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EEC243: ADVANCED IC PROCESSING AND LAYOUT
Homework #9 Solutions

Problem 1

(a)
d= 2.5 mm
C = 1 pF/cm^2
J=1mA/cm^2
V=1000V
From C= Q/V , $Q = 10^{-9}$ Coulombs/cm^2
J= Q/t , $t = 10^{-6}$sec

(b) A typical RF frequency (f =1/t) > 1 MHz can create a net surface charge transfer =0 at steady state .

Problem 2

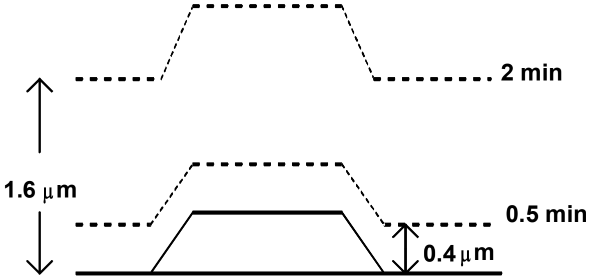
(i) Large loading effect will reduce the fluorine radicals in the plasma. This effectively reduces the F/C ratio and gives lower etching rate.
(ii) SiO_2 is considered to be an oxygen source when etched. When oxygen is present in the gas mixture, the C concentration will be lowered. The effective F/C ratio will increase and the tendency for polymerization to occur is reduced.
Another thoery (Coburn et al) states that CF_x has a lower adsorption on SiO_2than Si. Therefore, less polymerization also.
(iii) Ion bombardment enhances the surface etching processes because it can sputter away surface passsivation layers. We will expect a lower selectivity ratio between two materials if ion bombardment effect becomes significant.

Problem 3

(i) Increasing RF power will increase substrate bias voltage and also the plasma ion density. Therefore, there will be more CuCl sputtering.
(ii) The ion tranist time to cross the sheath thickness is about 1 μsec. Ions will experience more than one oscillations within the sheath for applied RF bias having period shorter than this transit time. This will reduce the maximum ion bombardment energy on the wafer surface. .Decreasing RF frequency gives higher ion energy of bombardment. Therefore more CuCl sputtering.
(iii) Higher wafer temperature gives higher CuCl vapor pressure which gives higher etching rate. The practical limit is resist degradation (reflow and carbonization) if substrate temperature is too high.
(iv) Low gas pressure has less ion-neutral collisions in the plasma sheath which gives higher ion energy. Higher etching rate. Low gas pressure also gives less bacldiffusion towards the substrate.
Less CuCl redeposition also gives higher etching rate.

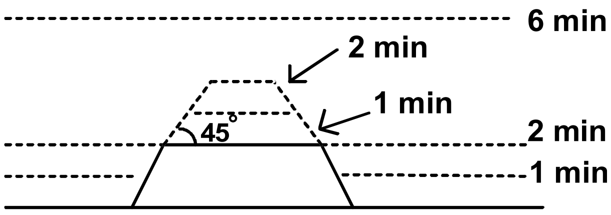
Problem 4

a.)
Deposition rate > etching rate for all θ. Net deposition.
On flat region : net deposition rate = 0.8 μm/min
On slope : net deposition rate ≡ 0.35 μm/min



b.)

On flat surface ; deposition rate > etch rate. . On slope, a new angle will develop until slope angle = 45° which makes deposition rate = etch rate
For thicker deposition, SiO_2 continues to build up on flat portion and buries the cone if sufficiently thick. If width of the Al line is narrower, a cone may have developed at the 6 min profile.

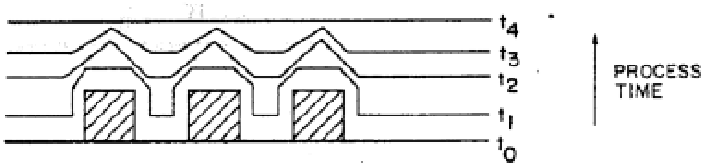


c.)

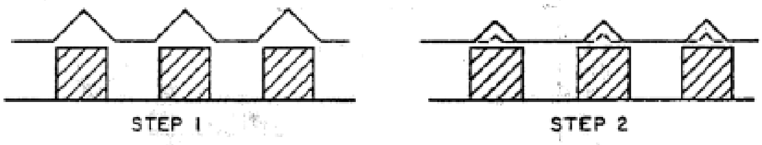
Etching rate > Deposition Rate for all θ . No net deposition for all times. [We assume Al & Si won't be etched by bombardment].

d.)

We can operate with conditions of part (b) and switch to part (c).



(1) SINGLE STEP PLANARIZATION



STEP 1: HIGH DEPOSITION/LOW ETCH RATE
STEP 2: LOW-ZERO DEPOSITION/HIGH ETCH RATE