Carbon Nanotubes

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Outline

Introduction

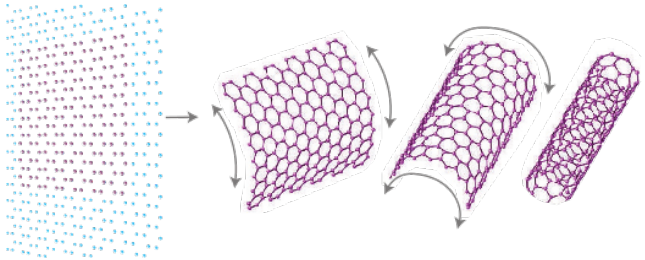
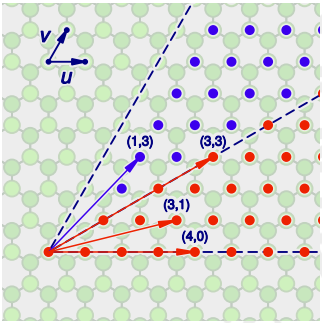


Figure: Rolling up graphene to form SWCNT. [5]

- Carbon nanotubes (CNTs) are an allotrope of carbon
- CNTs can be regarded as rolled up graphene
- Single-walled (SWCNT) and multi-walled (MWCNT) variants exist
- Different configurations: rolling angle

Configurations

- Graphene consists of sublattices A and B
- Chiral vector $\vec{w} = n \cdot \vec{u} + m \cdot \vec{v}$
- Circumference $|\vec{w}| = |\vec{u}|\sqrt{n^2 + nm + m^2}$, $|\vec{u}| \approx 246\,\text{pm}$

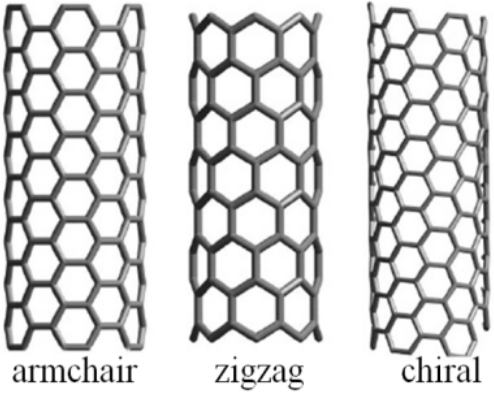


[7]

Configurations

Common classifications are (for $k \neq 0$):

- **Zigzag** $(k, 0)$ or $(0, k)$
- **Armchair** (k, k)
- **Chiral** (n, m) with $m > 0, n \neq m$

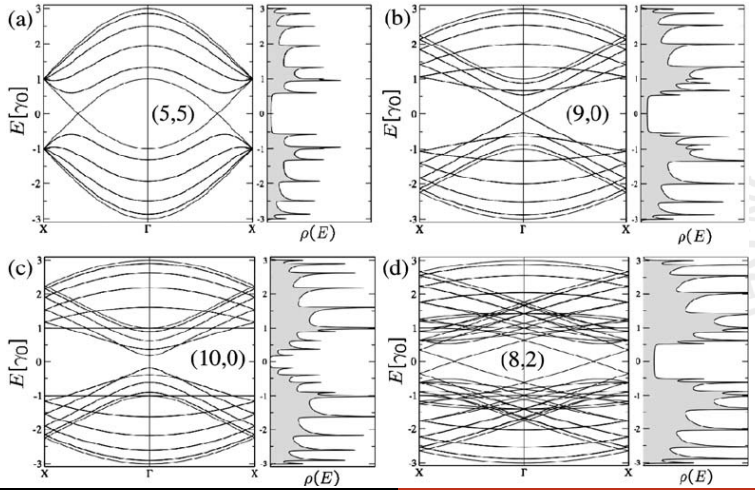


[3]

Properties of CNTs

- Inherited from graphene
- CNTs are thin thus light
  $\rightarrow (2, 2)$ is the thinnest type with a diameter of 0.3 nm
- sp^2 bonds
  $\rightarrow$ strong (SWCNTs 23 times stronger than steel[1]) and stable
- Electronic structure along tubular axis depends on type[6]
  - Unlike graphene, not semimetallic
  - Zigzag and armchair both achiral: most metallic
  - Chiral: most semiconducting
  - MWCNT: metallic

Band structures and DOS



[4]

Applications

There are many applications of CNTs[2]:

- Theoretical (academic) playground
- Composite materials (from hockey sticks to vacuum barriers to bullet-proof vests)
- Catalysis (large surface area, binds a lot of materials)
- Transistors
- ...

Still a lot of research is going on.

Conclusion

Summary

- Carbon nanotubes are versatile molecules
- CNT types (n, m) come in zigzag, armchair and chiral flavours

Outlook

- CNTs superconductors?
- CNT transistor computing?

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