Teacher's Preparatory Guide

An Easy (Bake) Approach to an Edible Nano Lab

Purpose:

The purpose of the lesson is to get young students interested in basic nanotechnology concepts associated with creating "wafers" used in chip fabrication in cleanrooms. Cleanrooms are used to make nanoscale devices with the most common ones being chips used in electronic devices The lesson also provides students with a general overview of the purpose and use of a completed wafer, a better understanding of how a wafer is created using standard nanotechnology lab equipment, and a hands-on creation of a simulated wafer model using a common toy in this edible science lab activity.

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Time required: One Hour

Level: Middle School physical or general science

Big Ideas in Nanoscale Science and Engineering:

- Models and Simulations
- Size and Scale
- Forces and Interactions

Teacher Background:

Teaching younger children applications associated with nanotechnology can be quite daunting based on their inabilities to process complex concepts. Not only is scale an abstract principle that is difficult for young adolescents to understand, the use of common lab equipment can be very challenging to comprehend. By using an EasyBake® oven and a spinning apparatus made of simple, easy-to-find components, middle school students can learn basic science concepts and develop their understanding of wafer fabrication which is an important part of nanotechnology processes and methods. Intel has excellent resources to explain this process (see resources). In preparing the teacher to discuss these concepts, key vocabulary, tied directly to nano-based applications should be addressed:

Wafer: A disc-shaped device that is made of a single crystal of silicon and is used to hold "nano-developed" devices and information used in a research setting.

Spinner: A machine used to evenly disperse liquid material over a surface as typically used in wafer applications in a nano-based lab environment (cleanroom).

Etching The process of making grooves or patterns on the surface of a material as typically used in wafer applications in a nano-based lab environment.

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Coating: The process of applying a uniform layer of material over an object as typically used in wafer applications in a nano-based lab environment.

As students prepare the "wafer" in the spinning device, the teacher can discuss the need to have "uniformity" (e.g. sameness) in their cake/brownie mixture as it is spread across the baking pan in the spinning process. Next, the evenly spread mixture is sent to the oven where it bakes and hardens, similar to the preparation of a wafer in a lab setting. Once baked, the cake/brownie mixture is ready for the hole-punched pattern to be placed on top and have sprinkles added. This represents a mask placement in a traditional nano-based lab environment. Finally, the candy coating topping is added and let to cool. This illustrates a coating process that is used to seal all components on a wafer.

Materials: The following materials are needed for the completion of this lab:

- A sample wafer and/or silicon chip that students will be allowed to pass around the class and view. Many electronic devices contain these chips and it is easy to access one from unwanted electronic devices.

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- An EasyBake® oven (hint: These can often be found used at various thrift stores, in their toy departments, for minimal expense often below $5.00)
- Metal baking tins for the over (comes with oven as standard equipment or can be purchased at retails stores in the kitchen appliance or housewares departments)
- Spatula (same as above or use a regular kitchen spatula to push the container into the oven)
- A 100 watt light bulb for the oven
- Packaged cake or brownie mix (Duncan Hines® Snack Size Brownie Mix works best)
- Water
- Eggs (optional)
- Vegetable oil
- Spray-on vegetable non-stick coating
- Sprinkles (available at local grocery on the baking aisle)
- Smucker's® Magic Shell Ice Cream Topping (available at local grocery)
- A freezer unit or refrigerator with a small freezer
- 3-5 quart plastic container and lid large enough to hold the computer fan
- A D cell battery (recommended) or larger 6-volt lantern battery
- A 120mm direct current computer fan assembly (Note: AC current assembly will not work for this device). This device can be found at any electronics store specializing in computer parts such a Fry's or Radio Shack.
- Loose electrical wires or alligator clips and a Switch (optional – available at most electronics stores specializing in computer parts such as Frye's and Radio Shack)
- Clear or Masking Tape
- Construction Paper
- Single Hole Puncher
- Cups – plastic to hold batter for each group
- Paper Plates
- Markers or pencils
- Scissors
- Insulated gloves
- Aprons

Safety Goggles or Safety Glasses

Advance Preparation:

-Collect materials for construction of the spinner as discussed next (Illustration 1). Prepare the "spinner" device by placing the computer fan motor into the plastic container (Illustration 2). By cutting the ends of the wires, a positive and negative connection must be established between the fan and the battery. Cut or punch a small hole in the side of the container for the wires to pass through. This will allow the fan to spin inside the "closed/sealed" container and minimize splattering of the cake/brownie mix. Students must connect the wires directly to the battery with tape when performing the lab, or an optional switch (Illustration 3) may be connected and attached to the side of the container.

