

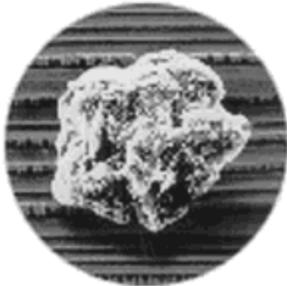
## The Journey Inside<sup>SM</sup>: Microprocessors Student Handout: How Clean Is Clean?

### How Clean Is Clean?

You know that the transistors and other components on a chip are very small and that the electrical wires between the transistors are very thin. Scientists use a unit of length called a micron when referring to chips. One micron is a millionth of a meter. This is a very small unit of measure. A human hair is about 100 microns in diameter.

The wires between components in a chip are 0.13 microns wide. Can you imagine a wire that is about 1/1000th of the diameter of a human hair?

A strand of hair is huge compared to the size of the components on a chip. The transistors on a chip are so small that a chain of 2,400 transistors could be placed around a strand of hair. The connections between transistors are about 1/1000th the diameter of the same strand of hair. This size difference means that if an eyelash or strand of hair falls on a chip during the fabrication process, thousands of transistors can be destroyed.



A dust speck landing on the chip's surface during fabrication ruins the chip.

Dust particles range from 1-400 microns in diameter. Pollen grains are about 10-80 microns in diameter. These particles are very large compared to the width of the wires in a chip. Fabrication of chips is done in a building called a fab. A special room in the fab—the clean room—is where the chips are made. To build a modern, fully equipped fab costs more than one billion dollars.

One of the key features of a clean room is its lack of contaminants. Because a single hair or a dust particle can ruin an entire chip, air must be thoroughly filtered. The workers in the clean room wear bunny suits to help reduce contaminants. The cleanest room you might be familiar with is an operating room in a hospital. People entering this room take special steps to ensure they do not carry contaminants into the room. However, the air in the clean room needs to be much cleaner than the air in a hospital operating room.

### Activities

1. Take a careful look at a strand of human hair. A strand of hair is about 100 microns in diameter. Can you see the end of the strand of hair? Take a look at various strands of hair. You might want to look at the hairs from some animals as well as different people. (A magnifying glass or microscope may prove helpful.) Report on the results of your exploration.

2. The transistors on a chip are extremely small. If a chip that is 2 centimeters wide uses transistors that are 0.5 microns wide, you could place approximately 40,000 transistors side by side in a line across the chip. That is not something you can see. The following explorations help you to visualize just how small such components are.
  - a. Measure the width of each of the materials listed in the table below.
  - b. If this number represented the width of a single transistor, calculate how large the chip would need to be to hold 40,000 transistors in a line across its surface.
  - c. If any dirt lands on a chip during manufacture, many components are ruined. Think of a penny as representing a particle of dirt on your chip. For each different material, calculate the number of transistors in the line that would be covered if you dropped a penny (your piece of dirt) onto the surface of such a chip. (You will need to find the diameter of the penny.)

Material	Transistor	Chip Width	Number of Chips
Sewing Thread			
Shoelace			
Rope			

3. You may have seen miniaturized model cars or furniture. All the original details need to be reproduced on an extremely small surface compared to the original object. The circuits on a chip are designed using very large surfaces. Machinery reduces these layouts to extremely small patterns for placing on the chip.

Suppose you were able to create the pizza of your dreams. You have a pizza crust that is 12 inches across and enough of every topping you like to produce a masterpiece.

Think about what is necessary if you want to use exactly the same number of toppings and exactly the same quantities, but you only have a pizza crust that is 6 inches across. What are some of the difficulties you would encounter? How do you eat this pizza?