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EE 432 Lab
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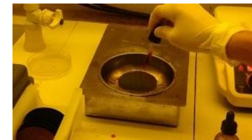
Report 2

A. Overview

This section comprised of source and drain construction for the NMOS and PMOS. This includes two different photolithography and doping steps. The first lithography was for the PMOS source and drain. The PMOS s/d were doped with Boron to create p-type regions. Then, for the second lithography, the NMOS s/d areas were exposed and doped with Phosphorous to create n-type regions.

B. Photolithography and etching for PMOS Source and Drain

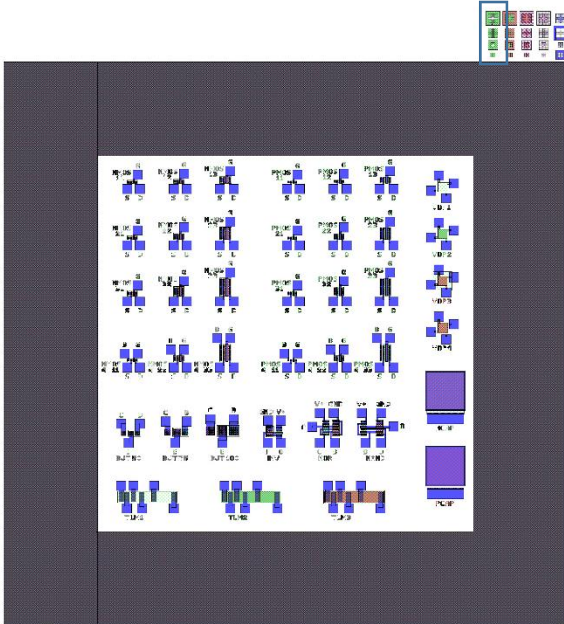
The photolithography and etching for the PMOS source and drain was performed by using a mask to expose a photoresist layer and etching away the oxide underneath.

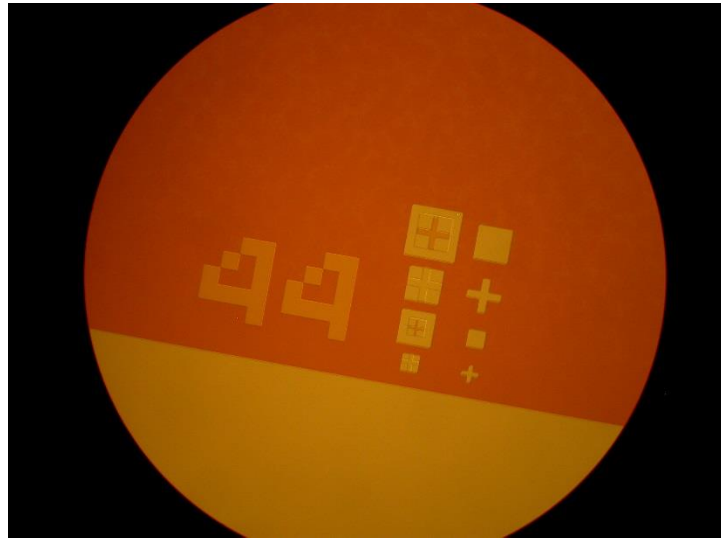


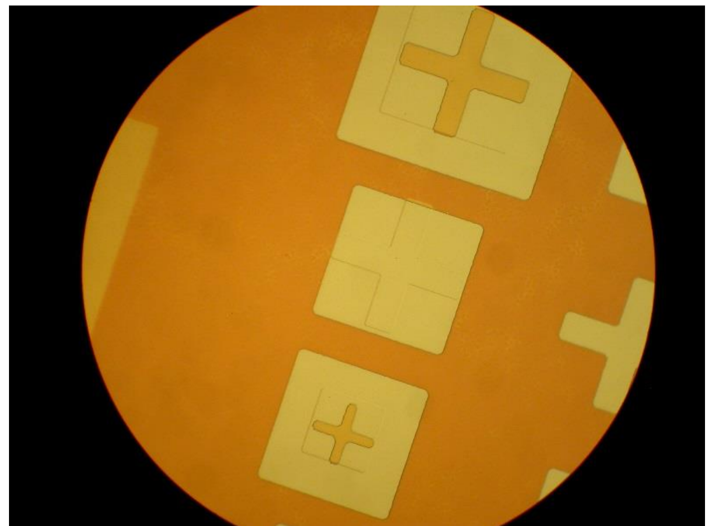
Steps:

