Improving the intrinsic cut-off frequency of graphene transistors without channel length scaling: going beyond the quasi-static approximation

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Abstract

Recently, due to its high carrier mobility [1], graphene has attracted researchers to facilitate high performance radio-frequency electronic devices. In this conference, we present novel and original ways of improving the intrinsic cut-off frequency of dual-gate graphene field-effect transistors (G-FET), drawn in Fig. 1, beyond the usual quasi-static approximations. In particular, we explicitly computed the time-dependent displacement and particle currents in the drain, gate and source contacts in G-FETs for different geometries, but the same channel length (See Fig. 2). As indicated in the transient simulations of Fig. 3, the ultimate responsible of the high-frequency behavior of graphene transistors is not the electron transit time τ_e, but a different time τ_i defined as the duration of the total current peak while the electron is crossing the device [2,3]. G-FETs with the same channel length, but different lateral dimensions can provided an improvement on the intrinsic cut-off frequency of one order of magnitude. The role of the Klein tunneling and positive-negative energy injection on the high-frequency behavior will also be discussed using semi-classical and quantum tools [4, 5].

References

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Figures

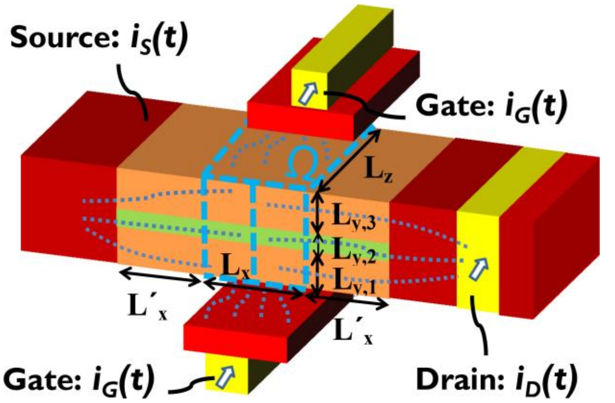

Fig.1. Schematic representation of a double gate graphene device with active region $\Omega = L_x \times (L_{y,1}+L_{y,2}+L_{y,3}) \times L_z$.

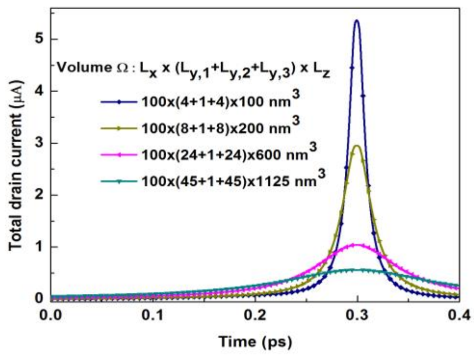

Fig. 2. Total drain current i(t) due to an electron traversing volume Ω with a fixed channel length L_x=100 nm and different lateral dimensions.

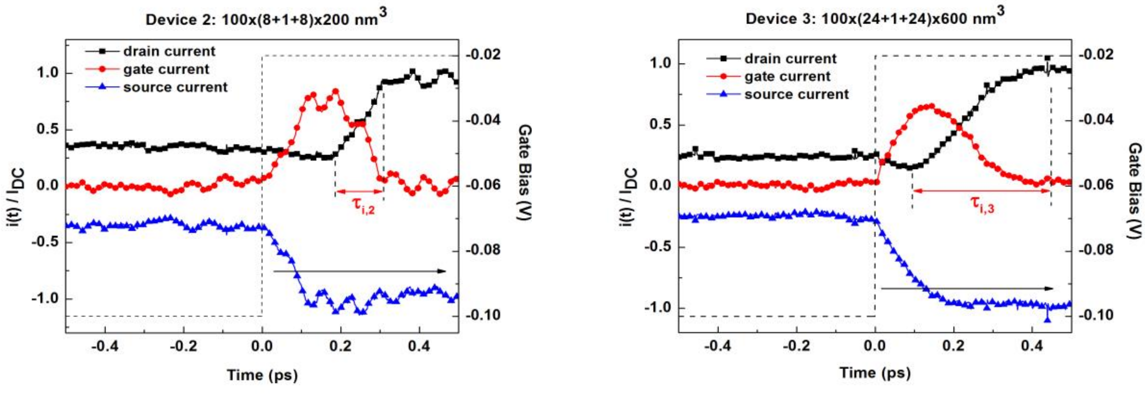

Fig. 3. Total transient currents i(t) computed in the drain, source and gate of device 2 (left) and of device 3 (right) when a step voltage is applied to the gates, while the drain bias is fixed to 0.1 V Current transit time $\tau_{i,2}<\tau_{i,3}$. Notice the overall current continuity and we normalize the plot to the final DC drain current $\mathbf{I_{DC}}$.