Tailoring two dimensional materials in LEEM

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By using in situ low energy electron microscope (LEEM) technique, we show that tailored twin grains, which are defined in a face-centered cubic structure with stacking sequence of (111) planes reversed in the two sides of (111) mirror plane, are expected to have epitaxial lattice for single crystal graphene growth because of the C_{6V} symmetry of the graphene lattice. Using first principle calculation, we reveal the orientation mechanism of a graphene domains on arbitrary Cu surface and build the quantitative lattice match relation of all the twinned copper crystals. We further experimentally realized the predicted twinned copper by introducing microhardness indent and external induced driving force, which is proved to be ideal substrate for single crystalline graphene epitaxy. [1]

We also use LEEM to explore the dynamic intercalation of lithium into bilayer graphene on SiC. Stacking engineering in van der Waals (vdW) materials is a powerful method to control topological electronic phases for quantum device applications. Atomic intercalation into the vdW material can modulate the stacking structure at the atomic scale without a highly technical protocol. Here we report that lithium intercalation in a topologically structured graphene/buffer system on SiC(0001) drives dynamic topological domain wall (TDW) motions associated with stacking order change by using an in situ aberration-corrected low-energy electron microscope in combination with theoretical modelling. We observe sequential and selective lithium intercalation that starts at topological crossing points (AA stacking) and then selectively extends to AB stacking domains. Lithium intercalation locally changes the domain stacking order to AA and in turn alters the neighbouring TDW stacking orders, and continuous intercalation drives the evolution of the whole topological structure network. Our work reveals moving TDWs protected by the topology of stacking and lays the foundation for controlling the stacking structure via atomic intercalation. These findings open up new avenues to realize intercalation-driven vdW electronic devices.[2]

[1] Nature Communications volume **13**, Article number: 1773 (2022)

[2] Nature Nanotechnology 2023 Oct 18(10):1154-1161 (2023)