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

1.
I'm really looking forward to take this test [**x**] (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.. Reaction $SiCl_2H_2 + H_2 = 2\ HCl + SiH_4$ thus law of mass action

$$\boxed{\frac{[SiCl_2H_2]\cdot[H_2]}{[HCl]^2[SiH_4]} = K(T) \Rightarrow [HCl] \propto [SiCl_2H_2]^{1/2}}$$

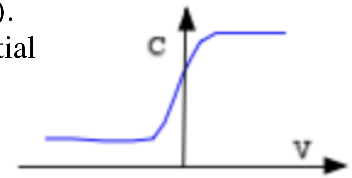
[ ] $[SiCl_2H_2]$
[x] $[SiCl_2H_2]^{1/2}$
[ ] $[SiCl_2H_2]^{0.05}$
[ ] $[H_2]^4$
[ ] $[SiCl_2H_2]^2$

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 *It can be correct for p-type Si*
[ ] Correct for n-type Si *It is generally not correct for n-type Si*
[ ] ,Always correct for float zone grown Si *It is not always correct for Si, floatzone or not has very little to do with it*

5
Cross mark the correct statement(s) only
The thermal oxidation growth rate for SiO_2 on Si
[x] 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. *In lecture notes we have said its like this, Other reasons have been given*
[ ] is increasing exponentially with the doping concentration, *No from data in book. not even reaction rate it is prop to n?*

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 .



[x] n-type *accumulation at positive bias, attract electrons*
[ ] 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 *NB it say Si, not SiO2,*
[x] The area density of charges in the oxide *from the flat band*
[ ] The break down voltage of the oxide *no, however you will be unable to measure C when reach BV*
[ ] 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
[x] Gas transport
[ ] Space charge neutrality
[ ] Recombination

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Describe Henry's law in the space provided before problem 10
Concentration of gas molecules just inside the surface of a material is proportional to the partial pressure just outside the surface

10

Consider MBE growth of GaAs. Mark the correct statements only.

[ ] The growth is typically performed at atmospheric pressure *No, usually UHV*

[ ] The growth rate (at constant temperature) varies parabolic with time

[x] 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

[x] Surface diffusion of ad atoms occur at the growth temperature.

[ ] AlAs is grown in a different growth chamber than where GaAs is grown *Usually the same, but of course can be grown in different*

[ ] MBE is presently the only technique used for growing Mo(molybdenum) doped GaAs. *No Mo doping, Vapor pressure Mo very low,*

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What are the dominant diffusing species during so-called wet oxidation of Si.

[x] 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 = *Metal Oxide Semiconductor*

[c] CVD = *Chemical Vapor Deposition*

[d] MBE = *Molecular Beam Epitaxy*

[e] LPCVD = *Low Pressure Chemical Vapor Deposition (NOT Liquid Phase* :-)

[f] ALE = *Atomic Layer Epitaxy*

[g] SLS = *Strained Layer Superlattice*

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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 = 22

[b] To grow a 1 μm thick oxide on Si in steam at 1000 °C, we need to grow 1Exx sec, where xx= 03

[c] The activation energy for vacancy concentration in Si is 2Exx eV where xx= 0

and where the value for the different charge states adds a spread about 1Eyy eV where yy = 0.. -1

[d] The solid solubility of As in Si at 1100 °C is about 1Exx cm^3 where xx= 20

[e] The bandgap of InAs is about 3Exx eV where xx= -1

14

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)

[x] k

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

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The segregation coefficient is important for Czochralski growth because

[ ] The sign indicates whether striations will develop

[x] It explains why floatzone 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

[x] 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

[x] 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

[x] * 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.

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

[ ] Vacancies can 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 *it is called intrinsic*

[x] 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

[x] A 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
[x] An As layer

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

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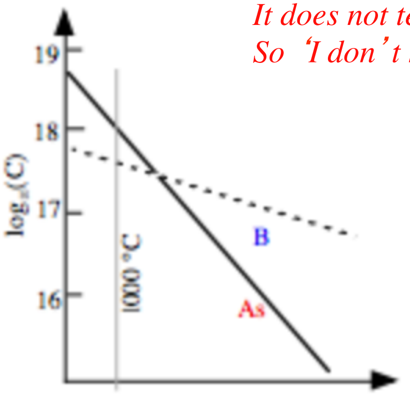
The figure below shows the solubility of B and A in a *new insulator* in contact with Si as a function of temperature. The Insulator is in contact with regions of
that is rich in B (boron) and other that are rich in As at t
same concentration. When annealing at 1000 °C, which
part of the insulator will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



Solubily is an equilibrium property
It does not tell how fast a state is reached
So 'I don't know' is the only correct answer