Student Worksheet

Understanding Scanning Probe Microscopes (SPM)

Introduction: A start-up company called ElectraMap has hired your team of consultants to use electric current to map a surface. This company would eventually like to be able to make images of very small surfaces that cannot be seen through an optical microscope. These surfaces are most likely at the nanoscale which is below the visible light range (380nm-740nm) which is why an optical (light) microscope is not an option to examine the surfaces. ElectraMap would like your ideas on how this might be done. Your team must advise this company how to increase the detail of the map to get the best image of the surface.

Pre lab: Sandpaper is measured by the number of abrasive particles per square inch, called *grit.* You will given 3 types of sandpaper that will feel significantly different in texture (see table at right). Use your fingertips to feel across the sandpaper. Answer these questions:

Grit	Feel
40–60	*Coarse*
80–120	*Medium*
150–180	*Fine*
220–240	*Very fine*
280–320	*Extra fine*
360–600	*Super fine*

1. What does sandpaper feel like?

2. Describe the textures.

3. What tool are you using to measure the grit?

4. What do your fingers represent?

5. Why does the grit with the highest number feel the smoothest?

6. How would this same sandpaper feel if your fingertip was as small as a needle?

Materials per group:

- egg carton
- 60.0 cm of aluminum foil
- permanent ink marker
- conductivity apparatus
- nail
- meter stick
- ring stand
- small ruler (inches/cm ~1 foot long)

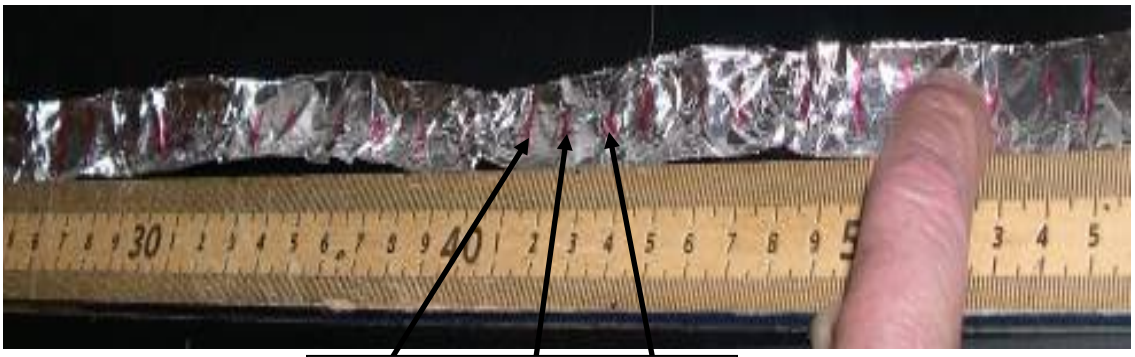
Directions for the Activity:

Question: How can you make a detailed map of a surface using an electric current?

Make a Prediction:

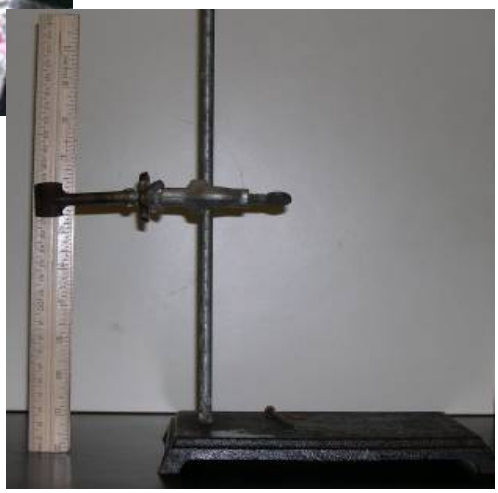
Procedure:

1. Cut the 60.0 cm-long aluminum foil into 4.0 cm-wide strips. Fold each strip over about 3 times so that it is about 1.5 cm wide. (This makes the foil less likely to rip unless you use heavy-duty foil.)
2. Mark each strip of aluminum foil with a permanent marker every 1.0 cm as shown below.



