

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

Muhammad Asad¹, Marlene Bonmann¹, Xinxin Yang¹, Andrei Vorobiev¹, Jan Stake¹, Luca Banszerus², Christoph Stampfer², Martin Otto³, Daniel Neumaier³

¹Terahertz and Millimetre Wave Laboratory, Department of Microtechnology and Nanoscience, Chalmers University of Technology, SE-41296 Gothenburg, Sweden,

²2nd Institute of Physics, RWTH Aachen University, 52074 Aachen, Germany,

³Advanced Microelectronic Center Aachen, AMO GmbH, 52074, Aachen, Germany

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 (v) 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 v , 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 $30 \Omega\cdot\mu\text{m}$ at μ above $2000 \text{ cm}^2/\text{Vs}$ 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.

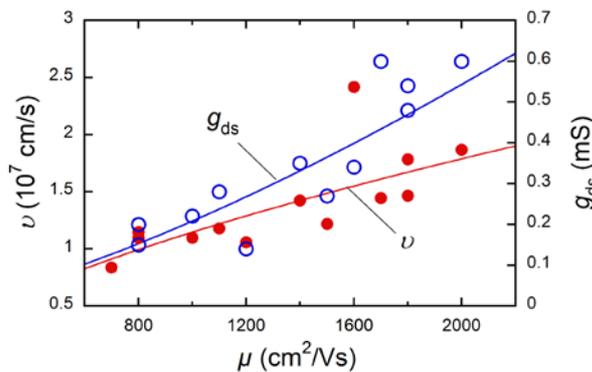


Fig. 1. The high-field velocity of charge carriers, v , (filled circles) and differential drain conductivity, g_{ds} , (open circles) vs low-field mobility, μ , of GFETs. The lines are power-fitting curves.

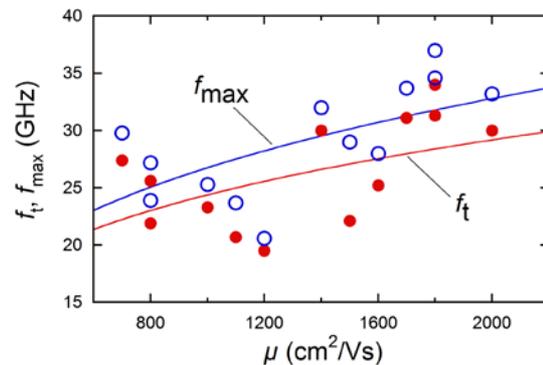


Fig. 2. The measured (extrinsic) transit frequency, f_t , (filled circles) and maximum frequency of oscillation, f_{max} , (open circles) vs low-field mobility, μ , of GFETs with gate length of $0.5 \mu\text{m}$. The lines are power-fitting curves.

References

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