Searching for Disorder in Order

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Fueled by the need to develop a more efficient and reliable form of nonvolatile memory for the next generation beyond FLASH memory, a large amount of effort has been dedicated to understanding the structure of both the SET and RESET states of phase-change devices. Most of this structural work has focused upon the structure of Ge-Sb-Te (GST) alloys in either the as-deposited sputtered amorphous state (RESET) or the laser or thermally crystallized SET state with few or no structural studies performed on the structure of electrically switched GST due to the difficulty of carrying out structural investigations on devices with sub-micron dimensions. In addition, the recent finding that structural disorder in GST alloys leads to Anderson localization and concomitant effects on transport has made the need for further studies of order ever more pressing. A particularly pertinent question is the length scale of the ordering present in GST alloys.

In this talk, we explore ordering on different length scales in the SET phases of GST alloys by a variety of complementary techniques including the average structure by Bragg Diffraction, short-range structure by X-ray absorption, and ordering on intermediate length scales using total scattering. We find that Ge-rich phase-change alloys lying along the technologically important GeTe-Sb_2Te_3 pseudobinary tie-line exhibit a ferroelectric transition at the Curie temperature in which the crystal structure transforms from rhombohedral to cubic on the average, while on the local scale as probed by x-ray absorption, the structure remains rhombohedral for temperatures from room temperature to well above the Curie temperature. We then reconcile this apparent contradiction by introducing a model in which the average structure averages to cubic on intermediate time scales, but remains rhombohedral locally.[1]

In the final part of the talk, the measurement of local structure on the actual scale of functional phase-change devices will be introduced. XANES spectra from functional phase-change devices taken with a 100 nm x-ray beam will be shown and the results discussed.

References

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