Insights into new effects of two-dimensional materials

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It is hard to imagine how small nanotechnology is. One nanometer is a billionth of a meter, corresponding to a typical size of molecule. In fact, if a pearl has a nanometer size, then one meter would be the size of the Earth. Nevertheless, current development of nanoscience and nanotechnology gives possibility to see and to control individual atoms and molecules and effectively to study new nanostructured materials.

Current trend in nanotechnology development is investigation of a special kind of nanostructured materials having the form of films of only one atom thickness, which is much smaller than one nanometer. These materials are considered two-dimensional (2D) because they represent the thinnest unsupported crystalline solids that can be realized.

This 2D materials family is expected to be significantly expanded because a lot of elemental and compound sheets are still uncovered. The outstanding properties of 2D materials have generated immense interest for both conventional technology and the nascent flexible nanotechnology because among other considerations, these atomic sheets afford the ultimate thickness scalability desired in a variety of essential material categories, including semiconductors, insulators, transparent conductors and transducers. The fundamental science is also fascinated by 2D materials. Indeed, each 2D layered material, whose thickness is minimally possible, exhibits novel properties different from its bulk counterpart. Therefore, in this physical limit, materials researches often bring unusual results and paradoxes that cannot be emerged in common 3D world.

In the present talk, I will give a brief overview of the current development of 2D materials science and show examples of the controversial effects demonstrated in various 2D materials. I will discuss graphene, because of its exceptional electronic, optical and mechanical properties. However, in 2D materials beyond graphene, there is a wide spectrum of electronic properties that ranges from insulators and semiconductors to metals and even superconductors. In addition, I will especially focus on the special family of 2D materials which naturally cannot exist in 2D state but as was recently found even these materials can be transformed to monoatomic films in a specific way.