Length dependent symmetry in narrow chevron-like graphene nanoribbons

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Graphene nanoribbons (GNRs) are an exciting material due to their excellent and tunable electronic properties. For instance, GNRs with armchair edge termination possess a width-dependent band gap, whereas zigzag GNRs are expected to host spin-polarized edge states and be semi-metallic [1]. The electronic properties of GNRs are incredibly sensitive to minor changes in structure and through on-surface synthesis, GNRs can be fabricated with atomic precision allowing the investigation of the effect of tiniest structural changes [2]. The combination of excellent electronic properties, tunability and precise control over width, shape and edge termination make GNRs a promising candidate for future electronic and spintronic devices.

Previously narrow chevron-like GNRs, which host a combination of zigzag and armchair edge terminations, were synthesized on a Au(111) substrate from the prochiral precursor 6,12-dibromochrysene employing a combination of enantiomer selective Ullmann-type coupling and thermally induced cyclodehydrogenation reactions [3]. The structural model for the narrow chevron-like GNRs and a high-resolution scanning tunneling microscopy image are shown in Figure 1. An interesting yet unexplored property of these ribbons is the potential effect of the structural symmetry on the electronic properties. Depending on the number of monomer units incorporated into the ribbon, an even number of units leads to a mirror symmetric ribbon while an odd number results in a point symmetric one. We characterized the electronic properties using scanning tunneling spectroscopy, also in dependence of their length and parity. In addition, we observed different coupling defects resulting in bent as well as cross-linked GNRs. These structural defects were investigated with high-resolution scanning tunneling microscopy and spectroscopy. It turned out that the defects of both the bent and cross-linked GNRs are based on a five-membered ring and cause a change of the electronic properties of the ribbon, forming a heterojunction which can be fabricated from a single precursor molecule.

References

Figure 1. (a) Structural model of the narrow chevron-like GNR; (b) High-resolution constant height scanning tunneling microscopy image (bias voltage 5mV, scale bar 1nm) of a chevron-like GNR consisting of four monomer units. A CO functionalized tip was used to resolve the structure of the GNR.