Response of polar materials to electric fields studied by X-ray absorption spectroscopy

Verena Ney[1], Katharina Ollefs[2], Fabrice Wilhelm[2], Andrei Rogalev[2] and Andreas Ney[1]

[1]. Solid State Physics, Johannes Kepler University, Linz, Austria.
[2]. ESRF, 6 rue Jules Horowitz, BP 220, F-38043 Grenoble Cedex, France
email: **verena.ney@jku.at**

Compounds like the cubic sphalerite (e.g. ZnSe) and hexagonal wurtzite structures (e.g. ZnO) lack the centre of symmetry and are therefore capable of exhibiting piezoelectric and related effects depending on polar symmetry [1]. Electrostriction in general can be found in any piezoelectric material, where the application of an electric field causes a distortion of the material. However, usually hydrostatic pressure is applied in practical experiments and it has been shown that e.g. the photoluminescence in ZnO is consequently shifted to smaller energies [2]. In addition, the dependence of the structure of ZnO has been studied by x-ray diffraction and extended x-ray absorption fine structure spectroscopy (EXAFS) upon applying hydrostatic pressure [3]. A comparable effect upon applying an electric field and thus indirectly applying pressure through piezoelectric distortion has not been observed yet. Although ZnO is of interest as a piezoelectric material, e.g. for surface acoustic wave devices, the electrostriction coefficients for ZnO have so far been only derived by theory [4].

Here we will study the effect of an external electric field on epitaxial layers of ZnO (doped with Co) and a ZnSe single crystal with element specificity by means of x-ray absorption near edge spectroscopy (XANES). Using hard x-rays we can “look” through the contacts and therefore lattice distortions can be measured with x-ray linear dichroism (XLD) while applying an electric field. Using linear polarized light furthermore enables us to probe parallel or perpendicular to the applied field. We can show that there is a rigid band shift of the entire absorption spectrum which depends linearly on the electric field. The magnitude of the shift is shown to be different for the elements Zn, Co and Se. This implies that the shift of the host cation site (Zn) compared to dopants (e.g. Co) differs. Furthermore the effect is isotropic. The results are discussed in terms of e.g. electrostriction, piezoelectric distortion, Stark effect, etc.. These measurements demonstrate new possibilities to study electrically active materials via XANES, i.e. with element specificity.

References

[1] - D. Berlincourt, H. Jaffe, and L. R. Shiozawa, Phys. Rev. **129**, 1009–1017 (1963).
[2] - G. H. Li et al., phys. stat. solidi (b) **244**, 87 (2007).
[3] - F. Decremps et al. Phys. Rev. B **68**, 104101 (2003).
[4] - I. Kornev et al., proceedings 29th Int. Conf. Phys. Semicond., p. 71 (AIP, 2009).