Supporting Information:

Graphene-based plastic absorber for total sub-terahertz radiation shielding

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S1. The SE parameters in THz regime

The transmission (T), reflection (R), and absorption (A) parameters are calculated using the following expressions:

$$T = \left(E_0^{(T)} / E_0^{(inc)}\right)^2 \cdot 100\%$$

$$R = \left(E_0^{(R)} / E_0^{(inc)}\right)^2 \cdot 100\%$$

$$A = 100\% - T - R$$

where $E_0^{()}$ is the complex THz electric field amplitude measured using the TDS technique (see Figure S3B). The logarithmic scale of the radiation attenuation can be derived as follows:

$$SE[dB] = -10dB \cdot \log_{10}(T)$$
$$SE[dB] = 20dB \cdot \log_{10}\left(E_0^{(inc)} / E_0^{(T)}\right)$$

The relation between linear and logarithmic scale of shielding efficiency is the following:

10dB – 90%

20dB – 99%

30dB – 99.9%

40bB – 99.99%

The specific shielding efficiency (SSE) stands for SE parameter divided by the material density, and it is expressed in the dB·cm^3/g.

S2. The reflectance spectra

Figure S4A shows reflectance measured at a 45° angle of incident beam for bare PDMS and composite samples with three different graphene loads. The Fabry–Pérot interference can be seen in the reflectance spectra for the bare PDMS sample; the frequency range coefficient is relatively low. The muffled Fabry-Pérot interference is also visible in the graphene/PDMS sample with 0.1% and 3% of graphene load that oscillates around 15% (1 dB) (see Fig. S4A).

In contrast, the reflectance spectra of the 10% wt. graphene/PDMS spectra without Fabry-Pérot interference is visible, and the reflectance is increasing with frequency from about 20% at 0.1 THz to about 35% at 0.8 THz. Fig. S4B shows that the reflectance measured at different angles (45° and 60°) of incident THz beam for reference and 10% wt. graphene/PDMS composite. For bare PDMS samples, the Fabry-Pérot interference is visible at both 45° and 60° angles. The spectra shift due to different optical paths. A bigger difference is visible in the graphene/PDMS composite sample where the reflectance is larger at 60° incidence angle. The reflectance value at 0.8 THz is about 67.5% relative to about 35% when measured at 45° angle.

S3. THz EMI shielding demonstration on video

The tunable VDI (Virginia Diodes, output power c.a. 20 mW, 0.28-0.29 THz, diagonal horn 0.35 inch) illuminates a sophisticated diffractive optical component. This collimates a divergent beam and projects a segment of a line of the camera matrix. A camera screen presents mm wave images projected on the matrix of the detectors. The camera works as a mm wave to visible light converter. Our composite is placed in front of the camera matrix. By moving a composite sample horizontally, we can observe the screen and line shortening/disappearing line. This is a simple demonstration of how efficiently our material can shield the camera matrix.

