USC Department of Physics Graduate Seminar

GRAPHENE NANORIBBONS

Nahid Shayesteh,
Outlines...

- Carbon based material
- Discovery and innovation of graphene
- Graphene nanoribbons structure
- Application of Graphene nanoribbons

Nahid Shayesteh, Department of Physics
1. Replace silicon-based micro electronics.
2. Exhibit superior physical properties in many aspects.
3. Industrial applications

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The term *graphene*

- **1962**—Hanns-Peter Boehm coined graphene as a combination of *graphite* and the suffix *–ene* to describe single-layer carbon foils.

Hanns-Peter Boehm: Born January 9, 1928 in Paris
German Chemist
Professor Emeritus in Ludwig-Maximillians University in Munich, Germany
Pioneer of graphene research

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Mitsutaka Fujita (藤田 光孝 Fujita Mitsutaka)

- Introduced graphene nanoribbons as a theory model to examine the edge and nanoscale size effect in graphene.

- Japanese Physicist

- Born: August 16, 1959

- Died: March 18, 1998

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Definition: thin strips of graphene

- Graphene nanoribbons
- GNR’s
- Nano-graphene ribbons

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The structure of Graphene consists of...

- Honeycomb Lattice
- 2 Dimension thin layer of Carbon atoms

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The carbon-carbon bond length in graphene is about 0.142 nanometers.

Graphene sheets stack to form graphite.

One stack of 3 million sheets = 1 millimeter thick.

Graphene is the basic structural element of some carbon allotropes including...

- Graphite
- Charcoal
- Carbon Nanotubes
- Fullerence

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The Energy gap of the 1 dimensional graphene nanoribbons (GNRs), can be...

- Produced lithographically by patterning 2 dimensional graphene through a chemical route
- Different crystallographic orientations
- Tuned with varying widths

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Graphene projections...

- Display hopeful electronic properties.
  (as a conductor of electricity as well as cooper and as a conductor of heat better than all other known materials)
- Possess very high electron or hole mobility
  (comparable to the properties observed in Carbon nano tubs)
- Longest measured mean-free path
- High optical transmission
  (optical transmission and infrared reflectivity can be tuned as a function of the applied voltage)

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Graphene is considered a semimetal, because...

- There is no present band gap (band gap is zero).
- There is a narrow channel width (transverse direction) & a band gap can be provided.

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Graphenenanoribons (GNRs) can be obtained by unzipping the single wall carbon nanotubes.
The ribbon form of graphene (GNR)
- Inherited almost all of the attractive properties of the carbon nanotube and graphene.
- Additional benefit of a tunable band gap.
- Tunable semiconducting behaviors vis a vis changing ribbon width.

The first bandgap measurements are made by...
- Phaedon Avouris.
- Philip Kim

Opening of energy gaps...
- Reported: 0.5 eV in a 2.5 nm wide armchair ribbon

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Zigzag & Armchair GNRs are metallic or semiconducting electronic properties that depend on the width of the nanoribbon.

Electronic properties depend on...

- the edge shape
  1. armchair
  2. zigzag

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Liang work shows certain armchair GNRs can display semiconducting behavior.

Armchair ribbon is semiconducting when

- $N = 3p$ or
- $N = 3p + 1$
- # of dimer lines $N = 3p + 2$ is semimetal behavior (p is integer).

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Zigzag GNRs are either...

1. Semiconducting
2. Metallic

And

Expected to be more conductive

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Applications…

- In transparent conductive electrodes
- In liquid crystals
- Solar cell systems
- Light emitting diodes
- P-N junctions
- Schottky diodes
- Field effect transistors

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A p–n junction is formed at the boundary between a p-type and n-type semiconductor-type created in a single crystal of semiconductor by doping.

A Schottky is a special case of a p–n junction, where metal serves the role of the n-type semiconductor.
A transistor is a semiconductor device used to amplify and switch electronic signals and power.

The field-effect transistor (FET) is a transistor that relies on an electric field to control the conductivity of a channel of one type of charge carrier in a semiconductor material.
New types of the graphene base material can be achieved.

Carbon based material have different application depend on their structure.


Thank you for your time and consideration. I will be more than happy to answer any questions or concerns that you may have at this time.