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UWBG ULTRAWIDE BANDGAP POWER ELECTRONICS

Temperature Dependent Thermal Conductivity of Al-Rich $Al_xGa_{(1-x)}N$

Effects of Disorder in the Wurtzite Structure

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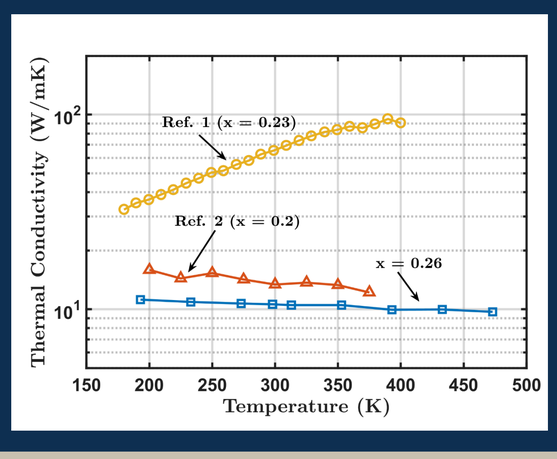
Need: Tunable wide band gaps for power electronics.

Problem: Performance and reliability is diminished in power electronics at high operating temperatures. Material properties needed to predict performance.

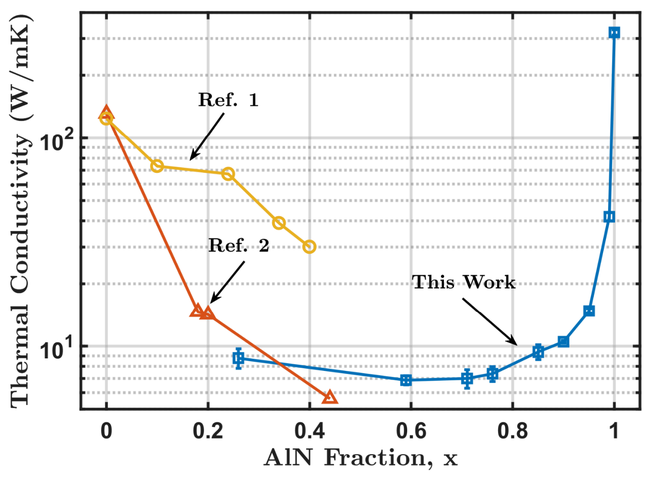
Premise: AlGaN has tunable wide band gap, but alloys have low thermal conductivity. What is the thermal conductivity? ***Previous studies disagree.***

Factor of 5+ difference in magnitude and contradictory trends in literature



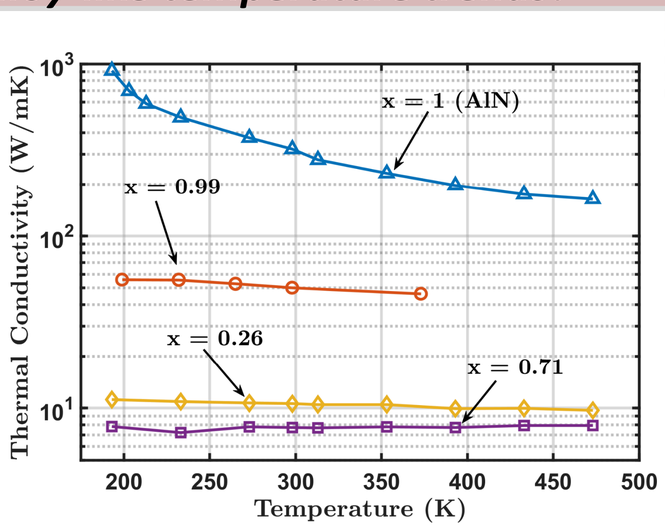
AlGaN Thermal Conductivity

Question 1: ***What is the thermal conductivity of AlGaN?***



Takeaway: ***Alloying produces typical bathtub shape with disordered alloy-like magnitudes.***

