Far-infrared near-field optical imaging and Kelvin probe force microscopy of laser-crystallized and -amorphized phase change material $Ge_3Sb_2Te_6$ used for active metasurfaces

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Chalcogenide phase change materials, such as $Ge_3Sb_2Te_6$ (GST326), reversibly switch between non-volatile amorphous and crystalline states with a strong contrast in optical properties. Inducing the switching process with a focused laser enables novel active nanophotonic devices via local change of the dielectric function, e.g. for re-programmable metasurfaces. Nanoscale characterization of the resulting local optical properties is essential for laser-switched devices but is mostly unexplored to date. Here, we show that combining mid- and far-infrared (THz) scanning near field optical microscopy (SNOM) and Kelvin probe force microscopy (KPFM) allows us to clearly distinguish four different states of laser-switched GST326. Additionally, we use the higher sensitivity to free charge carriers of far-infrared compared to mid-infrared SNOM and find evidence that the local conductivity of crystalline states depends on the switching process and history. This implies that further studies are necessary to enable reliable, reversible switching between well-defined states over many cycles. The combination of (far-infrared) SNOM and KPFM is well-suited for these in-depth investigations.