ZnO is one of the wide bandgap semiconducting materials and also the most widely used transparent conductive oxide (TCO) layer in solar cells. Very conform layers can be prepared by atomic layer epitaxy (ALD). This promises that even structured solar cells can be covered by this method in which the layer is formed in many cycles, as only a monolayer thick material is deposited in a single cycle. Here we study the structure of ALD ZnO layers deposited on various single crystalline substrates using conventional and high-resolution transmission electron microscopy (TEM) as well as by X-ray diffraction (XRD).

Diethyl Zinc (DEZ) and water were used as precursors for growth of ZnO on single crystalline sapphire, GaN, SiC and diamond substrates. The growth was carried out between 150°C and 300°C without any buffer layer and the nominal thickness of the layers is 40 nm. The layers were characterised by TEM using a Philips CM20 conventional microscope operating at 200 kV and a spherical aberration (Cs) corrected FEI Titan for high-resolution imaging at 300 kV. All of the samples in cross-sectional and in-plane geometries have been thinned by conventional Ar ion milling at 10 kV with a final polishing at low voltages (<1 keV). XRD was used to determine the orientation of the grown layer. The X-ray and TEM results will be compared in this study.

The ZnO layer on sapphire was found polycrystalline. Fig. 1 shows the overview of the whole grown layer in cross-section. The contrast of the ZnO layer clearly shows the polycrystalline nature of the layer, which was supported by electron diffraction patterns as well. Fig. 2 is a high resolution Cs-corrected TEM image showing grains in the ZnO layer with different orientations. The fact, that efforts to grow single crystalline ZnO on single crystalline sapphire, GaN, SiC and diamond substrates. The growth was carried out between 150°C and 300°C without any buffer layer and the nominal thickness of the layers is 40 nm. The layers were characterised by TEM using a Philips CM20 conventional microscope operating at 200 kV and a spherical aberration (Cs) corrected FEI Titan for high-resolution imaging at 300 kV. All of the samples in cross-sectional and in-plane geometries have been thinned by conventional Ar ion milling at 10 kV with a final polishing at low voltages (<1 keV). XRD was used to determine the orientation of the grown layer. The X-ray and TEM results will be compared in this study.

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Fig. 1: Cross-sectional TEM image showing the whole ZnO layer.

Fig. 2: High-resolution TEM image of the sapphire/ZnO interface region showing the polycrystalline ZnO.