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Advanced research and nanotechnological applications of atomic monolayer materials

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Abstract

Atomic monolayer (AM) materials attract significant attention due to their unique intrinsic properties and a great potential in various applications. They are implemented in the following areas (i) Nanosensors, (ii) Digital logic elements, (iii) THz applications, (iv) Quantum dots, (v) Industrial and automotive nanodevices. Well known examples are carbon nanotubes and graphene. Other AM materials are transition metal dichalcogenides (TMDC), transition metal oxides, graphitic carbon nitride, and topological insulators like Bi_2Te_3. Exploiting the diverse and unique intrinsic properties of AM leads to creating the new generation of nanodevices which were not available before. At Northwestern we conduct experimental and theoretical studies focused on the following topics. (a) Efficient thermoelectric nanocoolers and energy generators based on atomic monolayers and nanotubes. (b) Andreev reflection as a probe of interface properties. (c) AM quantum dots as elements of the THz and magnetic field nanosensors and lasers. Our experimental devices involve multi-terminal AM and nanotube field effect transistors (FET). Special attention is paid to obtaining the nanotube and AM quantum dots. Resonant character of chiral tunneling and low inelastic scattering rates serve as reasons why the electric current density can be much higher than in ordinary semiconducting devices. Depending on the circuit configuration, our quantum dots function as thermoelectric coolers, energy co-generators, or sensors the external fields. By measuring, e.g., the d.c. current-voltage curves of AM FET quantum dots which are exposed to an external THz field we are able to determine the THz field parameters. In this way we are utilizing the AM FET which actually works as a very sensitive and efficient THz field sensor. We find that the AM FET setup has a strong potential for designing of the THz sensor arrays, AM made qubits, and THz lasers. We conclude that the setups based on atomic monolayer materials might outperform the conventional semiconducting devices.

Biography

Serhii Shafraniuk has completed his Ph.D. at the age of 26 years from Kiev State University and postdoctoral studies from Department of Physics, Kiev University. He is the research associate Professor at Northwestern University, a premier nanotechnology research organization. He has published more than 100 papers in reputed journals and served as an organizing committee member of several international conferences.