Dynamic Design: A Collection Process

Enough is Enough

TEACHER GUIDE

BACKGROUND INFORMATION

In Part I of "Enough is Enough," students will make a model of a cross section of the wafer at a width of 100 nanometers. They will use beans to model the wafer materials, solar wind particles, and contaminants. Students will then model the process by which contaminants are removed before analysis takes place. In Part II, students will begin to learn about working on a product design team (PDT) by organizing this activity into a designer's notebook. This process will continue in the assessment activity in this module where students will use the full PDT approach. The purpose here is not the construction of wafers. This activity focuses on contamination and how to deal with it. An activity on constructing wafers on the array frame will be featured in the upcoming module, *Dynamic Design: The Clean Room*. Students will measure the mass of the sand collected on frames of different shaped wafers. In this case the sand represents solar wind particles. Students will investigate the amount of contamination collected with the sand by observing a sample of the sand under a microscope and counting the number of grains that are a certain color. Students will then brainstorm ways that contamination can be kept to a minimum. At the conclusion of this activity, students complete a presentation of the problem, process, and solution. This activity provides an opportunity for teachers to make specific skill and knowledge assessments.

NATIONAL SCIENCE STANDARDS ADDRESSED

Grades 5–8
Science as Inquiry
Abilities necessary to do scientific inquiry
Science and Technology
Abilities of technological design.

Grades 9–12
Science as Inquiry
Abilities necessary to do scientific inquiry
Science and Technolgy
Abilities of technological design.

View a full text of the National Science Education Standards.

NATIONAL MATH STANDARDS ADDRESSED

Grades 9–12
Math Standard: Geometry
Represent and solve problems using geometric models.

View a full text of the National Math Education Standards.

MATERIALS

For each group of three to four students.

Part I

- Medium-sized transparent plastic cup
- Popcorn kernels (30 ml)
- Pinto beans or lentils (one half cup per group)
- Dried rice (30 ml)

Part III & IV

- About 15 cm piece of double-sided tape
- Small amount of cleaned beach sand (50 ml) (Can be sand box sand from discount department store)
- Scissors
- Background frame master (from briefing)
- One cm graph paper or transparency
- Triple beam balance

Part V

- Two dissecting microscopes or hand lens
- One 4x4 cm section of 1 mm graph paper on a transparency

Part VI

- Three different-sized spheres (BBs, beads, candies)
- Ring stand
- Graham crackers
- Clay or sticky tack
- Stopwatch and meter stick
- Student Text, "Micrometeoroids and More" (one per student)

PROCEDURE

Part I: Caution, Contaminants!

1. Explain to students that they will be modeling the location of contaminants and solar wind in the collector wafers. Provide materials and assist any group that may need help.

2. Ask students what the various parts of the model represent. (Beans represent collector material; popcorn represents contaminants; rice represents embedded solar wind.) Explain that the cup represents a cross section of the wafer that has a width of 10 nm. Where were most of the contaminants located in the model? (Most of the contaminants were located near the surface and most of the solar wind was located in the middle of the collector material.) How would you recommend the contamination be removed? (Answers will vary. Student may suggest using a laser or some mechanical method to remove the top layer.)

Alternate Strategy Tip

For a math extension, have the students calculate the ratio of the width of their model to the width of a solar collection wafer.

Part II: Getting Ready

1. Organize students into groups of 3-4. Explain the students' role as members of a product design team (PDT). If your students have completed the *Heat: An Agent of Change* module, this process will be familiar to them. Review the design process in the appendix if the students are not familiar with the process.

2. Explain to students that they will be keeping a designer's notebook to record information, data, and drawings by members of the PDT. They may organize their notebooks as they see fit, but the final notebook should contain the following elements:

   Design:
   - General concept: What are you trying to accomplish?
   - Design ideas and notes: How will you accomplish the task?
   - Sketches and diagrams: What does the product look like and how will it be put together? These may change over time.
   - Information sources: Where do your ideas come from?
   - Data and calculations: What are the results of completed tests?

