Supplementary information for

Direct measurement of crystal growth velocity in epitaxial phase-change material thin films

Mario Behrens*, Andriy Lotnyk*, Jürgen W. Gerlach, Martin Ehrhardt, Pierre Lorenz and Bernd Rauschenbach

Leibniz Institute of Surface Engineering (IOM), Permoserstr. 15, D-04318 Leipzig, Germany
Email: mario.behrens@iom-leipzig.de, andriy.lotnyk@iom-leipzig.de
**Figure S1:** (a) x-ray diffraction θ-2θ-pattern and (b) high-resolution transmission electron microscopy (HRTEM) image of an epitaxial trigonal Ge$_2$Sb$_2$Te$_5$ (t-GST) thin film deposited on a Si(111) substrate. Selected area electron diffraction (SAED) pattern of (c) t-GST and Si confirming epitaxial relationship and (d) t-GST and Pt (ring pattern), where 5-fold periodicity of spot intensities reveals high structural ordering.
Figure S2: HRTEM image of the epitaxial t-GST thin film after application of four successive single ns-laser pulses of fluences of 35, 15, 35 and 15 mJ/cm². An epitaxial relationship between the initial t-GST and the recrystallized cubic GST (c-GST) layer is present.
Figure S3: Selection of high-resolution scanning transmission electron microscopy (HRSTEM) images of the epitaxial t-GST thin film shown in figure 3 (corresponding reflectivity measurements shown in figure 1). The applied laser fluences are in figure (a) 22 mJ/cm², in figure (b) 26 mJ/cm² and in figure (c) 28 mJ/cm². The interfaces between t-GST and c-GST layers are indicated by a dashed red lines.
Figure S4: (a) time-resolved reflectivity and (b) HRSTEM results on single ns-laser pulse irradiation of a 50 nm thick epitaxial t-GST thin film. The thickness of the recrystallized c-GST layer is 20 nm. Considering a delay time of ~4 ns after the 20 ns long laser pulse for crystallization to start, a crystal growth velocity of 1.4 m/s is calculated.