Surface Work Function Engineering of Diamond-like Carbon Through Spatial Selective Gallium Implantation

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Bottom-up synthesis of materials with high spatial selectivity has long been a goal of nanotechnology. However, to obtain spatially selective nucleation and exact control over the size and shape of the domain during the synthesis, spatial modification of the surface work function landscape of substrate must be realized at the growth temperature. Herein, a spatially controllable surface work function landscape of diamond-like carbon (DLC) thin layer was achieved through spatially selective implantation of gallium into DLC using focused ion beam (FIB). Under various FIB conditions, two typical features with a size of 5 μm by 5 μm were obtained: “valley” with a step height of 3.5 nm, and “hill” with a step height of 4 nm. Gallium precipitated after one-hour-long in-situ annealing process at 500°C or 300°C in a high-vacuum environment (10^{-9} torr). At 500°C, the surface work function of valley feature was 51 meV higher than that of the unimplanted region, while the surface work function of hill feature was 16.8 meV lower than that of the unimplanted region. However, as the annealing temperature dropped to 300°C, the surface work functions for hill and valley featuressurface were 51.8 meV and 88 meV lower than those of the unimplanted region, respectively. Both gallium precipitation and change of DLC properties contributed to the shift in surface work function. Therefore, a spatially controllable surface work function landscape can be realized by carefully tuning the annealing conditions and spatial arrangement of hill and valley features, facilitating the selective area growth of materials in various nanofabrication processes.

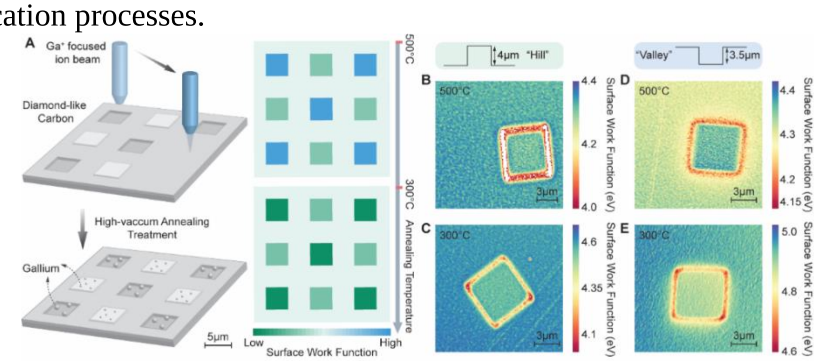

Figure 1. (A) Scheme of spatial selective implantation of gallium into DLC using focused ion beam and the surface work function mapping for the pattern under different annealing temperature. Corresponding surface work function mapping for for **(B** and **C)** “hill” and **(D** and **E)** “valley”. Surface work function mapping**s** for **(B)** and **(D)** were collected under the annealing temperature of 500°C, while **(C)** and **(E)** were collected under the annealing temperature of 300 °C.

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