Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
Manipal University

FIRST SEMESTER M.TECH (ME) DEGREE END SEMESTER EXAMINATION - NOV/DEC 2016

SUBJECT: VLSI PT (ECE - 5124)

TIME: 3 HOURS **MAX. MARKS: 50**

Instructions to candidates

- Answer **ALL** questions.
- Missing data may be suitably assumed.

1A. Match the following.

(i) Positive resist are	(a) Float zone process
(ii) Planar defects	(b) Short range order
(iii) Wafer for Power devices are fabricated using	(c) one
(iv) Amorphous Si crystal	(d) grain boundaries
(v) Lattice point in Simple cubic cell	(e) Diazoquinones (DQ) or Diazonaphthoquinone (DNQ) based

1B. Consider the SEM image of pillars shown in Fig. 1B. Explain the process of fabrication using optical lithography using negative resist.

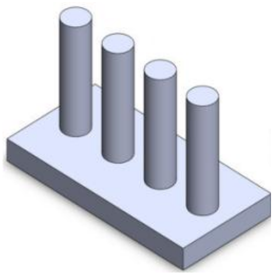


Fig. 1B.

1C. Within a cubic unit cell, sketch the following directions (i) [3 -1 2] (ii) [3 -1 3].

(5+3+2)

2A. Mr. Pedro has decided to fabricate a MOSFET. He has taken a n-type wafer with 5 x 10^{16} As atoms/cm^3 . His first step is to grow a 0.9 micron thick oxide on the (100) Si wafer. He want to grow this as fast as possible so that he can use the maximum furnace temperature of 1200 °C.

(i) How long does it take to grow the first 300 nm?

(ii) How long does it take to grow the second 300 nm?

(iii) How long does it take to grow the third 300 nm?

(iv) Sketch a graph showing the thickness-dependence of the oxide growth time for both wet oxidation and dry oxidation.

(v)Briefly explain the trend you observe in growth times for i – iii , terms of a microscopic picture of the growth process.

Rate constants for wet oxidation of silicon.

Oxidation temperature (°C)	A (μm)	Parabolic rate constant B (μm^2/h)	Linear rate constant B/A (μm/h)	τ (h)
1200	0.05	0.720	14.40	0
1100	0.11	0.510	4.64	0
1000	0.226	0.287	1.27	0
920	0.50	0.203	0.406	0

Rate constants for dry oxidation of silicon.

Oxidation temperature (°C)	A (μm)	Parabolic rate constant B (μm^2/h)	Linear rate constant B/A (μm/h)	τ (h)
1200	0.040	0.045	1.12	0.027
1100	0.090	0.027	0.30	0.076
1000	0.165	0.0117	0.071	0.37
920	0.235	0.0049	0.0208	1.40
800	0.370	0.0011	0.0030	9.0

2B. Explain the Czochralski method of silicon wafer fabrication.

2C. Explain the fabrication of PN diode.

(5+3+2)

3A. Consider the cross-section shown in Fig. 3A, that is to be doped with As using ion implantation to form the source/drain regions. Assume the Si substrate is initially doped with B with a uniform concentration of 10^{16} cm^{-3}.

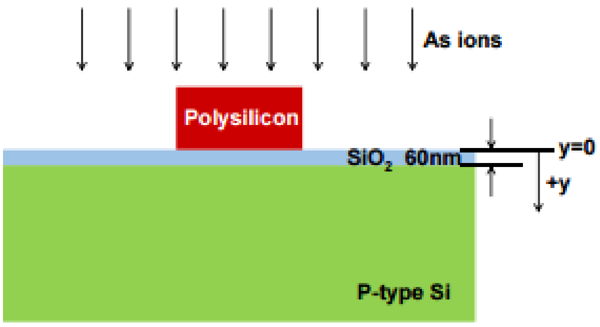


Fig. 3A.

(i) Assume that the SiO2 and polysilicon layers have the same ion stopping power as Si, and that SiO2 thickness is 60 nm. What are the ion implantation dose and energy required to achieve a peak concentration of 10^{19} cm^{-3} of As at the SiO2 and Si interface in the source/drain regions (i.e., y = 60 nm)?

(ii) Continuing from (a), calculate the junction depth of the source/drain regions.

(iii) What is the minimal thickness of the gate polysilicon for the polysilicon and SiO2 stack to serve as an effective implantation mask that decreases the As concentration in the channel region below 1/10th the background concentration?

3B. Explain E-beam lithography technique with neat diagram. What is proximity effect?

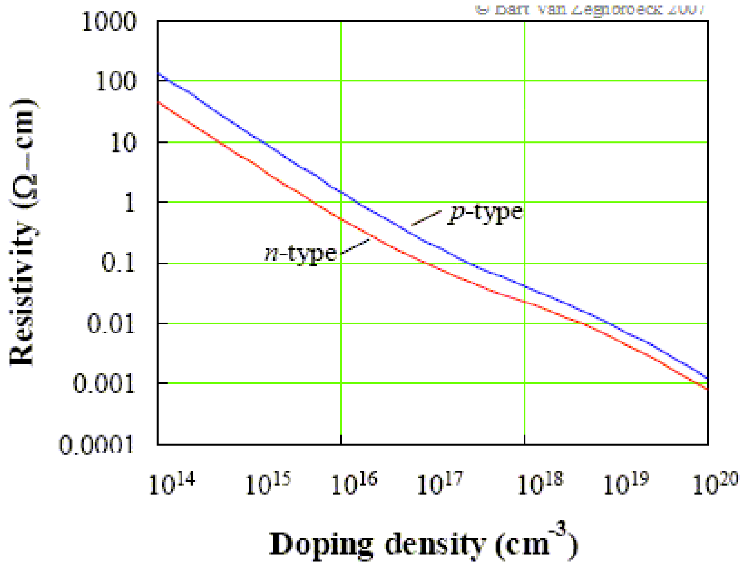
3C. Explain dual damascene fabrication process.

