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Supporting Information

Single-walled carbon nanotube layers for millimeter-wave beam steering

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Supporting Figures

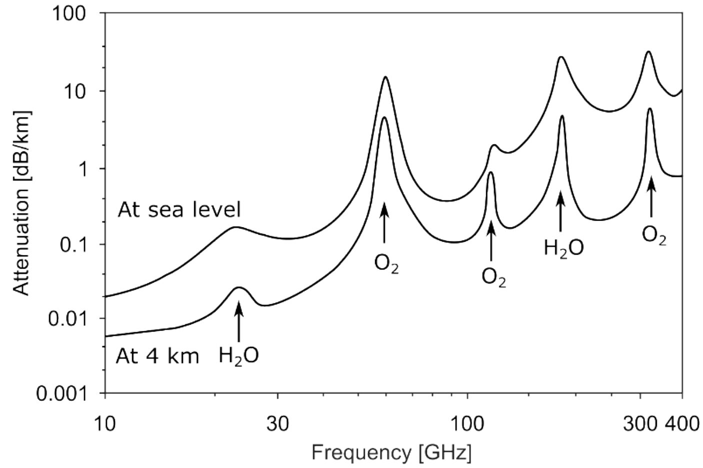

Figure S1. Average atmospheric absorption of millimeter-waves at sea level and at 4 km of altitude.[1] The arrows indicate oxygen and water vapor absorption peaks.

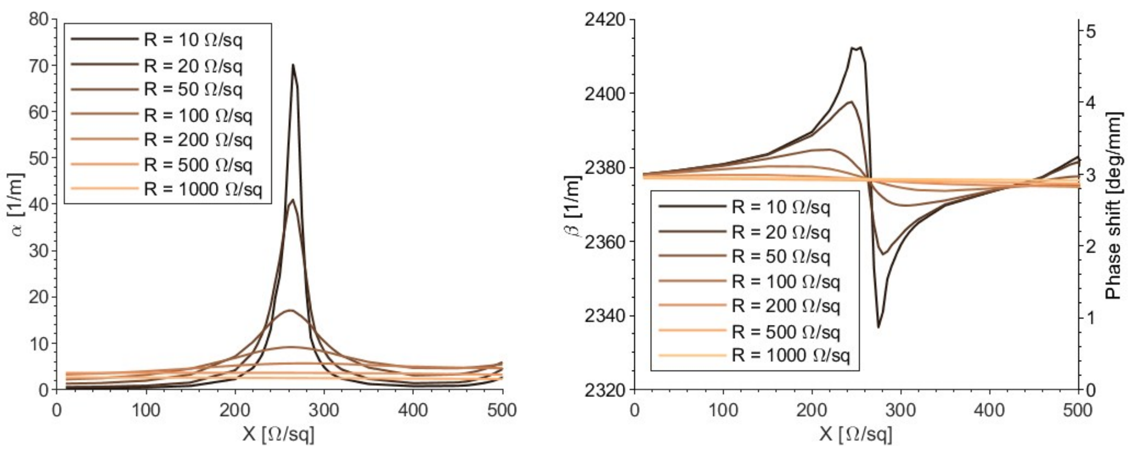

Figure S2. Simulated attenuation constant (α) and phase constant (β) of an electromagnetic wave propagating along the z axis at 90 GHz for a sapphire dielectric rod waveguide (DRW) with a cross-section of 0.4 mm by 0.8 mm and varying surface impedance values $Z(\omega) = R(\omega) - jX(\omega)$

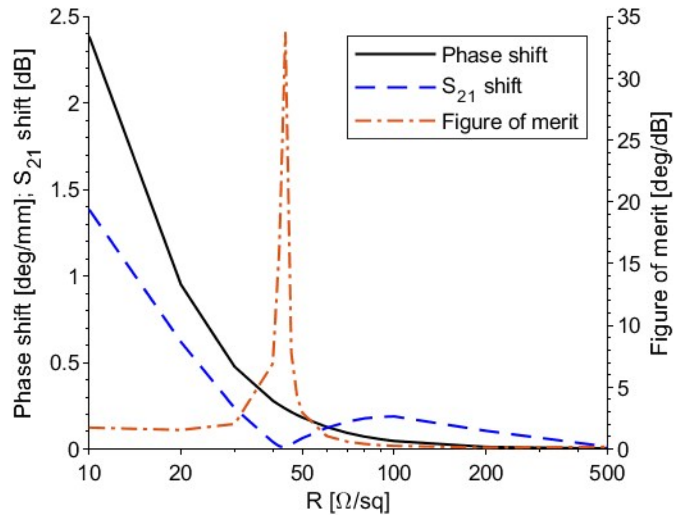

Figure S3. Simulated figure of merit of the phase shifter at 90 GHz for varying *R* and fixed *X* = 185–205 Ω sq^{-1}.

