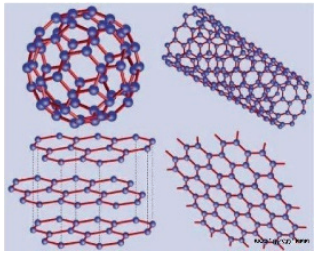
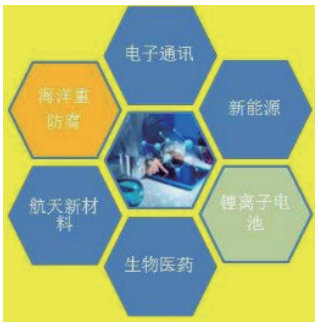
Tektronix®

碳基半导体材料及电子器件测试

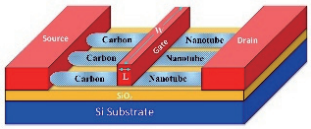
概述：



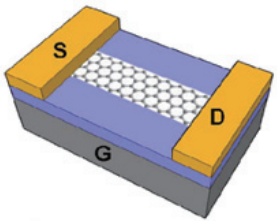
碳基半导体材料，是在碳基纳米材料的基础上发展出来的。所谓的**纳米材料**，是指三维空间尺度至少有一维处于纳米量级 (1–100nm) 的材料，包括：**零维材料** – 量子点、纳米粉末、纳米颗粒；**一维材料** – 纳米线或纳米管；**二维材料** – 纳米薄膜，**石墨烯**；**三维材料** – 纳米固体材料。按组成分，纳米材料又可以分为金属纳米材料、半导体纳米材料、有机高分子纳米材料及复合纳米材料。



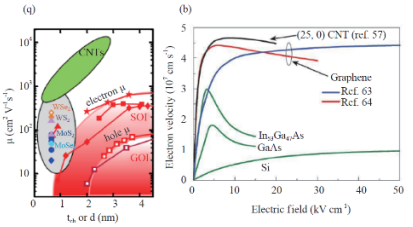
由于纳米材料某一维度达到纳米尺寸，其特性将表现出异于宏观尺寸的材料，这些特性包括：表面与界面效应 – 熔点降低，比热增大；小尺寸效应 – 导体变得不能导电，绝缘体却开始导电，以及超硬特性；量子尺寸效应和宏观量子隧道效应。纳米材料的理化性能包括：高强度、高韧性；高比热和热膨胀系数；异常电导率和扩散率；高磁化率。基于以上特性，纳米材料已经被广泛用于多个领域。



我们更关注的是半导体纳米材料，因为它是构建碳基电子器件的重要原料。

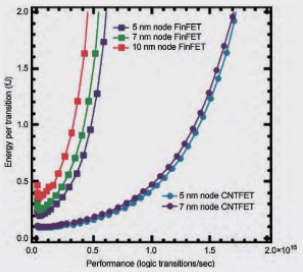


所谓**碳基电子器件**，是指用碳纳米半导体材料材料（三维体材料金刚石、二维材料石墨烯和一维材料碳纳米管）为沟道的电子器件 – 金刚石主要用于超宽禁带半导体器件；碳纳米管可以用来制作碳纳米管场发射器、碳纳米管 CNFET、单电子晶体管、碳纳米管传感器、碳纳米管存储器、碳纳米管开关等；石墨烯可以用来制作零带隙、顶栅石墨烯场效应管、双层石墨烯晶体管、双极超导石墨烯晶体管、石墨烯纳米带场效应管等。



理想的晶体管沟道材料 – 碳纳米管

碳基电子芯片是由 CNT 构建的集成电路，之所以用半导体碳纳米管来制作碳基芯片，是因为科学家们对各种半导体纳米材料测试后甄选出的最优方案。碳基芯片被认为是后摩尔时代的新曙光，这主是因为碳纳米管的极限尺寸和当前的硅要基材料大致相同，制作工艺改变不大。此外，碳基芯片比硅基芯片具有更优的性能和更低的功耗以及更高的工作频率（电子迁移率 100000 cm^2/V.S vs 1000cm^2/V.S，频率 100GHz Vs 10GHz)。



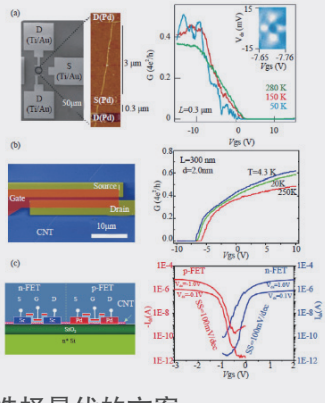
IBM 关于未来硅基和碳纳米管基场效应晶体管的性能比较

我国在碳基芯片研究领域处于世界领先地位，北京大学彭练矛院士课题组一直站在碳基芯片领域的前沿。尽管碳基芯片目前与传统硅基芯片相比还有明显差距 (1.4 万晶体管 vs 亿级集成度)，但彭院士认为 15 年后碳芯片技术有望成为主流芯片技术，我国将在芯片领域将实现弯道超车。