1. Spin HDMS (hexamethyldisilazane) adhesion layer
    a. Spins at 4000 rpm for 25 seconds
2. Spin PR
    a. A25014E-IR
    b. Spins at 4000 rpm for 25 seconds
3. Prebake
    a. Cooked on hot plate at 120°C for 1 minute
4. Exposure
    a. Align the mask with the wafer features(Used first alignment features)
    b. Exposure machine for 90 seconds
5. Develop PR
    a. Soaked In MIF-300 developer for 60-90 seconds
6. Cascade rinse
    a. Soaked for 3 minutes to wash off developer
7. Dry

8. Inspect
    a. Used microscope to inspect the features on the wafer to make sure everything went well.
    b. They looked good. There were a few contaminations we spotted but most of the wafers were good.





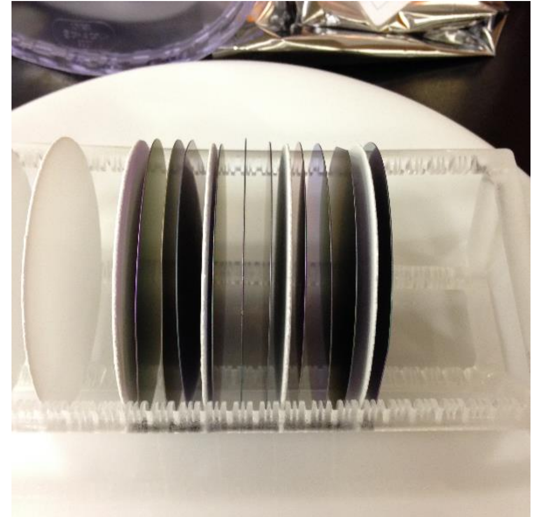


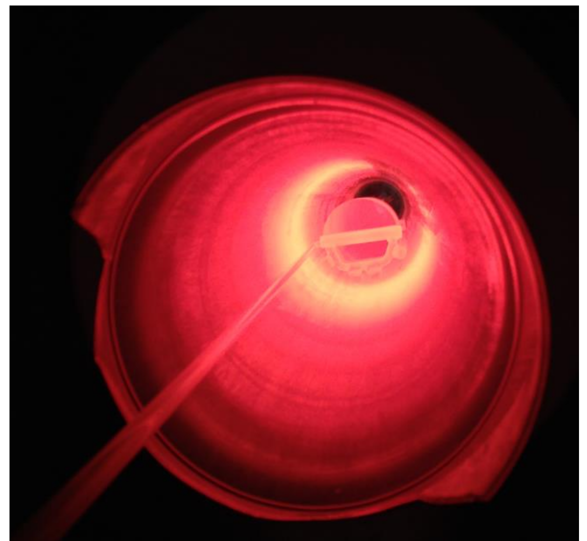
C. Boron deposition and drive for PMOS

For boron deposition, we must do a standard clean and perform a deposition step, then a drive step.

Steps:

1. Standard clean
    a. All standard clean steps
2. Place wafers in boat with device side facing boron source wafers and shield wafers on the other side of device wafers.
3. Boron Predeposition
    a. Push
        i. Tempuature at 850°C
        ii. Push at rate of 1 inch / 12 seconds
    b. Recovery
        i. Ambient 1 lpm N2+1 lmp O2
        ii. For 20 minutes
    c. Source
        i. Ambient 1lpm N2 + 1 lpm O2 + 40 sccm H2
        ii. Tempature 850°C
        iii. For 2 minutes
    d. Soak
        i. 2 lpm N2 flowing
        ii. 850C
        iii. For 50 min
    e. Pull
        i. 2lpm N2
        ii. 850°C
        iii. Pull out at 1 inch / 12sec
4. Deglaze
    a. BOE
        i. 30 seconds
        ii. Takes off oxide layer
    b. Cascade rinse
        i. Takes off chemicals and residue
    c. Spin rinse and dry
        i. Cleans and dries wafers
5. Standard clean
    a. All steps from part C again
6. P-well Low -Temp Oxidation and Boron drive
    a. Bubbler on
        i. Temp at 98°C
        ii. 200 sccm N2
    b. Push
        i. .3 slpm dry N2
        ii. Furnace temp at 800°C





    iii. Rate at 1 inch/12 sec

c. LTO

    i. 200 sccm bubbler N2 vent bubbler to tube
    ii. Temp at 800°C still
    iii. Let sit for 30 mins

