Production of Large-Area Nucleus-Free Single-Crystal Graphene-Mesh Metamaterials with Zigzag Edges

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Abstract

In addition to conventional monolayer or bilayer graphene films, graphene-mesh metamaterials have attracted considerable research attention within the scientific community owing to their unique physical and optical properties. Currently, most graphene-mesh metamaterials are fabricated using common lithography techniques on exfoliated graphene flakes, which require the deposition and removal of chemicals during fabrication. This process may introduce contamination or doping, thereby limiting their production size and application in nanodevices. Herein, we demonstrate the controlled production of wafer-scale high-quality single-crystal nucleus-free graphene-mesh metamaterial films with zigzag edges. We utilize the ^{13}C-isotopic labelling graphene-growth approach, large-area Raman mapping techniques, and a uniquely designed high-voltage localized-space air-ionization etching method to directly remove the graphene nuclei. Subsequently, a hydrogen-assisted anisotropic etching process is employed for transforming irregular edges into the zigzag edges within the hexagonal-shaped holes, producing a large-scale single-crystal high-quality graphene-mesh metamaterial film on a Cu(111) substrate. The carrier mobilities of the fabricated field-effect transistors on the as-produced films are measured. The findings of this study enable the large-scale production of high-quality low-dimensional graphene-mesh metamaterials and provide insights for the application of integrated circuits based on graphene and other two-dimensional metamaterials.

References

[1] Tian, Bo, et al. Advanced Materials (2022): 2201253.

Figures

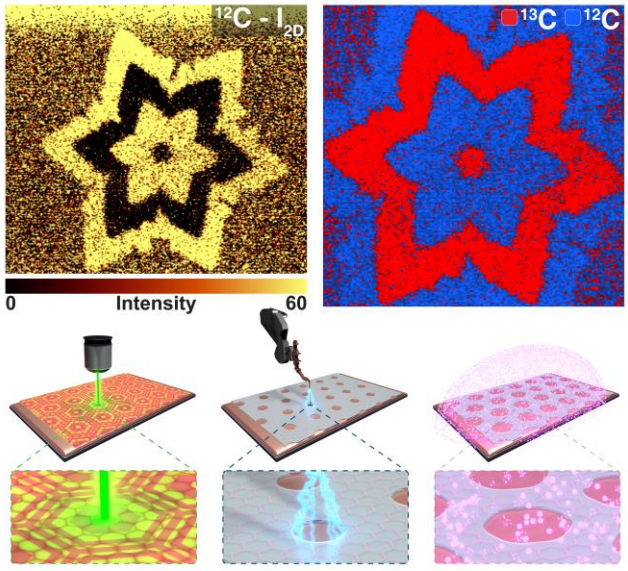

Figure 1: A controllable production approach of wafer-scale high-quality single-crystal nucleus-free graphene-mesh metamaterials with zigzag edges.