Zongping Chen
School of Materials Science and Engineering, Zhejiang University
38 Zheda Road, Hangzhou 310027, China

chenzp@zju.edu.cn

Precision synthesis of structurally defined graphene nanoribbons by chemical vapor deposition

Graphene nanoribbons (GNRs), quasi-one-dimensional narrow strips of graphene, have shown great promise for use as advanced semiconductors in electronics. Compared with the lack of structural control in GNRs fabricated by “top-down” approaches, atomically precise GNRs can be “bottom-up” synthesized by surface-assisted assembly of molecular building blocks1. Such “bottom-up” synthesized ultranarrow (~1-2 nm) GNRs have demonstrated a wide range of bandgaps with visible to near-infrared absorption, rendering them highly interesting for a broad range of applications in next-generation transistors, as well as optoelectronic and photonic devices.

To establish facile and scalable on-surface synthesis of GNRs for real device applications, we demonstrate here an efficient chemical vapor deposition (CVD) process for inexpensive and high-throughput growth of structurally defined GNRs over large areas even under ambient-pressure conditions. This “bottom-up” CVD method allows the growth of chevron-type GNRs2, armchair GNRs with various width3, N-doped GNRs as well as their heterojunctions, demonstrating the versatility and scalability of this process, which provides access to a broad class of GNRs with engineered structures and properties based on molecular-scale design. Moreover, with the CVD method, we have also recently demonstrated the highly efficient lateral fusion of armchair GNRs into wider GNRs, under the CVD growth at higher temperature4. The large-area availability of the CVD-synthesized GNR films enabled also the device integration and studies1. The FET devices built on the transferred GNRs exhibited a high current on/off ratio of >6000, and a high photoresponsivity of ~105 A/W for small incident power in the visible-UV range, which is 8 orders of magnitude higher than the devices based on graphene. These results pave the way toward the scalable and controllable growth of GNRs, and provide practical solutions to the current challenges in graphene-based nanoelectronic, optoelectronic and photonic devices.

References

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