   Summary Information:
   - What was accomplished each day?
   - What should be written at the end of each session?

3. Encourage each student to be responsible for a section of this notebook. Encourage all students to read and review the sections as they are completed.

4. Review the student procedure for Part III.

5. Hand out the procedure for constructing wafers. Remind students that their first job will be to complete the design component in their notebooks. After everyone agrees with the design, they may work on construction.

Part III: Constructing Student Wafers

Student Procedure:
1. Choose one design from the Student Activity "Finding The Perfect Fit" to test area and amount of particles it can collect.

2. Cut out the shapes and use double-sided tape. Find the area of each of the wafers by using the counting squares method.

3. Apply the wafers to the background frame. Cut out the outside of the frame. Once this is done, remove the protective paper from the outside of the double-sided tape and measure the mass of the frame and wafers. The mass in grams should be recorded.

4. Capture sand particles onto the double-sided tape by blowing on sand with a straw or small fan causing the sand particles to move onto the tape. The mass will then be measured and recorded. Using subtraction, calculate the mass of the sand that was collected

Part IV: Constructing Hexagon Wafers

1. Students will repeat the above process using the hexagon shaped wafers similar to those that will be used by Genesis scientists. Ask the students to write a problem statement that includes variables. For example, “How does the area of the wafers on the frame affect the mass of sand collected?” A next step would be to have the students list the independent and dependent variables (I.V. = area of wafers, D.V. = mass of sand collected). Students should list the variables to be controlled (amount of sand poured onto the frame, the amount of time for students to shake the sand off, etc.). Then ask students to write a hypothesis using the variables. As the area of the wafers increase, the mass of the sand collected also increases. Area and mass will again be calculated. Students will then compare the amount of particles collected using both their shaped wafers and the hexagon shaped wafers. Once again, before any construction begins students need to complete the design phase in their notebooks.

2. After the students have conducted their experiments for Part II, students should write a conclusion statement that answers the problem statement and uses data to support this answer. Students should evaluate two designs and recommend either the student design, hexagon design or another design, that would need to be tested.

Part V: Counting Contaminants

> **Alternate Strategy Tip**
>
> You may ask interested student to collect micrometeoroids. Go to http://learn.jpl.nasa.gov/micromet.htm to learn how.

1. Hand out the Grading Checklist to the students and review your expectations. Discuss the criteria for evaluation with the students.

2. Students will use a microscope or hand lens, a representative sample from their wafer design, and the one mm graph transparency to count the number of colored sand particles. The teacher chooses which color of grain will represent the contaminants. If the sand does not have any observable colored grains, teachers may add glitter or another substance that is easily identifiable. Each student should complete this procedure and the students within each group should average their results.

3. In groups, students will then brainstorm ideas for reducing contamination. After organizing and categorizing the ideas they will include in the report, students should write their plan in their report.

4. Students write a report to the Jet Propulsion Laboratory that includes the following:
    1. Cover sheet (with descriptive title)
    2. Abstract or overview
    3. Introduction (problem statement and rationale for design)
    4. Body of the Report
        A. Purpose or problem statement (all parts)
        B. Variables identified (Parts II, III)
        C. Hypothesis statement (Part II)
        D. Description of the design (materials, written description, diagrams)(all parts)
        E. Results of the experiment (all parts)
        F. Conclusion and inferences from the experiment (all parts)
    5. Conclusion section (including recommendations for controlling contamination and clean up)
    6. Appendix (resources used, etc.)

5. Have the students read the text, "Micrometeoroids and More!"

The following grading rubric can be used to assess the "Wafer Construction" design activity final report. There are 20 possible points. If further detail is desired, the tool may also be used as a rubric, where each item is scored on a scale of 1-5, with "5" being full credit, making 100 possible points.

