ENGINEERING

Eng 1 Eng 2 Capstone Aerospace

NTI DAY 2

Please complete the attached assignment and turn in within 3 days of the NTI Day.

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Short Circuits

by Charles Piddock

How small can transistors get?

Ladies and gentlemen, boys and girls, consider the amazing shrinking transistor! Watch it contract a million times until it becomes a tiny dot visible only under a powerful microscope!

We all know that technological progress is not an actual magic show. Still, it almost seems like magic the way the *transistor*, the main component in all modern electronics, has diminished in size since being invented in 1947.

The first transistor, made of gold, plastic, and *germanium* (a metallic crystal), was about the size of an adult's fingernail. Today's transistors, etched on silicon wafers, can't be seen with the naked eye. The minimum size of a transistor is now 45 *nanometers*. A nanometer is one-billionth of a meter-roughly the width of three or four atoms.

Computer engineers are trying to make transistors even smaller. How tiny can they go?

Chip Switches

Every transistor has the same basic properties: It can both conduct and stop the flow of electricity. The word *transistor* is a combination of two words: *transfer* and *resistor*.

All transistors are made from materials called *semiconductors.* A semiconductor is a cross between a good conductor (such as copper) and a good insulator (such as rubber). It can be made to accept or reject the flow of electrons in a circuit. Germanium, used in the first transistors, is a semiconductor. So is silicon, widely used today.

A transistor's ability to control the flow of electricity has made possible our entire computerized world. All computers depend on the *binary system* to convert electric signals into useful information. The binary system has only two numbers: 1 and 0. When a transistor allows electricity to flow through, it registers a 1. When the transistor stops the flow of electrons, it registers a 0. Millions or billions of those 1s and 0s, flashing off and on hundreds of millions of times a second in programmed patterns, enable your computer to do everything it does-from allowing you to play *World of Warcraft* to letting you type up a school science report.

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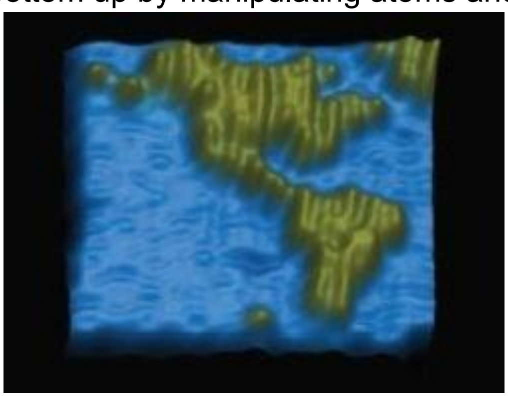
DNA strands twisted into smiley faces (above) and a map of North and South America (below)
Paul W.K. Rothemund and Nick Papadakis

Inner Limits

A transistor that is only a few atoms wide is incredibly small. But researchers want to make transistors even smaller and cheaper to produce. Chip-making technology has run into a big problem, however. Transistors smaller than 45 nanometers and etched on silicon chips don't work very well. They tend to leak electrons, making them less efficient.

To get around that problem, scientists are using *nanotechnology* to look at new materials and new methods to produce transistors. Nanotechnology is the engineering of materials on the atomic level, building new materials from the bottom up by manipulating atoms and molecules.



Paul W.K. Rothemund

One promising area of nanotechnology is the use of *graphene*, a carbon fabric that is only one carbon atom thick. Graphene is strong, stable, and can act as a semiconductor. If researchers can find a practical way to etch transistors onto graphene, smaller and immensely faster computer chips can be more cheaply made.

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"[The ultimate goal] of electronic engineers is the so-called ballistic transistor," physicist Andre Geim, a graphene researcher at the University of Manchester, told *LiveScience.* "It would be very, very fast, ultimately fast, in fact."

Another promising area of nanotechnology research involves using strands of *deoxyribonucleic acid* (*DNA*) to build transistors. DNA is the genetic material that determines the makeup of all living cells. Researchers can now take strands of DNA from bacteria and manipulate them into almost any shape they want. California Institute of Technology researcher Paul Rothemund has helped pioneer that technique. He has twisted DNA strands into smiley faces and maps of North and South America. Rothemund coined the phrase *DNA origami*, after the Japanese art of paper folding.

Rothemund and others are looking to shape DNA strands into a kind of scaffolding that could be attached to silicon wafers to make transistors. Because DNA does not conduct electricity, scientists are experimenting with ways to combine DNA with atoms of conducting materials, such as gold, to build transistors. DNA *replicates* (copies) itself. So if researchers can produce a DNA transistor, all they have to do is add the right "soup" of chemicals, and the DNA would reproduce itself, making millions of new nano-sized transistors at little or no cost.

