Electronic Supplementary Material

Radio frequency transistors based on ultra-high purity semiconducting carbon nanotubes with superior extrinsic maximum oscillation frequency

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S1 Open and short structure for de-embedding process

Figure S1 shows the open and short structure for the de-embedding process. A detailed description of the de-embedding process can be found in the paper and its supporting information published by C. Wang et al. [S1].

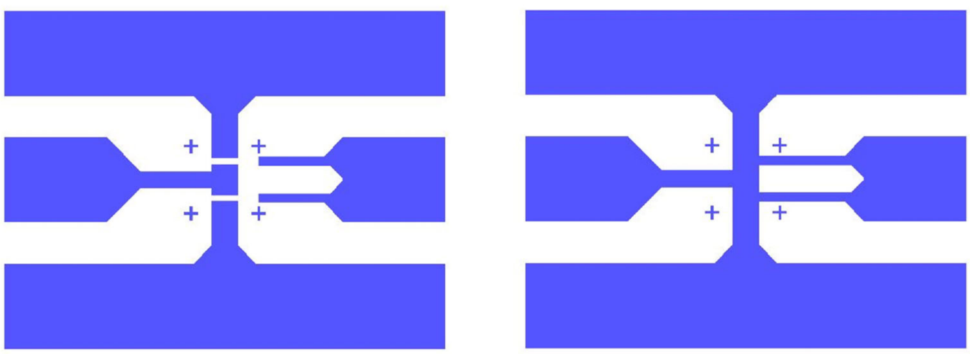

Figure S1 (left) Open structure for de-embedding process. (right) Short structure for de-embedding process.

S2 Statistical study of the radio frequency (RF) performance of the ultra-high purity semiconducting carbon nanotube transistors

The statistical results of the RF performance of eight ultra-high purity semiconducting carbon nanotube transistors are shown in Table S1. The extrinsic current gain cutoff frequency (f_T) has an average value of

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14.5 GHz with standard variation of 6.4 GHz, and the extrinsic maximum oscillation frequency (f_{max}) has an average value of 13.1 GHz with standard variation of 2.5 GHz. The intrinsic f_T has an average value of 20.9 GHz with standard variation of 6.5 GHz, and the intrinsic f_{max} has an average value of 15.1 GHz with standard variation of 4.6 GHz. From the statistical results, we can see that the ultra-high purity semiconducting carbon nanotube transistors have small device-to-device variation.

Table S1 Statistical study of the RF performance of the ultra-high purity semiconducting carbon nanotube transistors

	f_T (GHz)	f_{max} (GHz)
Extrinsic performance	14.5 ± 6.4	13.1 ± 2.5
Intrinsic performance	20.9 ± 6.5	15.1 ± 4.6

S3 Single-tone test

The extraction process of the 1 dB gain compression point at different frequencies for the single-tone test is shown in Fig. S2. We can see that the 1 dB gain compression point for the ultra-high purity semiconducting carbon nanotube transistors is from 8 to 14 dBm.