d. Turn bubbler off

e. Pull

    i. .3 slpm dry N2
    ii. Furnace temp at 800°C

f. Take wafers out of furnace boat

g. Deglaze

    i. BOE for 30 seconds
    ii. Cascade rinse
    iii. Spin rinse/dry

h. Put wavers back in furnace boat

i. Push

j. Ramp up

    i. Turn temp to drive tempature
    ii. Turn on bubbler

k. Wait for furnace to reach drive temp and begin oxidation

    i. Let bubbler vent to furnace
    ii. Wait for desired oxidation time

l. Bubbler off

m. Drive

    i. Set nitrogen to 1slpm
    ii. Wait a long time

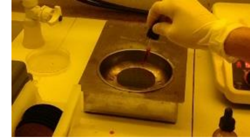
n. Ramp down to 800°C or 600°C

o. Remove wafers

p. Unload wafers and move to storage bin

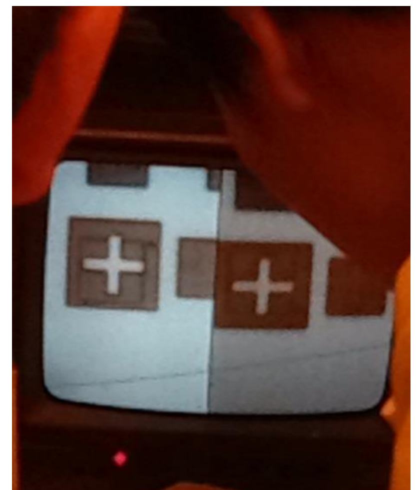
D. Photolithography and etching for NMPS s/d

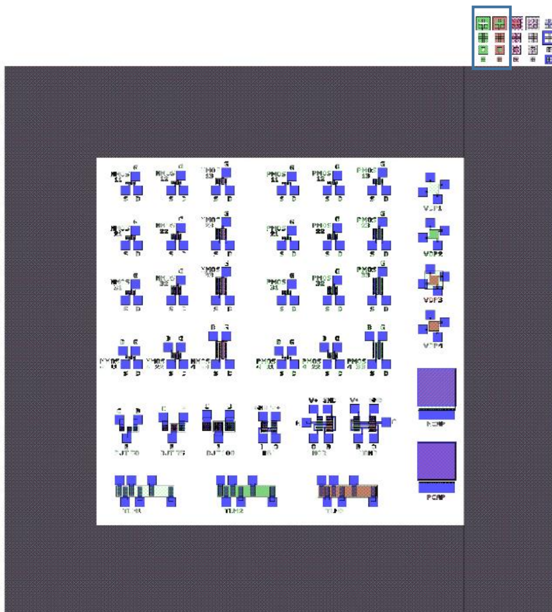
The photolithography and etching for the NMOS source and drain was performed by using a mask to expose a photoresist layer and etching away the oxide underneath. These exposed regions of silicon will be doped with Phosphorous to create n-type regions.

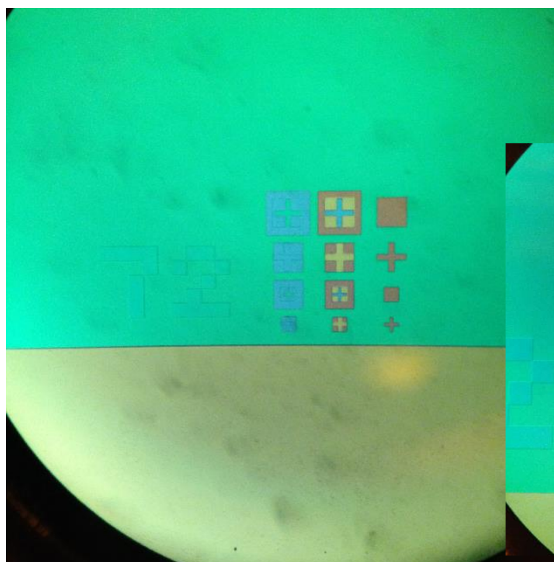


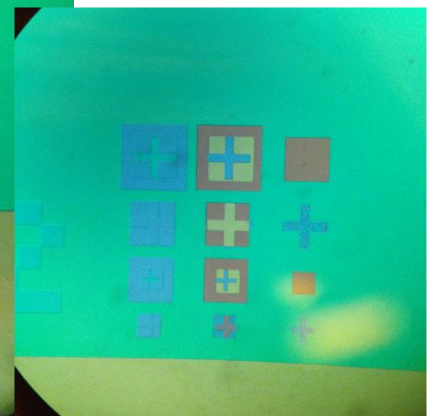
Steps:

