General instructions

The total time given for this examination is 3 hours. Read the complete exam before starting, and try to give short (but complete) answers, 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!

Question 1: Optical Lithography

a) Explain why the wavelength of light determines the minimum line width that can be printed.
b) If the light source can be considered a point source, then: how many lenses do we need *at least* for 1) contact/proximity printing and 2) for projection printing? Motivate your answer (e.g. with a drawing).
c) For what practical reason are mirrors placed in the optical path of a stepper?
d) Name two advantages of a laser light source (for the purpose of lithography) as compared to the high pressure arc lamp.
e) More advanced steppers use shorter wavelengths and therefore are able to print finer details. Can a more advanced stepper outperform older types in every respect, or are there exposures that can be easily done with an old stepper and hardly or not with a new one?

Question 2: CMOS

a) What is the main reason why CMOS technology has replaced the earlier (separate) NMOS and PMOS technologies?
b) Name the three most-used scaling scenarios in CMOS and describe them shortly.
c) The manufacturing of MOS transistors involves the growth of a gate oxide. The thickness of this oxide determines the capacitance between the gate and the silicon. Explain why the thickness of the gate oxide has to decrease when a new (smaller) CMOS generation is developed.
d) How would you change the silicon oxidation process, to create a thinner silicon oxide layer?
e) Draw a cross section of CMOS, including an NMOS and a PMOS transistor, and the N-well and P-well contacts.
f) Using the figure from question e), indicate what we mean with "parasites" in CMOS technology. A few examples will do.

Question 3: Photoresists

a) Name the 4 basic constituents of a photoresist and their main function.
b) 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.
c) Describe the proximity effect (that is particularly strong in electron beam lithography): what is the cause, and what is the result?
d) How can the proximity effect be suppressed?
e) Why is a photoresist baked after exposure? (You can name several reasons.)

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? Is this dramatic?

Question 4: Microchannels

a) Describe which techniques one can use to fabricate microchannels with dimensions of 100 micron wide in the following materials: silicon, glass, plastics. For each material at least 3 different techniques should be mentioned.
b) Give the typical cross-section that one can obtain with the techniques.
c) Describe one typical application for the microchannels, for each of these materials, and explain why the material is chosen for that application.