

AFM nanolithography of graphene

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I will discuss the local oxidation nanopatterning of graphene films by an atomic force microscope. The technique provides a method to form insulating trenches in graphene flakes and to fabricate nanodevices with sub-nm precision. We demonstrate fabrication of a 25-nm-wide nano-ribbon and sub-micron size nano-rings from exfoliated graphene flakes. We found that within certain range of writing parameters the written lines appear as bumps rather than trenches. We attribute the bumps to the partial oxidation of the graphene and incorporation of oxygen into the graphene lattice. These bumps are electrically insulating with conduction suppressed by more than 6 orders of magnitude. Annealing in hydrogen atmosphere partially restores the conduction (can be increased by 3 orders). Thus, AFM lithography provides a unique method of tunable local graphene oxidation.

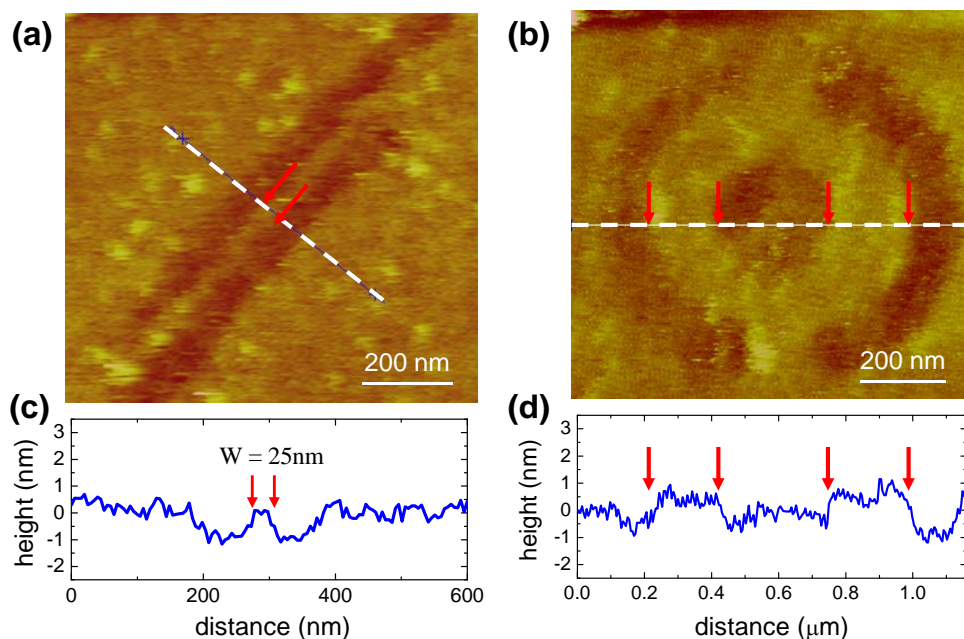


Figure 1. (a) AFM image of a nano-ribbon fabricated on a graphene flake with thickness ~ 1 nm. The width and length of the ribbon are 25 nm and 800 nm, respectively. (b) Height profile along the dashed line in (a). (c) A nano-ring (inner radius 160 nm, outer radius 380 nm) patterned on a graphene flake. Two long trenches, not shown in the picture, were subsequently drawn from the circumference of the ring outward to the edges of the flake to electrically isolate the ring device. (d) Height profile along the dashed line in (c).

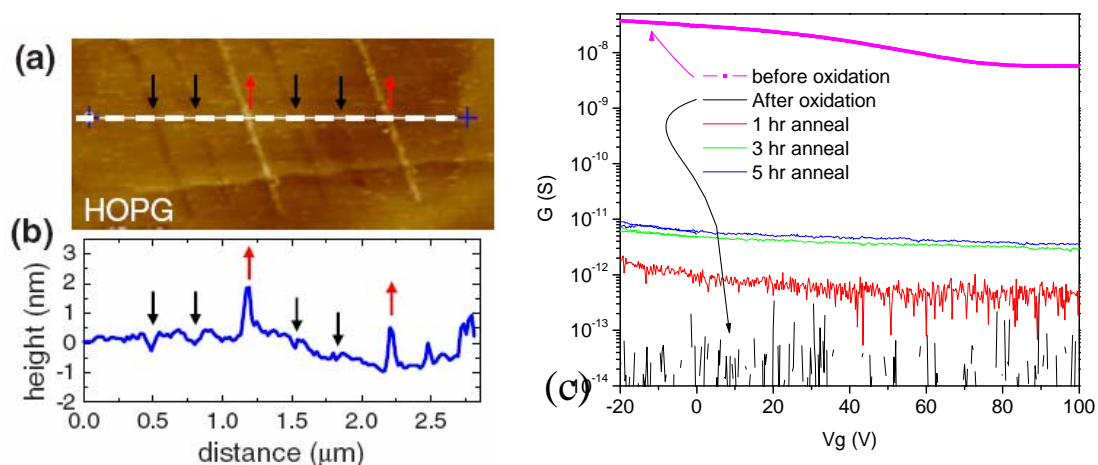


Figure 2. AFM images of line patterns created by the LAO technique. (a) Trenches or bumps were formed on HOPG surface. 6 lines (from left to right) are written with the same tip bias voltage of -20 V while the set point (SP) was cycled through 0.3, 0.2, 0.1, 0.3, 0.2, 0.1 volts, corresponding to 15%, 10%, 5%, 15%, 10% and 5% of the free-oscillation amplitude for an unloaded tip. (b) Height profile across the line marked in (a). Red arrows indicate bumps and black arrows indicate trenches. (c) Conductance across a “bump” line before and after oxidation, and after a sequence of annealing steps.