Supporting Information for

Microwave-Heated Graphene Realizes Ultrafast Energy Conversion and Thermal Storage

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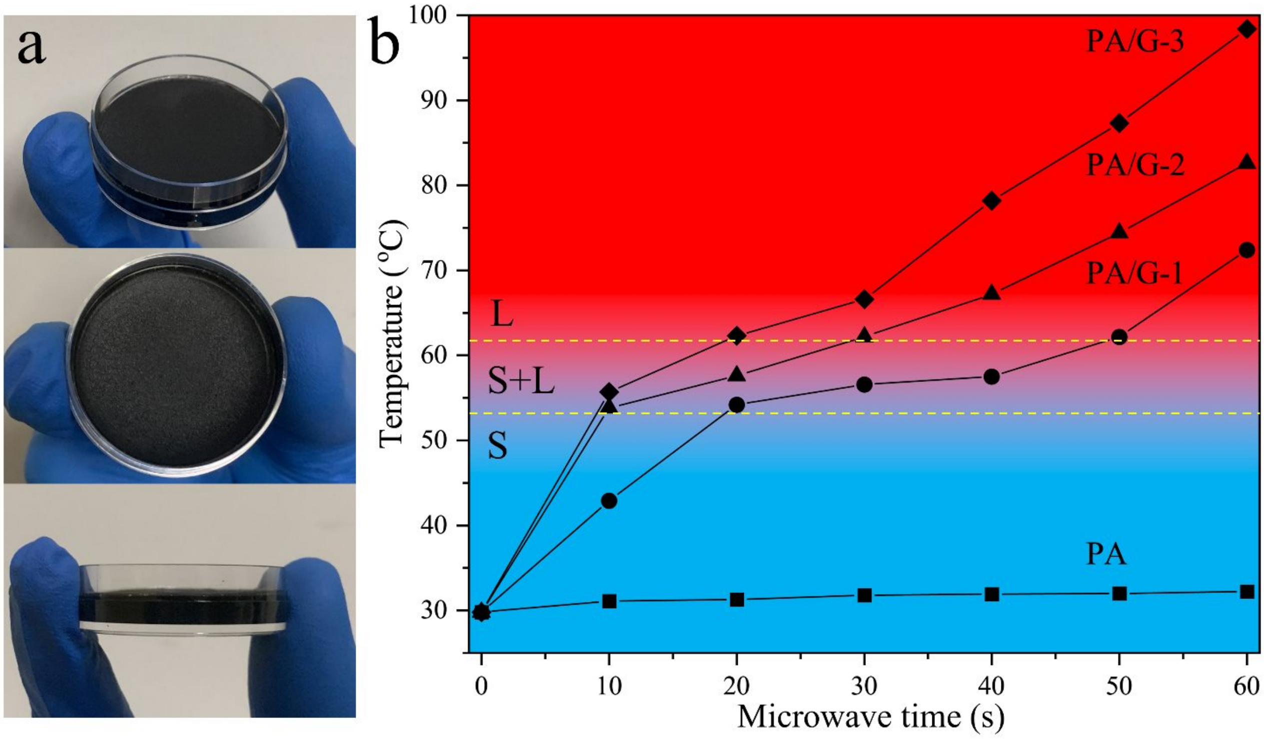

Figure S1. a Photograph of PA/G-1. b Heating curve of PA and composite PA/Gs.

The points in Figure S1b are recorded every 10 seconds. The corresponding action time of the sample in microwave environment (10s, 20s, etc.), then take it out immediately and record the temperature with the temperature test gun (UT302D-32 to 1050 ℃).

