EE128 Homework Set 1

Question 1:

You are designing a Si solar cell system that will be used to visit Superman's parents. Given that the planet Superman's parents live on has red sun sunlight the AR coating needs to be 0.1850μm. Design a thermal oxidation process that will create a SiO_2 AR coating on Silicon. Assume that the minimum furnace time step is 20minutes.

We will choose <111> as the substrate orientation due to <111> silicon's longer minority carrier lifetime, which will lead to more efficient cells.

We will choose a wet process to try to minimize the growth time. We will choose 900°C to start:

Temp oC	Temp (K)	Do	Ea/KT	Do*exp(-Ea/kT)	
900	1173	1.63E+08	20.27442673	0.255338294	
900	1173	3.86E+02	7.714172121	0.1723316	
	B/A	B	Thickness (um)	Time=Xo^2/B+Xo/(B/A) (hr)	
	0.255338	0.1723316	0.185	0.923128681	
				Time(min)=	55.38772

55 minutes is a valid solution, but can we reduce the time by increasing the temperature? 950°C?

Temp oC	Temp (K)	Do	Ea/KT	Do*exp(-Ea/kT)	
950	1223	1.63E+08	19.44554583	0.584917146	
950	1223	3.86E+02	7.398793048	0.23622851	
	B/A	B	Thickness (um)	Time=Xo^2/B+Xo/(B/A) (hr)	
	0.584917	0.23622851	0.185	0.461165015	
				Time(min)=	27.6699

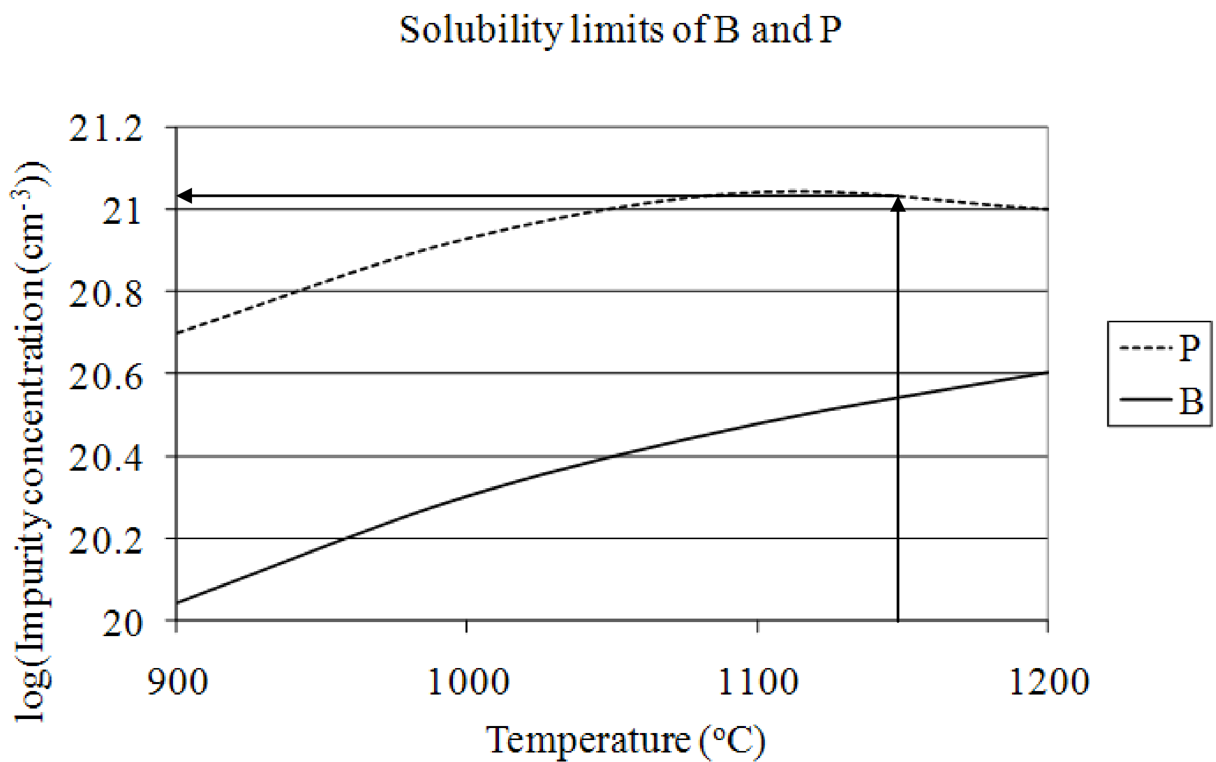
950°C for 28 minutes looks like a good process.

Question 2:

Design a diffusion process that will create a p/n junction on P-type Silicon doped to $5x10^{16}cm^{-3}$ with Boron to have junction depth of 0.25μm. Assume that the minimum furnace time step is 20minutes.

