Nanoscale phase transition of $Ge_2Sb_2Te_5$ induced by locally enhanced laser fields at a tunnel junction

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$Ge_2Sb_2Te_5$ (GST), a representative phase change material (PCM) has been extensively investigated as a promising candidate for next-generation data storage and processing devices, because of its outstanding processing performance and durability. It has been reported that the irradiation of the femtosecond laser pulses on GST induces the ultrafast amorphization, where the flipping of Ge atom takes place from the octahedral to the tetrahedral symmetry site [1]. However, the nanoscale characteristic of the phase change has been left unexplored although it is indispensable for revealing ultra high-density and ultrafast device performances. Here, by utilizing a scanning tunneling microscope (STM) coupled with femtosecond laser pulses, we demonstrate that nanometer-scale amorphous marks can be induced by locally enhanced laser fields at a tunnel junction. Figures 1(a) and 1(b) shows the morphology of the GST surface before and after laser irradiation, respectively. After the laser irradiation, a mound with a height of ≃ 0.3 nm and a diameter of ≃ 4nm was formed associated with the crystalline to amorphous phase change [2]. By measuring the current-voltage (*I*-*V*) curve, the differential tunneling conductance (d*I*/d*V*) and the *I*-*V* characteristics in the grid pattern with 5 nm intervals, we further found not only the bandgap change from ~ 0.3 eV to ~ 0.6 eV but also the laser-induced amorphous region comparable with the pixel size (a bright dot in Fig. 2(b)), which also support that the nanoscale amorphization was introduced by the locally enhanced laser fields with photoassisted STM.

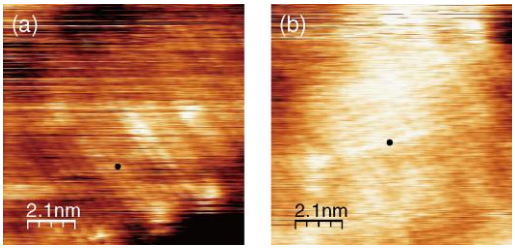

Figure 1. STM images of GST surface (a) before and (b) after laser irradiation.

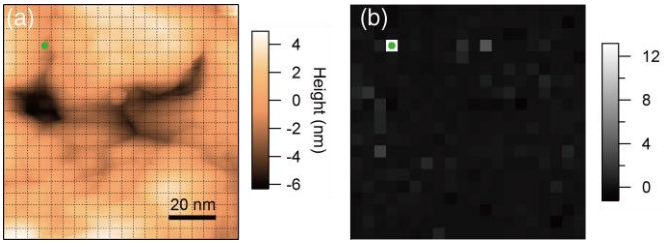

Figure 2. (a) STM topo image. (b) $-I$ (V = −200 mV)/ I (V = 600 mV) mapping after the laser irradiation. The bright dot shows the laser-induced amorphous region.

[1] J. Takeda *et al.*, *Appl. Phys. Lett.* **104** 261903 (2014).

[2] T. Kawaguchi *et al.*, Phys. Rev. B **101**, 060302 (2020).