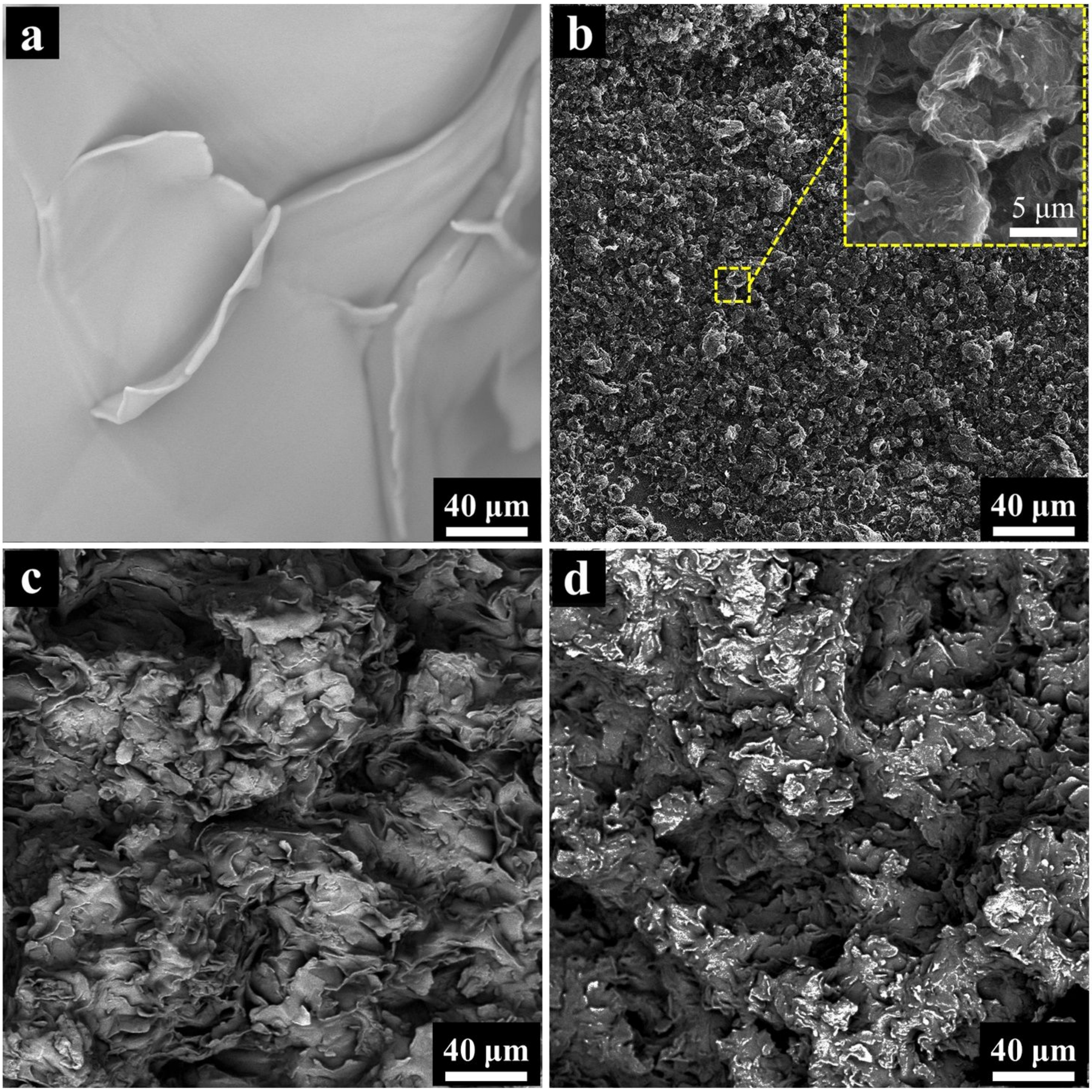

Figure S2. Microstructure characterization of PA, G, and PA/G. **a** SEM images of PA. **b** Graphene, **c** PA/G-1**, d** PA/G-3

The white parts are pure paraffin and the black parts are graphene wrapped by paraffin. We analyzed the composition of the sample after many melting/freezing cycles by Raman spectroscopy. The dark yellow curve is graphene and the red curve is the composite material PA/G-2. There are characteristic

D band and G band of graphene locate in 1350 cm^{-1} and 1580 cm^{-1}, respectively[1], and PA/G-2 also had the same peak in the same position. The black curve is pure paraffin, with an obvious characteristic peak near 1500 cm^{-1} and 2900 cm^{-1}. It can be seen that PA/G-2 contains the peak of PA in the same position. This result shows that after many repeated melting/freezing cycles the chemical formation of the composite was not affected.

