Heat transport in polycrystalline oxide thin films

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Progressive miniaturization and increasing integration and higher operating frequency of electronic devices cause problems with efficient heat dissipation from devices. This is why the thermal properties of thin films became very important for their specific applications, e.g. in TFTs and LDs. Knowledge about film thermal conductivity can allow to engineer heat extraction and then to improve reliability and efficiency of electronic structures.

This work presents the study of morphology and thermal properties of various oxide thin films, among them zinc oxides (ZnO) and indium tin oxides (ITO). The ZnO thin films were fabricated by the atomic layer deposition (ALD) method on Si substrates. The ITO samples were commercially available thin films deposited on glass (Hoya, Japan). The thickness of films used in the present work varied from 100 nm to 170 nm. Atomic force microscopy topographic images showed that the surface morphology is typical for polycrystalline thin layers with roughness equal to few nm. The X-ray diffraction measurements revealed polycrystalline structure with preferred orientation (100) for ZnO films and preferred orientation (222) for ITO films. Determination of the thermal conductivity of oxide thin films was realized by the use of scanning thermal microscopy (SThM). This nondestructive method allowed for quantitative measurements of thermal properties with high spatial resolution. Determination of the thermal conductivity was based on calibration curve build on SThM signal measured for reference sample of well-known thermal conductivity. These apparent thermal conductivities of the thin layer – substrate system were corrected in correlation to the spreading resistance analysis. The corrected values of the thermal conductivity of oxide thin films are gathered in the Table 1. Correlations between structure and morphology and thermal properties of the thin films and allowed to study the influence of deposition parameters like substrate temperature on thermal properties of the layers.

Table 1. Thermal conductivity of oxide thin films.

ITO Samples	κ / [$Wm^{-1}K^{-1}$]
REF	0.97
3A	3.6
9A	1.7
11A	1.6
ZnO Samples	κ / [$Wm^{-1}K^{-1}$]
330c	1.12
900c	2.81

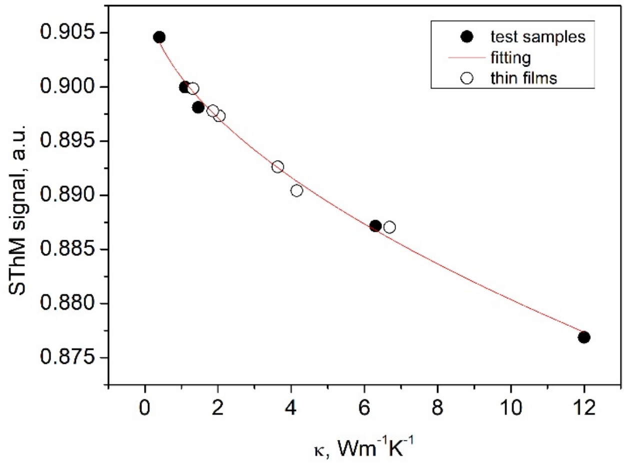

Fig. 1. SThM signal vs sample thermal conductivity measured for test samples and oxide thin films.

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