

Surface reconstruction governs graphene epitaxy on sapphire

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The direct growth of single-crystal graphene on dielectric substrates is highly appealing for semiconductor technologies, particularly in optoelectronics. Sapphire (α -Al₂O₃(0001), c-plane) is a platform holding great promise, yet graphene growth on this surface remains poorly understood and often results in rotational disorder and mosaicity [1,2]. A key source of ambiguity is that the role of the surface reconstruction, ubiquitous under growth conditions, is often overlooked. In this work, we provide experimental and theoretical results that clearly indicate how graphene epitaxy on sapphire is governed by the reconstructed interface [3,4,5]. Specifically, we show that two low-strain commensurate configurations of graphene on the most stable surface reconstruction under growth conditions, the $(\sqrt{31}\times\sqrt{31})R\pm 9^\circ$ phase, account for the majority of experimentally observed domains. We further suggest an alternative interpretation in which the frequently observed R30 orientation may emerge from the convolution of nearby commensurate diffraction spots, yielding a unified picture of graphene growth on sapphire. Our results highlight interface control as the key requirement for achieving flat, strain-free graphene with epitaxially constrained orientations on sapphire, and establish a consistent framework to interpret the commonly observed R30 feature and mosaicity.

References

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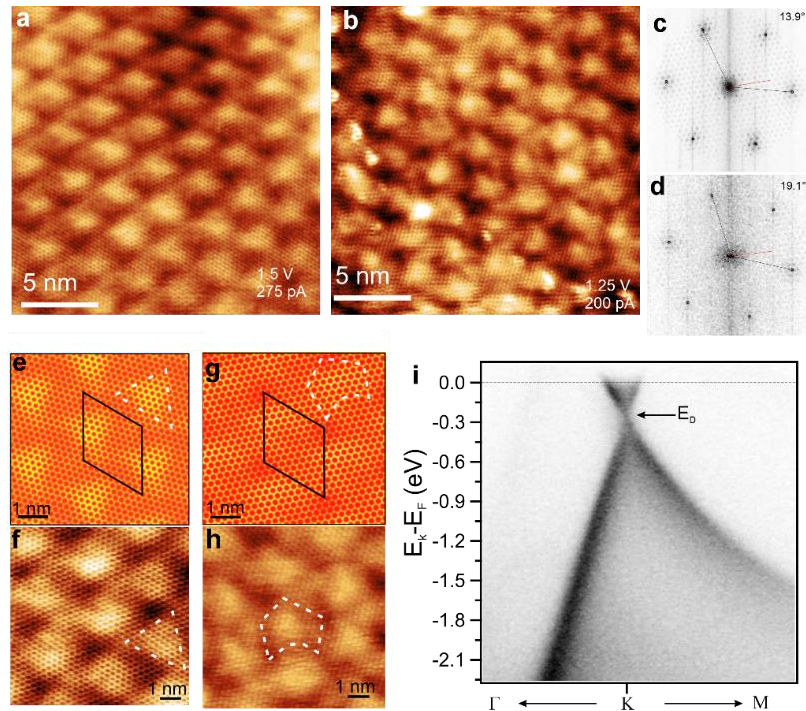


Fig. 1: **Structural and electronic properties of graphene/r31/sapphire.** **a** STM of r117. **b** STM on r112. **c** 2D-FFT of panel **a**. **d** 2D-FFT of panel **b**. **e** simulated pseudo-height map of r117. **f** measured STM on r117. **g** simulated pseudo-height map of r112. **h** measured STM on r112. **i** ARPES spectrum of Gr/r31/sapphire.