From Amorphous to Amorphous-Crystalline Mixture Boron Nitride: Evolution of the Thermal and Elastic Properties

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Amorphous boron nitride (a-BN) is a promising dielectric and protective coating [1,2], yet its nanoscale heat dissipation and elastic properties remain poorly quantified. Here we synthesize BN thin films by borazine-based chemical vapor deposition (800–1000 °C), revealing a temperature-driven transition from fully amorphous networks to mixed amorphous–crystalline films with embedded BN nanocrystallites [3]. Frequency-domain thermoreflectance shows an ultralow, thickness-dependent cross-plane thermal conductivity for a-BN (k_{out} < 0.5 W m^{-1} K^{-1} for 10–40 nm), which increases systematically with crystallinity up to ~1.5 W m^{-1} K^{-1}. Micro-Brillouin light scattering and finite-element modelling reveal a concomitant stiffening, with Young's modulus rising from 7.5 ± 0.7 GPa (800°C) to 53 ± 5 GPa (1000°C). Green–Kubo molecular dynamics simulations rationalize these trends via bonding topology and vibrational transport, and highlight how oxygen, hydrogen and carbon impurities and composition provide practical knobs to tune thermal and mechanical performance in BN for nano-electronics and coating applications.

References

[1] Ali Hossain *et al* 2024 *J. Phys. Mater.* **7** 035006
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Figures

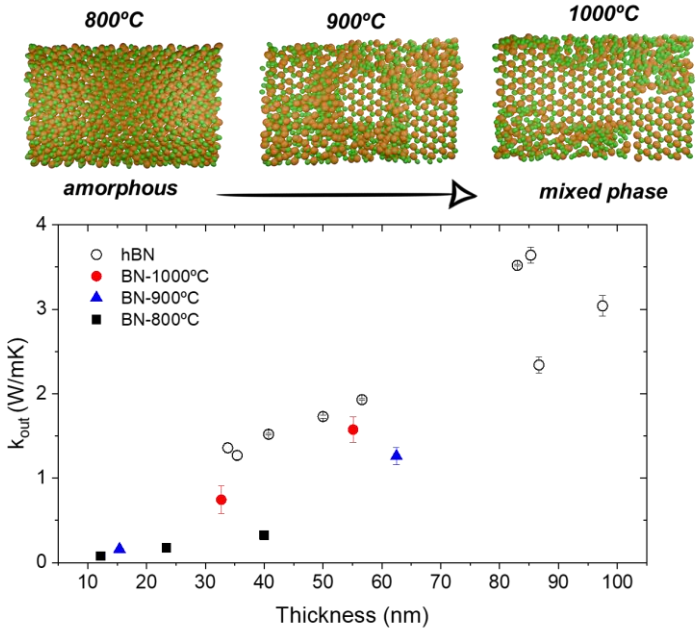

Figure 1: Structural evolution of a-BN films as a function of growth temperature and corresponding cross-plane thermal conductivity k_{out}.