Multi-gate quantum dots from armchair graphene nanoribbons

Jian Zhang,
Mickael Perrin, Oliver Braun, Gabriela Borin Barin, Rimah Darawish, Klaus Müllen, Pascal Ruffieux, Roman Fasel, Michel Calame

jian.zhang@empa.ch

Atomically precise graphene nanoribbons (GNRs) have attracted much interest from researchers worldwide, as they constitute an emerging class of quantum-designed materials, all tailored by controlling their width and edge structure during the chemical synthesis.[1-3] The major challenges toward their exploitation in electronic applications include reliable contacting, complicated by their small size (<50 nm), and the preservation of their physical properties upon device integration. In recent years, the exploitation of GNR properties for electronic devices has focused on their integration into field-effect-transistor (FET) geometry.[4] However, such FET devices, due to the presence of a single gate, have limited electrostatic tunability. Here, we report on the device integration of armchair GNRs into a multi-gate FET geometry and a one-dimensional contact geometry as well. With the above geometries, we measured the quantum dot behavior at low-temperature. By demonstrating the preservation of the armchair GNRs' molecular levels upon device integration, as demonstrated by transport spectroscopy, our study provides a critical step forward in the realization of more exotic GNR-based quantum devices.

References

[1] Cai, et al. Atomically Precise Bottom-Up Fabrication of Graphene Nanoribbons. *Nature* 2010, 466, 470.
[2] Gröning, et al. Engineering of Robust Topological Quantum Phases in Graphene Nanoribbons. *Nature* 2018, 560, 209.
[3] Yang, et al. Quasiparticle Energies and Band Gaps in Graphene Nanoribbons. *Phys. Rev. Lett.* 2007, 99, 186801.
[4] Llinas, et al. Short-Channel Field-Effect Transistors with 9-Atom and 13-Atom Wide Graphene Nanoribbons. *Nat. Commun.* 2017, 8, 633.

Figures

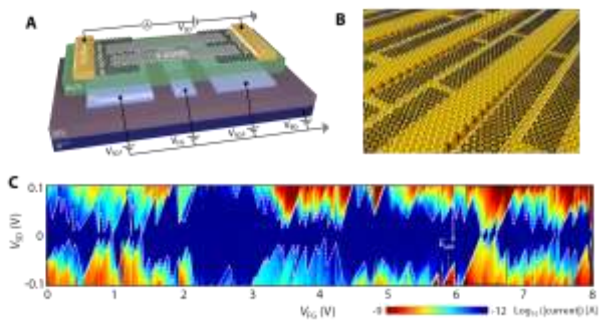

Figure 1: GNR device and the transport measurement. (A) Artistic illustration of a multi-gate 9-AGNR quantum dot device. (B) A sketch of the GNRs grown parallel to the Au(788) terraces. (C) Coulomb diamonds in a multi-gate 9-AGNRs device at low temperature.