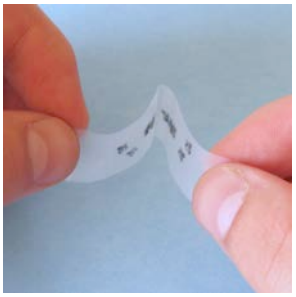
NanoDays
The Biggest Event for the Smallest Science!

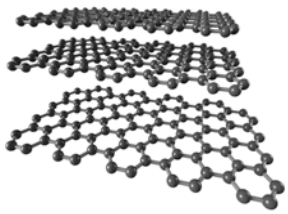
Explorando materiales: Grafeno

¡Intenta esto!

1. Toma un pedazo de cinta adhesiva de unas 3 pulgadas de largo. Haz un pequeño doblez en los dos extremos de manera que queden unas pestañitas sin pegamento de donde las puedas tomar.
2. Usa las pinzas para colocar una lámina de grafito en la parte pegajosa de la cinta adhesiva.
3. Dobla la cinta por la mitad (encima del grafito) y sepárala de nuevo. Haz lo mismo varias veces.
4. Pega tu cinta en una tarjeta blanca. ¿Qué ves?



¿Qué sucede?



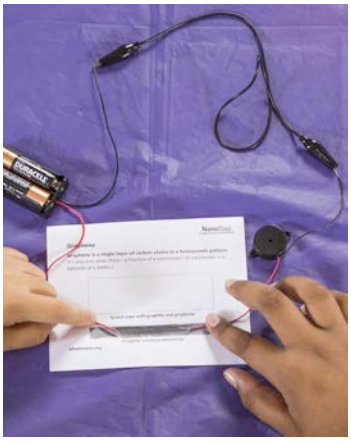
Grafito

Has hecho capas muy delgadas de grafito: y quizás hasta algo de grafeno, ¡el material más delgado que existe! El grafeno es una capa única de átomos de carbono, dispuestos en forma de panal de abejas.

Comenzaste con una lámina de grafito, que es un mineral hecho de varias capas de grafeno apiladas unas sobre otras. El grafito es el material de los lápices, comúnmente llamado "mina de lápiz". Esta técnica sencilla para crear grafeno a partir de grafito y cinta adhesiva, además de mediciones muy precisas de sus propiedades, ¡llevó a Andre Geim y Konstantin Novoselov a ganar el Premio Nobel de Física en el año 2010!

Ahora intenta esto…

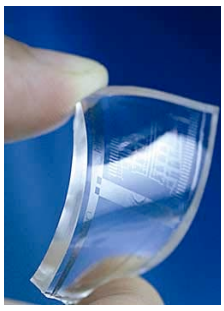
1. Utiliza el lápiz para rellenar el recuadro de tu tarjeta. Asegúrate de pintarlo completamente. Estás creando una capa fina de grafito.
2. Toca la capa de grafito con los dos cables. ¿Qué sucede?
3. Ahora mira la tela impresa. ¿Ves algún cable? Trata de tocar la tela impresa con los dos cables (¡en la tinta!)¿Qué sucede?



¿Qué sucede?

¡El timbre suena! El grafito en la tarjeta conduce electricidad, completando así el circuito eléctrico. El diseño en la tela está hecho con tinta que contiene nanoplaquetas de grafeno— diminutas capas de grafeno. Al igual que el grafito, estas nanopartículas de grafeno también conducen electricidad.

¿Por qué es nanotecnología?



Circuito flexible de grafeno

El grafeno es una capa única de átomos de carbono dispuesta en forma de panal.
El grafeno mide solamente el grosor de un átomo, es decir, ¡una fracción de nanómetro! (Un nanómetro es la milmillonésima parte de un metro).