碳基半导体材料及电子器件测试

碳基半导体纳米材料测试的目的在于筛选材料及材料的分子结构改良，特别是对碳基芯片，由于在制备碳纳米管时，卷曲直径和角度的细微差别，都可以影响到碳纳米管的导电性，即有可能得到金属特性的成品，而得到整齐划一的具有半导体特性的碳纳米管，是碳基芯片研究的首要条件。

对一维材料，以 **I–V** 特性测试为主。由于纳米材料尺寸极小，因此其所能承受的**测试电流超小**（达 fA 级），**测试电压超低**（达 nV 级），并且极易因为测试造成的自热而烧毁被测材料，因此必须选择与被测纳米材料性能相适应的，具有脉冲特性的测试仪器。



对二维材料及石墨烯，**电阻率、载流子浓度、载流子迁移率**测试是重要的测试项目，需要用**四探针及范德堡法**进行测试。

对碳基电子器件及碳基芯片，主要测试 I–V 特性，通过改变 碳纳米管的数量、位置和器件结构，进行测试对比，选择最优的方案。

碳基半导体材料及电子器件测试方案

碳基半导体材料及电子器件种类多，电性能各不相同，需选择最加匹配的 **SMU** 进行测试。4200 半导体参数测试仪可以覆盖全部应用，具体测试方案**详见下页**。

详情请致电技术热线：400–820–5835

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Keithley instrumentation is being used in a growing list of nanotechnology research and production test settings. The applications shown here are only a sampling of the nanotechnology test and measurement tasks for which our instruments and systems are suitable. If your tests require sourcing or measuring low level signals, Keithley instrumentation can help you perform them more accurately and cost-effectively.

Want low current measurements without the high price tag?

With <200µV burden voltage, the cost-effective **Model 6485 Picoammeter** ensures accurate low current measurements, even in circuits with very low source voltages. The **Model 6487 Picoammeter/Voltage Source** adds a 500V bias source for high resistance and resistivity measurements. The **Model 6482 Dual-Channel Picoammeter/Voltage Source** gives you two channels in one instrument to save rack space.

Trying to characterize high resistance nanomaterials?

The **Model 6517B Electrometer/High Resistance Meter's** built-in 1kV source, 200TΩ input resistance, and low current sensitivity make it an ideal solution.

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Studying highly resistive nanowires?

The **Model 6430 Sub-Femtoamp Remote SourceMeter®** instrument's low noise and drift performance make it ideal. It measures currents with 400aA (400×10⁻¹⁸A) sensitivity.

Polymer Nanofibers/ Nanowires	Semiconductor Nanowires	Carbon Nanotubes and Graphene	Single Electron Devices/Transistors	Carbon Nanotube Field Effect Transistors	Nanobatteries	Nanophotonics	Synthesized Molecular Electronics/Wires	Nanosensors & Arrays	Thermal Transport
High R/Low I, 1MΩ to 1014Ω	Low Power, R <10MΩ, Pulse	Low Power, R < 100kΩ	Low I, Low V	Low I, Pulse	Low I, Low Power	Low I, Pulse	Low I, Low Power	Low I, Low V	Low I, Low Power, Pulse

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The fully integrated **Model 4200 Semiconductor Characterization System** brings together all three core measurement types, DC-IV, AC impedence and transient I-V, in one easy-to-operate package. It's used in many phases of nano research, development, characterization, and production.

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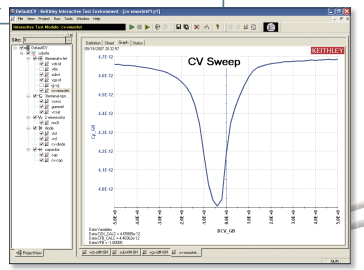
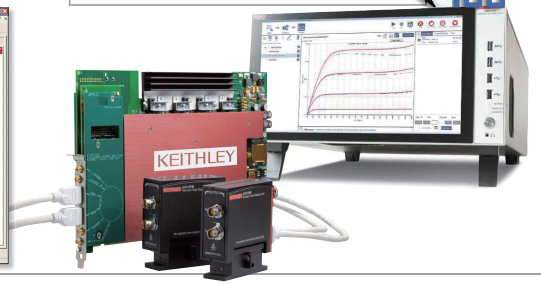
The **Model 4210-CVU Option** takes the guesswork out of obtaining valid capacitance-voltage (C-V) measurements quickly and easily, with intuitive point-and-click setup, complete cabling, and built-in element models.



Troubled by overheating problems?

The **Model 4225-PMU** option for the Model 4200-SCS performs pulsed I-V testing on a variety of devices for many different purposes, including preventing device self-heating by using narrow pulses and/or low duty cycle pulses rather than DC signals.



Testing lots of devices?

Series 2600B System SourceMeter® instruments let you make precision DC, pulse, and low frequency AC source-measure tests quickly, easily, and economically. They offer virtually unlimited flexibility to scale the system's channel count up or down to match changing application needs.

Looking for just a single channel?

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