1. Spin HDMS (hexamethyldisilazane) adhesion layer
    a. Spins at 4000 rpm for 25 seconds
2. Spin PR
    a. A25014E-IR
    b. Spins at 4000 rpm for 25 seconds
3. Prebake
    a. Cooked on hot plate at 120°C for 1 minute
4. Exposure
    a. Exposure machine for 90 seconds(Second alignment features)
5. Develop PR
    a. Soaked In MIF-300 developer for 60-90 seconds
6. Cascade rinse
    a. Soaked for 3 minutes to wash off developer
7. Dry
8. Inspect
    a. Used microscope to inspect the features on the wafer to make sure everything went well.
    b. They looked good. There were a few contaminations we spotted but most of the wafers were good.
    c. We can also see slight misalignment that may or may not cause issues.





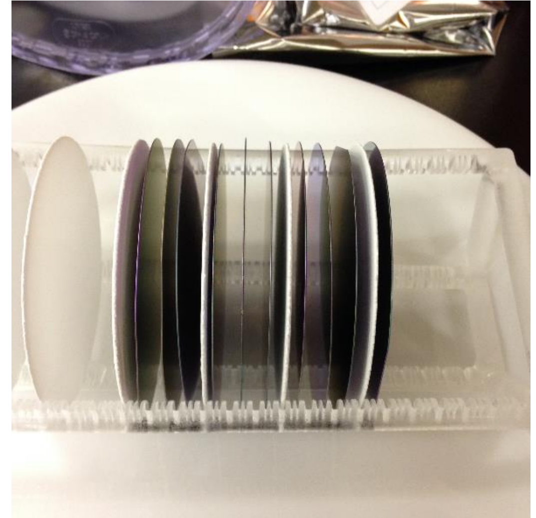




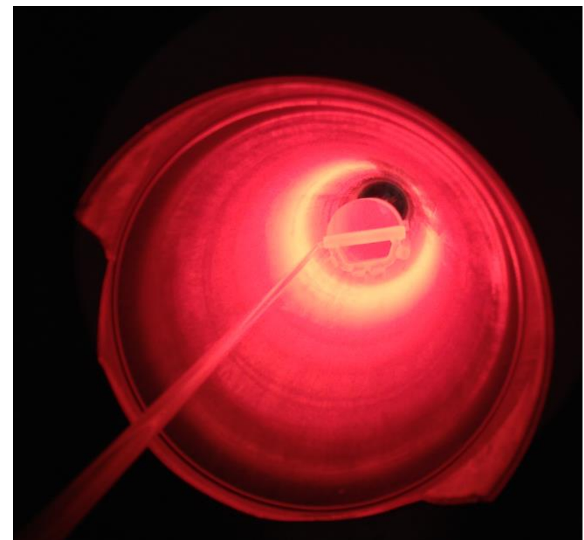
E. Phosphorus deposition and drive for NMOS

For Phosphorous deposition, we must do a standard clean and perform a deposition step, then a drive step.

Steps:



