**Supplementary Material**

**Title:**

Terahertz light-emitting graphene-channel transistor toward single mode lasing

**Short title:**

Terahertz light-emitting graphene-channel transistor toward single mode lasing

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**Abstract:**

This document provides supplementary information to “Terahertz light-emitting graphene-channel transistor toward single mode lasing.”

**1. Experimental Methods**

The emission experiments were carried out using Fourier-transformed far-infrared (FTIR) spectrometer with a Martin-Puplett-type interferometer, JASCO FARIS-1, at a series of temperatures starting from 300 K down to 100K. The sample was installed onto a dedicated sample housing which was placed in the cryostat and the biases were controlled using voltage/current source-measure units, Keithley 2400, while the radiation intensity was measured using a 4.2K-cooled silicon bolometer. Figure S1 (a) shows the experiment setup along with the sample holder, a zoomed view of the device is shown in the inset of S1 (b). The DFB-responsible THz photons are to be emitted from the edge of the graphene active region. Thus, the sample was placed so that its edge was facing to the FTIR interferometer via the parabolic mirror. The THz electric field of the laser or LED emission is polarized along with the in-plane drain-source axis. The sample was, therefore, rotated so as to align its THz photon field being transparent to the metal mesh filter placed at the entrance of the Martin-Puplett interferometer. To carry out the experiments, we first measured the background spectrum, i.e. the spectrum with a sample unbiased. Then we measured bias dependent spectra with current flowing through the sample and normalized it with the background spectra to eliminate the undesired effects arising due to static blackbody radiation and any spectral artifacts emitted from the elements inside the spectrometer

