We investigate phase-change material samples with nanodiffraction and fluctuation electron microscopy (FEM) combined with scanning transmission electron microscopy (STEM). Both methods rely on illuminating the areas of interest of the sample by a small (2 nm probe size) and almost parallel (convergence angle smaller than 2 mrad) electron probe. This creates nanodiffraction patterns with the spatial resolution defined by the probe size. We also extract information about the nanometer scale medium range atomic order (MRO) of amorphous materials by calculating the variance of the diffracted intensities in many nanodiffraction patterns a technique called STEM-FEM (Voyles & Muller, 2002). In the present work nanodiffraction is used to identify crystalline regions of Sb$_2$Te$_3$ samples. The STEM-FEM technique is used to gather information about the MRO of AgInSbTe (AIST) samples.

In order to understand the reaction mechanisms during the wet chemical synthesis of hexagonal Sb$_2$Te$_3$ platelets, we investigated intermediate stages of the reaction with nanodiffraction. By scanning the intermediate products with the electron probe and collecting nanodiffraction patterns at the same time, it is possible to identify the crystalline areas of the platelets. Understanding the reaction mechanism can help to improve the synthesis to create smaller (sizes below 50 nm) Sb$_2$Te$_3$ platelets. These platelets may have promising applications in possible nonvolatile memory devices.

AIST is a potential phase-change material for building nonvolatile data storage devices. A deep understanding of the crystallization kinetics of AIST is needed, because the crystallization speed is the limiting factor of the writing speed of possible memory devices. The MRO of the amorphous phase of AIST could play an important role in understanding the difference of crystallization speeds of as-deposited and melt-quenched AIST (Lee et al.). The normalized variance is calculated by doing FEM in STEM mode in a Titan-STEM.

References
Voyles, P.M., & Muller, D.A. (2002). Fluctuation microscopy in STEM. Ultramicroscopy 93, 147-159

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Fig. 1: (A) STEM angular darkfield image of a Sb$_2$Te$_3$ platelet. The orange box marks the region scanned by nanodiffraction. The blue cross marks the position of the electron probe on a crystalline region ((B) nanodiffraction pattern). The red cross marks the position of the electron probe on an amorphous region ((C) nanodiffraction pattern).

Fig. 2: Variance of as-deposited AIST plotted versus the diffraction vector k. The peaks in the plot show a strong MRO in as-deposited amorphous AIST capped with ZnS-SiO$_2$. 