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Illustration 1

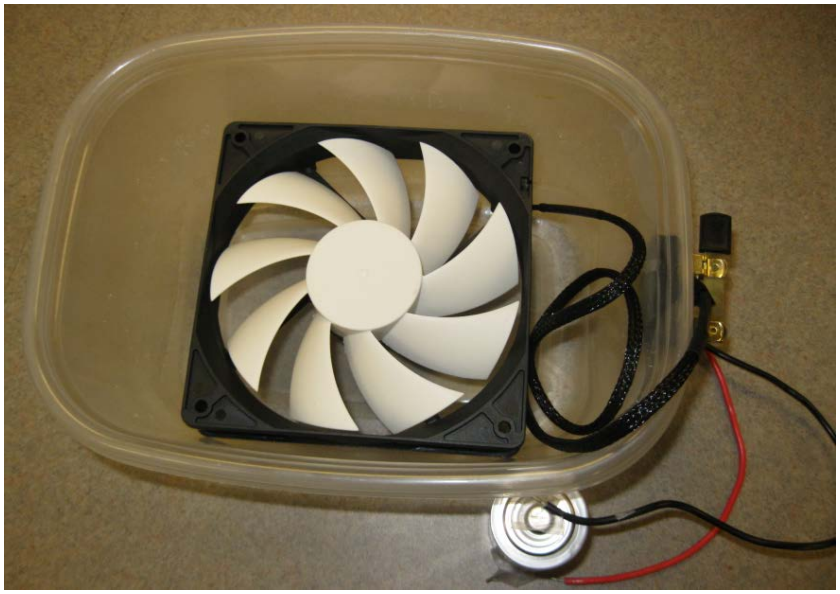
Illustration 2

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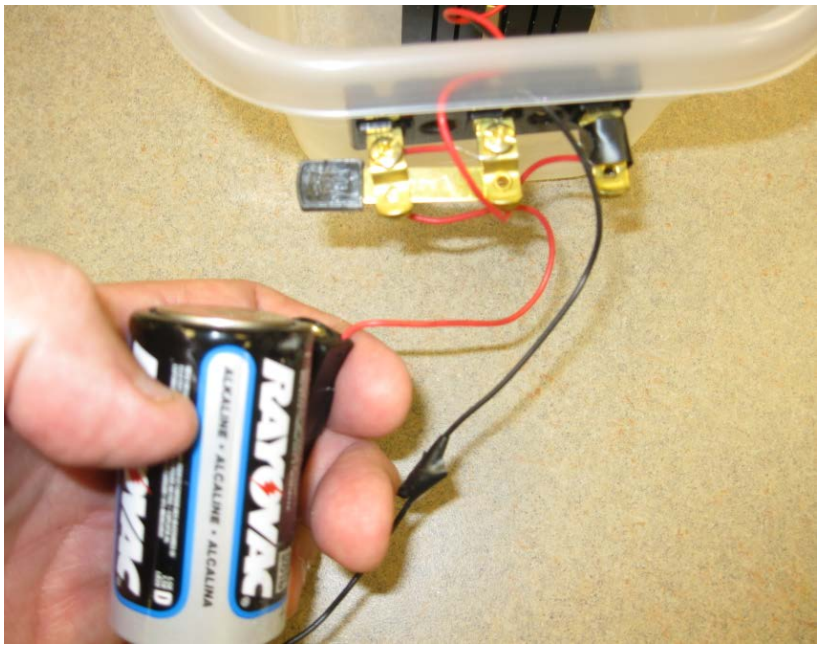
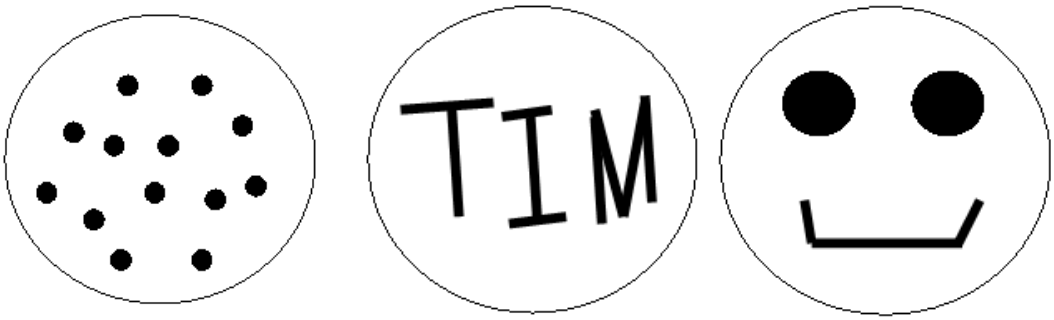


Illustration 3

-It is recommended that the teacher prepare the cake/brownie mix prior to lesson and has this ready in prepared cups to accelerate the completion of the lesson. Directions for the preparation are included in the packaging of the chosen mix. Note: Due to potential student food allergies, the addition of eggs is used at the discretion of the teacher. This lab will be able to be completed without the use of eggs. However, egg substitutes may also be used in lieu of eggs.

