UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering
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C. SPANOS **Special Issues in Semiconductor Manufacturing** **EECS 290H**
Fall 2005

PROBLEM SET No. 4
Due on Thursday 13th of October 2005, <u>at the beginning</u> of the class

1. Answer the following questions (briefly explain your answers)
   a) What is a "test statistic" in the context of Hypothesis testing?
   b) How is the *power* of a test related to the *sample size* of a test, assuming that the test statistic is an average of independent samples, and it follows the normal distribution?
   c) Is the power (P) of a test independent of the type I error?

2. Two types of photoresist (A and B) were used on a total of 8 randomly selected wafers, 4 for A and 4 for B. After patterned with a DUV stepper (using the same mask for all), the average line-width was measured in nm:

   A

97.23	96.28	98.17	95.03

   B

101.30	101.17	101.09	101.32

   Obtain a 95% confidence interval for the ratio of sigmas. State your assumptions carefully.

3. You are considering introducing a new etch recipe, hoping that it will reliably shrink your after-etch CD. (Remember that each nm you shave off the CD gives you about $15/microprocessor you sell!). You have determined that the sigma of the process is 1nm, and it will not be affected by the new process. Using a mask with 90 nm lines, and the old etch recipe, the average measured polysilicon line-width is 75 nm. You will be willing to switch to the new etch recipe only if you see a 2 nm improvement (i.e. your measured pattern goes from 75nm to 73nm) with α=0.05 and β=0.10. How many samples done with the new process do you need for this experiment?

4. We now have three types of resist to compare: A, B and C. We would like to use an ANOVA table in order to test the hypothesis of equivalence of the three treatments. A few wafers from the first group have already been measured. Look at the 4 measurements below and estimate the total number of wafers we need to measure if we would like to detect deviations in the order of 1nm between groups with a power of 80%, while the type I error is kept at 5%.

A:	96.96	96.59	97.26	97.47

   Explain all implicit assumptions.

(more on next page – sorry…)

5. To compare two photolithography processes (A and B), 4 of 8 wafers were randomly assigned to each. The electrically measured line width of several NMOS transistors gave the following averages (in μm):

A:	1.176	1.230	1.146	1.672
B:	1.279	1.000	1.146	1.176

Assuming that the processes have the same standard deviation, calculate the significance for the comparison of means.

6. Suppose there are now four photolithography processes to compare (A, B, C, and D). Using 15 wafers, the measurements are (in μm):

	I	II	III	IV
A	1.176	1.146	1.672	1.114
B	1.279	1.146	1.176	1.114
C	0.954	1.079	1.204	0.699
D	0.699	1.114	1.114	

Calculate the full ANOVA table and find the level of significance for rejecting the hypothesis of equality. Explain any assumptions and perform the necessary diagnostics on the residuals.