Quiz 1, Time for quiz: max1 hour Allowed help: Std. mathematical and physical tables, calculator, no internet, no textbook.
The test is a service only

1.
I'm really looking forward to take this test [ ] (cross mark the politically correct alternative)

2
Cross mark only the correct course code which you register for
[ ] FYS4310
[ ] FYS9310,

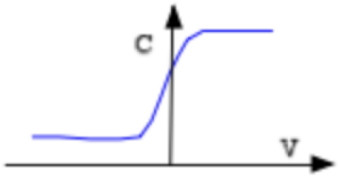
3
Cross mark the correct statement(s) only.
In a CVD reactor for Si epitaxial growth the feed gas is $SiCl_2H_2$ and H_2. The feed flow rates are 0.2 l/min and 4 l/min respectively. The HCl gas concentration in the chamber is proportional to..

[ ] $[SiCl_2H_2]$
[ ] $[SiCl_2H_2]^{½}$
[ ] $[SiCl_2H_2]^{0.05}$
[ ] $[H_2]^4$
[ ] $[SiCl_2H_2]^2$

4
Cross mark the correct statement(s) only
'The energy required to create a Si vacancy (free energy of creation) with a net positive charge of one elementary charge is less than that required to to create a neutral one' This statement is ..
[ ] never correct for Si
[ ] correct for n-type Si
[ ] always correct for float zone grown Si

5
Cross mark the correct statement(s) only
The thermal oxidation growth rate for SiO_2 on Si
[ ] is faster for wet oxidation than for dry oxidation because the equilibrium concentration of water molecules are higher than that of oxygen at identical gas pressure.
[ ] is increasing exponentially with the doping concentration,

6 (* 2210 stuff)



The figure to the right shows a CV curve of a MOS capacitor (Metal-Oxide-Semiconductor). The sign of the voltage is defined as positive when the metal is a positive electrostatic potential with respect to the semiconductor. The graph tell if the semiconductor is n-type or p-type. The doping type of the semiconductor is.

[ ] n-type
[ ] p-type
[ ] don't know

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From a CV curves MOS capacitor structures yielding C-V curves like that shown in problem 6 can be used to find:

[ ] The dielectric constant of Si
[ ] The area density of charges in the oxide
[ ] The break down voltage of the oxide
[ ] The elementary charge

8

When growing CVD Si at high temperature, the rate limiting mechanism in the growth process is.

[ ] Step creation
[ ] Step flow velocity
[ ] Chemical reaction rate
[ ] Space charge neutrality
[ ] Gas transport
[ ] Space charge neutrality
[ ] Recombination

9

Describe Henry's law in the space provided before problem 10

10
Consider MBE growth of GaAs. Mark the correct statements only.
[ ] The growth is typically performed at atmospheric pressure
[ ] The growth rate (at constant temperature) varies parabolic with time
[ ] The As vapor pressure is much higher than that of Ga
[ ] Crystals can be grown fast, but the quality can not be as good as Czochralski grown (bulk) material
[ ] Surface diffusion of ad atoms occur at the growth temperature.
[ ] AlAs is grown in a different growth chamber than where GaAs is grown
[ ] MBE is presently the only technique used for growing Mo(molybdenum) doped GaAs.

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What are the dominant diffusing species during so-called wet oxidation of Si.
[ ] water
[ ] silicon
[ ] oxygen
[ ] nitrogen
[ ] vacancies
[ ] hydrogen and oxygen molecules

12
There are many acronyms used throughout the course. Please write the what the following acronyms stands for
[a] VLSI=Very Large Scale Integration
[b] MOS =
[c] CVD =
[d] MBE =
[e] LPCVD =
[f] ALE =
[g] SLS =

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Give an order of magnitude answer to these questions

[a] In 1 cm^3 of GaAs there are 5Exx atoms where xx =

[b] To grow a 1 μm thick oxide on Si in steam at 1000 °C, we need to grow 1Exx sec, where xx=

[c] The activation energy for vacancy concentration in Si is 2Exx eV where xx=
and where the value for the different charge states adds a spread about 1Eyy eV where yy =

[d] The solid solubility of As in Si at 1100 °C is about 1Exx cm^3 where xx=

[e] The bandgap of InAs is about 3Exx eV where xx=

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The growth of an epitaxial Si layer in a CVD chamber is diffusion limited, then the instant growth rate dx/dt varies with time as {where k is a parameter independent of t, and x is the thickness)

[ ] $k*t$

[ ] $\ln(k*t)$

[ ] $\exp(-k*t)$

[ ] k

[ ] $k*t^{1/2}$

15

The segregation coefficient is important for Czochralski growth because

[ ] The sign indicates whether striations will develop

[ ] It explains why float-zone technique yields less oxygen

[ ] It controls nucleation of precipitates in the crystal towards the seed

[ ] It is zero

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The following statements can be true or false. Check with a cross the statements that are TRUE only

[x] This is a test

[ ] The most common material for the crucible in Czochralskii growth of Si is silica

[ ] Crystalline Si is too brittle to withstand the processing and handling used for making electronic devices

[ ] A getter process is done during float Zone growth to get as few vacancies as possible in Si

[ ] Twins often occur when growing epitaxial Si on wafers with the surface normal along <111>

[ ] When silicon is exposed to water vapor at 1000 °C, the surface will be covered by silicon monoxide

[ ] * In silicon the electron mobility in n-type is higher than the hole mobility when the doping concentration is the same in n and p type.

[ ] In a piece of crystalline Si the room temperature electron mobility is highrer than that of the hole in the same material, at all doping concentrations in the range 1E11 cm^3 to 1E20 cm^3.

[ ] Vacancies ca condense on an atomic plane in a disk like fashion, creating a stacking fault. The dislocation bounding that stacking fault is called an extrinsic dislocation

[ ] The equilibrium vacancy concentration in Si, depends upon the doping concentration

[ ] The vacancy concentration in Si decreases with increasing temperature as $1/T$.

[ ] It is fundamentally impossible to grow a dislocation free crystal at a finite temperature

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Which of these denote a polar surface?

[ ] A cold surface

[ ] A surface which is biased

[ ] A surface which is biased positively

[ ] The surface facing the gas flow in Atomic Layer Deposition

[ ] An AlAs (111) surface

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When growing GAAs on Si(111) surface, by MBE the first atomic layer is likely to be
[ ] A (211) layer
[ ] A Ga layer
[ ] A 7x7 reconstructed layer
[ ] An As layer

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Which of these materials can be called a semiconductor. Mark all that apply! [ ] A (211) layer
[ ] Single crystal Silicon
[ ] Silica
[ ] Aluminum saturated with silicon
[ ] Indium Arsenide doped with Zn
[ ] Silicon rubber
[ ] Silane
[ ] Gallium phosphide at 100 °C
[ ] Ice
[ ] Sapphire
[ ] Tin at 30 °C
[ ] Zink Selenide
[ ] Graphene

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The figure below shows the solubility of B and A in a *new insulator* in contact with Si as a function of temperature. The Insulator is in contact with regions of Si that is rich in B (boron) and other that are rich in As at the same concentration. When annealing at 1000 °C, which part of the insulator will first reach 10 percent of the solubility limit?
[ ] That above the A region
[ ] That above the B region
[ ] I don't know