High Performance Graphene Nanoribbon Transistors

Zafer Mutlu
Postdoctoral Researcher, Bokor Group
Electrical Engineering and Computer Science
UC Berkeley

Abstract: Recent advances in on-surface organic synthesis have led to the development of rational bottom-up graphene nanoribbon (GNR) growth with atomic precision. This atomic precision leads to versatile electronic properties tailored by the widths and edge topologies, which make GNRs promising candidates for future transistor technologies and quantum information processing. However, a range of fundamental synthesis, integration, and materials science challenges have impeded the fabrication of devices with the expected performance. Here, recent progress in integrating bottom-up synthesized GNRs into devices will be presented. GNR transistors with high on-state current and excellent switching performance were successfully fabricated. Transistor structures fabricated include back-gate and double-gate field-effect transistors (FETs). Uniform high-k dielectric growth on relatively inert ultranarrow GNR surface offering superior electrostatic control were demonstrated. GNRs can also be stitched together to build nanoporous graphene (NPG) from the bottom-up. NPG exhibits uniform electronic band gap with localized frontier electronic states that are unattainable in bulk graphene, top-down etched graphene nanomeshes and the GNR chains it is composed of. The switching performance of transistors made with NPG is high and correlated with the degree of structural perfection. The theoretical charge transport analysis also reveals strong conductance anisotropy effects in NPG, which is fundamentally a consequence of the well-defined geometry at the atomic level afforded by the bottom-up synthesis. Finally, challenges and opportunities of GNRs as transistor channels will be discussed, together with possible further improvements and future research directions.


Bio: Dr. Zafer Mutlu is a postdoctoral researcher with Prof. Jeffrey Bokor in the Department of Electrical Engineering and Computer Sciences (EECS) at University of California, Berkeley (UCB) and a research affiliate at the Molecular Foundry at Lawrence Berkeley National Laboratory (LBNL). He is also part of the Berkeley Emerging Technologies Research (BETR) Center. He received his PhD in Materials Science and Engineering (MSE) from University of California, Riverside (UCR) in 2016, where he continued his postdoctoral research until joining to UCB in 2018. His current research focuses on bottom-up synthesis and nanoelectronics devices of graphene nanoribbons. His doctoral research was on the synthesis and phase engineering of two-dimensional materials. His research work has appeared in highly respected journals, including ACS Nano, Nano Energy, JACS, and Advanced Functional Materials, and in prestigious conferences, including IEEE International Electron Devices Meeting (IEDM), Semiconductor Research Corporation (SRC) TECHCON Conference, American Physical Society (APS) Meeting, Materials Research Society (MRS) Meeting, and the International Society for Optics and Photonics (SPIE) Meeting. During his postdoctoral studies, he has mentored several undergraduate students from diverse and underrepresented backgrounds under the National Science Foundation (NSF) funded TTE-REU (UCB) and MAC-REU (UCR) programs in his research.