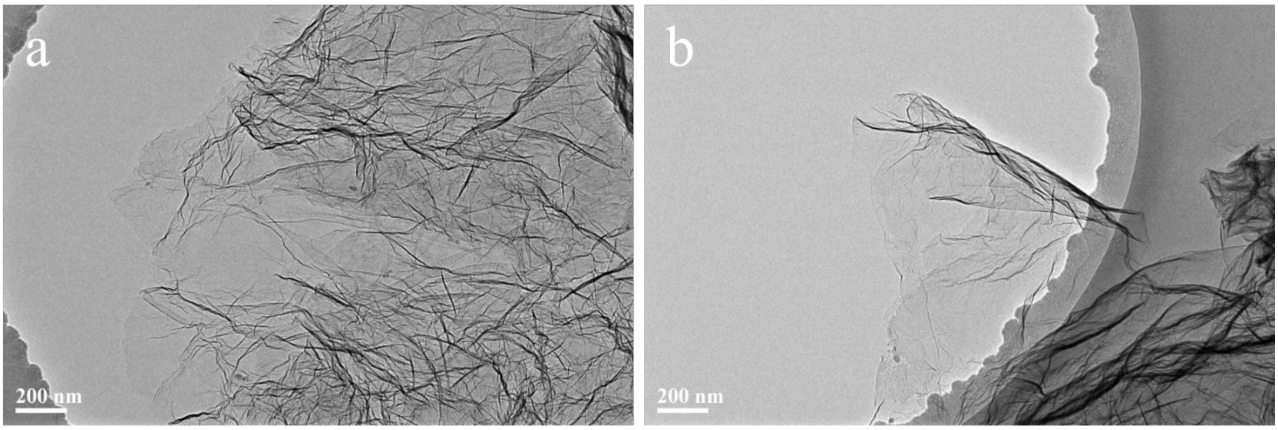

Figure S3. a, **b** TEM of Multi-layer Graphene

The microstructure of graphene was observed using high-resolution TEM. A small amount of graphene was ultrasound dispersed in water. Under TEM, as shown in Figure S3, We can see these few-layer graphene and the folds that appear in the layers.

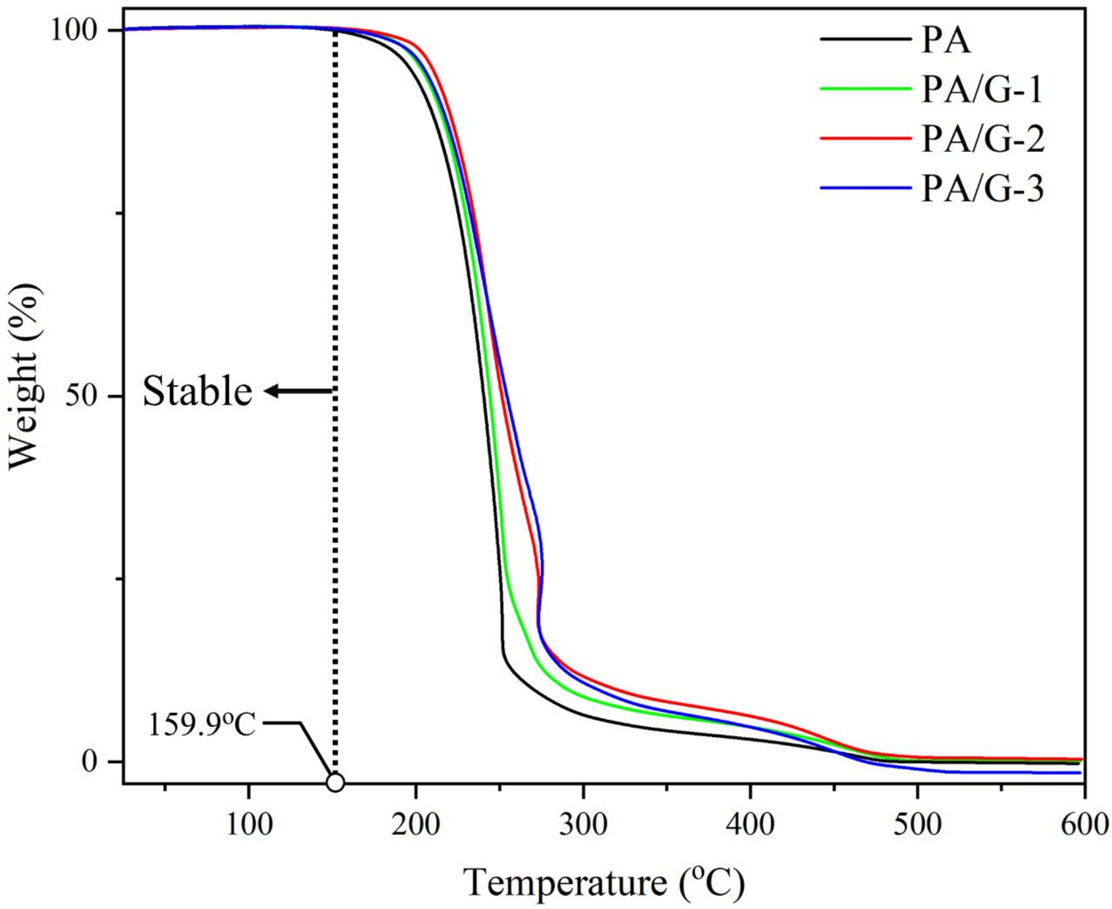

Figure S4. TGA curve of PA/G-1 in air atmosphere

It can be seen that the mass of PA/G decreased rapidly at about 240 °C, because the samples reacted with oxygen and burned at this temperature. What we need to pay attention to is that the sample mass is almost unchanged before 159.9 °C, which can meet our requirements of reusing microwave heating the composite material and applying it to heat storage and heat preservation.