S4. Supporting figures

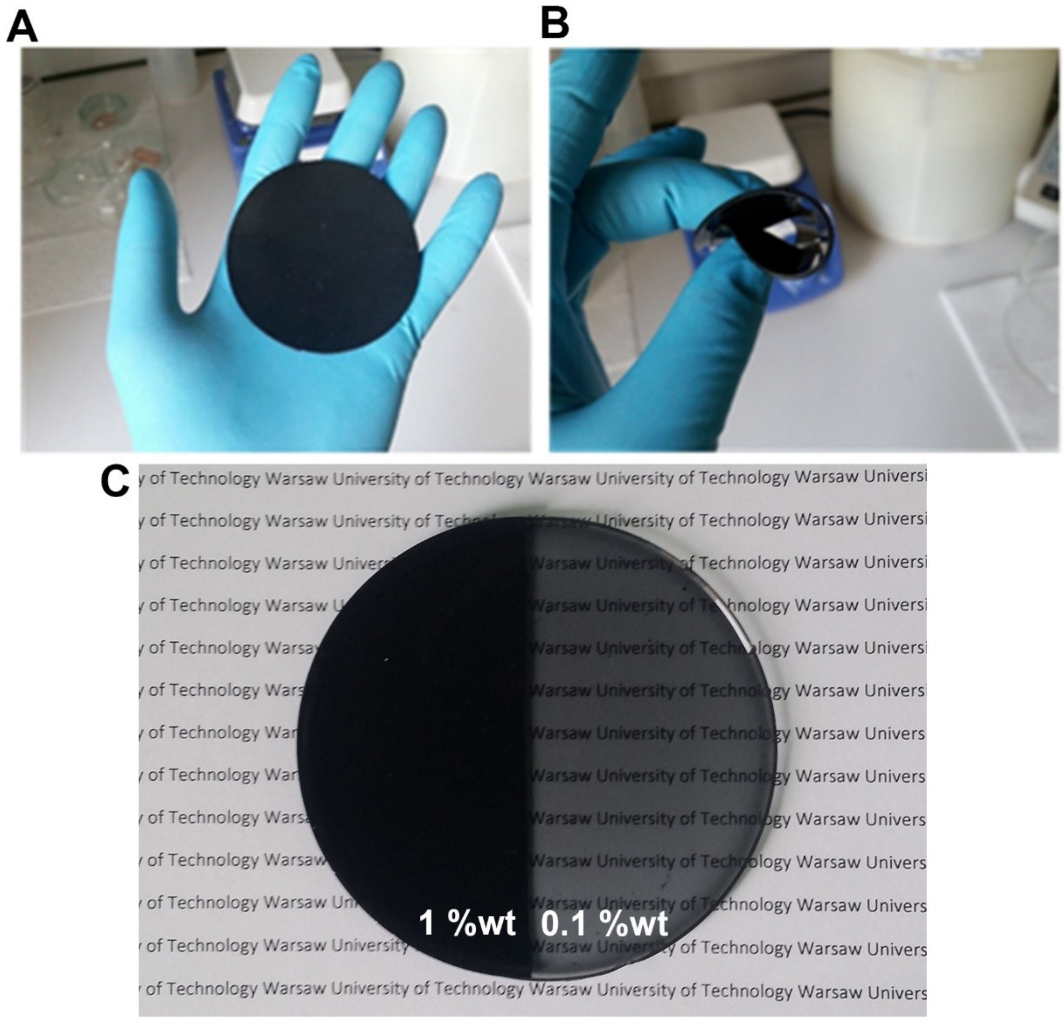

Figure S1. The nanocomposite. (A,B) Photographs of graphene-based composite sample showing their flexibility and lack of transparency in visible light at 3% wt. graphene. (C) Comparison of the material with low and high graphene content (0.1% wt). We note that all composites with graphene concentration above 1% are fully opaque for visible light.

