Optoelectronic mixing at 1.55um with high mobility graphene

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Owing to its high carrier mobility, broadband optical absorption and short photo-carrier lifetime (~ 1ps), graphene is a promising candidate for optoelectronic applications such as optoelectronic mixer (OEM) at telecom wavelength [1,2]. These key components for RF telecommunication and radar systems are electronic frequency converters controlled by an optical excitation. The first high frequency (30 GHz) graphene OEM [1] was based on a graphene channel exhibiting a carrier mobility of around 2000 cm^2/V.s [1].

In this work, we experimentally investigate the mixing efficiency of an OEM made of high-mobility graphene embedded into a coplanar waveguide (CPW) under a 1.55 µm laser illumination (Fig1a). The graphene layer is sandwiched between two hexagonal boron nitride flakes of 40 (bottom) and 20 nm (top) thickness respectively. The stack of size 3x3 µm^2 sets in a 50 Ω impedance matched CPW made of Cr (5nm)/ Au (100nm) allowing for RF signal injection. The substrate made of high resistivity Si/ SiO_2 (2 µm) is used as a backgate to tune the graphene Fermi energy (all measurements were performed at room temperature).

From DC measurements, we estimate a field-effect carrier mobility of 44 000 cm^2/V.s. Fig. 1b plots the 67 GHz photocurrent amplitude as a function of $V_G - V_{CNP}$ for increasing V_{DC} biases. When injecting into the OEM an RF electrical signal at frequency f_{RF} = 2-65 GHz and illuminating the graphene channel with an optical power modulated at fixed frequency f_{LO} = 67GHz, we obtain a record and almost flat down-conversion efficiency P_{IF}/P_{RF} = -40dB at $f_{IF} = f_{LO} - f_{RF}$ over a broad RF range (2-65GHz) (Fig1c, [4]). Such performances are reached at a doping of 1.10^{12}/cm^2 in the photo-bolometric regime where the photodetection efficiency stems from the temperature dependence of screening [3], which affects the scalar contribution of strain disorder to conductivity. The authors acknowledge the financial support from the European Union's Horizon program under grant agreement No. 785219 and No. 881603 Graphene Flagship.

References

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Figures

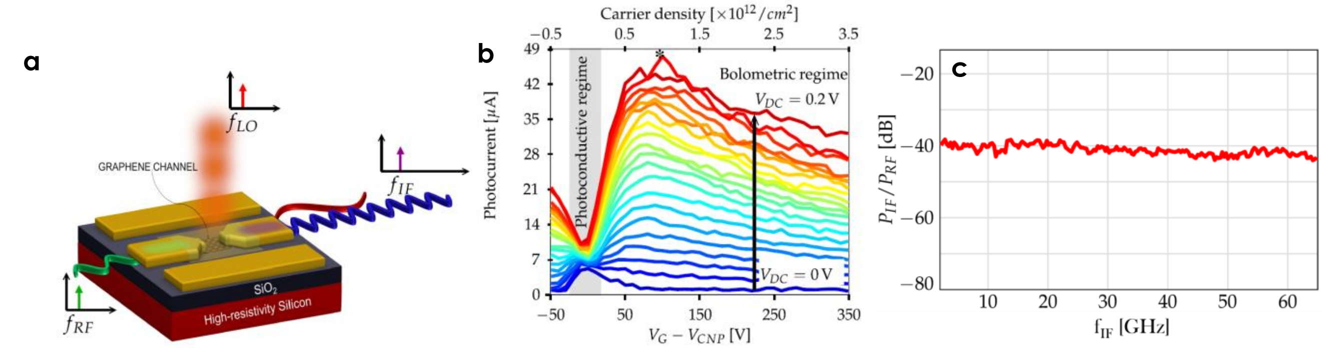

Figure 1a: Schematic of the graphene-based OEM. **b.** Photodetection mode (DC bias, f_{LO} = 67 GHz): 67 GHz photocurrent as a function of backgate voltage ($V_G - V_{CNP}$) for different DC bias (V_{DC}).
c. Optoelectronic mixer mode (RF bias, f_{LO} = 67 GHz): Down-conversion mixing efficiency (P_{IF}/P_{RF}) as a function of the intermediate frequency ($f_{IF} = f_{LO} - f_{RF}$ = 2-65 GHz).