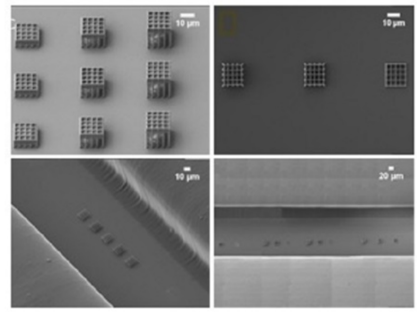
#ScienceAtHome

Nano at Home

Life is S’more Fun with Nanotechnology!





Science concept you will learn about in this activity: lithography

Safefy: Adult supervision needed for heating!

Background:
Lithography is a cheap method of printing invented in Germany in 1796. It was built on a simple chemistry concept that “like dissolves like,” a saying that chemists use to remember if liquids are miscible (which means mixable, two words that helpfully sound familiar). That is, liquids that are similar to each other are “more happy” to interact than materials that are different than one another. For example, water and vinegar mix well together, but vinegar and oil don’t mix well and eventually separate—which is why you need to shake up some salad dressings before you use them. This concept is called polarity. In this example, water and vinegar are polar, but oil is nonpolar.

Lithography harnesses the chemical concept of polarity to create artwork or print text! Originally, an image was drawn on a surface with something nonpolar (wax, fat, oil, etc) and then the surface would be treated with acid to etch into the non-covered surface. After the etching, the surface is cleaned. When the surface is made damp with water, the water would be retained in the rough surface where the acid had etched (creating a polar surface). Then an oil-based ink (nonpolar) could be applied and would be repelled by the water and move into the smooth areas of the surface that had originally been protected by the wax. Then a blank piece of paper could be pressed against the surface and the ink would transfer. This could be used to make multiple copies of a drawing or text!

This original version of lithography has been modernized to enable us to create nanotechnologies! The concepts remain the same, though. A product (called a mask) is used to protect a surface, which enables an action like etching to be performed on the unprotected areas. Today, the mask is cured, or solidified, using light, and the designs can be on the nanoscale. All these elements put together produce a process called *nanophotolithography*. Developing this process has helped make things like transistors even smaller, which enables industries to make smaller and smaller technology. (For more about nanoparticles and photolithography, see our blog post at sustainable-nano.com/2019/04/19/smore-fun-with-nanoscience.)

Experiment 1: S'more Lithography

In this activity you will use the concept of lithography to make a delicious dessert!

Materials:

- marshmallows (chocolate, graham crackers, and other delicious alternatives are optional)
- aluminum foil
- scissors or an x-acto knife
- tongs
- hair dryer or heat gun or magnifying glass or food coloring

****Safety**** Some steps will require adult supervision

Directions:

1. (optional) Leaving marshmallows to sit out on the counter overnight is helpful for drying out the surface to encourage browning. This will not affect the final flavor or texture of the marshmallow if you decide to roast it later.

2. Fold a piece of aluminum foil so that it is at least 6 layers but still wide enough to cover the whole marshmallow. We want to protect the marshmallow as much as possible from the heat.

3. Use scissors or an x-acto knife to cut out a shape. Remember that the open areas you cut (the negative image) is the shape that will appear on the marshmallow. Try to make the lines clean to make your design look as nice as possible! Giving the aluminum template a slight curve will help it form to the marshmallow better to prevent covered areas from being affected.

4. Put the marshmallow on a heat safe surface (I used a coated paper plate and that worked well) and cover with aluminum foil design.

5. Select a method of marshmallow lithography: heat gun, hair drier, sunlight & magnifying glass, or food coloring. Each method is described in detail below.

Example foil masks

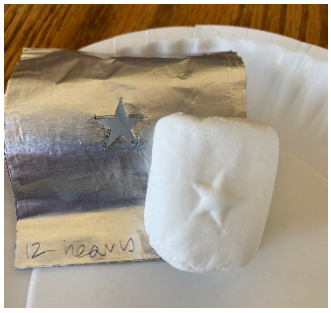
Method 1: Heat gun

This method roasts the exposed area and produces the most even and detailed results

a) **Using tongs** (to protect your fingers) hold the designed aluminum foil over the marshmallow. The foil should be in light contact with the marshmallow to prevent hot air from moving under the foil, but not pressed too firmly or the hot corners of your design may melt into the soft marshmallow.
b) Use a heat gun at the hottest setting, holding it around 6 inches from the marshmallow.
c) Heat the marshmallow until it browns. You may need to modify the distance and heat from the gun depending on your materials. It may even be necessary to occasionally move the foil away from the marshmallow if it is getting too hot.

Method 2: Hair drier

This method isn't hot enough to brown the marshmallow, but will produce a puffy design



a) **Using tongs** (to protect your fingers) hold the designed aluminum foil over the marshmallow. The foil should be in light contact with the marshmallow to prevent hot air from moving under the foil, but not pressed too firmly or the hot corners of your design may melt into the soft marshmallow.
b) Use a hair dryer at the hottest setting, holding it around 4 inches from the marshmallow.
c) Heat the marshmallow until the exposed area becomes puffy. You may need to modify the distance and heat from the hair drier depending on your materials. It may even be necessary to occasionally move the foil away from the marshmallow if it is getting too hot.

Method 3: Sunlight and a magnifying glass

This method requires a little finesse, but it's fun and a good way to use a sunny day. Best suited for more mature marshmallow enthusiasts.

a) Form the aluminum foil around the marshmallow so you don't need to hold it with your hands
b) Use a magnifying glass to catch sunlight and move the magnifying glass closer or further away from the marshmallow to focus the light into a strong point focused on your design.
c) Hold the light in place until it burns. This will generate multiple small fires that should stop as soon as you blow them out or remove the magnifying glass.
d) Repeated the previous step until you have burned in the design.
e) Interested in learning more about burning glasses? Check out the Wikipedia page at wikipedia.org/wiki/Burning_glass.

Method 4: Food coloring

This is a good alternative if you do not want to use heat. It also provides the most detailed results

a) On a non-absorbent surface (e.g. plate, wax paper, or aluminum foil) put 1-2 drops of each color of food coloring you want to use.
b) Hold the designed aluminum foil over the marshmallow.
c) Using a paper towel, q-tip, or paint brush, dab colors onto the exposed portion of the marshmallow.

Final step: Enjoy eating your marshmallows!

To make a s'more, sandwich 1-2 toasted marshmallows along with a piece of chocolate between two squares of graham cracker. The heat of the marshmallow will melt the chocolate and make a delicious gooey dessert!

Experiment 2: Crayon Lithography

In this experiment, you will use lithography will create a piece of art!

Materials:

- paper
- white crayon
- colored markers

If you don't have marshmallows at home, or just don't like them, this is a great alternative.

Directions:

1. Using a white crayon, draw a design on a piece of paper. It will be hard to see, but if you catch it in the light, you should be able to tell where you drew.
2. Use a colored marker to scribble over the drawing to fully reveal the art!

This process is actually the most similar to original lithography, since the wax (hydrophobic, nonpolar) protects the paper from the water-based marker (polar). When comparing to nanophotolithography, the wax acts as the mask (like the aluminum foil), the marker is similar to the heat, and the paper is the marshmallow.

Image credits: Experiment images by Stephanie Mitchell; page 1 lithography images from https://bannisterimages.com/blog/stone-lithography-printmaking & https://blog.timed-center.at/en/timed-projects/timed-center-core-facility-medical-3d-nanolithography-for-additive-manufacturing/