcogenides; data storage; in-situ synchrotron X-ray diffraction; phase change materials; nanostructures

Acknowledgments We would like to thank SOLEIL synchrotron for allocating beamtime on DiffAbs beamline. Ph. Joly (Synchrotron SOLEIL, DiffAbs) is thanked for technical support. IPCEI/Nano 2022 program is acknowledged for partial funding of this work.