

## Electronic Supplementary Information

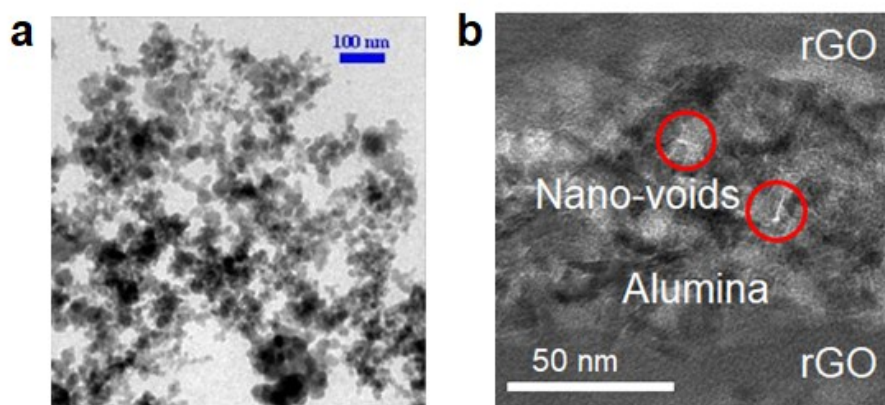
# Binder-Free Heat Dissipation Films Assembled with Reduced Graphene Oxide and Alumina Nanoparticles for Simultaneously High In-Plane and Cross-Plane Thermal Conductivities

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### S1. TEM observation of alumina NPs and nanoscale-voids of alumina NPs



**Figure S1.** (a) TEM image of 80 nm-sized alumina NPs (purchased from Korea Nanomaterials, image is available at the company's website: [https://koreanano.co.kr/shop/item.php?it\\_id=KRU3008](https://koreanano.co.kr/shop/item.php?it_id=KRU3008)), (b) Cross-sectional TEM observation of rGO/alumina complexed film.

### S2. Thickness and size information of the Cu, rGO, and rGO/alumina films.

**Table S2.** Thickness and diameter of Cu, rGO and rGO/alumina films.

Sample	Thickness	Size
Cu	10 $\mu\text{m}$	Diameter 4 cm
rGO	9.3 $\mu\text{m}$	Diameter 4 cm
rGO/alumina	9.8 $\mu\text{m}$	Diameter 4 cm

### S3. Electrical insulation between LED and heat dissipation film for thermal management tests.

**Table S3.** Measured electrical resistivities of heat dissipation films before and after applying silicon-based grease

	Electrical resistivity without grease ( $\Omega.m$ )	Electrical resistivity with grease ( $\Omega.m$ )
Cu	$2.2 \times 10^{-8}$	$5.49 \times 10^4$
rGO	$1.6 \times 10$	$6.71 \times 10^4$
rGO/alumina	$4.2 \times 10$	$7.24 \times 10^4$