Giant terahertz polarization rotation in ultrathin films of aligned carbon nanotubes: supplement

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In addition to the polarization-dependent THz time-domain data for the main 45-nm thick CNT film shown in the main text, time-domain THz waveforms for another CNT film (with a thickness of 30 nm) on a Si substrate are shown in Fig. S1. The left and right panels, $E_x$ (Left) and $E_y$ (Right), respectively, correspond to the two orientations of the output polarizer. The input polarization was set along the x-axis. As the angle between the carbon nanotube alignment direction and the input light polarization changes, the pulses in the time-domain waveform change. The most drastic change, as mentioned in the main text and is the basis of this work, is the disappearance of the second pulse observed at ~30 degrees (see Fig. S1), which we refer to as the ‘magic angle’.

This angle corresponds to the disappearance of the second pulse for the $E_x$ output polarization. Further, we determined how the magic angle depends on the CNT film thickness and the underlying substrate, as shown in Fig. S2. According to Fig. S2a, the magic angle changes by about 5 degrees when the CNT film thickness varies from 30 nm to 100 nm. Fig. S2b shows that increasing the refractive index of the substrate decreases the magic angle by about 10 degrees.

Fig. S1. Time-domain THz waveforms obtained for a 30-nm thick CNT film. The measured electric field is shown as a function of time for co-polarized, $E_x$ (Left), and counter-polarized, $E_y$ (Right), configurations. The angle between the input polarization and the alignment orientation of carbon nanotubes is indicated on the right.
As discussed in the main text, the existence of the magic angle is explained by the polarization rotation of the THz wave upon transmission through and reflection by the CNT film. Fig. S3. Fig. S4. show Faraday and Kerr angles (defined in the main text) as a function of the angle between the input light polarization and the alignment direction of carbon nanotubes for 30-nm thick CNT films on Si and quartz substrates, to complement the data presented for the 45-nm thick CNT film on Si in the main text. In both cases, the angle of polarization rotation is about 20° and 110° for transmission and reflection, respectively.

Fig. S3. Polarization rotation for the 30-nm thick CNT film on a Si substrate. a. The angle of polarization rotation upon transmission through the CNT film. b. The angle of polarization rotation upon reflection from the CNT film. Arrows indicate the polarization rotation direction as the angle, θ, between the CNT alignment direction and the input THz polarization changes.
Fig. S 4. Polarization rotation for the 30-nm thick film on a quartz substrate. 

(a) The angle of polarization rotation upon transmission through the CNT film. 
(b) The angle of polarization rotation upon reflection from the CNT film. 

Arrows indicate the polarization rotation direction as the angle, $\theta$, between the CNT alignment direction and the input THz polarization changes.