2D NANO-ELECTRONIC MATERIALS FOR BIO-SENSING AND BIG DATA

SUMMARY

The last two decades have experienced rapid technological developments in the search of cheap and high accuracy devices for fast bio-molecular identification. In the realm of DNA and protein sequencing, there has been an increasing interest in the use of nanopores in solid-state materials because of their distinct advantage over biological pores in terms of flexibility in pore design and mechanical strength. Two-dimensional (2D) solid state materials such as graphene and Molybdenum di-sulphide (MoS2) in particular have attracted attention because of their atomically thin layered structure and electrically active characteristics, predisposing them to offer single base resolution and simultaneously multiple modalities of detecting biomolecular translocation. 2D nanopore devices promise seamless integration with semiconductor electronics and are poised to revolutionize a variety of technologies such as genomics, point-of-care diagnostics and digital data storage to name a few.
The past year has witnessed a flurry of activity to experimentally realize nanopore Field Effect Transistors (FETs) and understand the fundamental sensing mechanism in such devices. Currently, the dominant consensus from theoretical calculations has involved the electrostatic modulation of the FET current due to the translocating biomolecules. In this talk, we review and provide insights into this sensing principle by modeling the electron flow through 2D material nanopore FETs. We describe a method to systematically characterize nanopores FETs by contrasting the changes in the FET behavior before-and-after nanopore drilling and DNA translocation. We outline measurable predictions of high-resolution FET based sensing of DNA-protein complexes and damaged DNA. We compare these FET signals to the corresponding ionic current signals calculated from all-atom Molecular dynamics simulations. Further, we also outline possible techniques to improve the detection SNR by augmenting pore and device design with statistical signal processing algorithms. Finally, we propose a scalable device design of nanopore FETs to detect and identify translocations of single-biomolecules in a massively parallel scheme.

BIOGRAPHY

Dr. Leburton joined the University of Illinois in 1981 from Germany, where he worked as a research scientist with the Siemens A.G. Research Laboratory in Munich. In 1992, he held the Hitachi LTD Chair on Quantum Materials at the University of Tokyo, and was a Visiting Professor in the Federal Polytechnic Institute in Lausanne, Switzerland in 2000. He is involved with research in nanostructures modeling and in quantum device simulation. His present research interest encompasses non-linear transport in quantum wires and carbon nanotubes, and molecular and bio-nanoelectronics He is author and co-author of more than 300 technical papers in international journals and books. Dr. Leburton is a fellow of the APS, the OSA, the AAAS, the ECS, and the IOP. He is also a member of the New York Academy of Science. In 2011, he was elected as an Associate Member to the Royal Academy of Sciences of Belgium. He served as the Chairperson, an advisory, and program committees for numerous international conferences. In 1993, he was awarded the title of "Chevalier dans l'Ordre des Palmes Académiques" by the French Government. In 2004, he was a recipient of the ISCS Quantum Device Award and the Gold Medal for scientific achievement by the Alumnus Association of the University of Liége, Belgium. In 2019, he was a recipient of the CCMR Serendipity Award, Seoul, South Korea. In 2020, he received the IEEE-NTC Nanotechnology Pioneer Award for his pioneering contribution to the simulation of semiconductor nanostructures and low dimensional nanoscale devices. From 2011 to 2015, he was a Distinguished Lecturer for the IEEE Nanotechnology Council.

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