

Name: _____ Date: _____ Class: _____

Student Worksheet

Small Scale Sculpting: Guided Inquiry I

Safety

Be careful not to splash vinegar in your eyes; it is an irritant. Hot plates may cause burns.

Introduction

You will sculpt a piece of chalk with a process called *etching* by using etch mask materials and acid. You will etch features on the chalk using a process similar to that used to make computer chips—only the computer chip features are 1,000 times smaller!

Materials

- chalk of 2 mask designs
- 50 ml beaker of vinegar
- pH paper
- timer
- 6 oz cup of water
- paper towel
- caliper
- calculator

Question: How can engineers sculpt tiny features?

Prediction: _____

Procedure: Etching Chalk

1. Measure the pH of the vinegar with pH paper. Record the pH.
2. Place **Mask #1** chalk upright into the beaker of vinegar. Record your observations.
3. After 4 minutes, remove the chalk. Place it into a cup of water. Stir gently for 10 seconds.
Remove the chalk. Place it on a paper towel to dry.
4. Dump used vinegar solution in sink, rinse out and refill with fresh vinegar.
5. Repeat steps 1–3 with **Mask #2**.
6. Measure the pH of the vinegar. Record the pH in the table below.

Record Your Observations

Chalk	Evidence of a chemical reaction	pH of vinegar: a) <i>before</i> experiment: _____
Mask #1		b) <i>after</i> Mask #1: _____
Mask #2		c) <i>after</i> Mask #2: _____

Analyze the Results

1. What evidence did you observe to indicate that a chemical reaction had taken place?

2. Why was the chalk placed in the water after the vinegar reaction?

3. How did constant stirring during the chemical reaction affect the resulting etch?

Procedure: Calculating the Etch Rate

- Carefully remove the tape off of **Mask #1**.
- Use the caliper to measure the diameter of the masked (taped) region and the diameter of the unmasked region. Record in mm.
- Complete the table below to calculate the etch rate of Mask #1.

Record Your Observations—Etch rate of Mask #1:

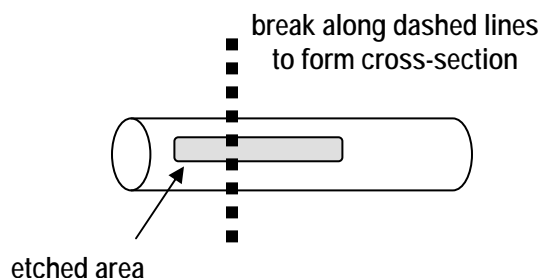
Diameter of masked region (mm)	Diameter of unmasked region (mm)	Diameter difference (mm)	½ of diameter difference (mm)	Time (min)	Etch rate (mm/min)

Question: What could you change to speed up the chemical etch rate?

Prediction: _____

Procedure: Observing Sidewall Profiles

1. Carefully remove the tape from **Mask #2**.
2. Carefully break the chalk (as shown in the diagram at right) *in the middle of the etched portion* of the chalk. This will form a *cross section* of the chalk.



3. Hold the chalk so that the circle part of the chalk is right in front of your eye. Notice the trenches. Draw an etch sidewall profile for each “trench” that you see in the space below.

Record Your Observations

<p>Sidewall profile of Wide Trench (Mask #1)</p>

<p>Sidewall profile of Narrow Trench (Mask #2)</p>

Analyze the Results

1. Compare the etch depth of **Mask #1** to that of **Mask #2**. Why is there a difference in etch rate between the two pieces of chalk? Explain.

2. Compare the sidewall profiles of the wide trench and the narrow trench.

3. Explain why the chalk did not etch straight down by using factors that contribute to the chemical reaction taking place.

Draw Conclusions

List the factors that may affect the etch rate of chalk in vinegar.

Student Worksheet

Small Scale Sculpting: Guided Inquiry II

Safety

Be careful not to splash vinegar in your eyes; it is an irritant. Hot plates may cause burns.

