In-Class Exercise
MOS Transistors
SOLUTIONS

Here are some background questions to review:

1. Draw a picture of a bandgap of a semiconductor and label the conduction band, valence band, and bandgap energy.

Callister, Figure 18.4d or 18.6

2. Discuss ways that you can increase the conductivity of a semiconductor.

To increase the conductivity, the electrons need to have empty spots they can move into when a voltage is applied.

One way this can be accomplished is to move electrons from the valence band to the conduction band. Then, when a voltage is applied, the electrons in the conduction band will be able to move. Electrons in valence band will also be able to move because there now will be some empty spots in that band that electrons can exchange with. The excitation of the electrons from the valence band to the conduction band can be done with heat or light.

Another common way to increase the conductivity is to dope the semiconductor. The silicon (or other semiconductor atom) is replaced with atoms that have more or less electrons. Atoms that have less electrons will accept an electron from neighboring Si atoms. This will come out of the valence band (creating an empty sopt known as a hole in the valence band). For atoms that have extra electrons, these electrons can be pulled into the conduction band with relatively little energy. This creates extra conducting electrons.

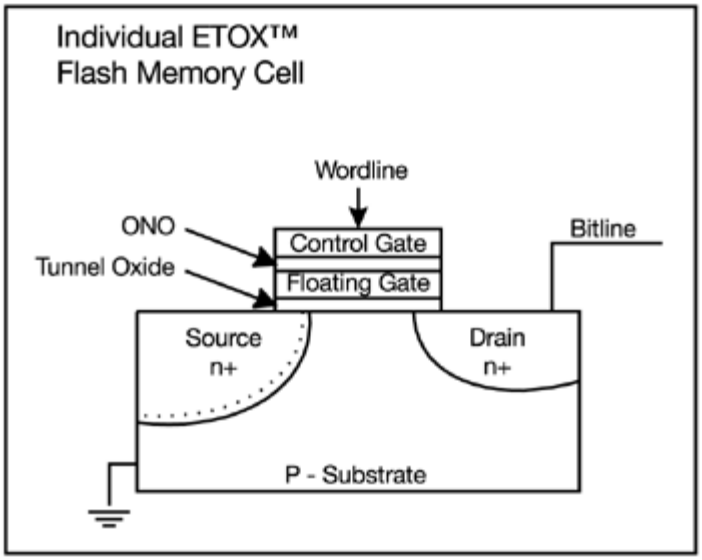
3. What is the difference between an intrinsic and extrinsic semiconductor?

An intrinsic semiconductor is pure (undoped). It can be a compound semiconductor such as GaAs. An extrinsic semiconductor has impurities (dopants) added to change the conductivity.

4. Draw a schematic of a FLASH device and label the metals, semiconductors, and insulators.

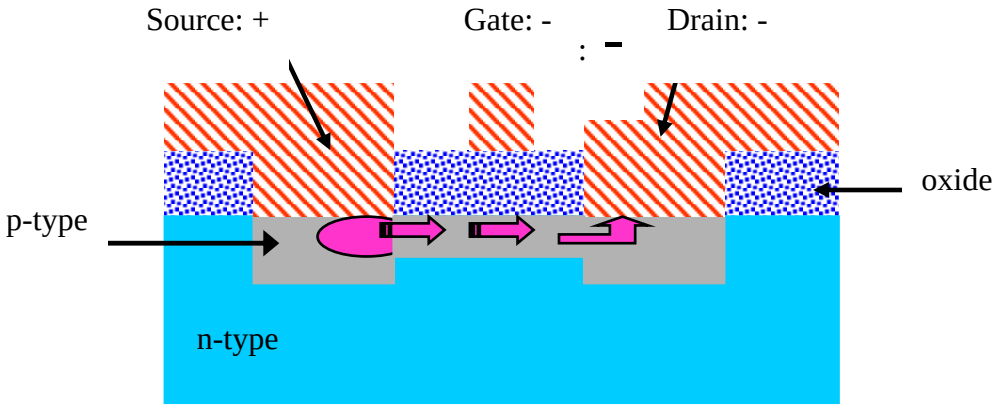
See picture below from Intel's site:
http://www.intel.com/design/flash/articles/what.htm

- The bit line, word line, and ground are metal interconnect lines.
- The floating gate and control gate are actually made of polysilicon but it is doped to have a high conductivity. (It is used as a "metal".)
- The source, drain, and substrate are extrinsic semiconductors.
- There are insulating layers between the substrate and floating gate and between the floating gate and the control gate.



Also See "How Stuff Works" site.
http://computer.howstuffworks.com/flash-memory1.htm

THE QUESTIONS FROM THE IN-CLASS EXERCISE:
Based on our discussion of N-MOS transistors. Draw a P-MOS transistor. Discuss what you think the polarity (+/-) needs to be on the source, drain, and gate to turn on the transistor.



Do you know what a C-MOS transistor is?
CMOS stands for complementary Metal Oxide Semiconductor. It is when a N-MOS and P-MOS transistors are made side by side. They complement each other because one polarity voltage applied to the gates will turn on transistor on and the other one off.
Check out:
http://www.eece.unm.edu/faculty/hersee/bp_eece_576.html
for an animated picture.