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This is a microprocessor, the brain of a computer. It holds data and instructions, performs calculations, and organizes operations. In most computers, the microprocessor is a chip made of a semiconducting material. Etched onto that chip are millions of transistors, which control the flow of electricity through the microprocessor. Today's microprocessors can each contain up to 1 billion transistors. Intel Corporation is now working on a microprocessor that has more than 2 billion transistors.
Science Photo Library/Photolibrary

Smart Dust

Making transistors much smaller and much more cheaply could transform our lives. Tiny, smart nanomachines could do any number of things quickly and invisibly. Their greatest use might be in medicine. Swallowed in a pill or injected, tiny, computerized "nanobots" might be able to repair damaged cells one at a time, restoring health invisibly and painlessly before destroying themselves.

The nanobots might repair pipes, bridges, airplane engines, and electrical equipment too. They might even help with housework. Kris Pister, a University of California physicist, envisions what he calls smart dust-nanobots that move around the house at night, eating dirt and generally cleaning up.

Such things are possible in your lifetime-all because scientists are now "thinking small."

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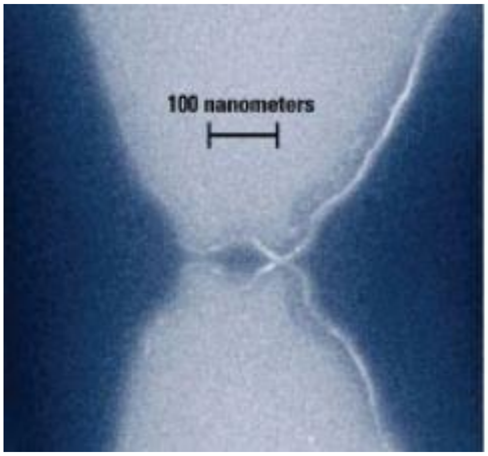

Left: A closeup of a graphene semiconductor. 1 nanometer = 1 billionth of a meter. Right: The smallest experimental model of smart dust, shown on a penny

Left: Mesoscopic Physics Group/University of Manchester; Right: Kris Pister

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Name: ___________________________________ **Date:** _______________

1. According to the text, when was the transistor invented?

A. in 1945

B. in 1947C. in 2000

D. in 2007

2. How does the author describe the changes transistors have undergone over time?

A. Transistors are used for the same things they were used for when first invented.

B. Transistors haven't changed much since they were invented.

C. Transistors have shrunk in size and become less useful.

D. Transistors have shrunk in size but increased in usefulness.

3. Read this paragraph from the text.

A transistor's ability to control the flow of electricity has made possible our entire computerized world. All computers depend on the *binary system* to convert electric signals into useful information. The binary system has only two numbers: 1 and 0. When a transistor allows electricity to flow through, it registers a 1. When the transistor stops the flow of electrons, it registers a 0. Millions or billions of those 1s and 0s, flashing off and on hundreds of millions of times a second in programmed patterns, enable your computer to do everything it does-from allowing you to play *World of Warcraft* to letting you type up a

school science report.

What conclusion can you draw about computers and transistors with this information?

A. Advanced computers no longer need a transistor to work.

B. Computers would not work without transistors.

C. Transistors are made up of 1's and 0's.

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D. Computers require millions or billions of transistors to complete simple tasks.

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4. Based on the text, how does the author likely feel about the future of transistors and nanotechnology?

A. hopeful and excited

B. concerned and worried

C. cautious and uncertain

D. to little information to determine

5. What is this text mostly about?

A. technology

B. nanotechnology

C. transistors

D. science

6. Read these sentences from the text.

> Ladies and gentlemen, boys and girls, consider the amazing shrinking transistor! Watch it **contract** a million times until it becomes a tiny dot visible only under a powerful microscope!

As used in the text, what does the word "**contract**" mean?

A. agreement or pact

B. form an agreement

C. shrink

D. get or incur, as in a virus or disease

7. Choose the word that best completes the sentence.

If scientists can figure out how to etch transistors onto graphene, _________ they will be able to create much smaller and much faster computer chips.

A. but

B. then

C. so

D. however

8. Based on the text, how are today's transistors different from the first ones that were invented?

9. Based on the text, what are some ways that smaller and cheaper transistors could transform our lives? Use evidence from the text to support your answer.

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