Plasma enhanced CVD growth of graphene on Ge(100) and Ge(110) surfaces

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To exploit the full capacity of graphene for CMOS technology a metal- and transfer free growth process is crucial. Due to the high catalytic activity and low carbon solubility Germanium (Ge) became a promising alternative substrate for graphene fabrication. However, to reduce any unintended diffusion of, e.g., dopants or Si substrate atoms [1]- it is mandatory to lower the process temperature.

Here, we report for the first time on the plasma-enhanced chemical vapor deposition (PE-CVD) of graphene on Ge(100) and Ge(110) at temperatures well below of the melting point of Ge.

Based on a low-temperature PE-CVD process originally developed for graphene growth on copper [2] we demonstrate that our process can be applied to reduce the graphene growth temperature on both, Ge(100) and Ge(110) down to 800°C [**Figure 1**]. To gain more insight into the growth process, we evaluated the nucleation density and the grain size in dependence of the growth time. We found that with increasing growth time the nucleation density increases linearly up to 75 μm^{-2} in 8 h of growth time for both, Ge(100) and Ge(110) substrates. The grain sizes, however, show a different behavior for the two Ge orientations: While the grain size is below 100 nm and nearly independent on growth time for Ge(100), it seems to increase gently with growth time for Ge(110) up to 125 nm, leading to an enhanced graphene coverage for Ge(110) with respect to Ge(100) at comparable growth times.

Raman measurements show an emerging 2D peak with increasing growth time from minutes to hours for both orientations. However, a large defect peak is present and remains constant, indicating amorphous carbon induced by the plasma process additional to the crystalline graphene formation. **[Figure 1]**.

References

[1] G. Lupina, M. Lukosius, G. Lippert, J. Dabrowski, J. Kitzmann, M. Lisker, P. Kulse, A. Krüger, O. Fursenko, I. Costina, A. Trusch, Y. Yamamoto, A. Wolff, T. Schroeder, A. Mai, ECS J. Solid State Sci. Technol. 6 (2017) M55

[2] B. Bekdüz, Y. Beckmann, J. Mischke, J. Twellmann, W. Mertin, G. Bacher, Nanotechnol. 29 (2017) 455603

Figures

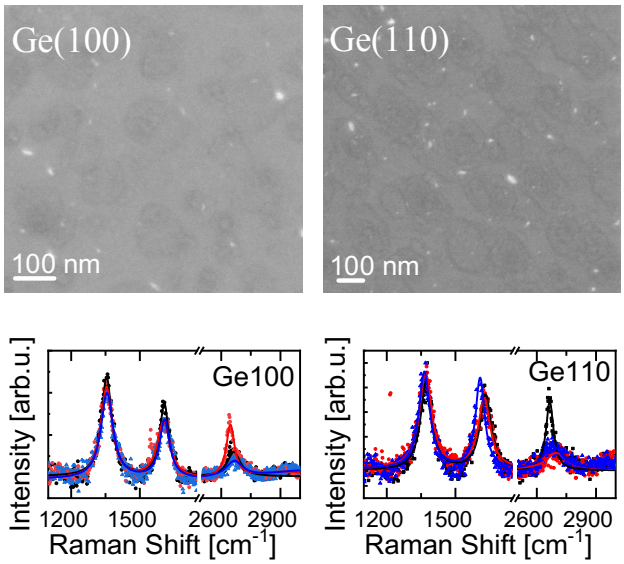

Figure 1: SEM images of graphene flakes (top) on Ge(100) (left) and on Ge(110) (right) grown for 8 hours at 800°C and the corresponding Raman measurements (bottom) on the same samples on randomly selected positions (represented by different colours).