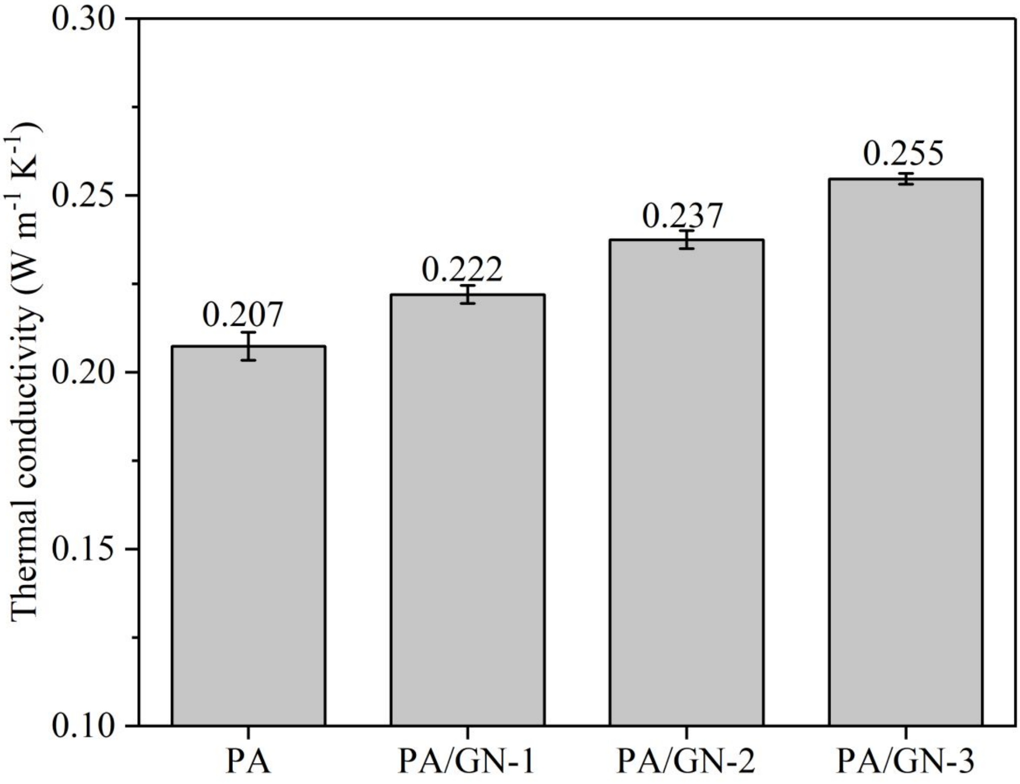

Figure S5. Thermal conductivity of PA, PA/G-1, PA/G-2, PA/G-3 composites

The definition of thermal diffusivity is $\alpha = \kappa/\rho c^2$, κ thermal conductivity, ρ material density and c specific heat capacity. The laser flash method directly measures the thermal diffusion coefficient of the material, and the thermal conductivity is calculated by the formula in section 2.3. Because the content of graphene is very small, in order to facilitate the comparison, the density and specific heat capacity are selected as the parameters of pure paraffin, that is, ρ is 0. 89 g cm^{-3} and c is 2. 9 J g^{-1} K^{-1}. The thermal conductivity of PA, PA/G-1, PA/G-2, and PA/G-3 are 0.207,0.222,0.237 and 0.255 W m^{-1} K^{-1}. It can be observed in Figure S5 that the thermal conductivity of the composite increases with the increase of graphene content. The reason is that graphene forms a dense network structure in the substrate PA, providing an active heat transfer channel. Due to its higher thermal conductivity than paraffin, the transfer speed of temperature of the composite is accelerated, and the temperature rises uniformly and rapidly in the microwave environment. The small thermal conductivity has little impact on the heating process and helps to maintain the temperature during the cooling process, which is in line with our expected purpose.