1. Introduction:
    ______ Cover sheet is included with a descriptive title
    ______ Abstract summarizes problem, experiments and results of each section
    ______ Statement of problem is clear, concise, and understandable

2. Body of Report:
    ______ Purpose statement describes each part of the experiment
    ______ Independent, dependent, and control variables are identified
    ______ Hypothesis including variables is clearly written
    ______ Materials are listed in an organized manner
    ______ Descriptions have qualitative observations
    ______ Diagrams are neat and accurately represent design
    ______ Formulas and calculations are appropriately displayed
    ______ Quantitative data is clearly organized in chart or table form
    ______ Data is interpreted and discussed
    ______ Modifications made to experimental design are communicated clearly as well as analyses, which led to consideration of redesign
    ______ Each experiment includes a conclusion statement that summarizes the data from that experiment
    ______ For each conclusion, an inference is written that explains why the event may have happened
    ______ For Part II, a statement showing whether students support or reject their hypothesis is included

3. Conclusion:
   _______ Conclusion statement that summarizes all parts is clear and concise
   _______ Recommendations for future design tests are clear and concise
   _______ Appendix including reference books, or initial designs or future designs is included

4. Other
   _______ Experiments were conducted in a safe manner and problems were reported to the teacher as they occurred

Part VI: It's a Hit!

This activity is a simulation of tests that were done at Johnson Space Center's Impact Laboratory to measure the effects of micrometeoroid impacts on the silicon wafers. The following text is a synopsis of the experiment:

> Three tests were performed in October 1995 using nylon spheres launched by a two-stage light-gas gun to impact with a velocity near 7 km/s. The projectile sizes were 164 microns, 238 microns, and 344 microns, all within the size needed for perforation. The wafer was held by rubber washers that should have mechanical properties roughly similar to the wafer fasteners for the spacecraft. The 164 micron projectile just perforated the wafer. A clean, single crack was observed in all tests. The observed crack in each test wafer seemed to be cleavage along the direction of crystal orientation. The washer support held the wafer intact so that no collector material was lost. It therefore appears that minimal damage will be incurred by perforating impacts. http://www.gps.caltech.edu/genesis/DocumentN.html

In this activity students will use crackers to simulate wafers. Student design teams will mount the cracker(s) onto the ring of a ring stand. Students will drop different projectiles from the same height and observe how the cracker is affected. If stop watches are not available, students can calculate the time by using the formula distance = ½ gravitational acceleration constant times time, squared.

$D = \frac{1}{2} at^2$

Distance = $\frac{1}{2}\ 9.8\ m/s^2 t^2$, solve for t.

> **Alternate Strategy Tip**
>
> Use a VCR camera to record the experiment. Replay the activity in slow motion using the frame counter. A VCR runs at 30 frames per second.

Students will also measure the speed at which the projectile is dropped (speed = distance/time) and compare this with the speed described in the above experiment. Size of the projectiles will also be compared.

REFERENCES

Book:

Zeilik, Michael. (1991). Astronomy, The Evolving Universe (pp.238-239). New York: John Wiley & Sons, Inc.

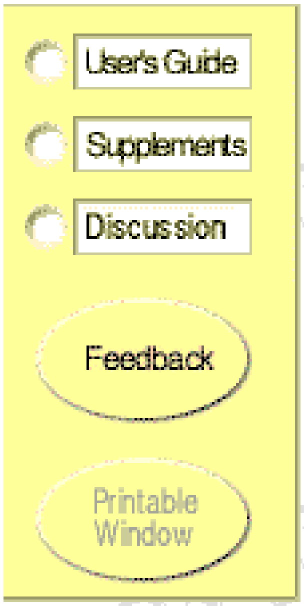
World Wide Web:

http://www.shuttle.nasa.gov/shuttle/archives/sts-82/crew/answers/answer17.html
Hubble Space Telescope and Micrometeoroids

http://learn.jpl.nasa.gov/micromet.htm
Edcuators Guide to Micrometeoroids

http://www-curator.jsc.nasa.gov/curator/genesis/Collectors.htm
JSC Genesis Team Collectors

http://www.gps.caltech.edu/genesis/DocumentN.html
Micrometeoroid Background and Genesis Contamination



NCTM Principles and Standards for School Mathematics Electronic Version: Discussion Draft (1998)