(5+3+2)

4A. A pn junction is to be formed 1µm from the surface in n-type Si substrate, which has a doping concentration of 10^{17} phosphorus atoms per cm^3 .
The junction is formed by a two-step diffusion of boron:
The pre-dep is solid-solubility limited at 1000°C and the drive-in is at 1100°C.
After the drive-in step, the sheet resistance is 50Ω/square.
Find out the appropriate diffusion times for both the (1) pre-dep and (2) drive-in steps.
Given: D_0=10.5 cm^2/sec and Ea=3.69 eV for Boron diffusion.
Surface concentration Co = $5\times10^{19}/cm^3$, solid solubility limit of boron at 1000°C (pre-dep temp) ≈ $2\times10^{20}/cm^3$ = Cs.

4B. (i) Sputtering process run in …….. and ………….. Mode.
(ii) In XeF_2 etching of Si, ?XeF_2 + Si -> ? + ? .
(iii) In PECVD process, ……………. helps to break up the gas molecules.

4C. In a four-point probe measurement on a silicon wafer that is uniformly doped n-type, the measured resistance is 40 Ω. If wafer is 400 µm thick and the probe spacing is 1 mm, determine the wafer resistivity and doping concentration. Use resistivity vs doping concentration graph.



(5+3+2)

5A. (i) Explain the basic principle of wet-etching with neat diagram.
(ii) Suppose you wanted to etch a V into a <100> Si wafer with an angle of 54.74^0 with respect to the <100> plane as shown in Fig. 5A. First, how deep would the etching need to be? Secondly, how long would it take? Use Silicon etching rate graph.

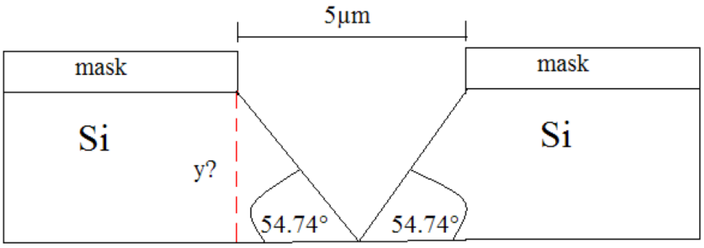
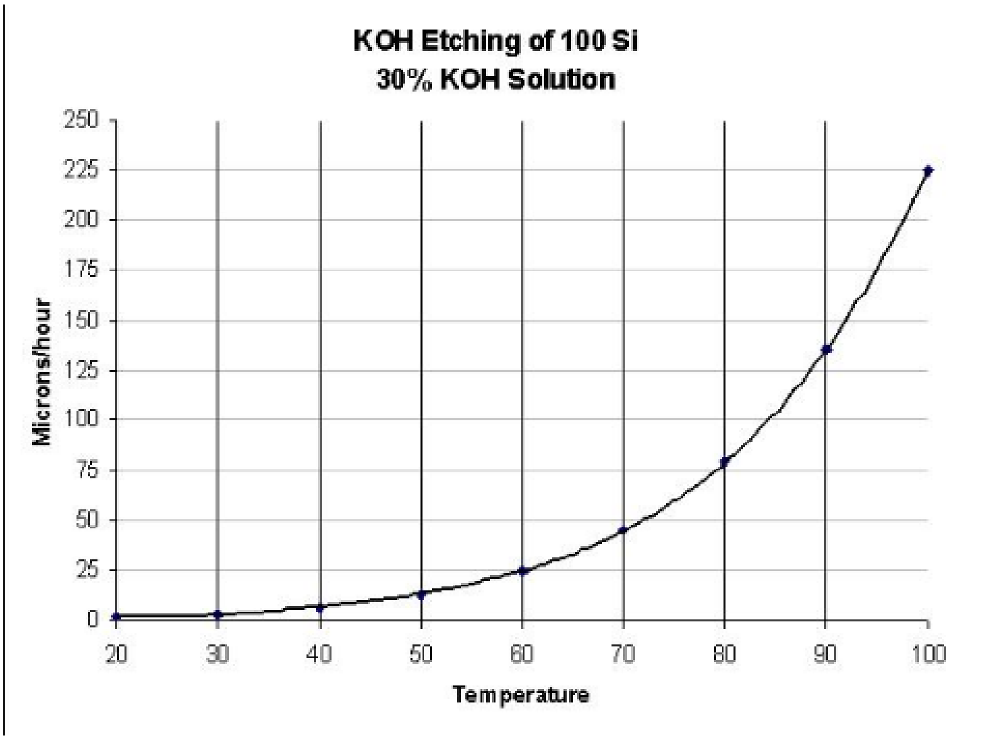


Fig. 5A.



5B. Explain the evaporation technique. Also explain different type of heating method used in evaporation.

5C. Explain the epitaxial process with neat diagram.

(5+3+2)