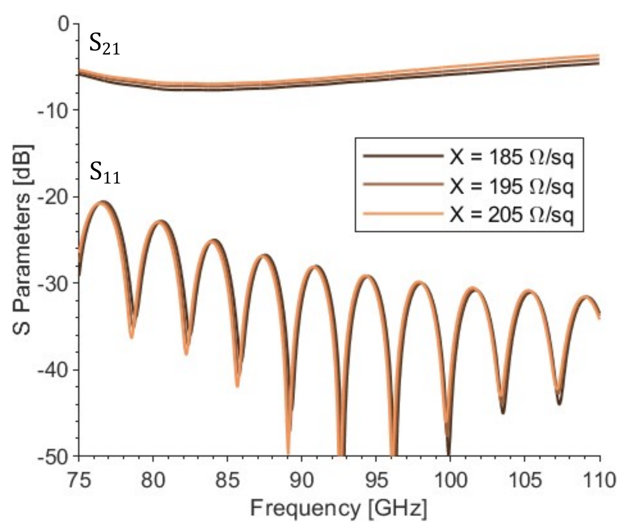

Figure S4. Simulated S-parameters of a 10-mm long phase shifter with fixed *R* = 44 Ω sq^{-1} and varying *X* between 185 Ω sq^{-1} and 205 Ω sq^{-1}.

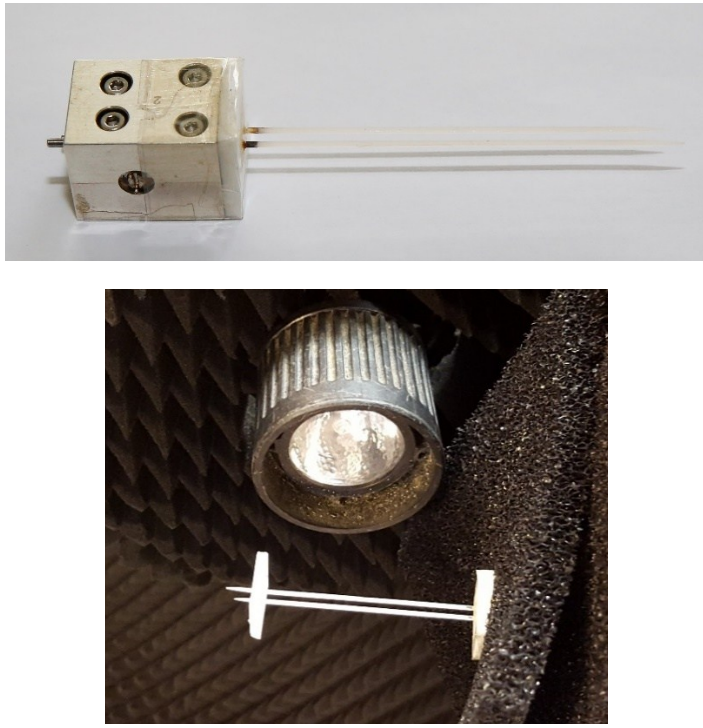

Figure S5. Beam steering measurement setup: WR-10 power divider block with dual-DRW antenna array. Illumination of the SWCNT layer with a tungsten halogen lamp. A slight misalignment between the antennas can be seen.

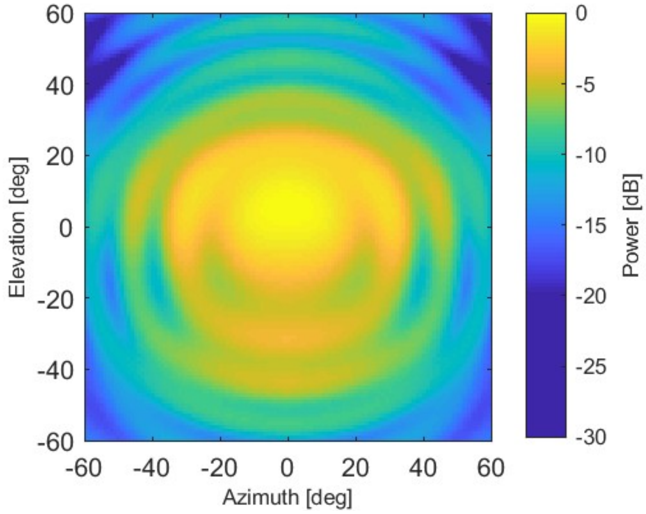

Figure S6. Simulated radiation pattern of the two-antenna array with a layer of SWCNTs at 90 GHz. Beam steering of approximately 10 degrees is observed due to impedance change of the SWCNT layer.

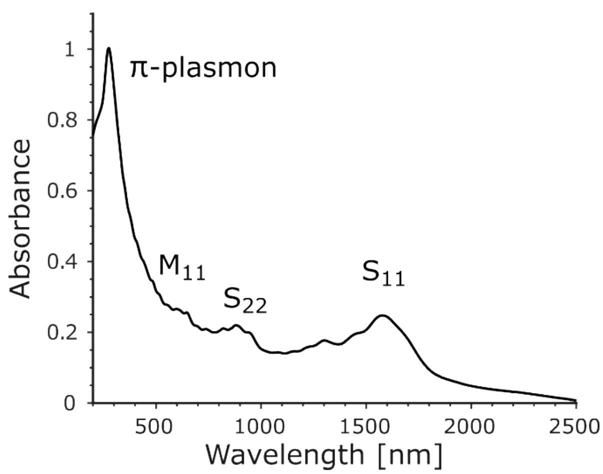

Figure S7. Optical absorbance spectrum of the SWCNT layer.[2]

References

1. Marcus, M.; Pattan, B., Millimeter wave propagation: spectrum management implications. *IEEE Microwave Magazine* **2005,** *6* (2), 54-62.
2. Smirnov, S.; Anoshkin, I. V.; Demchenko, P.; Gomon, D.; Lioubtchenko, D. V.; Khodzitsky, M.; Oberhammer, J., Optically Controlled Dielectric Properties of Single-Walled Carbon Nanotubes for Terahertz Wave Applications. *Nanoscale* **2018,** *10* (26), 12291-12296.