CHE323/CHE384
Chemical Processes for Micro- and Nanofabrication

Lecture 7
The Junction Diode

Chris A. Mack
Adjunct Associate Professor

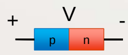
Junction Diode

- Biasing the p-n junction (applying a voltage between the p-side and the n-side) changes the depletion region width
- In one direction of bias, the depletion region gets bigger, and no current flows
- In the other direction, the depletion region gets smaller and current easily flows
- A device that allows current to flow in only one direction is called a diode

Biased P-N Junction

- If we "bias" the diode, apply a voltage V from the p-side to the n-side, almost all of that voltage will fall across the depletion region
- Applied voltage will add or subtract from the built-in voltage to create a junction voltage V_0-V

$$W = \sqrt{\frac{2\varepsilon_{Si}(V_0 - V)}{q}\left(\frac{1}{N_A} + \frac{1}{N_D}\right)}$$



Biased P-N Junction

- Reverse bias: a negative voltage makes the depletion width larger, and very little current flows (diffusion current is turned back by the higher electric field across the depletion region)

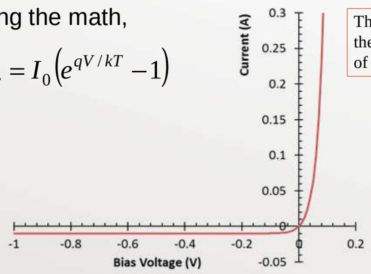
$$W = \sqrt{\frac{2\varepsilon_{Si}(V_0 - V)}{q}\left(\frac{1}{N_A} + \frac{1}{N_D}\right)}$$

- Forward bias: a positive voltage makes the depletion width smaller, and current can flow (increased diffusion current due to lower electric field/potential barrier)

Diode Equation

- Working the math,

$$I_{diode} = I_0\left(e^{qV/kT} - 1\right)$$



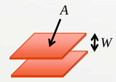
This is called the I-V curve of the device

P-N Junction Capacitance

- Separation of charge produces capacitance
- The capacitance of the p-n junction is easily calculated

For two parallel conducting plates of area *A* separated by distance *W*,

$$C = \frac{\varepsilon A}{W}$$



$$C_{p-n\ junction} = A\sqrt{\frac{q\varepsilon_{Si}}{2(V_0 - V)}\left(\frac{N_D N_A}{N_D + N_A}\right)}$$

P-N Junction Capacitance

- Example: $N_A >> N_D$ (called a p^+-n junction)

$$C(V) = A\sqrt{\frac{q\varepsilon_{Si}}{2(V_0 - V)}N_D}$$

- Measuring C(V) allows N_D to be extracted – a common measurement in semiconductor manufacturing

Lecture 7: What have we learned?

- How does bias affect depletion width?
- What is a diode?
- Why does a p-n junction act like a diode
- Be able to use the diode equation
- Be able to use the C(V) equation