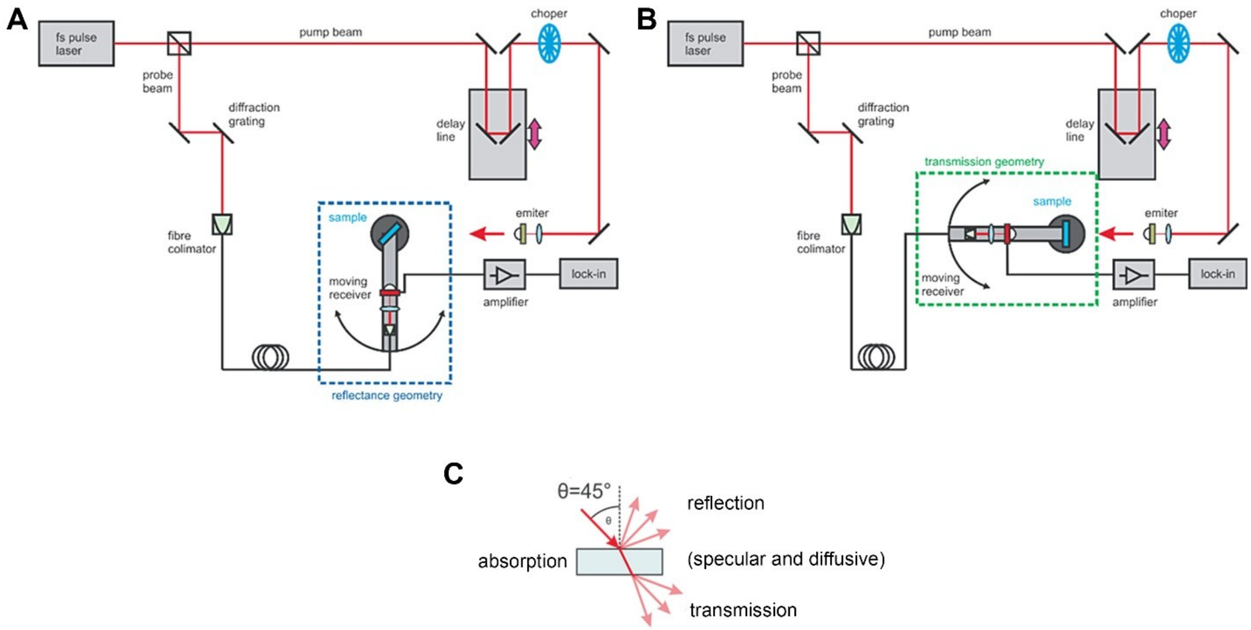

Figure S2. THz Goniometric Time Domain Spectroscopy. Schematic of optical setup used for (A) reflectance and (B) transmittance measurements of composite samples. (C) Schematic describing the specular and diffusive detection model both for reflection and transmission measurements.

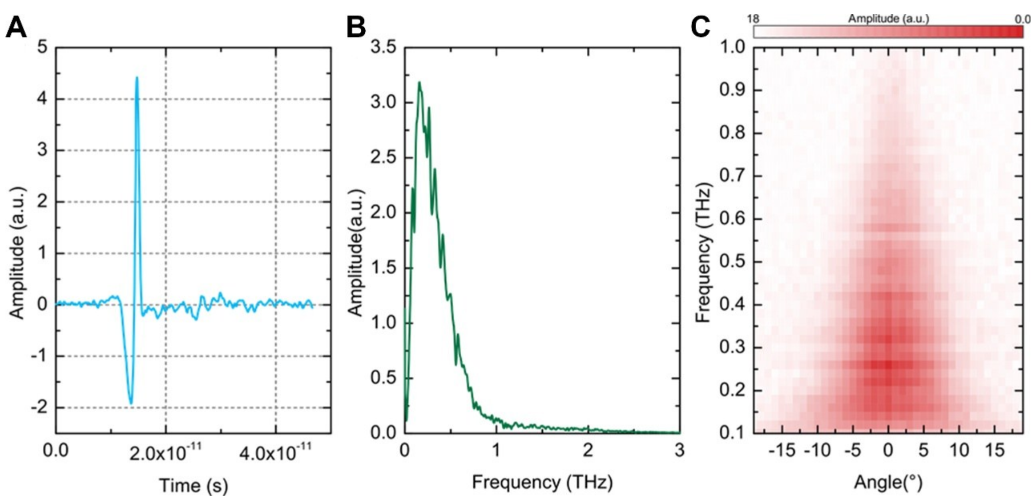

Figure S3. TDS raw data processing. It is a reference image without any sample. Polarization is the same as in Fig. 2. For fixed emitter aperture the beam divergence depends on frequency. Lower frequency results greater beam expansion. (A) Recorded signal in time-domain (B), Fourier transform of recorded signal (C) spatial plot of signal amplitude over frequency and angle.