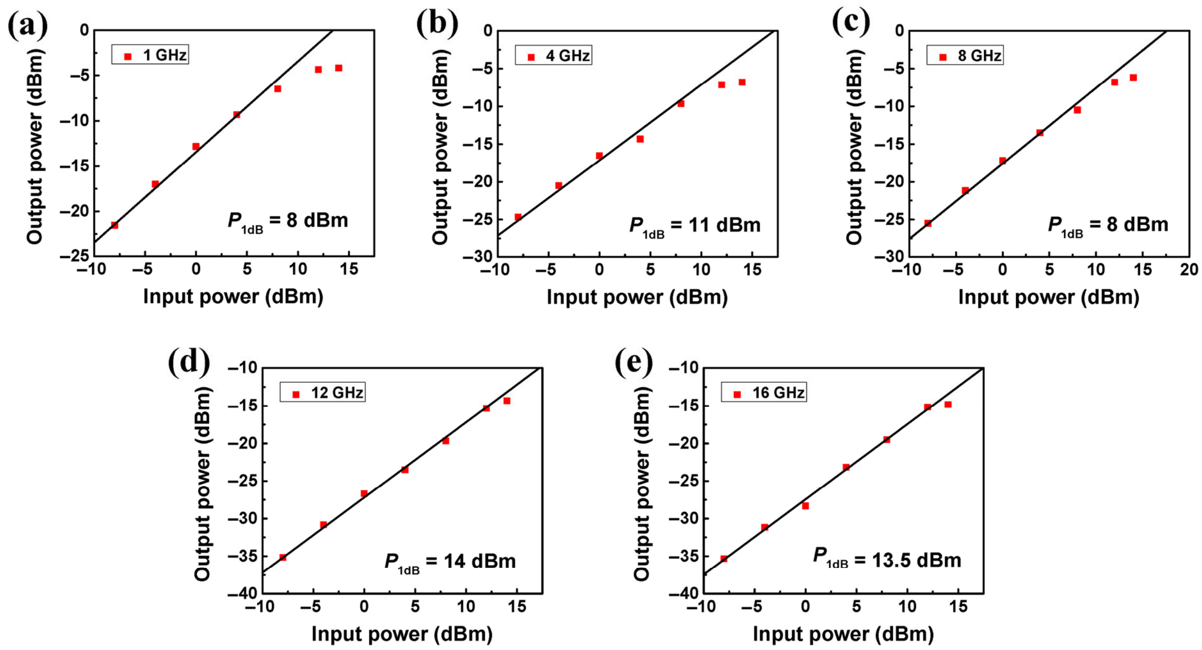

Figure S2 (a)–(e) Output power vs. input power curves at frequencies of 1, 4, 8, 12, and 16 GHz for the single-tone test.

S4 Mixer measurement

Besides measuring the mixer in the frequency range of 4 GHz, we also tested the performance of the mixer at 1, 2, 6, and 8 GHz. The output spectrum of the results are shown in Fig. S3.

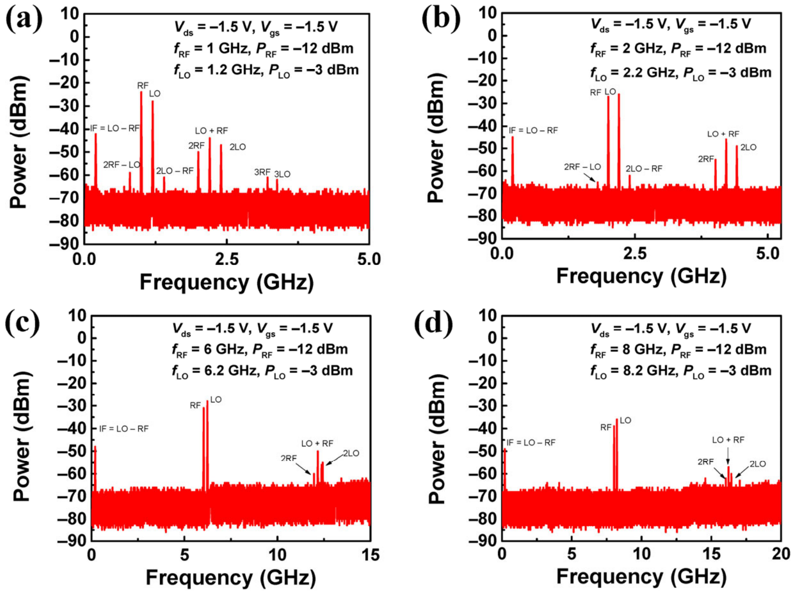

Figure S3 (a)–(d) Output spectrum for the mixer at frequencies of 1, 2, 6 , and 8 GHz.

Reference

[S1] Wang, C.; Badmaev, A.; Jooyaie, A.; Bao, M. Q.; Wang, K. L.; Galatsis, K.; Zhou, C. W. Radio frequency and linearity performance of transistors using high-purity semiconducting carbon nanotubes. *ACS Nano* **2011**, *5*, 4169–4176.