Electric Field Induced Displacements of Individual Atoms in Ferroelectric GeTe Thin Films Studied Using Standing Wave X-Ray Fluorescence

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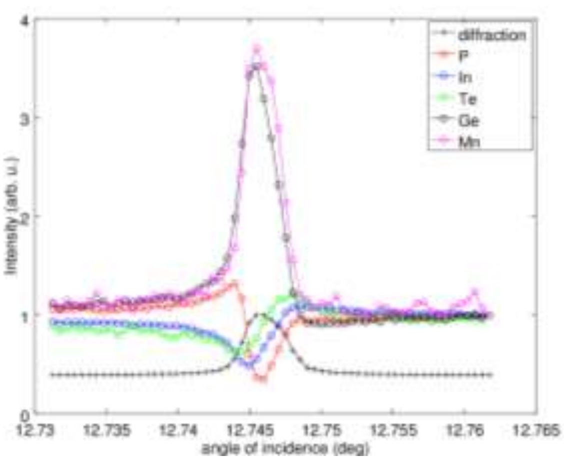
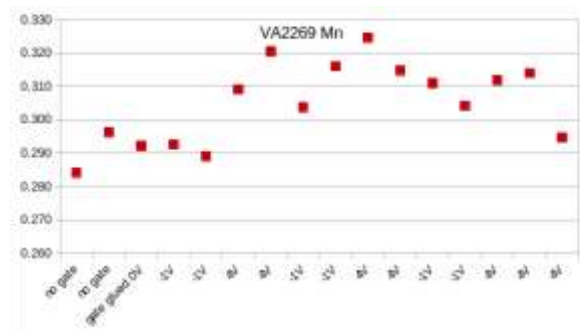
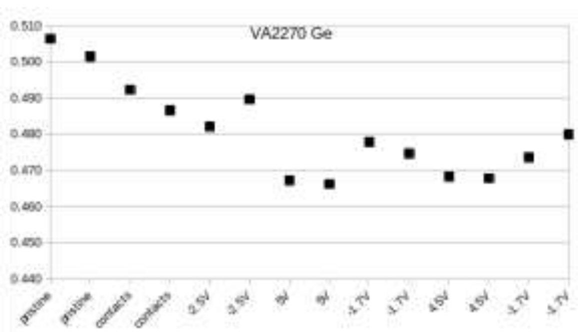
Abstract. Magneto-electric coupling in multiferroic materials have many possible applications in materials science. One of the promising multiferroic materials is manganese doped ferroelectric GeTe with optimal manganese concentration of about 13% [1]. The ferromagnetic transition temperature for such material is about 150K, while the ferroelectric temperature is higher.



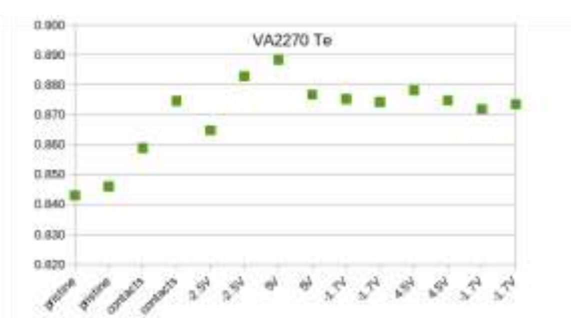
(a)



(b)



(c)



(d)

FIGURE 1. (a) Diffraction and fluorescence intensity of five atomic species as a function of angle of incidence. (b) Mn position in GeMnTe thin film with applied electric field. (c) and (d) Ge and Te atomic positions in applied field in GeTe layer.

The ferroelectric transition temperature of pure GeTe is about 650K. In the present work we have studied in-operando displacements of individual atoms using standing wave x-ray fluorescence in GeTe and GeMnTe thin films grown on InP(111).The samples were prepared by molecular beam epitaxy. The layer was covered with a sputtered carbon films which serves also as top electrode, while conductive substrate is a bottom electrode.

The measurement was performed at SLS synchrotron D05A beamline at photon energy of 11500eV. The standing wave is induced in vicinity of x-ray diffraction condition at a single crystal InP and propagates into thin film deposited on top of the single crystal. Changing the angle of incidence the phase of the standing wave is shifting and the fluorescence signal of individual atoms is measured. The fluorescence curve profile depends of the position of the corresponding atom in the crystalline lattice. An example of fluorescence curves of In and P atoms from substrate and Ge, Mn and Te atoms from the layer along with profile of the diffraction curve is presented in Figure 1(a). The period of the standing wave equals interplanar distance of the particular diffraction; in the case of 111 diffraction on InP it is 0.339 nm. Thus we are allowed to resolve atomic displacement with resolution of about 0.005 nm. The thickness of the studied thin film has to be very small since atomic positions in the films has to be in phase with the standing wave induced by a substrate. We have performed measurement with applying DC voltage to the device. The atomic shifts of Ge atoms in units of the InP 111 interplanar distance is shown in Figure 1(b).

We have shown the Ge and Mn atoms shifts with alternating electric field; although the shift is smaller than in bulk GeTe. Knowledge of the dynamics of the individual atoms in thin film plays an important role in the understaning surface oredering of the multiferroic GeMnTe.

REFERENCES

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