The role of displacement current in quantifying the speed of nano devices based on 2D materials

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The development of faster electron devices is a constant demand from industry and one of the reasons to look for high-mobility 2D materials. The ITRS roadmap envisions electron devices working at THz regime. Such devices are in the frontier between electronics (dealing mainly with particle current) and electromagnetism (dealing with displacement current). Therefore, the proper modelling of the speed of THz electron devices requires taking into account the displacement current (which is usually ignored in the literature).

In this abstract, the cut-off frequency for a dual-gate 2D channel FET is computed from the BITLLES simulator [1, 2]. The gate, drain and source total (displacement plus particle) currents are plotted in Fig. 1. In the THz range, the typical quasi-static approximation is no longer justifiable for speed predictions (see Fig. 2). Even in some devices (not shown here), the exact computation of the *Y*-parameters gives an infinite cut-off frequency showing that such figure of merit (FoM) provides a quite misleading information. We show that the intrinsic delay time τ_{d}, which can be extracted from time-dependent numerical simulations (explained in Fig. 1), is a reliable FoM for 2D high speed devices.

References

[1] X. Oriols, PRL, 98 (2007) 066803
[2] D. Marian, N. Zanghì and X. Oriols, PRL, 116 (2016) 110404
[3] S. E. Laux, IEEE TED, 32 (1985) 2028-2037

Figures

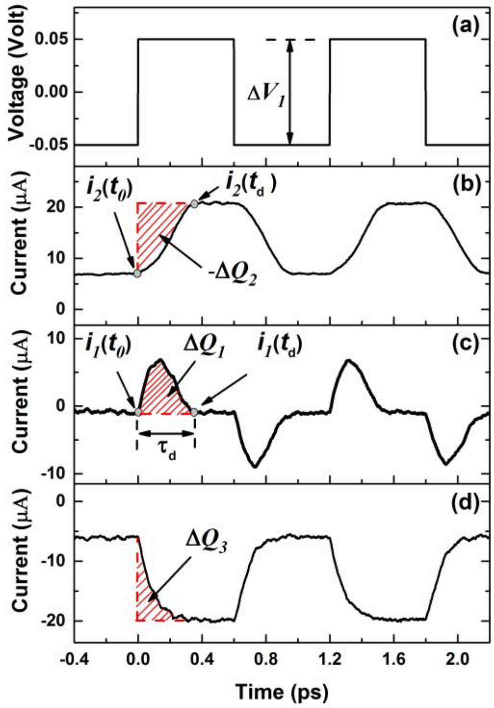

Figure 1: Total (displacement plus particle) transient currents on the drain (b), gate (c) and source (d) contacts of a dual-gate device when a sequence of square voltage pulses (a) is applied on the gate contacts.

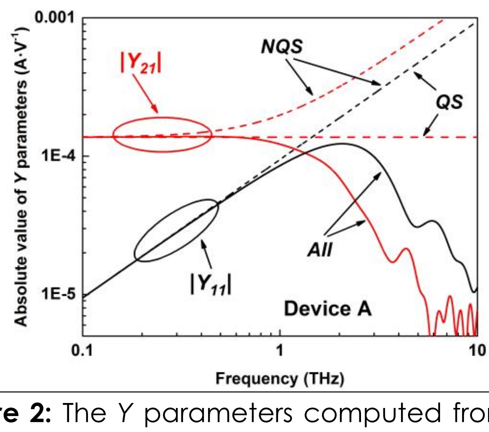

Figure 2: The *Y* parameters computed from the total current plotted in Fig. 1 by using three different expressions [3]: exact solution (solid lines), quasi-static and non-quasi-static approximations (dash lines).