Introduction

Your goal is to design an etch process that not only has a fast etch rate but also a vertical sidewall. Tomorrow you will be given 5 minutes to etch and produce an etched chalk sample. Today, find out as much information as you can.

Materials

- chalk with Mask #1
- 50 ml beaker of vinegar
- digital timer
- 6 oz cup of water
- paper towel
- caliper
- calculator

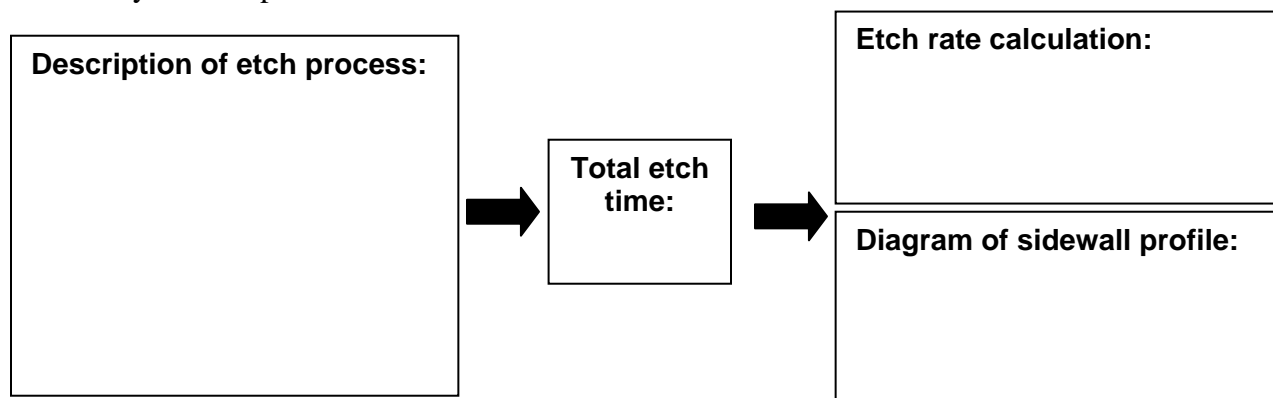
Question:

How can I make a fast etch rate with vertical sidewalls?

Prediction: Choose 2 factors of the chemical reaction to change. Be sure to explain how each factor affects the chemical reaction (with a fresh piece of chalk with the Mask #1 design).

Procedure: Design an Etch Process

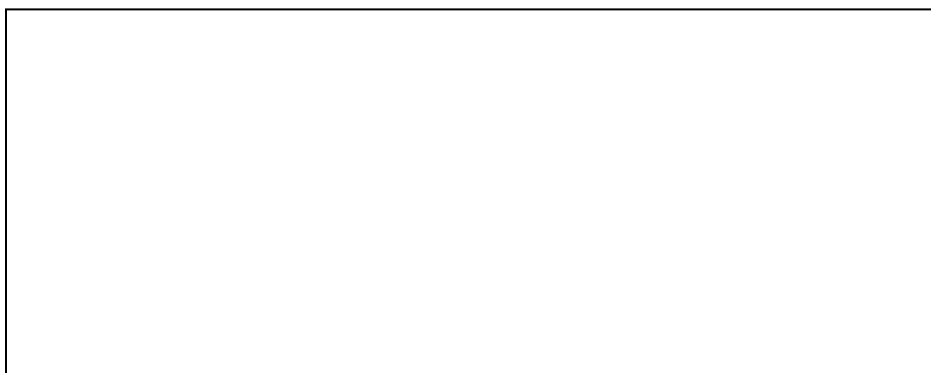
Describe your etch process in detail below:



Record Your Observations

Etch factor tested	Etch rate (mm/min)	Sidewall profile (sketch diagram)	How does the factor affect the chemical reaction?

Roll your chalk on an ink pad. Then, roll the inked chalk in the space below to print the design:



Analyze the Results

1. Was your etch rate faster than yesterday? If so, by how much?

2. Were your sidewalls vertical? If not, describe what they look like.

Draw Conclusions

What may have caused results of the etch to turn out differently from what you expected?
