Exam Technology (121073), 18 January 2010

General instructions
The total time given for this examination is 3 hours. Read the complete exam before starting, to avoid time problems in the end. It is not allowed to use reference material such as handouts, books, calculators or pda's during the exam. Good luck!

1. Moore's Law (15 points max)

a) What is Moore's Law? (phrase as literally as you can)
b) If Moore's Law were a law of physics, we would soon be manufacturing sub-atomary transistors. Make a motivated estimate in which year this would happen.
c) The clock frequency of digital signal processors increases exponentially with time. Name 2 other trends that follow in pace with Moore's Law.
d) Is it fair to say that the Digital Revolution is primarily fed by Moore's Law? Motivate your answer.

2. Photoresists (30 points max)

a) Name the 4 basic constituents of a photoresist and their main function.
b) Define and explain the Modulation Transfer Function.
c) Draw the graph that illustrates the relative resist thickness (t/t_0) as a function of the exposure dose, for a negative resist. Indicate if the scales are linear or logarithmic and explain what is seen.
d) Describe the proximity effect (that is particularly strong in electron beam lithography): what is the cause, and what is the result? How can the proximity effect be suppressed?
e) Why is a photoresist baked after exposure? (You can name several reasons.) What happens if the bake temperature is (slightly) too high?
f) A wafer gets stuck in a photoresist track. As a result, some wafers are held up for several minutes in intermediate stages of the lithography process. Why will the lithography process suffer by this? Will this error result in faulty chips?

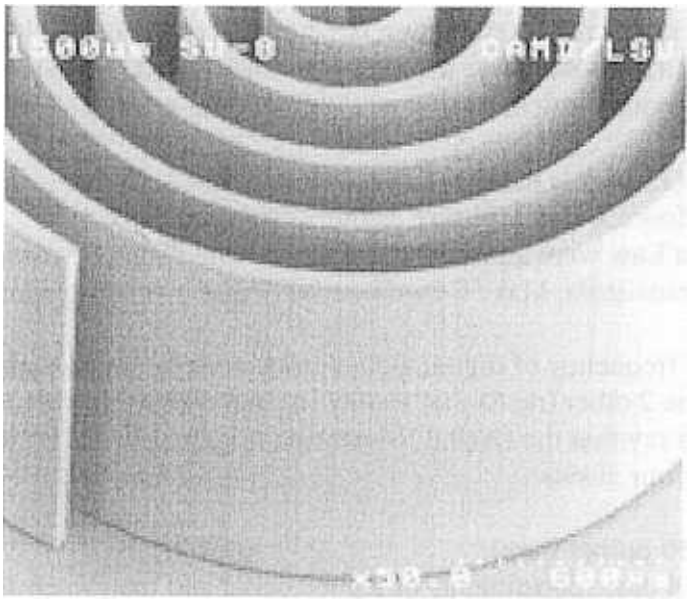
3. Deposition (30 points max)

a) In general, there are three main methods/techniques to deposit solid films of different materials: using a liquid source, PVD, and CVD. Explain the difference between these methods.
b) Name 6-7 general film properties (e.g. uniformity) and explain their meaning.
c) Compare CVD and PECVD; name the advantages and disadvantages of using plasma for deposition. Motivate your answer.
d) How does a plasma appear and what is it made of?

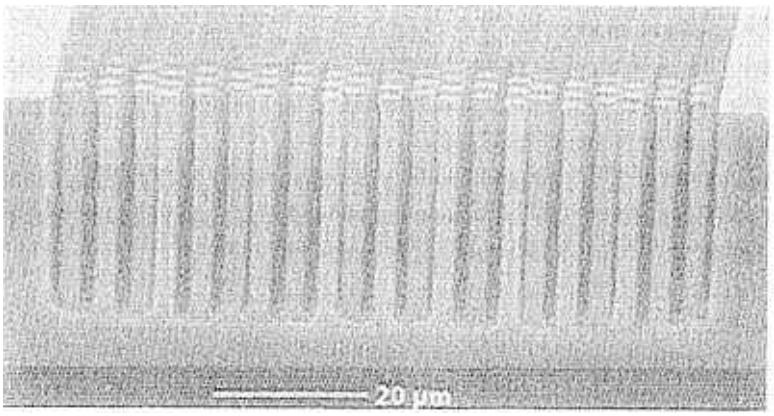
4. Wet etching (15 points max)

a) Give the definition and main purposes of wet etching.
b) What are the main process characteristics and problems of wet etching?
c) What kind of equipment is used for wet etching and what are the main considerations to be kept in mind when operating this equipment? (Name at least three.)

5. High aspect ratio structures (20 points max)
The picture below shows a structure with a high aspect ratio structure.



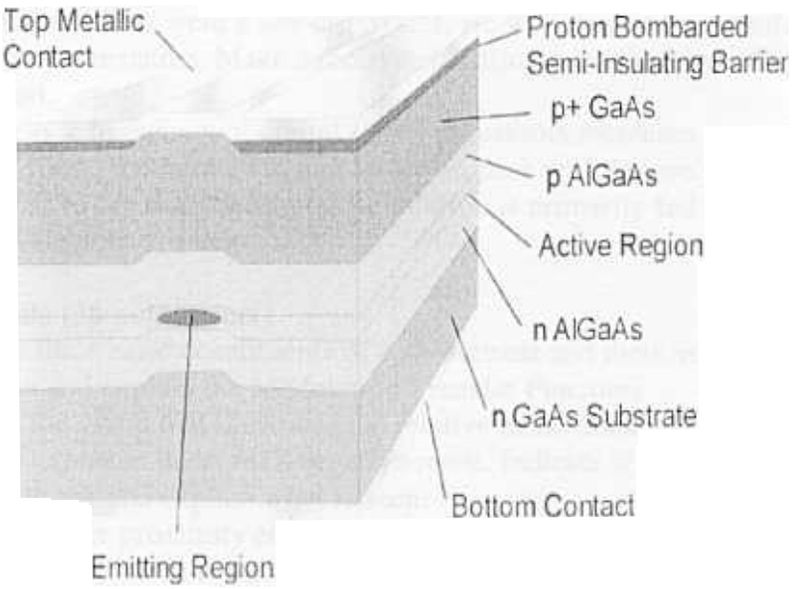
a) What is meant by "high aspect ratio"?
b) For all of the following lithography techniques, motivate if the shown structure can be printed (assuming that the shown material is photoresist, or "ink"):
   * projection optical lithography
   * X-ray lithography
   * dip-pen lithography
   * electron beam lithography
c) In some cases, high aspect ratios should be made in silicon, as shown for example in the figure below. Which techniques have been used to manufacture and image this structure?



6. Unknown devices (25 points max)

The figure below shows a sketch of a microtechnology device.

a) What kind of device is this? Motivate your answer.
b) Which deposition technique is used to create the layer stack of GaAs, AlGaAs, and GaAs? Why?



The picture below shows an intermediate fabrication result.

c) Give a process flow (step-by-step manufacturing plan) how this can be made, starting from a bare, flat silicon wafer.
d) What could be the purpose of this shown structure?
e) A processing error is visible in the figure. Explain what it is, how it arises, and what should be done to fix it (on subsequent wafers).