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Direct growth of two-dimensional crystals on dielectrics for nanodevices

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One of the largest problems, which result in little success of applying graphene in electronics industry, is the lack of a low-cost, reliable and controllable method to produce ultra-clean high-quality graphene directly on dielectrics at low temperature, which can directly be used in electrical devices. Plasma-Enhanced Chemical Vapor Depostion (PECVD) realizes catalyst-free growth of graphene on dielectrics; however structural defects easily form on edges, which terminate the graphene growth, resulting in low-quality graphene nanoclusters or non-crystalline samples. Here, we observe a critical equilibrium state of graphene edge growth, when we introduce H_2 plasma in PECVD. Moderate H_2 plasma etching removes edge defects, keeping the edges active in the whole crystal growth. Thus, we develop a critical PECVD method, which realizes catalyst-free growth of ultra-clean high-quality graphene, with size up to μm-scale for single crystals and to cm-scale for continuous films, directly on dielectrics. Both the locations and the orientations of the graphene crystals are controlled by patterned seeds and the growth temperature decreases to as low as 400°C when using C_2H_4 as the carbon source in critical PECVD. STM study reveals the pivotal role of H_2 plasma and a novel catalyst-free edge growth mechanism of graphene. Electrical measurement shows a high electrical quality with mobility much higher than normal PECVD graphene and comparable to that of Cu-CVD graphene and peel-off graphene, indicating its great potential as a general growth method for future graphene electronics.

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