EE6601, Semester 2, 2018/19
School of Electrical and Electronic Engineering, NTU

<u>Problem Set #1</u> (Etching)

(1)

(a) Explain why selectivity is an important consideration during etching of a film with respect to mask and underlying materials;

(b) Give example of silicon etchants that have different etching rate in the <100> and <111> orientations. What causes this difference and how it is utilized?

(c) Explain why over-etching is always used in a manufacturing environment;

(d) You are an etch engineer in a wafer fab and you are developing a recipe to etch a 1.0 μm new material deposited on Si wafer. This new film is known to have excellent selectivity with respect to photo-resist. However, the deposited film has a ±5% thickness variation and a ±4% etch rate variation. Determine the minimum required over-etch time for complete removal of the film and the selectivity to ensure that only a maximum of 2.5 nm of Si is removed;

(e) Refer to Figure 1. You are using 10:1 HF @ 20 ^{o}C to etch an MOS capacitor as shown. The etching rates are 1.0 nm/min and 30 nm/min for Poly-Si and SiO2 respectively. The as-printed mask line-width is 1 μm and you can only tolerate a maximum of 5% undercut at each side. Determine the maximum thickness of the poly-Si gate and the total etching time needed. State all assumptions in your calculation.

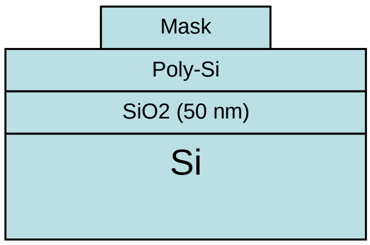

Figure 1

(2)

(a) Would it be possible to maintain a plasma using DC voltage? Explain the difficulties that might arise and how to overcome them in a plasma etch system;

(b) Do a study on a plasma etching method known as the Bosch Process that is used to etch very high aspect ratio profile;

(c) Chlorine-based chemistry is widely used to etch Al. Can a similar dry approach be used on Cu?

(d) A plasma etch process is found to produce an etch rate of 30 nm/min when etching a single wafer. When a second wafer is added to the reactor the etch rate falls to 24 nm/min. What etch rate would you expect for three and four wafers?

(e) For a particular plasma etch process in which the linear etch model is applicable, a degree of anisotropy of 0.8 or better is desired. If the unobstructed ionic flux on a flat surface is 3 x 10^{16} atoms cm^{-2} sec^{-1} (with K_i equal to 1), what unobstructed chemical flux would result in an anisotropy of 0.8. For this process S_C is 0.01 and K_f is 0.1;

(f) We want to see how the etch rate in the vertical direction might depend on pressure assuming that the etch follows the saturation/adsorption model. Assume that for a particular etch system that the chemical flux is directly proportional to the pressure, while the ion flux is inversely proportional to the pressure. That is $F_c=F_c'*P$ and $F_i=F_i'/P$. (P is normalized to 1 atm and unitless.) Also assume that density = 1 atom/nm^3, and that $K_iF_i' = S_cF_c' = 1$ atom/nm^2/sec:

(i) Plot the vertical etch rate versus pressure, P, from P = 0 to 10.

(ii) Repeat with $K_iF_i' = 40$ atoms nm^{-2} sec^{-1} and $S_cF_c' = 1$ atom nm^{-2} sec^{-1}.

(3)

(a) One way to measure etch rate is to weigh the sample before and after etching, and translating that into the etch rate. If you use this method to determine silicon etch rate of a 8” wafer with 50% etching area, what is the resolution of the weighing scale that you need if you intend to etch at least 500nm of silicon with 1% error at the most? You can use silicon density as 2.65 g/cm^3. State any assumption you use;

(b) Draw cross sectional schematics of the following structure under the etching conditions listed in Table, for two etching times: (i) right at end point, and (ii) 50% over-etch. State any assumption.

Profile	**A: S Selectivity**
Anisotropic	$\rightarrow \infty$
Anisotropic	5:1
Isotropic	$\rightarrow \infty$
Isotropic	5:1