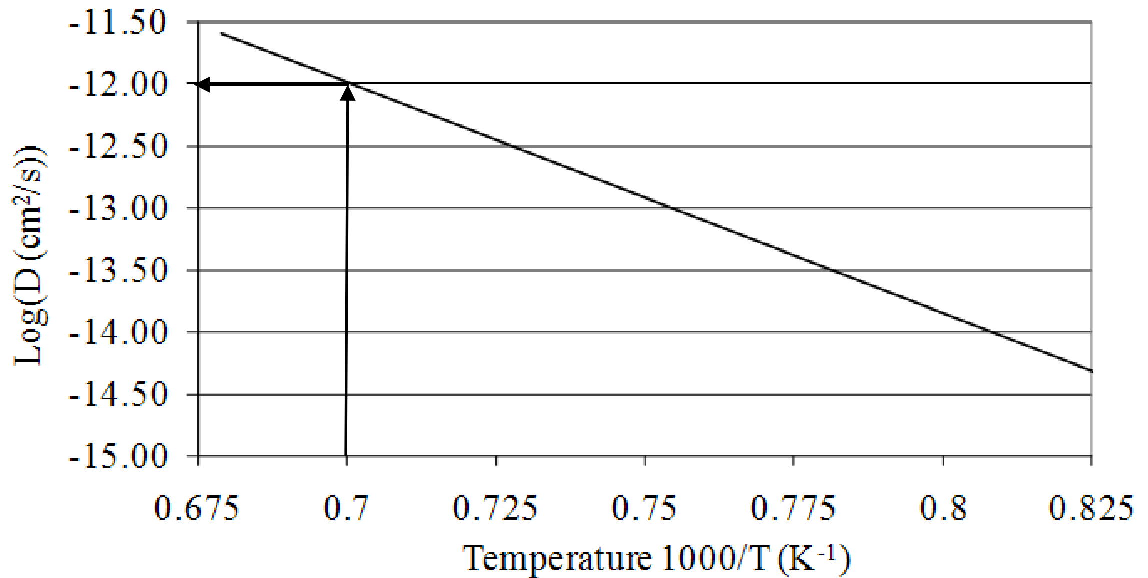
Since the substrate is p-type we need to use a column 5 element such as phosphorus to diffusion our p/n junction.

Let's Try 1150°C. First find No the surface concentration:



From the above graph $No=10^{21.05}\ cm^{-3}$.

Now Find D:



$$D = 10.5\,\frac{cm^2}{s}\cdot \exp\left(\frac{-3.69V}{8.62\cdot 10^{-5}\,\frac{V}{K}\cdot T}\right)$$

From the chart $D=10^{-12}$ cm^2/s, from the equation $D=1.06x10^{-12}$ cm^2/s.

$Z=erf^{-1}(1-Na/No)= erf^{-1}(5x10^{16}\,cm^{-3}/10^{21.05}\,cm^{-3})= erf^{-1}(1-5x10^{16}\,cm^{-3}/10^{21.05}\,cm^{-3})$
$=erf^{-1}(.999955)=2.88$

$Time=(x_j/Z/2)^2/D=(0.25x10^{-4}cm/2/2.88)^2/1.06x10^{-12}cm^2/s=281s=17.6s$

Too short!

Now I will walk the temperature down until I get a good time:

Temp (oC)	Temp(K)	1000/T(k)	NO	D	NA	Z	Xj	Time s	Time m
1150	1423	0.702741	1.12202E+21	1.00E-12	5E+16	2.886731231	2.50E-05	18.7502613	0.312504355
1150	1423	0.702741	1.12202E+21	1.06495E-12	5.00E+16	2.886731231	2.50E-05	17.60673451	0.293445575
1100	1373	0.728332	1.13501E+21	3.58209E-13	5E+16	2.888622016	2.50E-05	52.27600512	0.871266752
1050	1323	0.755858	1E+21	1.10963E-13	5.00E+16	2.867761342	2.50E-05	171.2208846	2.85368141
1000	1273	0.785546	7.94328E+20	3.135E-14	5E+16	2.829476956	2.50E-05	622.5445152	10.37574192
950	1223	0.817661	6.30957E+20	7.98753E-15	5.00E+16	2.790719263	2.50E-05	2511.742575	41.86237626
900	1173	0.852515	5.01187E+20	1.81119E-15	5E+16	2.751470784	2.50E-05	11395.32592	189.9220986

It looks like 950°C gives the most efficient time.

Question 3:

You are a process engineer and are trying to develop a process that will create a SiO_2 AR coating on Silicon that will be 0.1μm thick. The recipe you have selected is a wet oxide process on <111> Si for 1150°C for 1.56 minutes. You have noticed that the oxide thickness is not uniform at all after fabrication.

What do you think the problem is?

Given that the minimum furnace time is suggested to be 20 minutes, trying to grow something for 1 ½ minutes seems to be the main problem.

What is the solution?

Re-do the process so that a minimum furnace time is 20 minutes by lowering the temperature or switching to a dry process.