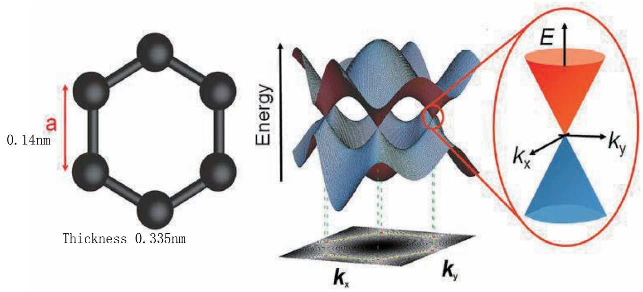
Two-Dimensional Materials Technology

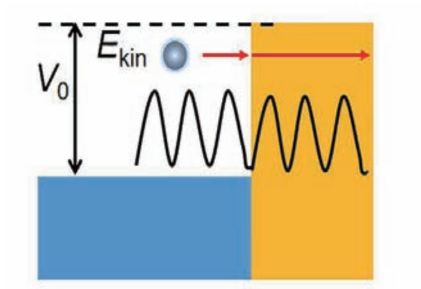
Two-dimensional (2D) materials are a class of materials with layered structure and atomic level thickness. Such materials have strong covalent bonds, atomic layer thickness, high surface atom exposure, and electron motion restricted within a 2D plane, resulting in high sensitivity to external electrical, light, thermal, and magnetic fields, and exhibiting unique properties such as extremely high electron mobility, excellent optical transparency, and superior mechanical strength, etc. They have great potential in bringing revolutionary applications in the fields of energy, electronics, medical and health, etc.

Graphene is the most typical one of 2D materials. It has ultrahigh electrical and thermal conductivity, excellent light transmittance, superior mechanical strength, and very high specific surface area.

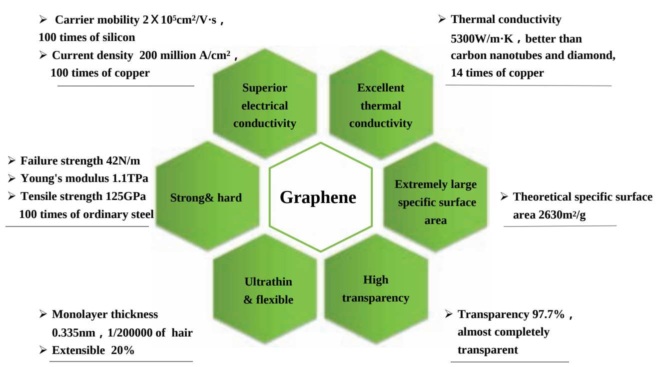
ENN is engaged in research and technology development of graphene and other 2D materials. The main research areas include: controllable preparation of high-quality materials, revolutionary applications in key fields such as energy, electronics, medical and health, as well as large-scale materials and product commercialization technologies.



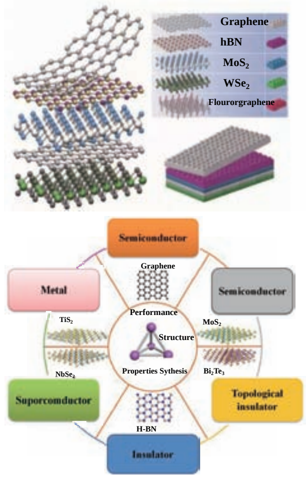
Graphene lattice and energy band structure



Barrier free electron transport between graphene lattices

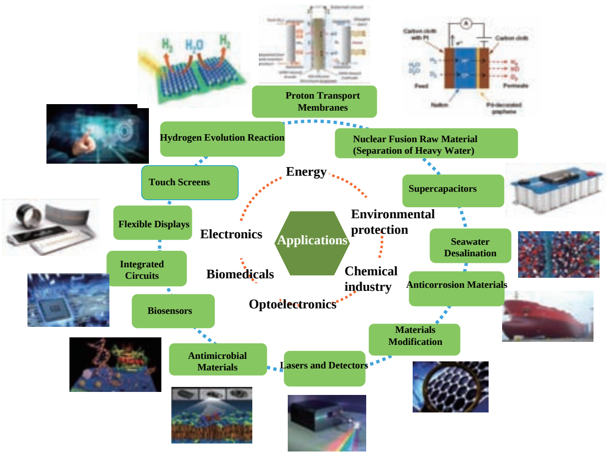


Superior properties of graphene



Typical two-dimensional materials

The 2D materials family include various types of materials ranging from insulators to superconductors, e.g., excellent insulator hexagonal boron nitride (h-BN), naturally band-gap tunable semiconductor molybdenum disulfide (MoS2), etc. Single-component 2D materials usually have superior properties far beyond that of their three dimensional (3D) counterparts. In the meantime, various 2D materials can form vertical or lateral van deer Waals hetero-structures, which result in property enhancement and greatly expand 2D materials application areas.



Applications of graphene

The 2D materials, as represented by graphene, have great potential in various applications and are highly expected to bring revolutionary breakthroughs in many key fields, such as:

Flexible Displays：Utilizing its outstanding mechanical flexibility and chemical durability, high transmittance, and excellent electrical conductivity, graphene can be used in flexible displays as the transparent conducting electrodes replacing brittle indium tin oxide (ITO).

High-Frequency Transistors：Superior carrier mobility and thermal conductivity of graphene facilitate fabrication of extremely high-frequency transistors. The theoretical cut-off frequency can reach Tera Hertz, which is higher than that of III-V compounds (850GHz), and hundreds of times higher than silicon based devices (Giga Hertz).

Photodetectors：Owing to good absorption over full spectrum and high carrier mobility, graphene based photodetectors have wider detection range, covering from ultraviolet to infrared, and high operating bandwidth (640GHz) that is 4-8 times higher than photodetectors currently available. The response time can reach 50 femtoseconds ($5*10^{-14}$s), hundreds of thousands times faster than current photodetectors. The power detection limit can reach as low as nW level, 1000 times better than Si base photodetectors (μW).

Biosensors：Graphene is one of the best candidate materials for highly sensitive biosensing applications due to its good biocompatibility, high specific surface area, outstanding electrical conductivity, and excellent chemical stability. Potential applications include real-time detection of glucose and glutamate by enzyme-modified graphene-based biosensors, detection of bacteria, viruses and cancer marking by immunosensors, DNA detection and analysis by gene sensors, etc.

Seawater Desalination：Graphene can be used for seawater desalination due to its excellent mechanical strength and chemical durability, highly selective permeability, providing better salt rejection and water transport.

Hydrogen Evolution Reaction (HER)：Utilizing high catalytic activity of MoS2, high carrier mobility of graphene, and low contact resistance between graphene and metal electrodes, graphene/MoS2 hetero-structures can replace Pt as catalyst for HER.

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