Investigating the quality of CVD-grown graphene on germanium using in-situ surface science methods

Andreas Becker
Jarek Dabrowski, Mindaugas Lukosius, Christian Wenger
IHP – Leibniz-Institut für innovative Mikroelektronik, Im Technologiepark 25, Frankfurt (Oder), Germany
becker@ihp-microelectronics.com

Germanium epitaxially grown on silicon has emerged as a relevant substrate for graphene growth because it is possibly compatible with established CMOS processing. Besides optimizing wafer-scale graphene growth on germanium template and subsequent transfer, we are exploring ways to directly integrate graphene growth into technological processing. However, major challenges are the relatively low quality of graphene on the standard orientation Ge(001) and the high required synthesis temperature. These challenges motivated an investigation of the growth process using a high-pressure preparation chamber for chemical vapor deposition that is connected to a surface science cluster tool. As a prerequisite for reliable graphene growth, we present a detailed study of the germanium substrate pre-cleaning and describe how to avoid etch pit formation. Furthermore, we investigated the influence of growth temperature on the quality of graphene on Ge(001), Ge(110) and Ge(111) using scanning tunneling microscopy, low-energy electron diffraction and Raman spectroscopy. We discuss graphene grain size and morphology, epitaxial alignment and intragranular defect density and conclude that the best graphene quality is obtained on Ge(110) at a growth temperature near the substrate melting point. Finally, we intend to bring up a discussion how enhancement of carbon etching might help improve the graphene quality.

REFERENCES

[1] A. Becker et al. (2019): Control of etch pit formation for epitaxial growth of graphene on germanium. Journal of Applied Physics, 126(8), 85306, https://doi.org/10.1063/1.5108774
[2] A. Becker et al. (2020): Influence of temperature on growth of graphene on germanium. (submitted)
[3] M. Lukosius et al. (2016): Metal-Free CVD Graphene Synthesis on 200 mm Ge/Si(001) Substrates. ACS Applied Materials & Interfaces, 8(49), 33786–33793, https://doi.org/10.1021/acsami.6b11397
[4] Jae-Hyun Lee et al. (2014): Wafer-Scale Growth of Single-Crystal Monolayer Graphene on Reusable Hydrogen-Terminated Germanium. Science, 344(6181), 286–289, https://doi.org/10.1126/science.1252268

FIGURES

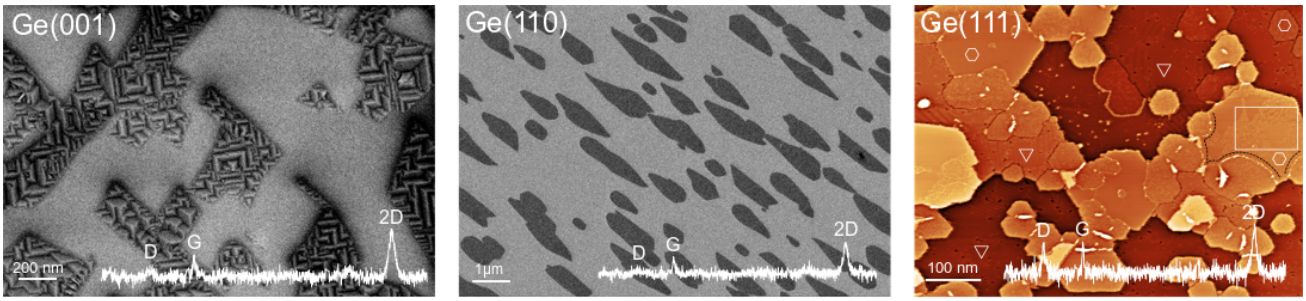

Figure 1: Scanning electron micrographs and scanning tunneling micrograph of graphene islands grown on different germanium orientations. Inset Raman spectra give an estimate of the island size and quality.