

## Engineered Quantum States in Graphene Nanoribbons

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Graphene provides an ideal platform to create materials with diverse electronic properties by rational control of its nanoscale structure. Quantum confinement effects can be exploited in strictly planar 2D (e.g. porous graphen) or 1D (graphene nanoribbon GNR) graphene structures. However, in order to achieve well defined electronic properties with high electron motilities the nanostructures need to be synthesized with atomic precision.

In our presentation we will review the recent progress in the bottom-up synthesis of atomically precise graphene nanostructures from molecular precursors [1]. Very recently, it has been found theoretically that localized zero energy modes can be obtained at the junctions of topologically dissimilar graphene nanoribbons (GNR) [2]. We have experimentally realized such GNR junctions using on-surface synthesis, i.e. by the polymerization of molecular precursors rationally designed to yield the desired final GNR on single crystal surfaces. By creating well defined periodic sequences of these topological electronic modes, one-dimensional electronic bands can be created, which are described by the Su-Schrieffer-Heeger (SSH) Hamiltonian representing the dimerized atomic chain [3]. By manipulating the intra- and inter-cell coupling strength we could further create SSH analogs with different Chern number and therefore topological class. The topological class distinction is evidenced by presence, respectively absence of zero energy end states at the termini of the corresponding GNR or their junctions to structurally dissimilar GNRs.

We will discuss the concept of topological boundary states in GNR junctions and the creation of 1D SSH-type electronic bands by their periodic arrangement on a host GNR. The theoretical basis of attributing  $Z_2$  topological invariants to these structures will be discussed. We then present the experimental synthesis of different structures exhibiting different topological classes. The structural characterization and atomic precision of these GNR was achieved by low-temperature scanning tunneling microscopy (STM) and high resolution non-contact atomic force microscopy (nc-AFM) [4]. The electronic properties are elucidated by scanning tunneling spectroscopy (STS), where we invoke the bulk-boundary correspondence to determine the topological properties.

### References

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