-Students should pre-cut a pattern with the construction paper that is the same size as the baking container. Students have the option of using a hole puncher or scissors to create a pattern of their choice. This will represent the "mask" on the edible wafer.

Examples of Patterns (Masks)



Safety Information:

Students are advised to wear eye protection, due to the potential of flying debris, and an apron or other clothing protection. Insulated gloves are also advised due to the use of the oven. Students should also be warned not to place their fingers in the blades of the turning computer fan and use caution when touching the pans when they are taken out of the hot oven.

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Directions for the Activity:

- Students are shown a sample lab "wafer" while the teacher discusses the application of this edible lab as it relates to the creation of a wafer in a cleanroom environment.

- The following clips may be used to illustrate chip/wafer production:
  http://www.youtube.com/watch?v=aWVywhzuHnQ

  http://www.youtube.com/watch?v=Q5paWn7bFg4

- Students may also be interested in seeing a cleanroom in action. There are live cameras in the Georgia Institute of Technology cleanroom at:
  http://cleanroom.ien.gatech.edu/cameras/
  - or they may take a virtual tour at:
    http://www.mcrel.org/nanoleap/remote_access/cleanroom.asp

- Students will spray their baking container will non-sticking cooking/baking spray. This will aid in the lab clean-up.
- Students will pour pre-mixed cake/brownie batter into their baking container. The batter should fill half the container since the mix will rise when baking.
- Students will curl tape. The curled tape will go on the bottom of the tin tray and will help hold the mixture in place when on the fan motor. This will guarantee that the tray stays in place when the fan motor turns on. It also allows the participant to center the tray on the fan to make sure mixture is "evenly divided." Students place their filled baking container on top of the spinning device. As students start the spinner by attaching wires to the corresponding battery leads, they will make adjustments to the baking container in attempts to make sure its spins evenly in its rotation. They will spin their baking container for approximately 10-15 seconds or until the mixture is spread evenly across the container.

Container (empty in above picture) loaded on "spinner" device

- Students will remove their container from the spinning device and insert the container into the pre-warmed EasyBake® oven for approximately 2-3 minutes. They should watch the mixture as it rises and remove once they notice a crust forming on top of the mixture.
- Remove the container and let the mix cool.
- Students will spray a light coating (one second spray) of the cooking/baking spray on top of the mixture. This will aid in the sprinkles sticking to the baked mixture.
- Students will apply their pre-designed pattern (mask) on top of the cooled mixture and add sprinkles over the pattern, ensuring the sprinkles are sticking to the baked mixture. Students should be reminded to lift the pattern off the mixture by picking it up and not sliding it across the top of the mixture. This keeps sprinkles in place.
- Students should place the container into the oven for 30 seconds to guarantee that the sprinkles stay in place.
- Once removed from the oven, students should pour a very light layer of the Smucker's® Magic Shell Ice Cream Topping onto the top of the mixture with the sprinkles. Students should be advised that adding too much topping will minimize their ability to see their design.
- Students will place their containers into a refrigerator's freezer for approximately five minutes to allow the topping to cool.
- Students may consume their wafer after class is allowed to see the various designs.

Procedure (from Student Activity Guide)

(Prior to lab, your teacher will guide you in completing a pattern)

a. You will need to spray your baking container with non-sticking cooking/baking spray. This will aid in the lab clean-up.

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b. Next, pour pre-mixed cake/brownie batter into our baking container. The batter should fill half the container since the mix will rise when baking.
c. You will then curl tape and place your filled baking container on top of the spinning device. As you start the spinner by attaching wires to the corresponding battery leads, you will make adjustments to the baking container in attempts to make sure its spins evenly in its rotation. You will spin your baking container for approximately 10-15 seconds or until the mixture is spread evenly across the container.

Container (empty in above picture) loaded on "spinner" device

d. Next, remove your container from the spinning device and insert the container into the pre-warmed EasyBake® oven for approximately 2-3 minutes. You should watch the mixture as it rises and remove once you notice a crust forming on top of the mixture.
e. Remove the container and let the mix cool.
f. Next, you will spray a light coating (one second spray) of the cooking/baking spray on top of the mixture. This will aid in the sprinkles sticking to the baked mixture.
g. Next, you will apply your pre-designed patter (mask), done prior to lab, on top of the cooled mixture and add sprinkles over the pattern, ensuring the sprinkles are sticking to the baked mixture. You should lift the pattern off the mixture by picking it up and not by sliding it across the top of the mixture. This keeps sprinkles in place.
h. You should then place the container back into the oven for 30 seconds to guarantee that the sprinkles stay in place.
i. Once removed from the oven, you should pour a very light layer of the Smucker's® Magic Shell Ice Cream Topping onto the top of the mixture with the sprinkles. Be advised that adding too much topping will minimize their ability to see your design.
j. Next, place your container into a refrigerator freezer for approximately five minutes to allow the topping to cool.

