GRAPHENE FLAGSHIP

Correlation between material quality and high frequency performance of graphene field-effect transistors

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In this paper, we present an experimental study of correlation between material quality and high frequency performance of graphene field-effect transistors (GFETs). Analysis of the low- and high-field charge carrier transport in a set of GFETs, including those with record high extrinsic transit frequency (f_t) and maximum frequency of oscillation (f_{max}) [1], indicates presence of spatially distributed imperfections causing both long- and short-range scattering and associated with e.g. charged defects and dislocations [2]. We applied the drain resistance, velocity and saturation velocity models and found the physical and equivalent circuit parameters defining the f_t and f_{max}, i.e. the low-field mobility (μ), residual carrier concentration, metal/graphene contact resistivity (ρ_{cm}), high-field carrier velocity (υ) and differential drain conductivity (g_{ds}) [3, 4]. Based on the μ as a measure of imperfections, we established correlations between all the parameters. As examples, Fig. 1 and Fig. 2 show dependences of the υ, g_{ds} and f_t, f_{max} on μ. The established correlations allow for understanding dominant limitations of the f_t and f_{max}, which clarifies the ways of further development of the GFETs for high frequency applications. For instance, the ρ_{cm} is below 30 Ω·µm at μ above 2000 cm^2/Vs and has only minor effect. The high g_{ds}, is currently main limiting factor, which, however, can be counterbalanced by increasing the carrier velocity via operating GFETs at higher fields, in the velocity saturation mode.

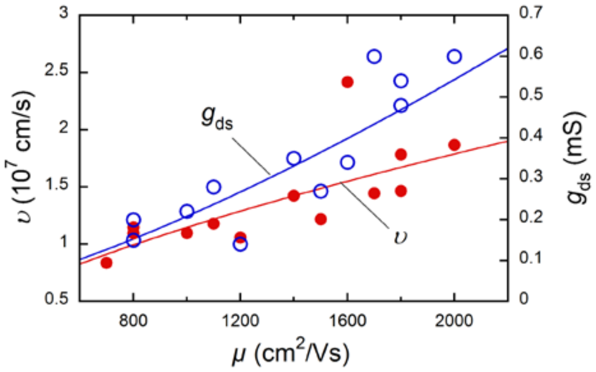

Fig. 1. The high-field velocity of charge carriers, υ, (filled circles) and differential drain conductivity, g_{ds}, (open circles) vs low-field mobility, μ, of GFETs. The lines are power-fitting curves.

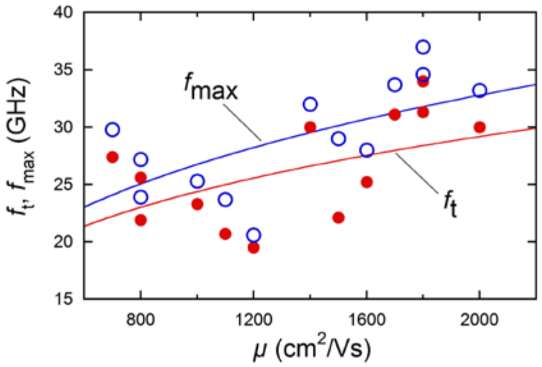

Fig. 2. The measured (extrinsic) transit frequency, f_t, (filled circles) and maximum frequency of oscillation, f_{max}, (open circles) vs low-field mobility, μ, of GFETs with gate length of 0.5 µm. The lines are power-fitting curves.

References

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