Molecular Assembly Connects Graphene Nanoribbons

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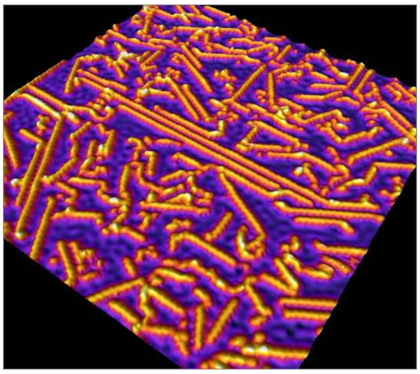
Graphene promises to be a revolutionary material only if its honeycomb structure can be tailored, both to engender desired properties from the nanoscopic scale, and to enable property access from the macroscopic scale. Conceptually, this can be achieved by cutting graphene sheets into atomically precise graphene nanoribbons (GNRs): the reduced GNR dimension widthways induces applicative properties (such as switchable band gap or spin-polarized edges), while the connection of the GNRs lengthwise provides property access. However, current graphene-processing techniques cannot fulfil both requirements at once, producing either connected GNRs with unquantifiable defects, or defect-free GNRs in entangled bundles. Here we show a surface-assisted molecular assembly (SAMA) that not only produces precise GNRs, but also connects these structures end to end. Combining scanning tunnelling microscopy (STM) and density functional theory (DFT), we found that the Cu substrate aligns precursor molecules to form and connect (3,1)-chiral-edge GNRs up to 50-nm long, with both localized zigzag-edge states and delocalized π-states. We also found evidence that π-delocalization is carried out throughout the connected GNRs, indicating electronic connection. By connecting a precise GNR (device) to other GNRs (electrodes), we demonstrate that SAMA can overcome the limitations of known graphene-processing methods; making possible the prospect for integrating graphene into current electronics. Our work indicates that, in addition to the width and edge configuration of the product GNRs, future bottom-up GNR-fabrication studies should also exploit both the substrate effects to control precursor alignments, and the polymerization chemistries to functionalize target electrodes for GNR connection. We anticipate this field will rapidly progress toward the inclusion of top-down methods to fabricate designer electrode platforms, on which GNR nanodevices can be self-assembled, connected, and characterized from the macroscopic scale—in one single step and *en masse*.



Caption: STM image of interconnecting (3,1)-GNRs on Cu{111} (image size: 70 nm × 70 nm).