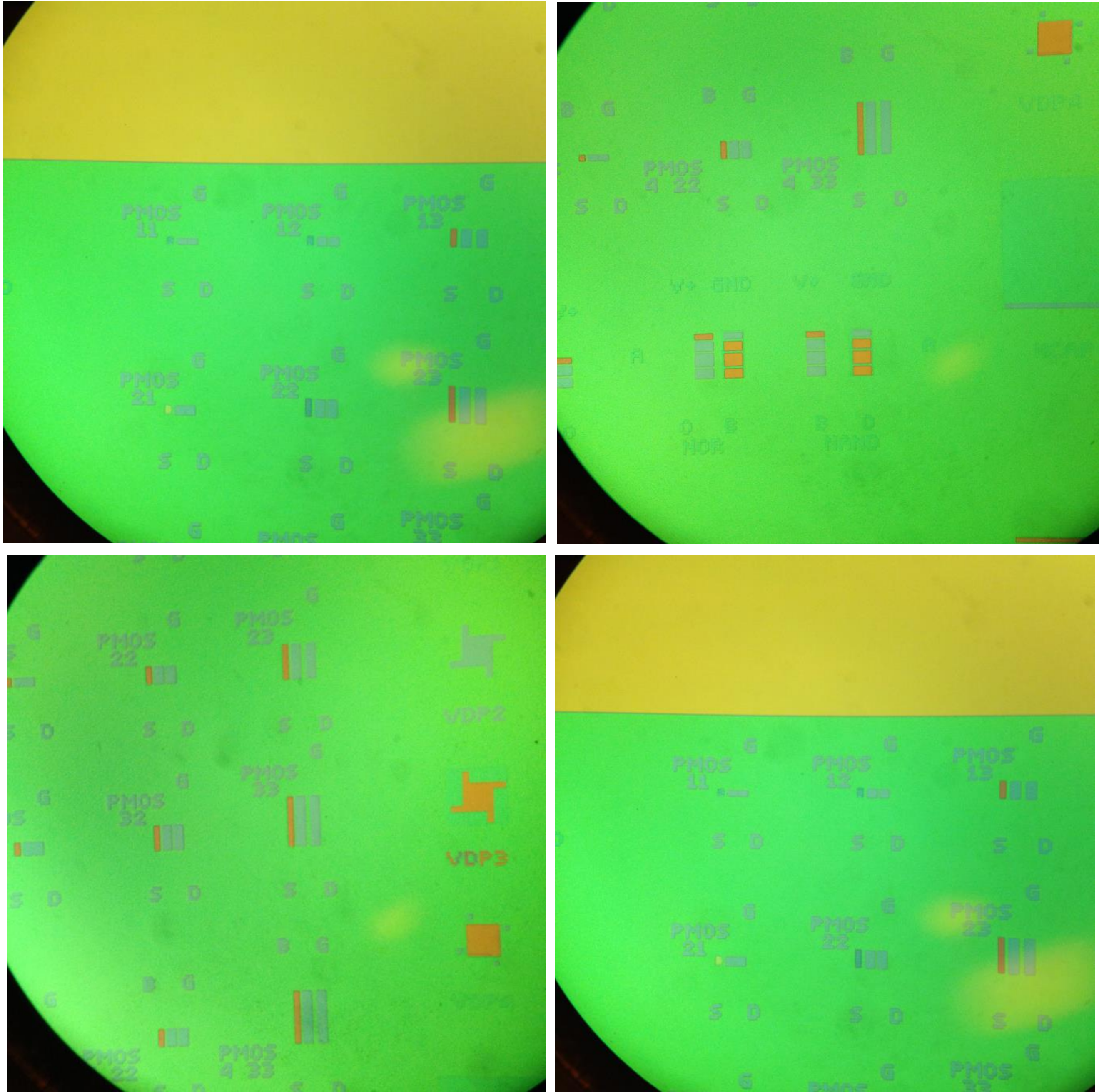
1. Standard clean
    a. All standard clean steps
2. Place wafers in boat with device side facing boron source wafers and shield wafers on the other side of device wafers.
3. Boron Predeposition
    a. Push
        i. Tempuature at 900°C
        ii. Push at rate of 1 inch / 12 seconds
    b. Source
        i. 1 lpm N2 flowing
        ii. Tempature 900°C
        iii. For 45 minutes
    c. Pull
        i. 2lpm N2
        ii. 900°C
        iii. Pull out at 1 inch / 12sec
4. Deglaze
    a. BOE
        i. 30 seconds
        ii. Takes off oxide layer
    b. Cascade rinse
        i. Takes off chemicals and residue
    c. Spin rinse and dry
        i. Cleans and dries wafers
5. Standard clean
    a. Since we did this in the same day, we did not have to clean the wafers.
6. P-well Low -Temp Oxidation and Boron drive
    a. Bubbler on
        i. Temp at 98°C
        ii. 200 sccm N2
    b. Push
        i. 1 slpm dry N2
        ii. Furnace temp at 800°C
        iii. Rate at 1 inch/12 sec
    c. Ramp up
        i. 1 slpm N2
        ii. Temp to 1075°C
        iii. Wait 10 mins



d. Oxidation
    i. 1 slpm H_2O
    ii. 1075°C
    iii. 10 mins
e. Drive
    i. 1 slpm N_2
    ii. 1075°C
    iii. 20 mins
f. Ramp Down
    i. 1 slpm N_2
    ii. Set to 800°C
    iii. Wait 8 min
g. Pull
    i. 1 slpm N_2
    ii. 800°C
    iii. 1 inch every 12 seconds
h. Unload wafers and move to storage bin after letting cool

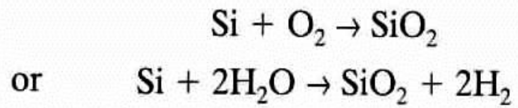
F. Results

We have not been measuring the oxide thickness in our group for some reason. But upon inspection of the wafers in the microscope, the devices look like they are forming correctly. There are a few transistors that are very small that looks like the source and drain are merged together so they may not function properly. But these are only a few wafers. Also, we lost track of which test wafer is which and we think that we messed up one of them so we can no longer test them with the spectrum analyser.



