Supplementary Information for the manuscript:

"Fast modulation of terahertz quantum cascade lasers using graphene loaded plasmonic antennas"

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This supplementary information consists of three pages and two figures.

In order to continuously cover the range between 2 THz and 3 THz, where quantum cascade laser sources strongly emit, the sample was designed to have 4 arrays independent and integrated, with a different size of the plasmonic antenna unit size, a = 20 μm, 22 μm, 24 μm, 26 μm. The simulations are reported in Fig. S1 a) where the S_{11} parameter, measuring the sample's reflectivity, is reported for incident radiation on different arrays. Fig. S1 b) reports the effect of different

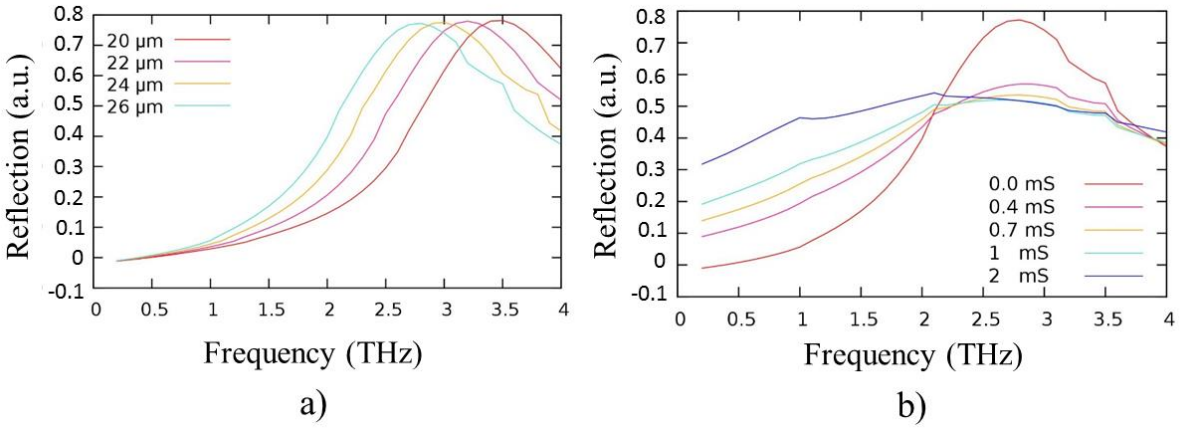

Figure S1 a) Simulated reflection resonances for the plasmonic antenna arrays having different *a* value, namely 20 μm, 22 μm, 24 μm and 26 μm. The array with a=26 μm shows a good overlap with the QCL frequency of 2.05 THz. b) The effect of increasing the conductivity affects the resonances by red-shifting the peak frequency and broadening the features.

graphene conductivity for the array with a = 26 μm. The positions of the resonant peaks agree well with the measured values and also qualitatively the model is capable of reproducing the frequency

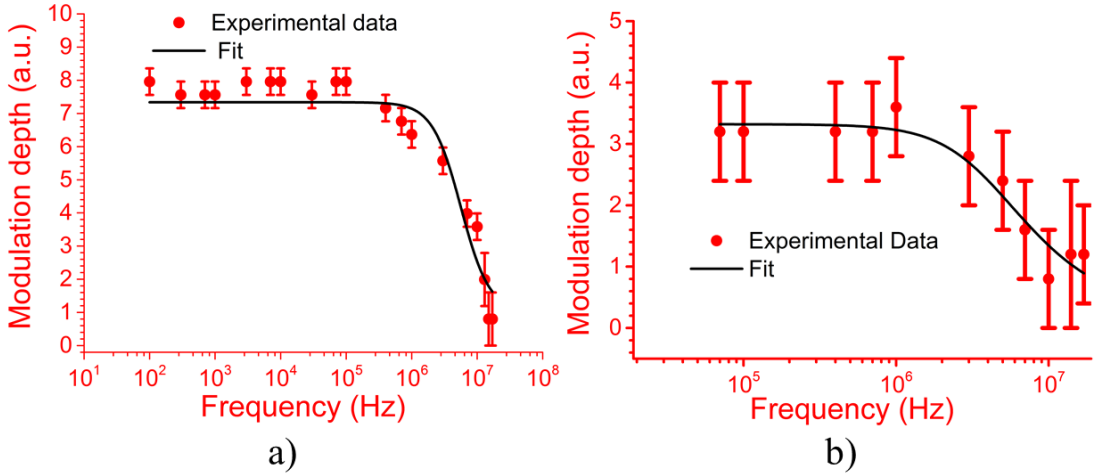

Figure S2 a) Modulation speed measurements performed at a DC voltage of 70 V b) Modulation speed measurements acquired with a DC gate voltage of 100 V. All the different sets of measurements yield consistent values for the modulation speed, as reported in Table 1)

shift and damping observed at different gate voltages, e.g. different graphene conductivity, shown in Fig. 3 b) in the main text.

Fig. S2 shows the modulation speed measurements whose fitting parameters are reported in Table 1) in the main text. Fig. S2 a) shows the data recorded with a DC gate bias of 70 V and the data

have been acquired from the lowest frequency to the highest one. This set presented the highest modulation depth. Fig. S2 b) presents a modulation speed experiment performed at a working point of 100 V starting from the highest frequencies and moving toward the lowest ones. Even though the modulation depth is reduced with respect to the modulation depths reported in Fig 7) in the main text and in Fig S2 a), because of a non-ideal alignment between the array and the beam spot, it is worth reporting because it helps in excluding the possible effect of a measurement drift.