Nanoelectronic Devices with Layered Semiconductors: Challenges, and advances in Fabrication and Performance

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The last 10 years have witnessed high interest in layered semiconductors of an atomically thin nature – be in graphene, the transition metal dichalcogenides, or related III-VI semiconductors. These materials span the range of electronic and photonic properties – from insulating, to semiconducting, and metallic and superconducting. Many researchers in the semiconductor electronics and photonics area consider them as potential building blocks for future devices.

But as with most new material systems, there is both significant hope, and even more "hype" for these layered materials for nanoelectronic devices. I will describe my perspective on this topic by presenting experimental results and theoretical predictions for various novel device architectures that exploit unique properties of these materials. Many exploit unique geometrical and quantum-mechanical features of these materials that arise from the electronic and spin structures, and their collective interactions. They can potentially enable fundamentally new tunneling based electronic switches, and high-speed RF devices. Some examples are the SymFET based on graphene that has been now demonstrated at room-temperature, interlayer tunneling Esaki diodes and transistors, and high-voltage nanomembrane switches. The application arena must not limit itself to digital switching – and indeed it must expand to create its own niche – just to survive!

Now while some preliminary work on these materials has been done, the growth, doping, fabrication and control of these materials are at a stage that Silicon was in 1940's – the years when doping was discovered at Bell labs. We cannot grow the layered materials controllably. We cannot etch them, and we still cannot dope these layered materials! I will present these rudimentary challenges to the attendees of the 3Beams conference to seek their help and expert advice.