Fractal-theory-based Shape and Quality Precise-artificial Control of Two-dimensional Materials

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Abstract

The precise control of shape and quality of two-dimensional (2D) materials during chemical vapor deposition (CVD) process remains a challenging task as the underlying growth mechanisms are still not well understood even after considerable efforts.

In this work, we combined the fractal theory with the CVD synthesis of 2D materials, proposed an atomic-scale fractal-growth mechanism of graphene, hexagonal boron nitride and transition-metal dichalcogenides, which is verified by perfect consistence of theory and experimental results. Furthermore, under the guidance of this mechanism, we synthesized various fractal-shaped single-crystal 2D materials, and eventually realized the precisely artificial control of their shapes, qualities and electric properties for the first time by manipulating the single-crystal net growth rate in CVD process.

Our study extends validities of the typical fractal theory down to atomic-thick 2D materials, establishes the precise-artificial adjustment for morphology and electric-transported properties, as well as allows to explore undiscovered novel low-dimensional materials and new-generation nanodevices.

References

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Figures

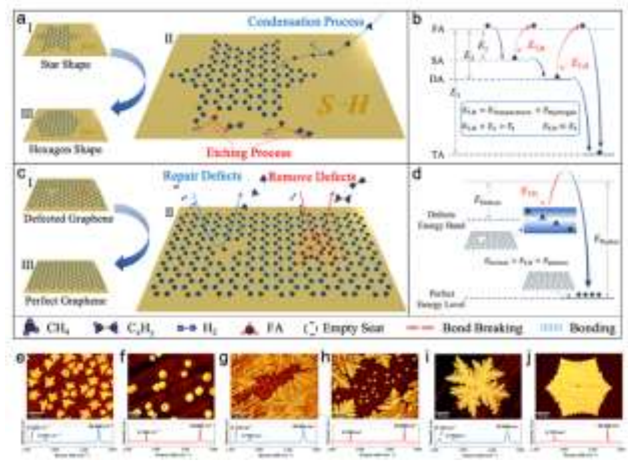

Figure 1: Control of the graphene shape and quality by utilizing the SCNGR. a, Schematic of the shaped change from star to hexagon under the influence of SCNGR. b, Energy diagram of FA, SA, DA, TA and ET,H which is determined by the growth temperature and ratio of H2/CH4. c, Schematic of the crystal quality improvement via removing extra-atoms defects and repairing vacancy defects in recrystallization process d, Energy diagram of defected and perfect structures. e, f, Raman mappings and spectra of star-shaped graphene (e) and hexagon-shaped graphene (f) in different ratios of H2/CH4. g, h, Raman mappings and spectra typify the influence on domain shapes of nucleation densities. i, j, Raman mappings and spectra of different crystal-quality graphene which are synthesized under low temperature (i) and high temperature (j), respectively.