THERMAL CONDUCTIVITY OF ScAlN: EFFECT OF LAYER THICKNESS

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Owing to its large spontaneous polarization wurtzite (wz) ScAlN is a promising material for high-frequency electronic devices, such as ScAlN/GaN high electron mobility transistors. These devices require effective thermal management to overcome self-heating issues. Thus, knowledge of the thermal conductivity of the constituent device materials is of crucial importance.

In this work, we report on the thermal conductivity (ThC) of wz-ScxAl1-xN layers with Sc composition up to x = 0.41 grown by magnetron sputtering epitaxy on Si(111) and sapphire substrates. The measurements are performed by transient thermoreflectance technique within a temperature range of 80–400 K. We focus on the boundary effects on the ThC and thermal transport across the layer/substrate interface. The experimental data are analyzed using a modified Callaway model, which accounts for all phonon scattering processes contributing to the ThC.

Our measurements and calculations for layers with different compositions and thicknesses of 80–2000 nm show significant effects of the phonon-layer-boundary and phonon-grain-boundary scattering on the ThC. The layer boundary effect is dominant at low temperatures, while the grain boundary effect dominates above room temperature. The contributions of both effects diminish with increasing layer thickness. Furthermore, we studied the temperature dependence of the thermal resistance across the ScAlN/Si(111) interface and found that it saturates at temperatures above 200 K at a very small value. This result indicates a diffusive phonon transport mode across the interface, which is consistent with our calculations using non-equilibrium Landauer approach and employing exact phonon density of state.