

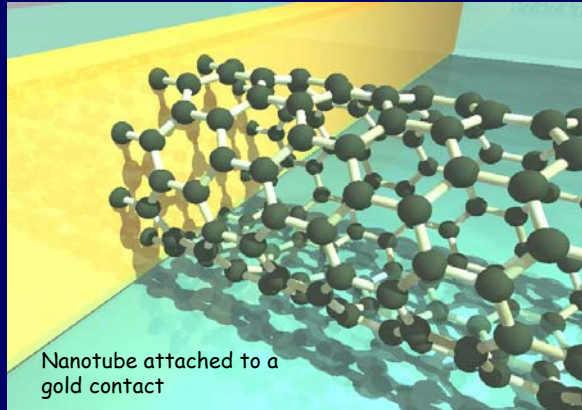
Carbon Nanotubes

Carbon Nanotube

-A tube formed from carbon atoms. Nanotubes are roughly 1 nm in diameter (80,000 times thinner than a human hair).

1D systems

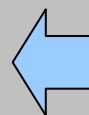
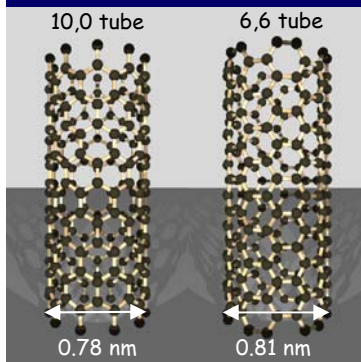
- Due to their high length to width ratio, nanotubes are essentially 1D systems. The reduced dimensionality can result in novel properties.



Nanoscale engineering

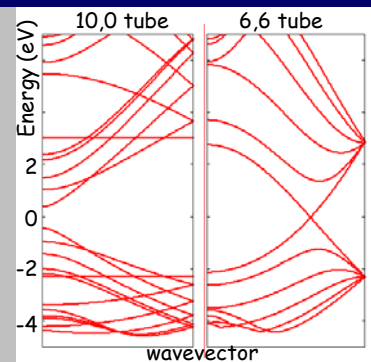
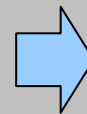
-Nanotubes can be made 20x stronger than steel, 1000x more conducting than copper and with thermal conductivity as high as diamond.

- The unique properties of nanotubes (and their small size) make them ideal components for nanoscale devices.



Depending on the atomic arrangement, nanotubes can be semiconducting like the 10,0 tube or metallic like the 6,6 tube.

From the atomic structure we can calculate properties such as the band structure (right) which are needed to understand nanotube devices.

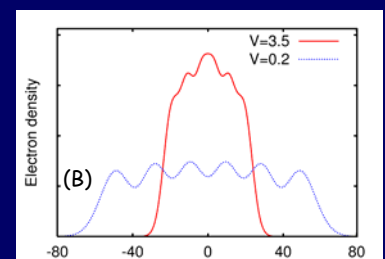
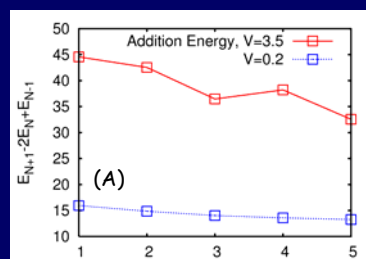
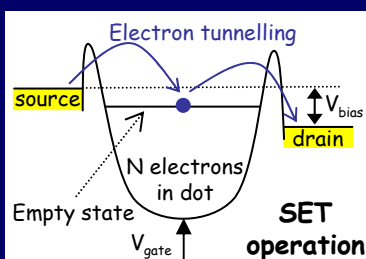
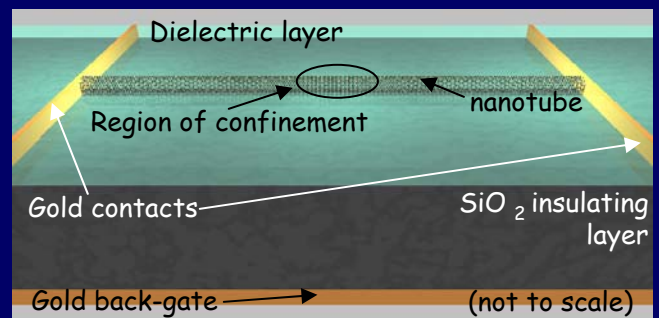


Artificial atoms and the single electron transistor

-A quantum dot is an artificial structure in which electrons can be confined in all 3 spatial directions. By modifying the properties of this 'artificial atom' we can create systems with electronic properties not seen in nature.

-In the nanotube dot-device (right) electrons are confined in the centre of a semiconducting tube when a potential is applied to the back-gate. The potential can be used to control the number of electrons on the dot.

- With a small bias voltage between the contacts, the tube dot-device acts as a single electron transistor (SET).



In the SET only 1 electron can tunnel through the dot at a time. The current is turned on by changing the gate voltage to move the empty level between the contact levels.

At Leicester we are studying the behaviour of interacting electrons in a nanotube dot. (A) shows the addition energy for a 22,0 tube. As the gate voltage is reduced, the Coulomb interaction dominates the single particle confinement: We drive the system into an unexplored 'strongly correlated' regime where the expected features in the addition energy disappear. This strongly-correlated behaviour is reflected in the 6-particle density, (B).