Low-leakage Top-Gated Field-Effect Transistors with Epitaxial Graphene on SiC/Si pseudosubstrates

Aiswarya Pradeepkumar[1,2], Han-Hao Cheng[3], Kai-Yu Liu[4], Matthew Gerbert[5], Semonti Bhattacharya[6], Michael Fuhrer[5,7], and Francesca Iacopi[1,2,7]

[1]School of Electrical and Data Engineering, Faculty of Engineering and Information Technology, University of Technology Sydney, Ultimo, New South Wales 2007, Australia
[2]Centre of Excellence in Transformative Meta-Optical Systems, University of Technology Sydney, Ultimo, New South Wales 2007, Australia
[3]Centre for Microscopy and Microanalysis, The University of Queensland, Brisbane, Queensland 4072, Australia
[4]Australian National Fabrication Facility, Australian Institute of Bioengineering and Nanotechnology, The University of Queensland, Brisbane, Queensland 4072, Australia
[5]School of Physics & Astronomy, Monash University, Melbourne, Victoria 3800, Australia
[6]Leiden Institute of Physics, Leiden University, Niels Bohrweg 2, 2333 CA Leiden, The Netherlands
[7]Centre of Excellence in Future Low-Energy Electronics Technologies, Melbourne, Victoria 3800, Australia

Epitaxial graphene (EG) on cubic silicon carbide on silicon offers the possibility of direct integration with the well-established Si-based CMOS technology to achieve integrated electronics and photonics with the highly sought-after dynamically tunable capabilities.

Electrostatic charge tuning via top- or bottom-gating is one of the most efficient options to dynamically control the charge in the EG. The application of efficient electrostatic gating to EG on SiC/Si formed by thermal decomposition via resistive heating [1] has been strongly hindered until now by two major limitations. 1) difficulty in achieving a continuous and uniform coverage of EG on the substrate [2] and 2) an unstable 3C-SiC/Si heterojunction [3, 4]. These issues resulted in current conduction through the underlying substrate system and a significant amount of gate leakage current (in the order of ~10^{-6} A) that dominated the EG characteristics. [1]

We address the challenges of growing epitaxial graphene on the 3C-SiC/Si system by adopting a solid-source catalytic alloy-mediated graphene synthesis to highly resistive 3C-SiC grown on highly-resistive Si wafers to obtain EG that is continuous on large scales and is electrically isolated from the substrate system. Note that this was not achievable with the prior EG growth attempts via the 3C-SiC sublimation [1]. In this work, we fabricate top-gated field-effect transistors on the epitaxial graphene synthesized on 3C-SiC (100) and 3C-SiC(111) substrates using Si_3N_4 (10nm) and SiO_2 (50nm) gate dielectrics. We find that the EG transistors demonstrate p-type conduction in agreement with the van der Pauw hall-effect measurements with a gate leakage current in the order of picoamperes - significantly smaller than the values reported in the literature. We also find that the drain current in EG/3C-SiC(100) is one order larger than the EG/3C-SiC(111), which is related to the amount of charge carrier concentration. These findings finally open the possibility of obtaining dynamic tunability of charge transport in graphene on SiC/Si for integrated nanoelectronics and nanophotonics functionalities.

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