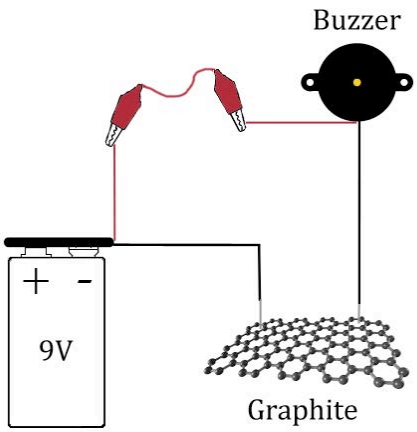
En el campo de la nanotecnología, los científicos e ingenieros crean nuevos materiales y aparatos nanométricos. El grafeno tiene un gran potencial en la nanotecnología gracias a sus propiedades útiles: es flexible, súper fuerte, casi transparente y conduce electricidad. La tinta de grafeno en la tela puede ser utilizada para hacer circuitos más flexibles y utilizables. Imagínate, ¡podrías cargar tu teléfono conectándolo a tu camisa! Los fabricantes de microcircuitos (chips) de computadoras están desarrollando circuitos de grafeno, modificándolo para convertirlo en semiconductor. Un día el grafeno podría ser utilizado para hacer pantallas electrónicas transparentes y flexibles, y microcircuitos de computadoras pequeñísimos y rápidos.

Learning objectives

1. Graphene is a single layer of carbon atoms arranged in a honeycomb pattern.
2. Graphene can be a semi-conductor.

Materials

- Flakes of graphite
- Plastic tweezers with a pointed tip
- Scotch tape
- White activity cards (or index cards)
- Soft drawing pencils (6B is best)
- Pencil sharpener
- Battery and buzzer circuit (9V battery, snap connector, alligator clip, and buzzer)
- "Graphene" image sheet
- Photocopy master for activity cards
- Bag printed with graphene ink



Battery and buzzer circuit

Graphite flakes and bag printed with graphene ink can be purchased from www.graphene-supermarket.com (natural Kish graphite, grade 200, #SKU-NKG-0501).

Battery and circuit materials can be purchased from www.radioshack.com (9v battery #55039849, snap connector #270-324, alligator clip #278-1156).

Buzzer can be purchased from www.newark.com (#89K7985).

Notes to the presenter

When assembling the buzzer and battery circuit use the alligator clip to connect the black wire of the battery to the black wire of the buzzer. Then use the red wires to touch the layer of graphite on the paper. The buzzer will not work if it is connected in the wrong direction to the battery. If the buzzer sound is faint, try putting the wires closer together on the graphite or put down a thicker layer of graphite.

If you have a molecular model set, you can build a model of graphene to supplement the illustrations in this activity.

Related educational resources

The NISE Network website (www.nisenet.org) contains additional resources to introduce visitors to atoms, molecules, and nanomaterials:

- Public programs include *Balloon Nanotubes, Electric Squeeze, Forms of Carbon, World of Carbon Nanotubes,* and *Tiny Particles, Big Trouble!*
- NanoDays activities include *Exploring Materials—Ferrofluid, Exploring Materials—Hydrogel, Exploring Materials—Liquid Crystals, Exploring Materials—Nano Gold, Exploring Materials—Thin Films,* and *Exploring Structures—Buckyballs.*
- Media include *What Happens in a NanoLab?* and *Zoom Into a Computer Chip.*
- Exhibits include *NanoLab.*

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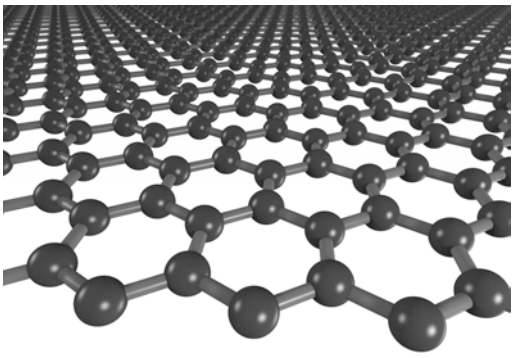
Graphene Background Information

What is graphene?

Graphene is a single layer of carbon atoms arranged in a honeycomb pattern. Graphene is only one atom thick—that's a fraction of a nanometer! (A nanometer is a billionth of a meter.)

Andre Geim and Konstantin Novoselov created thin layers of graphite by peeling apart tiny flakes using scotch tape. When they measured their results, they were surprised to learn they could create layers of a single atom thick! Before their work, scientists didn't think it was possible to create a sheet of carbon only one atom thick.



