

Prospects of Beyond-Graphene Materials and Devices

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(invited)

Carbon is truly a remarkable material, for not only sustaining life on earth, but for the promising materials properties it encompasses that emerge from its diverse and rich physical structures. Carbon based nanomaterials, such as graphene and carbon nanotubes, have been proposed for a wide variety of applications including high-frequency transistors,^{i,ii} interconnects,ⁱⁱⁱ stretchable electronics,^{iv} photovoltaics,^{v,vi} and plasmonics,^{vii}. In particular, although graphene has been shown to exhibit remarkable electronic, thermal, mechanical and optical properties, the absence of a band-gap poses concerns for its attractiveness in some applications, particularly in digital electronics where high ON/OFF ratios are desired. While a band-gap is induced in graphene through quantum confinement by creating graphene nanoribbons, the band gaps nonetheless are small (few hundred meV) and it is challenging to maintain pristine edge chirality due to defects that are induced during nanofabrication of the ribbons. Recently, layered 2D crystals of other materials similar to graphene have been realized which include insulating hexagonal-BN (band gap ~5.5 eV) and transition metal di-chalcogenides which display properties ranging from superconducting, semiconducting, metallic to insulating. The device applications of such systems show promising characteristics where MoS₂ transistors have been formed on flexible and transparent substrates, and transistors derived from 2D monolayers of MoS₂ show ON/OFF ratios many orders of magnitude larger than the best graphene transistors. In this talk, I will provide an overview of the Electronics, Photonics and Magnetic Devices (EPMD) program in the ECCS division where graphene, as well as other layered 2D nanomaterials, are playing an important role for enabling innovative device applications in electronics, photonics and sensing. I will also provide an overview of the NSF 2-DARE initiative under the Emerging Frontiers in Research and Innovation (EFRI) program.

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