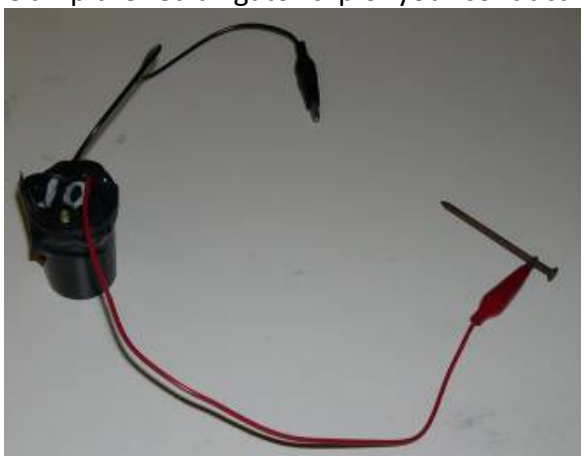
Markings on foil every 1 cm

3. Press the strip into the egg carton so that it follows the bumps in the carton as shown below. This will be your first surface to map.

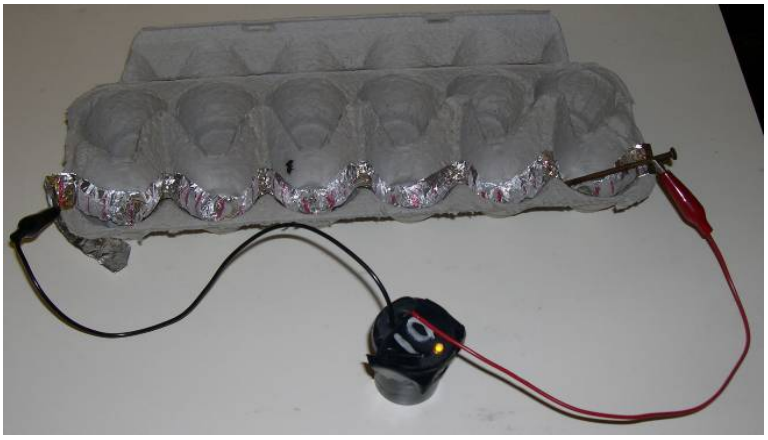


4. Clamp the ruler to the ring stand so that the ruler is perpendicular with the table (and touching the table). Make sure that the 0 cm/0 in mark touches the table.

5. Clamp the red alligator clip of your conductivity meter to a nail.



6. Clamp the black alligator clip to the left end of the aluminum foil.
7. Touch the nail to the foil. The LED should light. You are ready to take your first measurement.



8. Touch the tip of the nail to the foil so that the nail is perpendicular to the surface. The LED bulb should light.
9. Move the ruler near the nail so the flat edge of the nail is level with the marks on the ruler.
10. Record the height of the top of the nail in the chart on the next page.
11. Repeat steps 8–10 for the next mark. Continue to repeat this process until measurements have been taken across the entire surface. You may need to move the ring stand and ruler in front of the egg carton to get a more accurate measurement. Make sure that the nail is perpendicular to the surface for each measurement.
12. Repeat steps 8–11, but this time, measure every 4th mark.

Analysis: Record the height and position in the table below. Graph both data sets with the position as the *x*-axis and the height as the *y*-axis.

Measurement set *A*		**Measurement set *B***	
Position (cm)	**Height (cm)**	**Position (cm)**	**Height (cm)**

Questions:

1. Compare the graphs of measurement sets *A* and *B.* Which measurement set more closely resembled the surface? Why?

2. What happened to the accuracy when you gathered the data at every 4th mark?

3. Notice the first data point on your graph. This is not the actual height of the surface. Explain what you would need to do to make a graph using the actual heights of the surface.

4. How would the accuracy of your data change if you had more data points for the position?

5. How would tip size affect your results if you were using more data points as in question 4? Can you draw examples?

6. What could you image if you kept making the tip smaller? Give examples.

7. If you were looking for a certain feature, might less accuracy be better? Explain.

8. What would happen to the image if you were looking at very small things and loud music was playing nearby?

Conclusion: Create a written report on your recommendations to the ElectraMap Company. Remember they want to be able to image very small surfaces that cannot be seen with an optical microscope. These surfaces are most likely at the nanoscale and therefore below the visible light range. Include how to use electricity to get the most detailed image of a surface using your recommended techniques (s). Be specific and include measurements and drawings when possible.