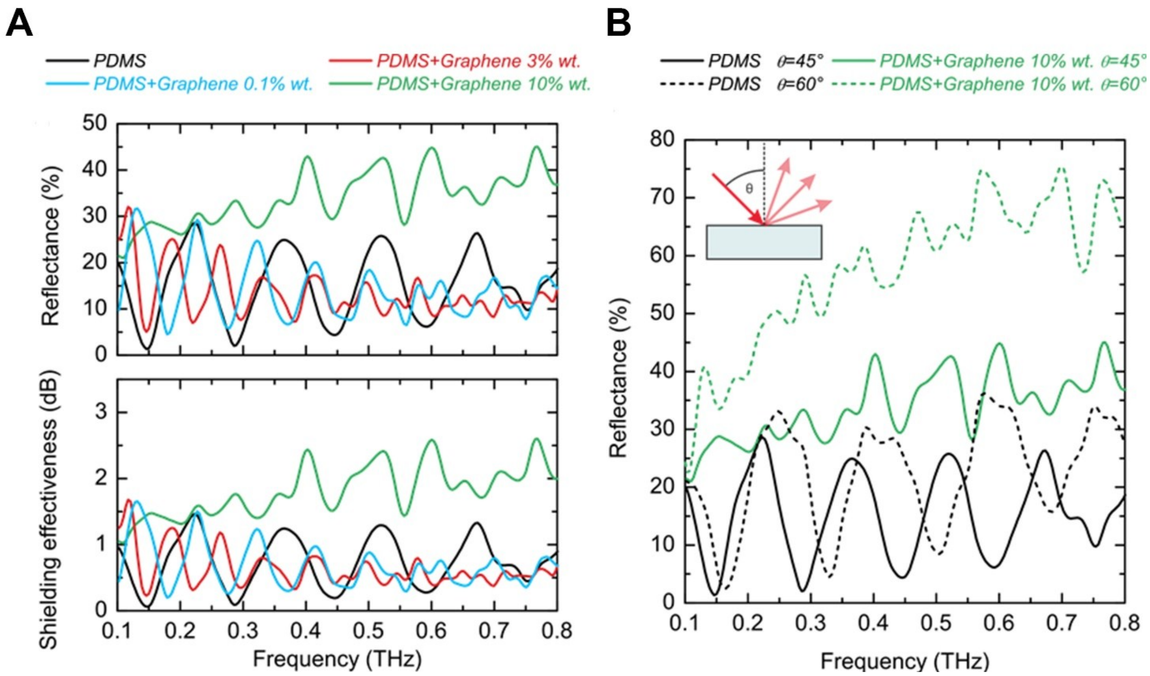

Figure S4. The reflectance spectra oscillation. (A) The measured reflectance spectra at 45° incidence angle for reference and graphene/PDMS composite samples with different graphene loading (% wt.). (B) Comparison of reflectance spectra of PDMS and graphene/PDMS composite sample with 10% wt. graphene at 45° and 60° incidence angle (inset shows the direction of incident and collected reflected light beam in setup configured for reflection measurements).

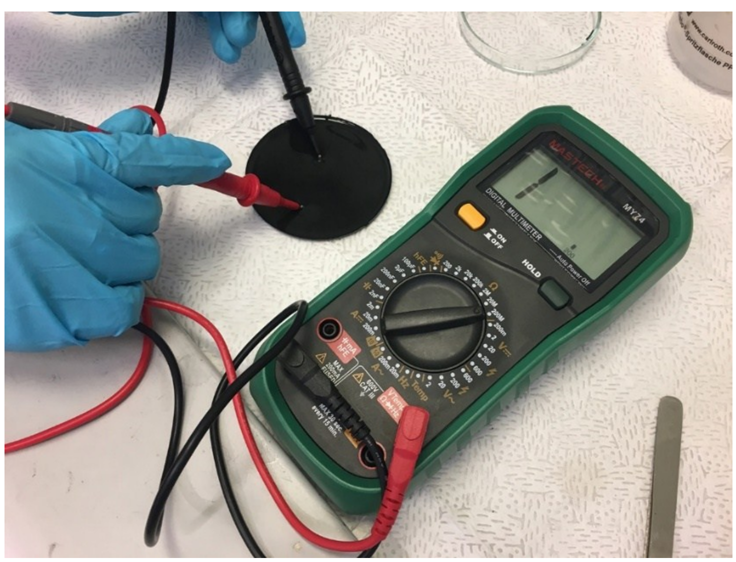

Figure S5 The results of out of range measurements of DC resistivity of our graphene-based composite sample. The measurement is performed on maximum available range - 200 MΩ