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Graphene Frequency Multipliers

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Summary

Since its discovery in 2004, graphene has attracted great interest for novel electronic devices. Its extremely high electron and hole mobility (>100,000 cm^2/Vs at room-temperature), in combination with its high critical electric field and thermal conductivity makes this material an excellent candidate for many high frequency electronic applications. Several groups have demonstrated the successful fabrication of graphene field-effect transistors (G-FET) for application in low noise amplifiers. However, the unique properties of graphene also allow for completely new devices, not possible in other materials, including non-linear electronics for full-wave signal rectification and frequency multiplication.

In this paper we demonstrate a new application for graphene: full-wave signal rectification and frequency doubling. Due to its ambipolar transport, graphene field-effect transistors (GFET) show a "V"-shaped transfer characteristic about the minimum conduction point. Frequency doubling can be realized with a single GFET by biasing the gate to the minimum conduction point and superimposing a sinusoidal input signal to the gate. Electrons and holes will conduct in alternative half cycles to produce an output signal at the drain, whose fundamental frequency is twice that of the input. Sublinear IV characteristics of the GFET near minimum conduction point help improve the spectrum purity of the output signal. In our experiments, for an input frequency of 10 KHz, the output signal showed excellent spectrum purity (94% of RF power at 20 KHz) in the absence of any filtering elements. Given the extremely high electron mobility in graphene (>100,000 cm^2/Vs at room-temperature), such ambipolar devices have the potential to operate at very high frequencies and allow the fabrication of new THz sources and sensors, as well as high speed transmitters and receivers.

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