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Ultrafast response of phase-change memory materials

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We describe recent experiments probing the first steps in the amorphous-to-crystalline transition that underlies the behavior of phase-change materials, examining both electric-field-driven and optically-driven responses in GeSbTe and AgInSbTe alloys. First measurements using femtosecond x-ray pulses at the Linac Coherent Light Source will be described which enable direct snapshots of these transitions and associated intermediate states. We will also describe studies using single-cycle terahertz pulses as an all-optical means of biasing phase-change materials on femtosecond time-scales in order to examine the threshold-switching response on microscopically relevant time-scales. These studies indicate nonlinear scaling with the applied electric field and field-induced crystallization as evidenced by ultrafast optical reflectivity and conductivity measurements, from which a mechanistic understanding of these phase transitions can be obtained.