

Graphene Nanoribbons as “Best of Two Worlds” between Graphenes and Conjugated Polymers

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We have shown that donor-acceptor (DA) polymers are not only efficient light harvesting materials for solar cells, but also high-mobility semiconductors for organic field-effect transistors (FETs). The mode of film deposition plays a crucial role for FET performance. However, processing can lead to different polymorphs, and device fabrication can thus become kinetically trapped in less favorable packing modes.

These drawbacks define an urgent need for materials with high intrinsic charge-carrier mobility and/or more robust assembly. This brings graphene into play. Before graphenes can be put to work in FETs and before their high charge-carrier mobility can be utilized, bandgap opening must be achieved. The best solutions to this longstanding problem are graphene nanoribbons (GNRs). Toward GNR-synthesis, techniques from materials science such as lithography or unzipping of carbon nanotubes are too undefined since they offer no control over size, aspect ratio and edge structure. Instead, bottom-up synthesis is the method of choice. Herein, we present, both, solution and on-surface protocols whereby in the latter case, we can either work under UHV-conditions (with additional STM monitoring of the reaction) or chemical vapor deposition.

The structural precision of the new semiconductors can be proven by both microscopic and spectroscopic tools. Controlled formation of the peripheries (arm-chair, cove, zig-zag) leads to edge states and thus allows an entry into

spintronics. Examples of FETs using either single GNRs or their networks are also shown. Bandgaps can be fine-tuned via the choice of the oligophenyl precursor monomer which is subjected to polymerization.

GNRs hold promise as a new generation of semiconductors, but will also allow to test emerging concepts such as that of topological insulators.

References

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