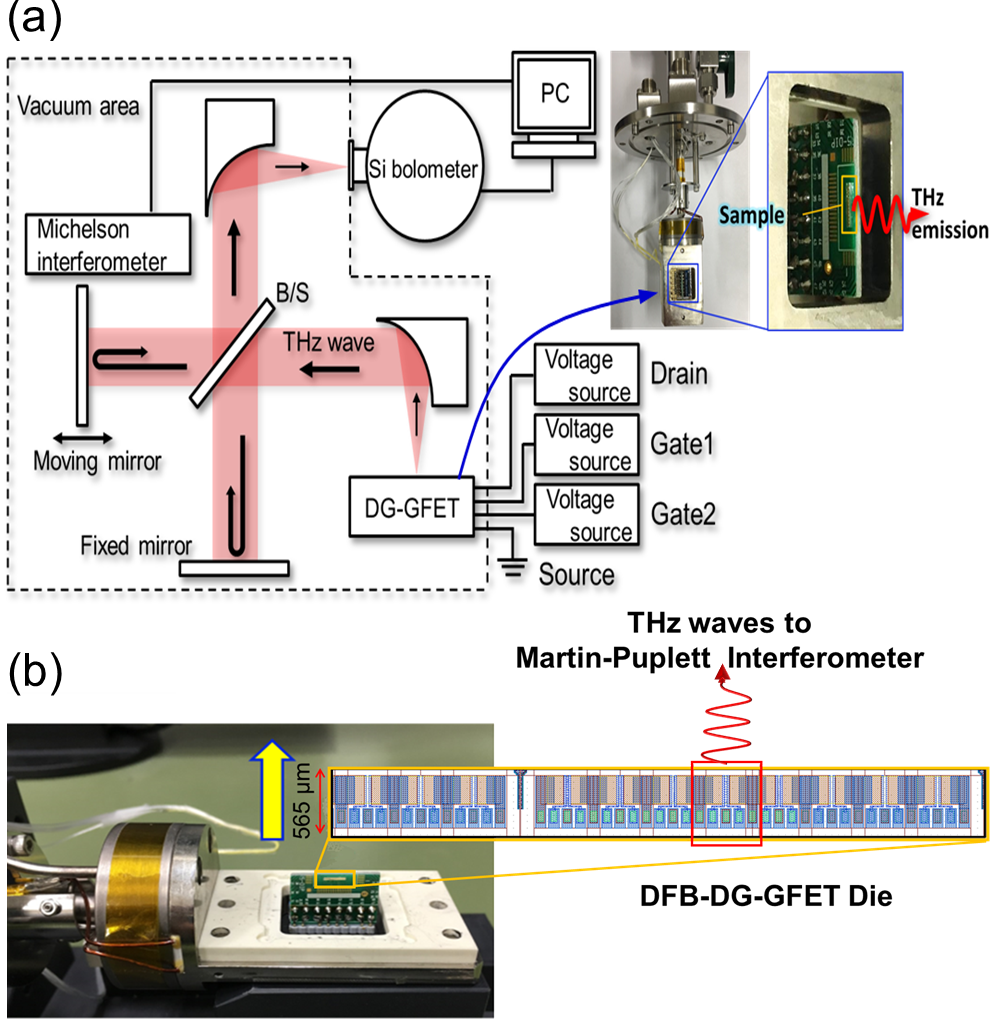
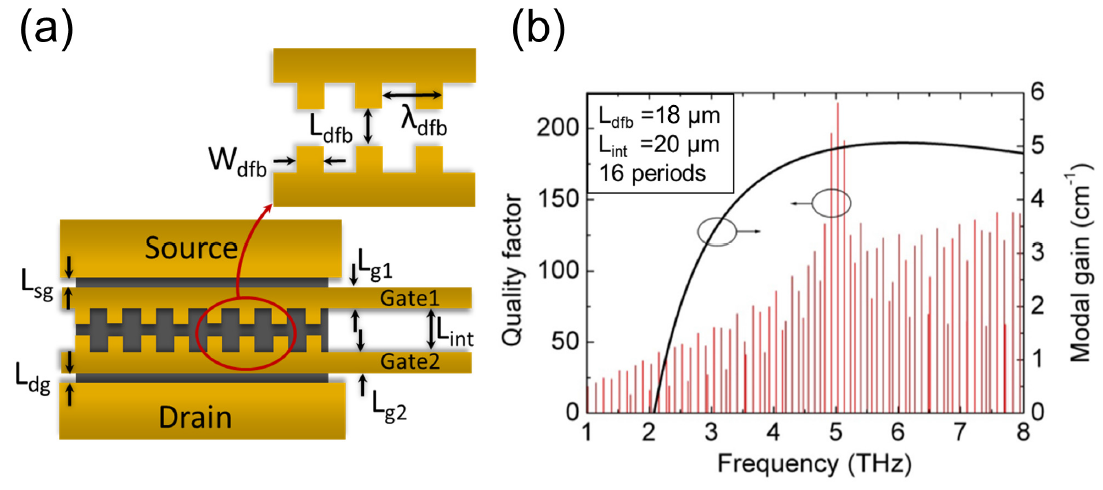


Fig. S1. (a) Measurement setup for THz emission experiments, (b) The sample die is installed in a cryostat with a dedicated mount holder.

**2. DFB Cavity Design Parameters**

Figure S2 (a) shows various DFB cavity design parameters. The improvement of quality factor hugely depends on these parameters. For example, when we increase the number of periods of DFB (NDFB) from 16 to 24 the Q value increases by 2 orders (see Fig. S2 (b) and S2 (c)). Figure S2 (d) gives numerically simulated Q values when the value of Ldfb, that is, the degree of concavity and convexity of DFB is changed. Here also, we can observe that an increase of the DFB cavity modulation index Lint/Ldfb from 20/18 to 20/4 give rise to an increase of the quality factor of the DFB cavity by two orders of magnitude. From these plots, it can be summarized that Q value is dramatically improved by increasing the number of periods of DFB and by increasing the degree of modulation of the gain coefficient i.e. by increasing the degree of unevenness of DFB structure.