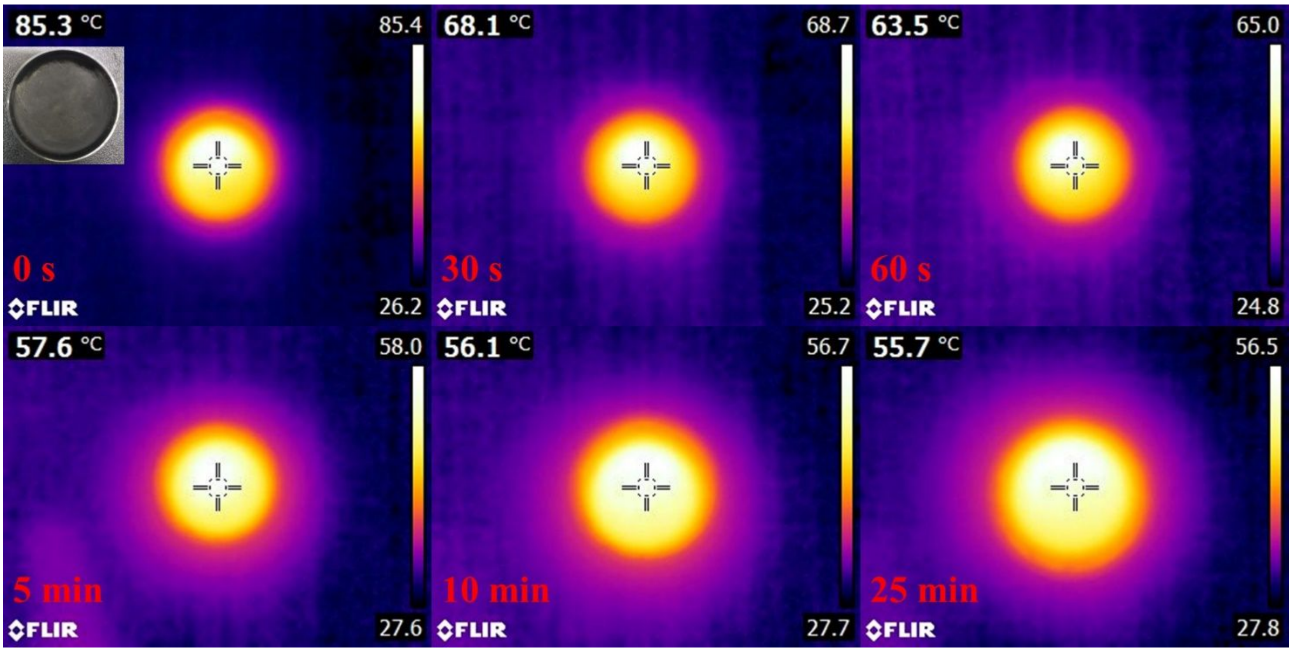

Figure S6. Infrared imaging photos of the cooling process

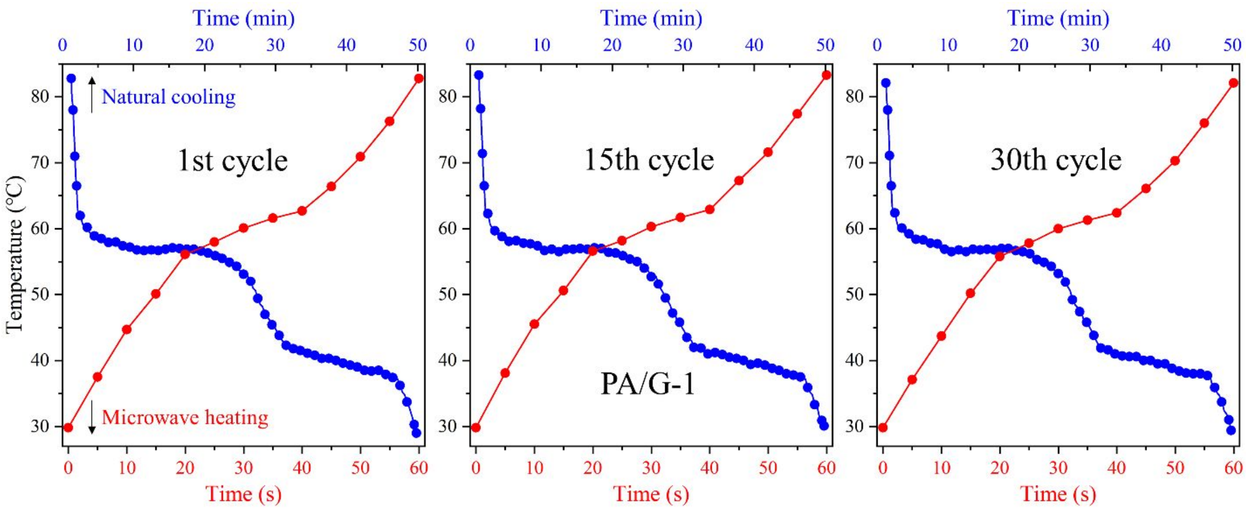

Figure S7. The temperature curve of PA/G-1 during cycle

In the process of cooling, the curve has a little bulge, which may be due to the inaccuracy of measuring point which is close to the outside of the composite or the possible error of the instrument.

