

EE 459: Introduction to Nanotechnology
Winter 2009
Homework #1 - Due Thu, Jan 22nd, 4:00 p

1. Calculate and plot both the theoretical resolution and depth of focus as function of wavelength for a projection exposure system with a NA of 0.65. Assume $k_1 = 0.6$ and $k_2 = 0.5$. Consider wavelengths ranging between 100 nm and 1000 nm (DUV and visible light). Indicate the common exposure wavelengths being used or considered today on your plot (g-line, i-line, KrF and ArF). According to these simple calculations, should an ArF source be adequate for the patterning of feature smaller than 100 nm ? (20 pts)
2. An X-ray exposure system uses photons with an energy of 2 keV. If the separation between the mask and wafer is 15 μm , what is the size of the smallest feature that can be fabricated with this system. (10 pts)
3. A given positive photoresist requires an exposure dose of 220 mJ/cm^2 to be 50 % dissolved in a developer. a) What are the threshold dose D_c and clearing dose D_o of the contrast of the resist is: i) $\gamma = 3$; ii) $\gamma = 5$; and iii) $\gamma = 8$ % ? (10 pts) b) Use a mathematical software to plot the response of these three resists on a single semi-logarithmic scale, similarly to the example found in Figure 1.2a) of textbook. Your plots should also indicate the values of D_c and D_o associated to each case (10 pts)
4. Explain **why** and **how** a lithography system employing extreme ultraviolet (EUV) radiation will operate substantially different from all previous generations of photolithography systems (5 pts).
5. Explain why two neighboring neutral molecules carrying no net charge can still experience electrostatic repulsion between them (5 pts).
6. What aspect of micro-contact printing makes it more attractive than dip-pen lithography for nanopatterning purposes ? (5 pts)
7. Chapters 1 and chapter 2 described two contrasting approaches to the fabrication and synthesis of nanostructures. These approaches are usually referred to "top-down" (chapter 1) vs. "bottom-up" (chapter 2). i) Describe in your own words the overall philosophy of both approaches. ii) Describe relative advantages and disadvantage of each (15 pts)
8. Name the main interaction types used in molecular self-assembly. Which interactions induce the self-assembly in SAMs, LBL, and block copolymers ? (20 pts)