Conversion of Epitaxial Graphene to 2D diamane on Silicon Carbide

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Abstract

The continued miniaturization of devices faces increasing challenges due to material and thermal constraints. To address these limitations, the synthesis of diamane—atomically thin, diamond-like structures—has garnered significant interest for the advancement of 2D electronics and spintronics [1,2]. Epitaxially grown graphene on insulating SiC offers a promising platform for constructing such 2D material heterostructures, enabling the large-scale assembly of 2D material devices with potential integration into established silicon technology and processing.
Building on our established expertise in producing bi- and mono-layer graphene on semiconducting SiC substrates [3,4], we present a novel approach for passivating graphene on 4H-SiC(0001) using atomic hydrogen under ultra-high vacuum (UHV) conditions. Starting with precursor bi-layer graphene intercalated with atomic hydrogen at high temperatures to achieve free-standing graphene on SiC, we passivated the surface through prolonged hydrogen exposure at ambient temperature. Using in-situ X-ray photoelectron spectroscopy (XPS) at the Australian Synchrotron, we observed the conversion of up to approximately 90% of the sp^2 graphene into sp^3-hybridized diamane (Fig 1) after extended atomic hydrogen exposure (up to 30 hours) at various temperatures. This transformation was further confirmed by Auger and STM measurements. We also verified the stability of the sp^3-hybridized diamane up to 600 ˚C.
Similarly, the partial conversion of epitaxial graphene into F-diamane through fluorination in a 10% F_2 in N_2 atmosphere at 70°C for 60 minutes was also confirmed by XPS measurements.

References

[1] Piazza, Fabrice, et al., Carbon, 169 (2020) 129-133
[2] P. V. Bakharev, et al. Nature Nanotechnology (2020) 15, 59
[3] N. Zebardastan, et al., Nanotechnology, (2023) 34,105601
[4] C. Mastropasqua, et al. npj 2D Materials and Applications (2025) 9, 32

Figures

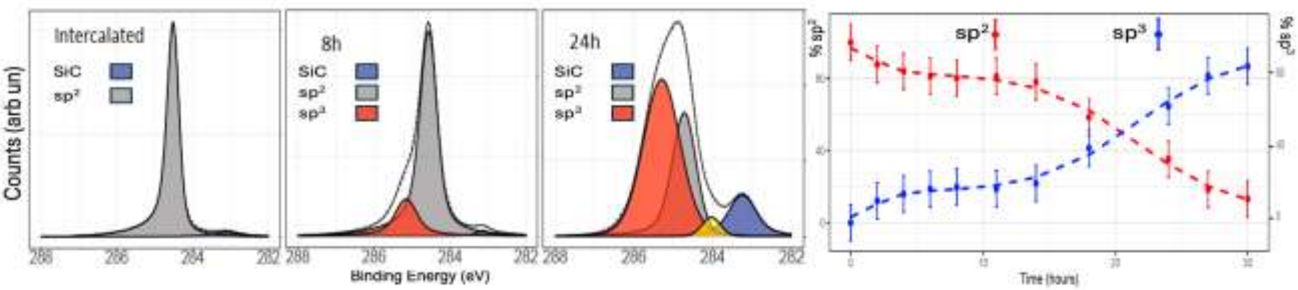

Figure 1: C1s XPS components at various stages of hydrogen exposure (left) and evolution of sp^2 and sp^3 peaks (right) as a function of hydrogenation in epitaxial graphene