THz Reflection Spectroscopy of Graphene on 200 mm Ge/Si wafers: Substrate Orientation and Doping Effects

Likhith Gummadi [1], Moriom Akter [1], Christian Wenger [1,2] and Mindaugas Lukosius [1]
[1] *IHP- Leibniz Institute for High Performance Microelectronics, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany*
[2] *BTU Cottbus Senftenberg, Platz der Deutschen Einheit 1, 03046 Cottbus, Germany*
gummadi@ihp-microelectronics.com

Germanium on silicon (Ge/Si) has emerged as a promising substrate for the complementary metal-oxide-semiconductor (CMOS) compatible graphene growth, enabling the integration of graphene into existing semiconductor fabrication flows. However, the crystallographic orientation of Ge is known to influence the surface morphology and defect density of the resulting graphene layer [1]. What remains largely unexplored is the role of Si doping type and density in graphene quality. Understanding their combined effect is essential for achieving reproducible and high-quality graphene growth. In this work, we investigate chemical vapour deposition (CVD)-grown graphene on 200 mm Ge/Si wafers with different crystallographic orientations and doping densities. We employ THz reflection spectroscopy as a contactless and non-destructive characterization tool to evaluate the transport properties of graphene. By directly probing free-carrier dynamics, THz spectroscopy allows us to extract key transport parameters like conductivity, carrier scattering time, mobility, and carrier density without requiring any device fabrication [2]. Using this approach, we demonstrate that carrier transport in graphene is largely limited by substrate-induced phonon scattering and surface morphology. These results provide insights into selecting optimal Ge/Si substrate parameters for scalable, high-quality graphene growth.

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101120938 (GATEPOST) and under grant agreement 101189797 (2D-PL).

[1] J. Sitek et al., *Applied Surface Science* **499** (2020) 143913.
[2] H. Lin et al., *Scientific Reports* **7** (2017) 10625.

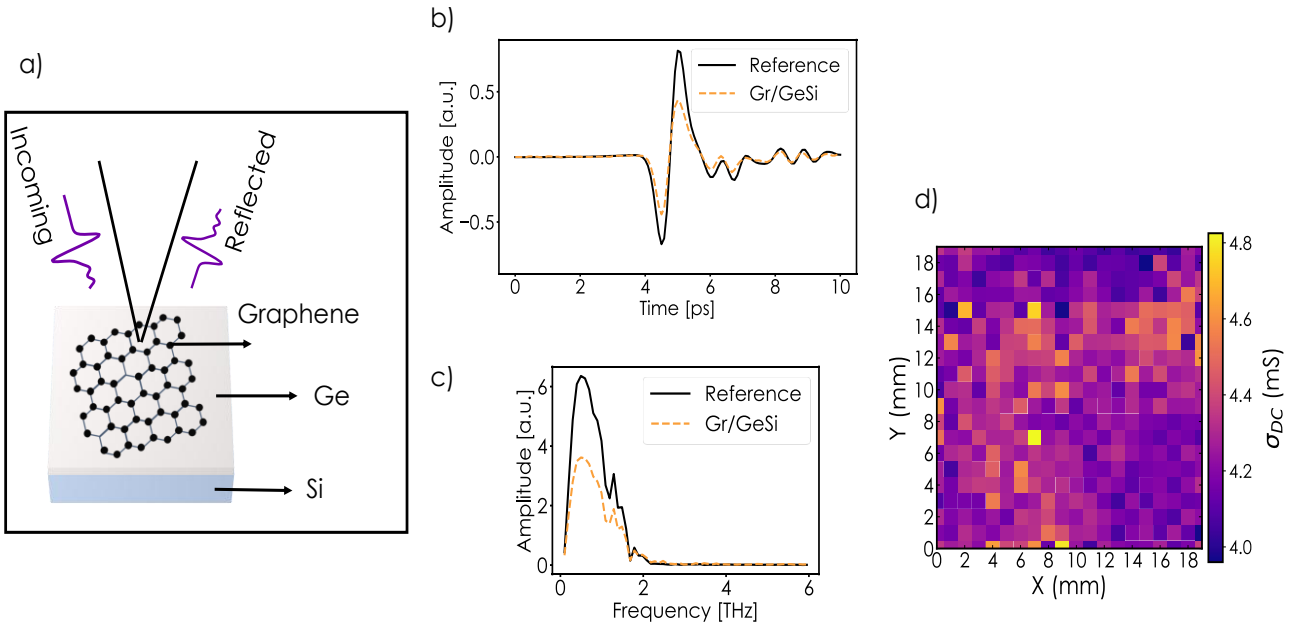

Figure 1: THz time domain spectroscopy of CVD Graphene on Ge/Si: a) Schematic of the sample stack. Reflected amplitudes of reference and Gr/Ge/Si pulses in b) time domain and c) frequency domain. d) Extracted graphene conductivity spatial map across the 20×20 mm² sample area on a 200 mm wafer.