Graphene

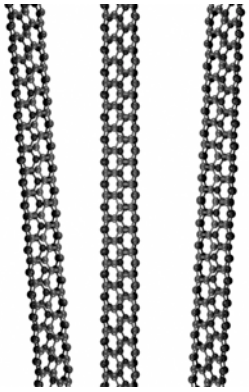
Graphene has many exciting potential uses, and this simple method makes it possible for many scientists to study and build things from it. Geim and Novoselev won a Nobel Prize in Physics for their work in 2010.

Graphene is just one form of carbon. Carbon atoms can bond together into many different structures that have very different properties.

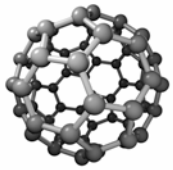
What other forms can carbon take?

Carbon can form diamond, the hardest natural material known on Earth. But it can also form graphite, a much softer material (commonly known as pencil "lead"). Both diamonds and graphite are made entirely from carbon. They have different properties because the carbon atoms are arranged differently at the nanoscale.

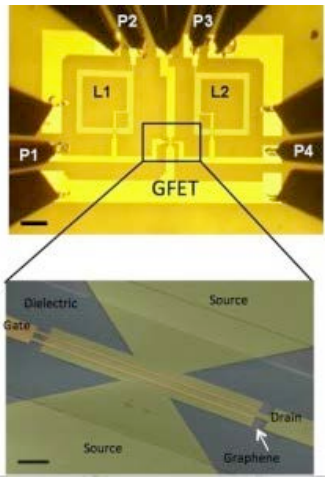
Carbon can also form two other tiny, nanometer-sized structures that are too small to see: buckyballs and carbon nanotubes. Carbon nanotubes are long, hollow tubes. They look like sheets of graphene rolled up. Buckyballs have a soccer-ball shape.



Carbon nanotubes



Buckyball



Graphene integrated circuit

How is graphene used?

Graphene's properties make it potentially useful in many ways. It's 100 times stronger than steel. (A thin sheet of graphene could support an elephant!) It's also flexible and nearly transparent. And it's an excellent conductor of electricity (slightly better than copper).

Graphene has a lot of potential in nanotechnology. IBM, Intel, Samsung, and other computer chip manufacturers are researching ways to use graphene in computer chips, by modifying it to make it a semiconductor. Researchers are also using graphene in composite materials, creating plastics that conduct electricity. Eventually, graphene might be in thin, flexible electronic components, transparent touch screens, and organic solar cells.

Credits and rights

Image of flexible graphene circuit courtesy Ji Hye Hong.

Image of graphene integrated circuit courtesy IBM.

Image of graphene sheet courtesy Jannick C. Meyer.

The background information presented in this guide was adapted from:

- "Applications Activity: Nanoarchitecture," developed by the National Science Foundation-supported Internships in Public Science Education (IPSE) Program at the Materials Research Science and Engineering Center (MRSEC) on Nanostructured Materials and Interfaces at the University of Wisconsin-Madison. The original activity is available at: mrsec.wisc.edu/Edetc/IPSE/educators/carbon.html.
- "Carbon Nanotubes & Buckyballs," developed by the National Science Foundation-supported Materials Research Science and Engineering Center (MRSEC) on Nanostructured Interfaces at the University of Wisconsin-Madison. The original activity is available at: mrsec.wisc.edu/Edetc/nanoquest/carbon/.
- "Nanoarchitecture: Forms of Carbon," developed by the National Science Foundation-supported Internships in Public Science Education (IPSE) Program at the Materials Research Science and Engineering Center (MRSEC) on Nanostructured Materials and Interfaces at the University of Wisconsin-Madison. The original activity is available at: mrsec.wisc.edu/Edetc/IPSE/educators/activities/carbon.html.

This project was supported by the National Science Foundation under Award No. 0940143. Any opinions, findings, and conclusions or recommendations expressed in this program are those of the author and do not necessarily reflect the views of the Foundation.