Study of crystallization and amorphization of GGST by laser irradiation from femto to microsecond range

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Ge-Sb-Te (GST) alloys are extensively investigated as Phase Change Materials for PCRAM due to their reversible transition between amorphous and crystalline phases under electrical current (1). However, their low phase change temperatures restrict broader applications, notably in the automotive industry. Ongoing research aims to adjust GST alloys towards higher germanium concentrations or by incorporating light elements line nitrogen at doping levels to enhance thermal stability and data retention. Despite these new insights, the instability of Ge-rich GST (GGST) films leads to poor cyclability and increased set drift (2). Long isothermal annealing studies of amorphous GGST films reveal their inherent instability, resulting in the decomposition into pure germanium and GST225 phases (3). Laser annealing emerges as a promising method to study annealing of GGST at different time scales (from fs to µs), that can be closely resembling conditions experienced in memory cells. In this work, we developed a state-of-art infra-red laser setup with modulated pulse duration ranging from fs to µs to irradiate GGST/Si samples from ST Microelectronics. We'll discuss the effects of laser irradiations on GGST annealing, covering fs amorphization and µs crystallization. We'll also detail our approach to characterize laser annealing effects using infrared and SEM microscopy, followed by HRTEM-HAADF and STEM-EDX analyses. For the first time, by tuning the µs laser to low fluence, we achieved crystallization of the 225-GST phase into large unidirectional grains while GGST remained amorphous. At high fluences, we observed Ge-rich GST phase decomposition into large pure Ge monocrystals and phases with various compositions, preceding GST225 formation. These findings offer insights into mimicking thermal switching dynamics in devices through laser irradiation.

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(2) Sousa, V.; et al.*)*; IEEE: Kyoto, Japan, 2015; pp T98–T99.
(3) Rahier, E.; et al. ACS Appl. Electron. Mater. 2022, 4 (6), 2682–2688.