Question 2: ***Glassy or alloy-like temperature trends?***

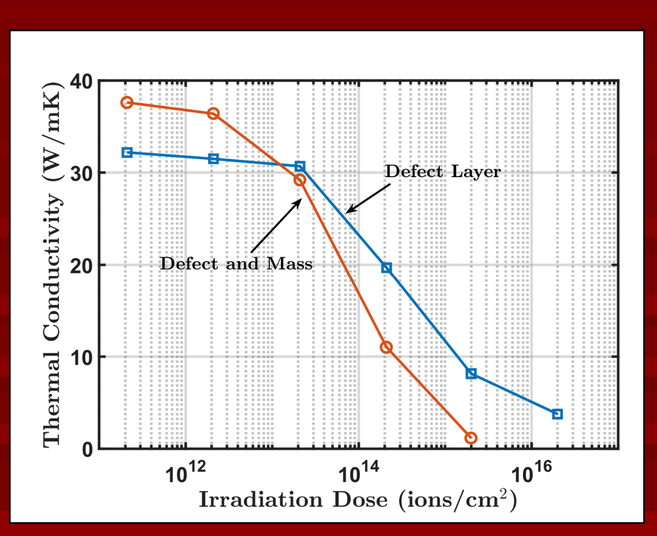


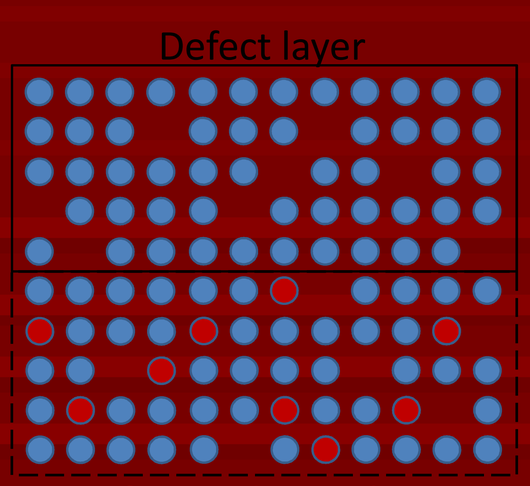
Takeaway: ***Our AlGaN alloys show only negative/flat, i.e. alloy, trends.***

Path: ***Previous study showed that positive trend could be due to defects, Ref. 3. ⇨ Test the influence of defects in the wurtzite structure.***

Defects and Mass Impurities

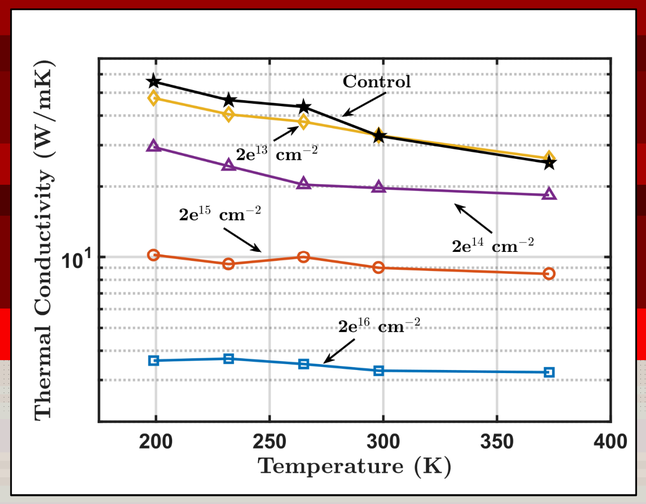
Question: ***Does irradiation create the defect types needed for a glassy temperature trend in wurtzite GaAs?***





Takeaway: ***Irradiation causes defect and impurity scattering.***

Takeaway: ***Even at the highest irradiation flux, temperature trend is negative.***



[1] Liu, W. & Balandin, A. A. Thermal conduction in Al_xGa_1-xN alloys and thin films *Journal of Applied Physics,* **2005**, *97*

[2] Daly, B. C. Maris, H. J. Nurmikko, A. V. Kuball, M. & Han, J. Optical pump-and-probe measurement of the thermal conductivity of nitride thin films *Journal of Applied Physics,* **2002**, *92*, 3820-3824

[3] Barman, S. Ganguly, A. & Barman, A. Phonon heat conduction in Al_xGa_1-xN film *EPL (Europhysics Letters),* **2012**, *97*, 36011

Summary

Magnitude

AlGaN thermal conductivity is in-line with other disordered alloys.

Trend

We found that the temperature trend is negative or flat, inline with other disordered alloys.

Defects

We were unable to recreate a glass-like positive conductivity trend in the wurtzite structure of GaAs through He irradiation.

The alloy/crystal nature of wurtzite thermal conductivity is robust against disorder.

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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