G. Appendix:

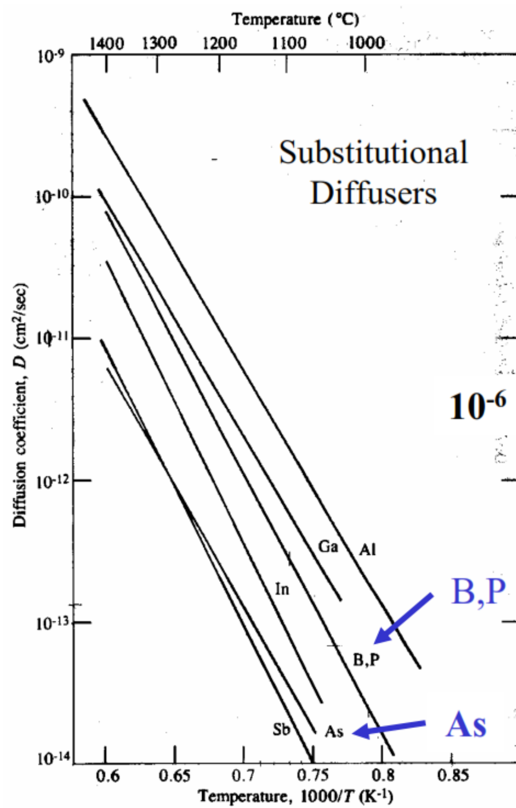
Oxidation Chemical Reactions:

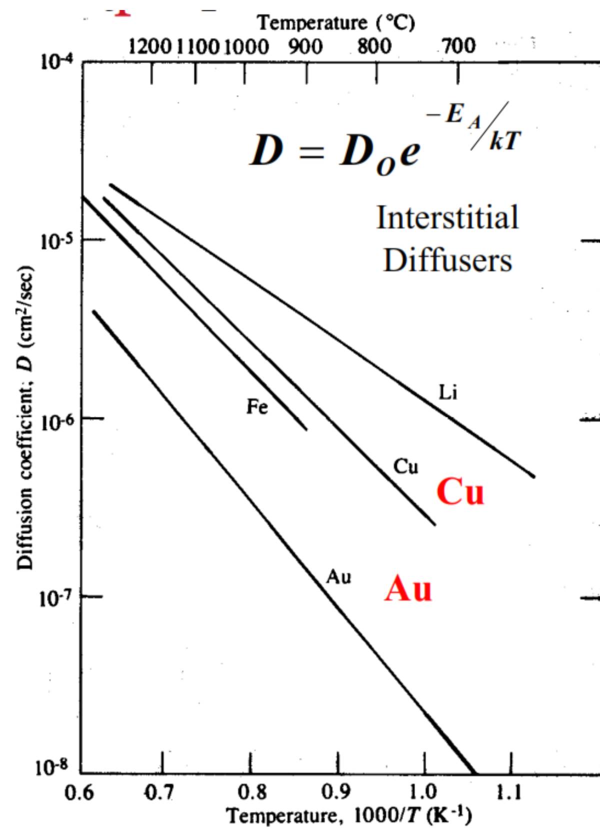


Oxidation Equations

$$\frac{x_o^2 - x_i^2}{B} + \frac{x_o - x_i}{B/A} = t \qquad \frac{\mathbf{B}}{\mathbf{A}} = \mathbf{C_2 \exp(-E_2/kT)} \qquad \mathbf{B = C_1 \exp(-E_1/kT)}$$

Diffusion Equations





$$D = D_0 e^{-E_A/kT}$$

Concentration : $N(x,t) = N_0 erfc\left(\frac{x}{2\sqrt{Dt}}\right)$

Total Dose : $Q = \int_0^\infty N(x,t)dt = 2N_0\sqrt{\frac{Dt}{\pi}}$

Concentration :

$$N(x,t) = N_0 \exp\left[-\left(\frac{x}{2\sqrt{Dt}}\right)^2\right] = \frac{Q}{\sqrt{\pi Dt}} \exp\left[-\left(\frac{x}{2\sqrt{Dt}}\right)^2\right]$$