UNIT ACTIVITY:
WAFER THICKNESS

What do automobiles, singing Barbie dolls, cell phones and computers have in common? To a worker in the semiconductor industry, the answer is obvious – they all use microchips, tiny electronic circuits etched on chips of silicon (or some other semiconductor material).

Manufacturing microchips is a complex process. It begins with cylinders of silicon, called ingots, which are 6 to 16 inches in diameter. The ingots are sliced into thin wafers, which are then polished. (See Figure 3.11.) The polished wafers are imprinted with microscopic patterns of circuits, which are etched out with acids and replaced with conductors (such as aluminum or copper). Once completed, the wafers are cut into individual chips. (See Figure 3.12.)

In order to remain competitive in a global market, American companies must process microchips correctly and repeatedly with almost perfect consistency. The only way to accomplish this is to measure and control all of the highly complex processes used to manufacture microchips. These companies rely on statistical techniques to ensure quality control at critical points in the processing. It is simply too costly to wait until the end and then reject defective chips.

Figure 3.11: Silicon ingots and polished wafers.

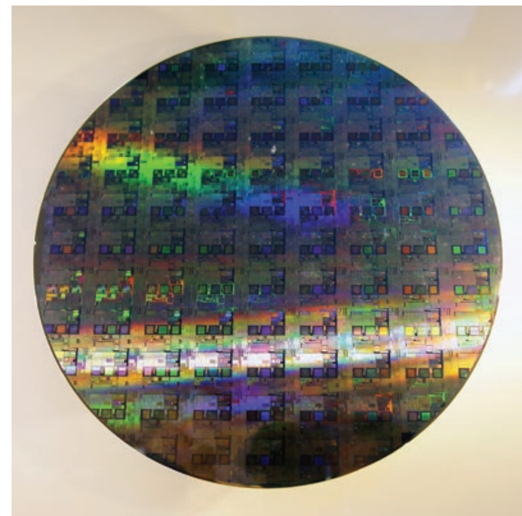

Figure 3.12: The grid pattern shows individual microchips on a wafer. (Credit: Peellden)

One critical stage in the manufacture of microchips is the grinding and polishing processes used to produce polished wafers. The wafers need to be consistent in thickness, not warped or bowed, and free of surface imperfections. The focus in this activity will be on adjusting controls in order to produce polished wafers that are consistently close to 0.5 mm in thickness.

The Wafer Thickness tool found in the Interactive Tools menu allows you to set three controls that adjust the grinding and polishing processes. Each control has three levels. After setting the controls, you can take a sample of polished wafers and measure their thicknesses.

1. Set all three controls to 1. Select a sample size of 10 and select Real Time mode. Then press the "Collect Sample Data" button. Watch as the sample wafers are measured. A graphic display (called a histogram) is formed in real time as data become available.

a. Describe what happens to the graphic display each time a new data value is added to the table. In other words, how is the histogram constructed?

b. Describe the shape or features of the histogram. Here are some questions to consider when describing the shape of the data:

- Is the histogram roughly symmetric about some center?
- Is there one interval that contains more data than other intervals?
- Are there any gaps between bars? In other words, are there intervals that do not contain data?
- In what interval did the smallest data value fall? In what interval did the largest data value fall?
- If you had to summarize the location (or "center") of these data with one number, what number would you choose? How did you choose this number?
- Do you think the controls are properly set to produce wafers of consistent 0.5 mm thickness?

2. a. Would another sample of 10 wafers manufactured under the same control settings as your first sample behave exactly as the first sample? To find out leave all settings as they were in Question 1 and click the "Collect Sample Data" button.

b. Answer Question 1b for the new sample.

3. Leave all settings as they are. Click the “Jump To Results” button. The sample size is now set at 25. Collect two more samples by clicking the “Collect Sample Data” button twice. Then click the “Compare to Previous” button. What characteristics do the two histograms have in common? How do the two histograms differ?

The manufacturer wants wafers that are 0.5 mm thick. However, it is not possible to grind and polish wafers so that every wafer has a thickness of exactly 0.5 mm. There will always be some variability in thickness. Hence, the problem is to determine the control settings that produce wafers that are consistently close to 0.5 mm in thickness. For the remainder of this activity, use the “Jump To Results” mode for data collection and select 50 for the sample size. (You could use sample size 25, but you may find that using the larger sample size gives better results.)

4. Your first task is to determine how each control affects the thickness of a sample of wafers. In other words, you should answer the following questions:

- How do the settings of Control 1 affect wafer thickness?
- How do the settings of Control 2 affect wafer thickness?
- How do the settings of Control 3 affect wafer thickness?

a. You will need to be systematic in how you change the controls so that you can determine how each control affects wafer thickness. Describe the strategy you will use to collect data that will allow you to answer the question about the controls. (You may need to collect more than one sample from each set of control settings before you are able to see changes in the data.)

b. Carry out the strategy you have outlined in (a). Describe what affect Controls 1, 2, and 3 have on wafer thickness. Print (or draw) some histograms that support your conclusions.

5. What control settings would you recommend in order to produce wafers that are consistently close to 0.5 mm in thickness?

Explain why you chose the settings that you did.