Motivations & Materials

Hexagonal boron nitride (h-BN) is a prime candidate as a heat-conductive material for next-generation electronics with high performance or passive heat-regulating textiles [4].

- H-BN shows excellent in-plane thermal conductivity: 370 W m⁻¹ K⁻¹ for bulk [2]; 751 W m⁻¹ K⁻¹ for a single layer [3].
- H-BN is usually included as a thermally conductive filler in polymers [5]. Commercial heat-conductive dielectrics [6] usually have a thermal conductivity of 0.8 to 4.2 W m⁻¹ K⁻¹.

- 2D few-layer flakes of h-BN can be obtained by ultrasonication-assisted liquid phase exfoliation.

Characterization

Raman & AFM characterization show the successful exfoliation of bulk h-BN powders into few-layer flakes

The Raman shift of 1364 cm⁻¹ showed our h-BN flakes are few-layer thick;

AFM statistical analysis: the lateral size and the thickness of the exfoliated h-BN flakes follow a log-normal distribution, which were peaked at 338 nm and 6.0 nm, respectively.

Thermal conductivities of h-BN composites

Increasing the h-BN mass fraction increases the overall thermal conductivity value of the composite.

\[
P_{\text{heater}} = P_{\text{cond}} + P_{\text{non-cond}}
\]

\[
P_{\text{cond}} = P_{\text{rad}} + k_{\text{loss}} \frac{dT}{dx}
\]

\[
P_{\text{non-cond}} = -kA \frac{dT}{dx}
\]

Discussions:

1. The larger the mass fraction of thermally conductive h-BN is, the more the contact points and heat release paths among the fillers may be. Thus, the generation of heat can be released more efficiently.
2. Being added exfoliated h-BN flakes, the thermal conductivity of the composite was improved.

H-BN coated textile for thermal tests

A h-BN coated textile: h-BN/polymer inks were drop casted on a textile

A textile was drop casted by the h-BN/polymer ink and dried overnight at the ambient temperature. The textile remains flexible after the coating. The successful coating of h-BN/polymer film may generate high thermally conductive paths, which will be tested by a customized textile temperature management setup in labs.

Conclusions & Reference

- The composites with bulk h-BN powders have improved thermal conductivities (up to 6.5 W m⁻¹ K⁻¹) than the composites with only polymers (1.1 W m⁻¹ K⁻¹).
- The exfoliation of bulk h-BN powders into delaminated few-layer h-BN flakes further improves the overall thermal conductivity of the composite to 21.7 W m⁻¹ K⁻¹.
- H-BN coating on the textile is successful and adds additional thermal conducting paths on the textile.