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k. You may consume our wafer after the class has been allowed to see the various designs of the other students.

Cleanup: This can be a very messy lab. Care must be taken to disassemble the oven for thorough cleaning either in a dishwasher or simple wash in sink. Ensure that the bulb is removed and any wiring does not come into contact with water and is, instead, wiped clean and dried prior to next use.

Worksheet (with answers)

Explain the term "wafer."

A disc-shaped device that is made of a single crystal of silicon and is used to hold "nano-developed" devices and information used in a research setting.

Explain how a silicon chip/wafer is used.

Silicon chips are used in computers and other electronic devicesand have nano scale features.

What are the steps in creating a wafer?

1. *Spin the material to provide a uniform application throughout.*
2. *Bake the wafer by applying heat.*
3. *Make etches or patterns to the wafer.*
4. *Bake again to seal in changes.*
5. *Apply a coating to seal and protect the wafer.*

Explain the term "coating."

The process of applying a uniform layer of material over an object as typically used in wafer applications in a traditional nano-based lab environment.

Explain the term "etching."

The process of making groove or patterns on the surface of a material as typically used in wafer applications in a traditional nano-based lab environment.

What is the purpose of the "spinning" application?

A spinner is a machine used to evenly disperse liquid material over a surface as typically used in wafer applications in a traditional nano-based lab environment. Spinning allows an "even" application.

Explain the term "uniformity."

Same, evenly distributed

How do the sprinkles relate to the wafer?

They represent nano-sized materials that would be laid onto the top of an actual wafer.

Explain the representation of the chocolate coating as it relates to the wafer.

This represents a film to be added to the surface of the wafer sealing all etches and additions to the wafer securely on the inside while also adding a level of protection to the wafer.

What is the role of the oven in the creation of a wafer?

The oven adds the energy to seal and solidify any changes made to the wafer.

Assessment and rubrics

As this lab is presented as a guided application practice, it is suggested that the edible component (final edible product) not be assessed due to the differences in the completion of the baking process. However, the student activity sheet (attached) provides an option for assessment. The following is a rubric to grade responses

The student is able to explain the term "wafer."

Strongly agree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	2	3	4	5

The student was able to accurately explain the uses of a silicon chip/wafer.

Strongly agree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	2	3	4	5

The student was able to explain how the wafer is created by identifying steps in the creation.

Strongly agree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	2	3	4	5

The student is able to define the term "coating."

Strongly agree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	2	3	4	5

The student is able to explain the term "etching."

Strongly agree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	2	3	4	5

The student is able to explain the purpose of the "spinning" application.

Strongly agree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	2	3	4	5

The student is able to explain the term "uniformity."

Strongly agree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	2	3	4	5

The student is able to explain the representation of the sprinkles as they relate to the wafer.

Strongly agree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	2	3	4	5

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The student is able to explain the representation of the chocolate coating as it relates to the wafer.

Strongly agree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	2	3	4	5

The student can explain the role of the oven in the creation of a wafer.

Strongly agree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	2	3	4	5

Resources:
To learn more about nanotechnology and chip making, here are some web sites with educational resources:

- http://www.intel.com/about/companyinfo/museum/exhibits/sandtocircuits/facts.htm
- http://newsroom.intel.com/docs/DOC-2476
- http://pcplus.techradar.com/2009/05/21/how-silicon-chips-are-made
- MEMS – Making Micromachines DVD http://www.siliconrun.com/sr_mems.shtml
- How Microprocessors Work at How Stuff Works: http://computer.howstuffworks.com/microprocessor1.htm

National Science Education Standards:

Middle School Content Standards
• Standard A
- Identify questions that can be answered through scientific investigations
- Recognize and analyze alternative explanations and predictions
- Communicate procedures and explanations

• Standard B
- Properties and changes of properties in matter

• Standard E
- Understandings about science and technology

• Standard F
- Science and technology in society

• Standard G
- Science as a human endeavor
- Nature of Science

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Next Generation Science Standards

MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural sources and impact society.

MS-PS2-1&4: Models can be used to represent systems and their interaction

MS-PS-3C: Relationship between energy and forces

MS-ETS1-4: Developing and using models

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