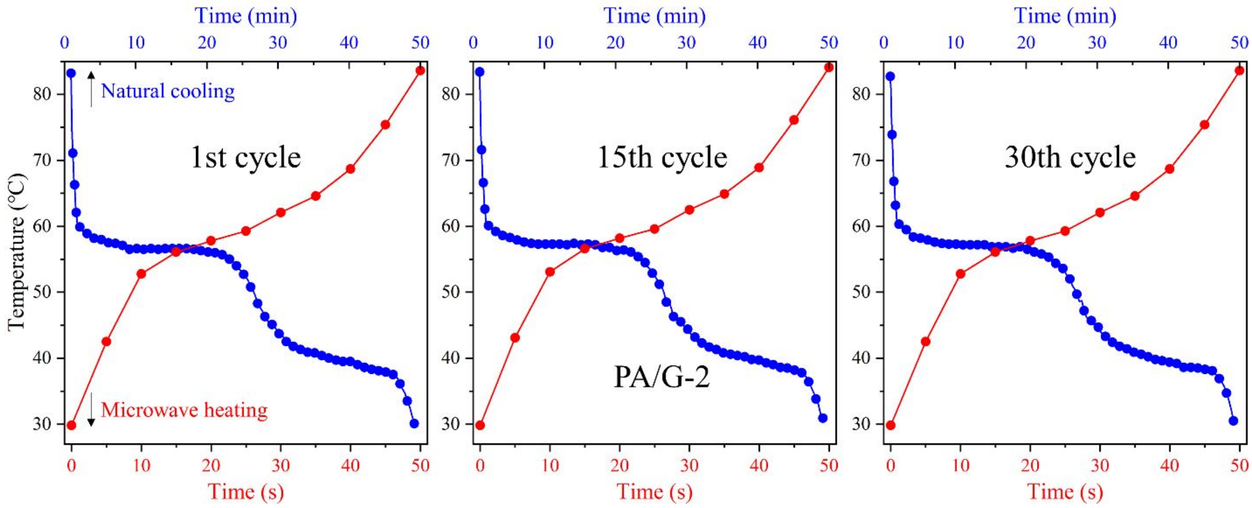

Figure S8. The temperature curve of PA/G-2 during cycle

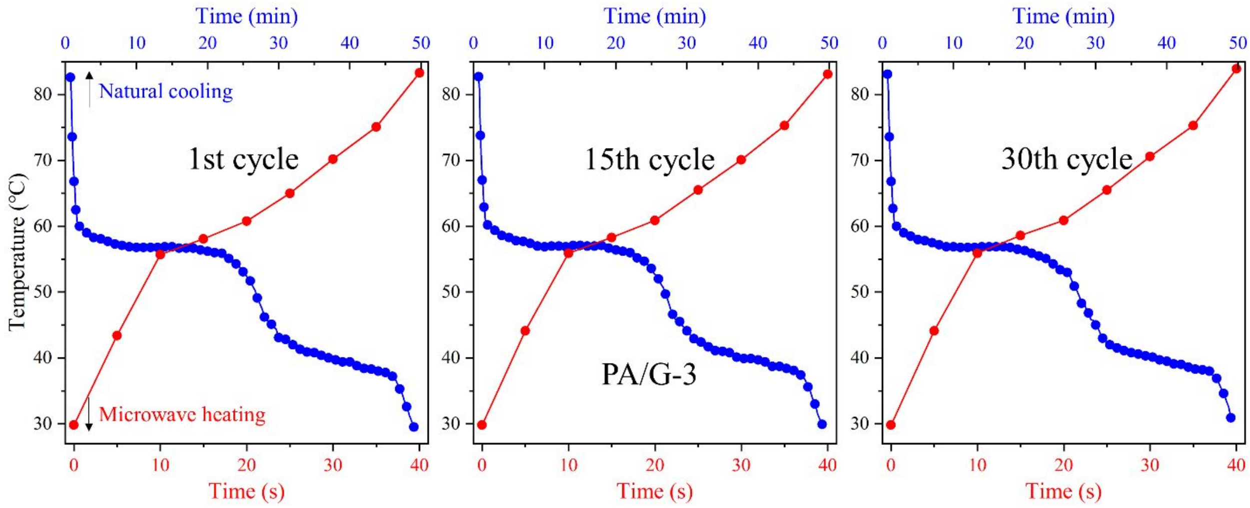

Figure S9. The temperature curve of PA/G-3 during cycle

Figure S10. Intuitive heating process under high-speed camera

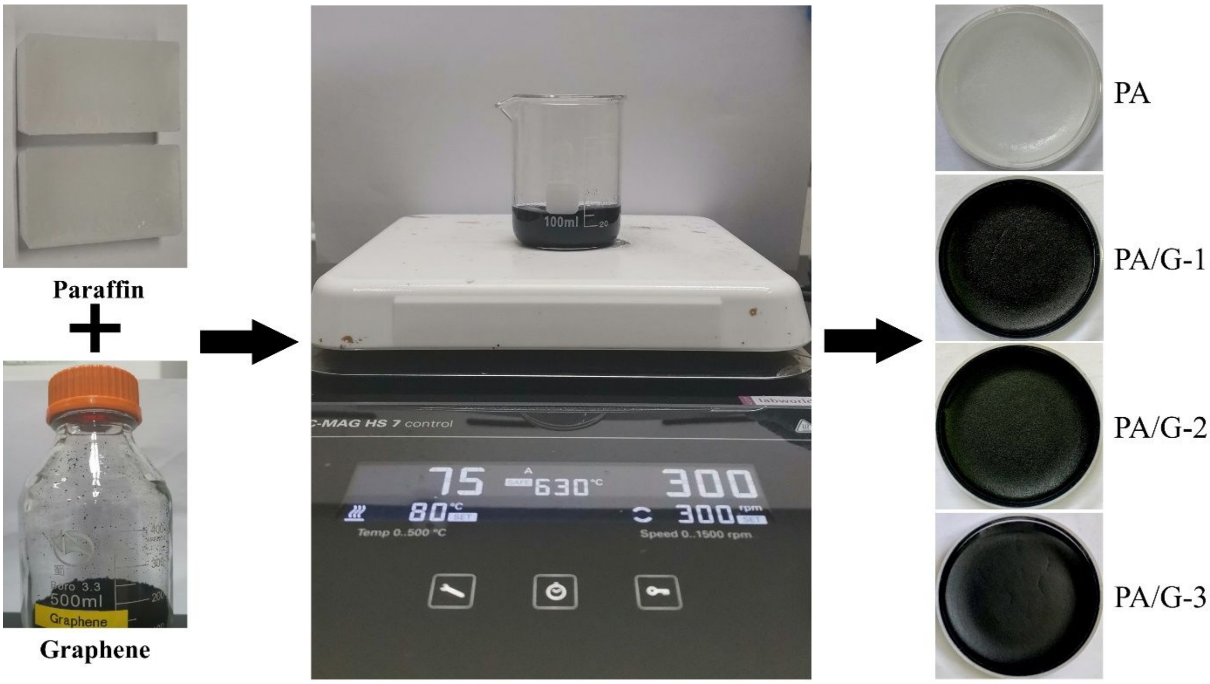

Figure S11. Physical diagram of material and preparation process

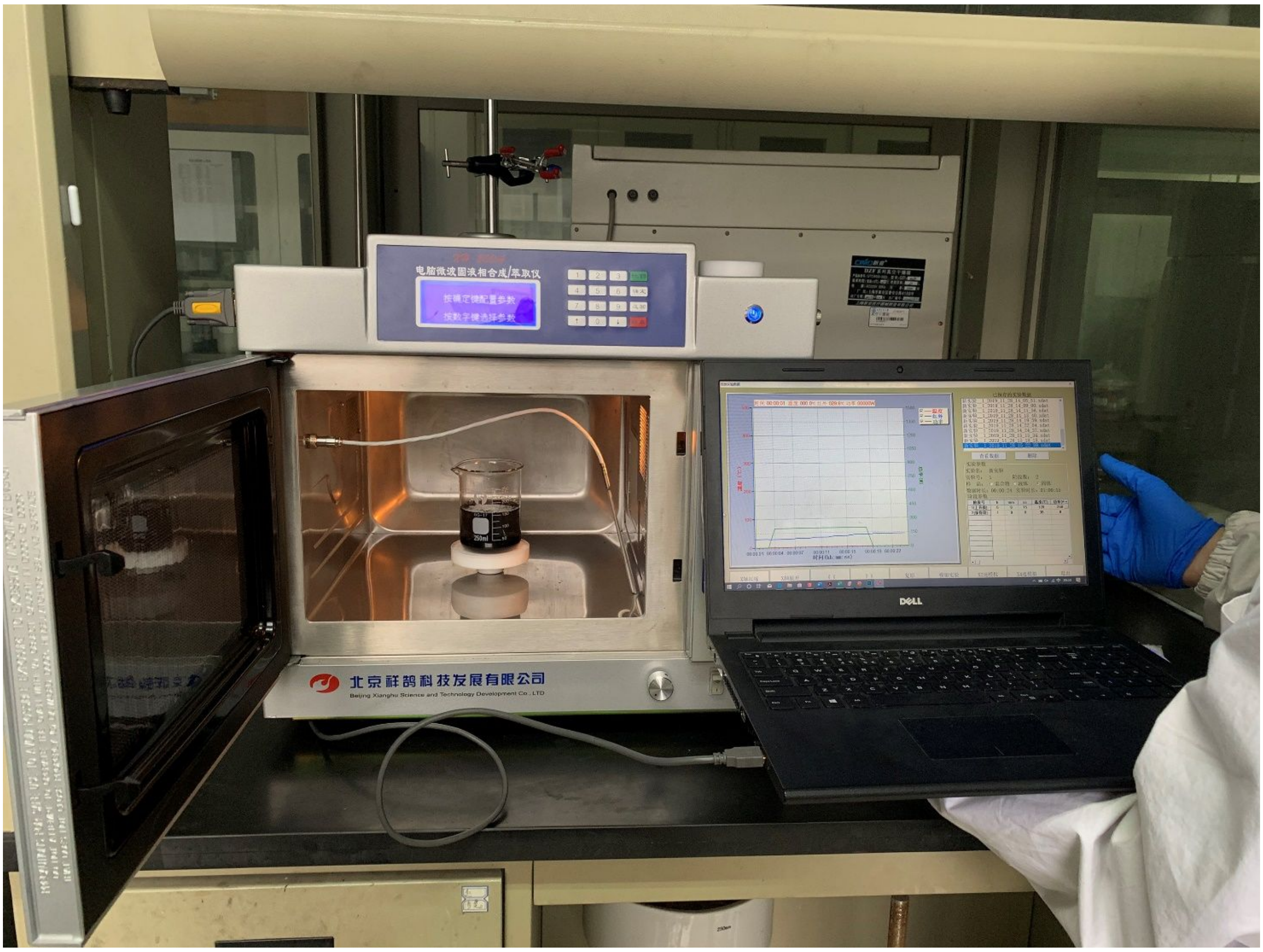

Figure S12. Experimental equipment and test diagram

Table S1. Sample information.

Sample name	The mass ratio of G (wt%)
PA	0
PA/G-1	0.5
PA/G-2	0.75
PA/G-3	1.0

Table S2. Thermal properties of the PA and PA/G composites.

