Growth optimization and comparison of epitaxial graphene on 4H- and 6H-SiC

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Graphene-based quantum Hall resistance standards promise highest precision for metrological application under relaxed conditions of lower magnetic fields and higher temperatures compared to the so far used GaAs-based resistance standards. However, metrological applications require high quality graphene material and large scale devices. For such applications, fabricating epitaxial graphene by polymer-assisted sublimation growth (PASG) on SiC offers various advantages, such as production of large-area ultra-smooth defect- and bilayer-free graphene sheets, as well as reliable reproducibility. With the PASG method, the early formation of a buffer layer stabilizes the SiC surface and prevents step bunching of unfavorably high SiC surface terrace steps. We grow graphene on 4H- and 6H-SiC polytypes with different parameters (such as miscut, polymer concentration, etc.) to investigate the influence of the substrate on the electronic properties of graphene. Differences between 4H- and 6H-SiC growth are two and three terrace types, respectively, having inequivalent surface energies and subsequently different surface decomposition velocities [1]. We observe different step patterns on 6H-SiC of either alternating 0.25 and 0.5 nm high terrace steps with alternating surface potential or equally distributed 0.75 nm steps. 4H-SiC on the other hand results for optimal growth in equally distributed very low step heights of 0.5 nm and equivalent SiC terrace types with equal surface potential. Directly after Hall bar patterning the graphene is vacuum annealed and encapsulated by a copolymer to avoid contamination. Our magneto-transport measurements show significantly lower electron densities in graphene grown on 4H-SiC ($6-8\times10^{11}\ cm^{-2}$) in comparison with graphene grown on 6H-SiC ($2\times10^{12}\ cm^{-2}$). Additionally, in graphene on 4H-SiC the onset of the $\nu=2$ plateau in the quantum Hall effect (light blue line in Fig. 1) is observed at 8 T, whereas in 6H-SiC graphene the $\nu=2$ plateau is well out of our measurement range, with only the $\nu=6$ plateau visible at 7 T. We argue therefore that graphene grown on 4H-SiC is a better starting point for optimization towards graphene-based resistance standards with a significantly lower electron density and thus applications at even lower magnetic fields.

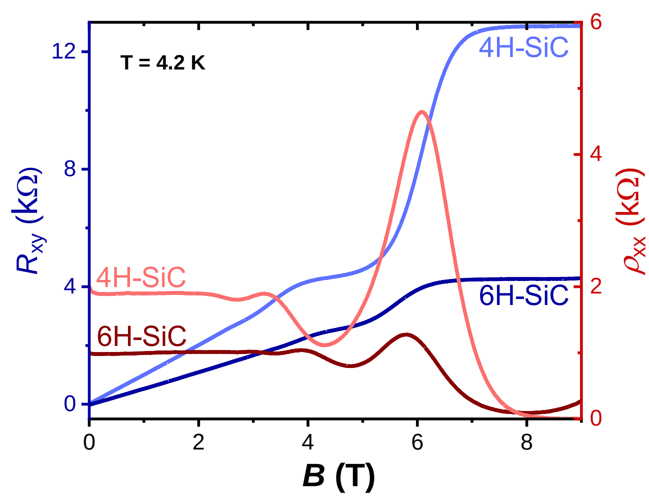

Fig. 1: Quantum Hall measurements on encapsulated epitaxial graphene grown on both 4H-SiC (light blue and red) and 6H-SiC (dark blue and red). The red lines correspond to the longitudinal resistance as a function of the magnetic field (B) and the blue show the Hall resistance. The measurement temperature is 4.2 K.

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