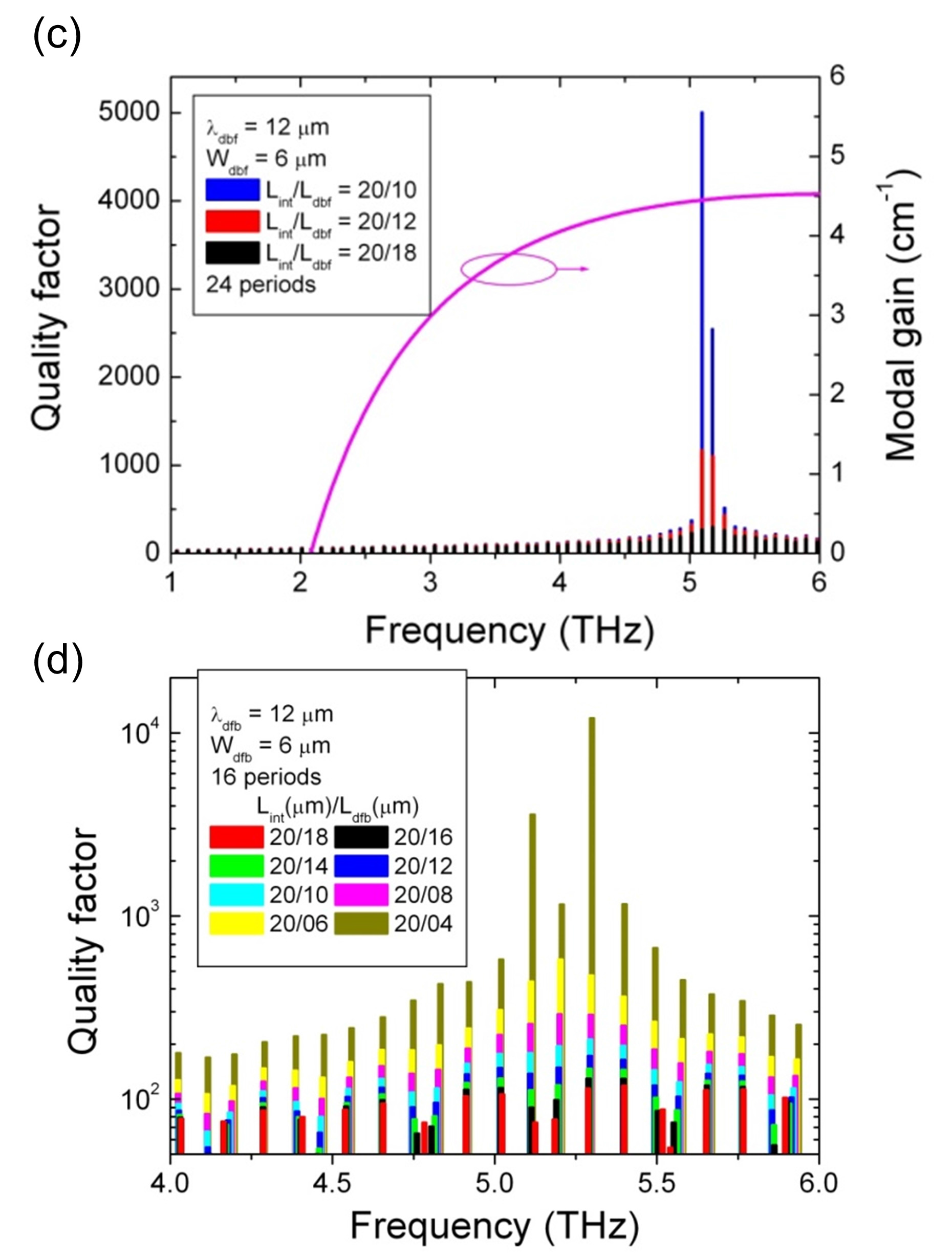


Fig. S2. (a) Design parameters for the DFB structure; numerical simulation plots for these DFB cavities having different design parameters (b) NDFB = 16, (c) NDFB= 24, and (d) comparison of quality factors for various DFB cavity modulation index.