Sample name	Melting Process			Freezing process			The mass ratio of G (wt%)
	T_{onset} (°C)	T_{peak} (°C)	Latent Heat (J g^{-1})	T_{onset} (°C)	T_{peak} (°C)	Latent Heat (J g^{-1})	
PA	52.59	59.96	196.21	57.46	53.38	196.29	0
PA/G-1	52.56	60.15	193.02	57.88	52.97	193.08	0.5
PA/G-2	52.54	60.46	191.52	57.71	52.17	191.13	0.75
PA/G-3	52.63	60.36	189.98	57.88	52.28	190.04	1.0

All of these materials exist a peak value of heat flow in Figure 3a during the exothermic process, in other words, the heat flow of 53.38 ℃ is the largest and the values of these materials are different result from different specific heat capacities, which are: PA > PA/G-1 > PA/G-2 > PA/G-3. So, when the materials are lowered by the same temperature, the heat flow of PA is the fastest. In other words, PA releases the most heat.

Table S3. Thermal diffusivity of the PA and PA/G composites.

Sample names	Thermal diffusivity (mm^2 s^{-1})
PA	0.080
PA/G-1	0.086

PA/G-2	0.092
PA/G-3	0.099

1. Liu, B.; Sun, H. J.; Peng, T. J.; Zhao, X. L., Effect of Microwave Irradiation Time on Structure, Morphology, and Supercapacitor Properties of Functionalized Graphene. *JOM* **2019,** *71* (2), 613-620.
2. Behnia, K.; Kapitulnik, A., A lower bound to the thermal diffusivity of insulators. *J Phys Condens Matter* **2019,** *31* (40), 405702.