Birla Institute of Technology and Science, Pilani
MEL G611 IC Fabrication Technology
Comprehensive Exam   Open Book

Time:75 Mins   Date: 11.12.2017   M.M: 40

You may need: Atomic weight of Si = 28.09 g/mol, Atomic weight of As = 74.92 g/mol, density of Si (in solid and liquid) = 2.33 g/cm^3, atomic weight of SiO_2 = 60.08 g/mol. density of SiO_2 = 2.21 g/cm^3, Avogadro's number= 6.023*10^{23} atoms/mol, Distribution coefficient (k_0) of B = 0.8, P= 0.35, As= 0.3, Ga = 8*10^{-3} , Sb = 0.023, Al = 2.8*10^{-3}

Q-1 Boron ions (B+) are implanted into a n-type Si wafer with background doping concentration of 10^{16}/cm^3. Regions I of the wafer is covered with SiO_2 with thickness t_{SiO2} and Region II has no oxide. The boron concentration C(x) versus depth x for Region I is sketched in the figure (1) below. For simplicity, let us assume the ion stopping powers, ion scattering characteristics and number of collisions are identical for both silicon and silicon dioxide.

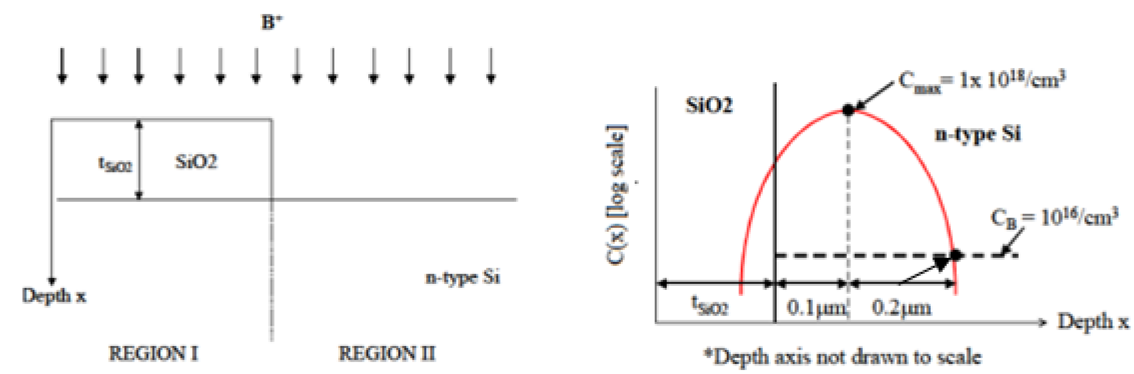
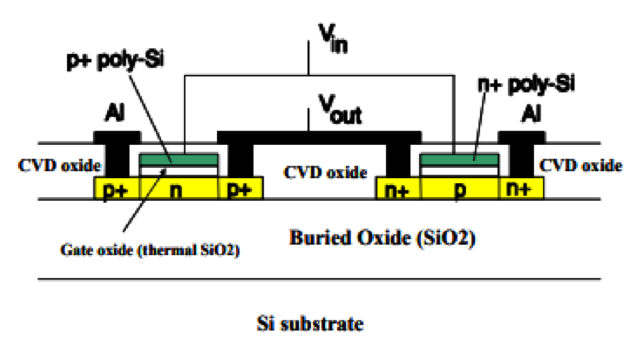


Figure (1)

(a) What is the kinetic energy of the B+ ions (in keV) ?
(b) What is the boron implantation dose (in cm^{-2}) ?
(c) What is the thickness of the SiO_2 (t_{SiO2}) ? **[10M]**

Q-2 The figure (2) shows a poly-Si gate CMOS on SOI (silicon on insulator) structure. Design a process flow and sketch and label the cross-sections of the device after each lithography step. The starting material is 1µm-thick n-type single-crystalline silicon on SOI with N_d = 2*10^{15}/ cm^3. **[10M]**



PTO

Figure (2)

Q-3 You need a 300 mm diameter silicon ingot and decide to use the Czochralski technique to grow it. Further, you want to have a 5×10^{16} atoms/ cm^3 of arsenic if one fourth of the ingot is grown. Assume mass of the initial melt is twice the mass of the final silicon ingot and crystal growth is done under the rapid-stirring condition.

(a) Find the initial concentration of As atoms in the melt.
(b) Calculate the mass of the silicon charge if the length of the final ingot is 1 meter in length.
(c) Calculate how many grams of As should be added to the silicon charge. **[8M]**

Q-4 A process is desired that oxidizes a region within a shallow trench of depth 100 angstroms as shown in the figure (3) below. The region outside the of the trench is initially masked so that only the region in the trench is oxidized (see step 1 below). We desire a high quality oxide of thickness 1000 angstroms, grown at 1000 °C within the trench region. After the high quality of oxide is finished, the mask is removed and a fast, low quality oxide is to be grown at 1000 °C over all the regions (see step 3). The final result is to have a flat, planar oxide over the entire wafer as shown in the step 4. Assume no lateral oxidation and at 1000 °C take:

A = 0.165 µm , B = 0.0117 μm^2 / hr and $\tau = 0$ for dry oxide.
A = 0.226 µm , B = 0.287 μm^2 / hr for wet oxide.

(a) What time is required to result in 1000 angstroms of high quality oxide inside the trench?
(b) What time is required for the 2nd oxide (low quality oxide) such that the final surface is planar?
(c) What is the low quality oxide (wet oxide) thickness outside the trench (see step 4) and also calculate the total oxide thickness (wet oxide +dry oxide) in the trench area? **[12M]**

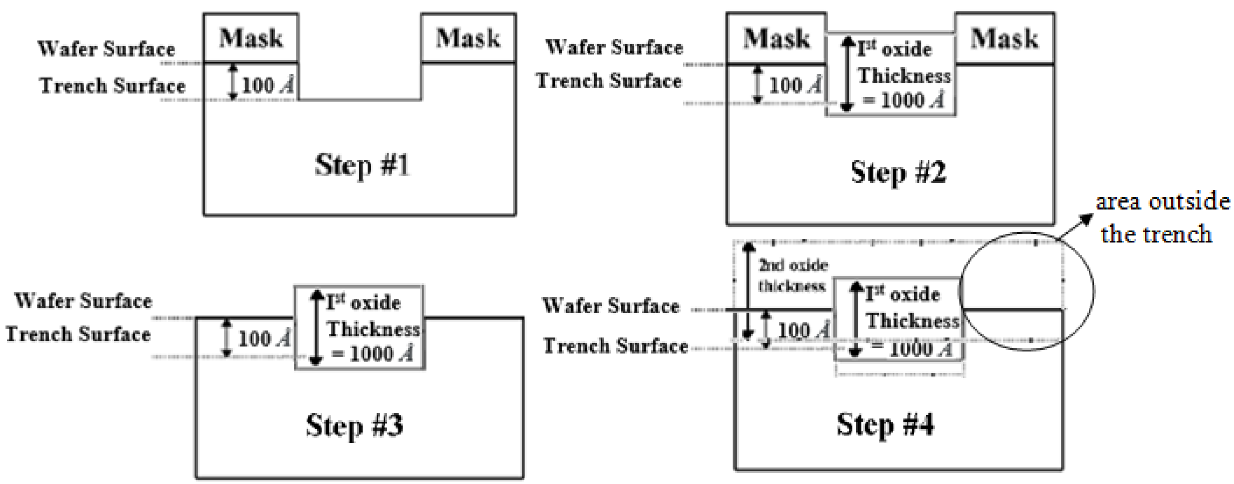


Figure (3)