Supplementary Information

Characterization of graphene nanoplatelets (GnPs)

Dimensions (both lateral and thickness) of GnPs were characterized using Scanning Electron microscopy (SEM) and Atomic force microscopy (AFM). AFM image shown in Fig. 1 below shows a GnP with a thickness of 80 nm. This is close to the vendor (Graphene Supermarket) specified average thickness of ~60 nm. The lateral dimension of GnPs was measured using SEM shown in Fig. 2. The average lateral dimension of GnP



from showing an ~80 nm thick



Fig. 2 SEM image of GnP flakes

Measurement of thermal diffusivity

The samples were first strained to the desired length. To prevent sample failure and to ensure uniform strain, the samples were strained at a very small draw rate of 20 μ m/min. Heat was applied during the drawing process to maintain the samples at 60 to 70 °C. Once the sample was strained to the desired value, it was removed from the tensile transducer, and prepared for thermal diffusivity measurement using Angstrom method.

Thermal diffusivity was measured using the Angstrom method³³ by applying a sinusoidal heat signal at the middle of the sample and measuring temperature (T) response at two different

locations along the sample allowing the thermal diffusivity to be estimated using, $\alpha = \Delta x^2 / [2\Delta t \ln(A_1/A_2)]$ where Δx is the distance between the two thermocouples, Δt is the phase difference between the two *T* responses and A_1 and A_2 are the amplitudes of the two temperature profiles. The sample was placed inside a vacuum chamber to eliminate convective heat losses and a turbo vacuum pump was used to maintain the pressure in the chamber to below 20 mtorr.

Effect of Dispersion of GnPs within the composite



Figure. 3 a) and b) Variation of thermal conductivity with mixing temperature and time respectively during melt-compounding.

The effect of dispersion of GnPs on nanocomposite k was studied by varying the values of mixing time and temperature used during composite preparation through micro-compounding. Variation of k with these parameters was studied for the 10 wt% sample at an applied strain of ε = 2 (shown in Figure 3a and b). We first studied the effect of mixing temperature at a fixed mixing time. Figure 3a shows the change in k with mixing temperature. At low temperatures, the high melt viscosity prevented efficient dispersion of GnPs leading to low composite k. At a higher temperature of 240 °C however, degradation of the polymer material was observed (in the form of

defects during the drawing process) which led to a decrease in k. A maximum in k was observed at 200 °C, allowing its choice as the optimum temperature. Next the mixing time was increased from 10 min to 90 min while keeping the mixing temperature at 200 °C. The composite k increased up to a mixing time of 40 min and then became constant (Figure 3b). Increasing the mixing time improves the dispersion of GnPs within the composite. Beyond 40 mins, the constant k suggests a well dispersed state of GnPs; the fact that k is constant also suggests that nanofiller breakage does not occur upon further mixing. This led to the choice of 40 mins for mixing time. Data reported in main manuscript in Fig. 3 was obtained from samples prepared using the above optimum mixing time and temperature of 40 mins and 200 °C.

Confirmation of improvement in dispersion of GnPs upon increasing mixing time was achieved by studying the composite samples using micro-computer-tomography (μ CT). Zeiss Xradia 410 X-ray Computed Tomography (CT) equipment was used to image the GnPs embedded within the composite matrix. The images for 10 min and 40 min mixing time are shown in Fig. 4a and b respectively.



Figure. 4 μ CT images of the 10 wt% PE-GnP composite prepared with different mixing times of a) 10 mins and b) 40 mins.

Figs. 4a and b clearly show that increasing the mixing time breaks up the agglomerates and leads to a more uniform dispersion of the GnPs within the polymer matrix.