

Quick Start Micro Training LLC
Very Quick Start™ Optoelectronics Course
 Dr. Ted Dellin

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**7-Hour Narrated E Learning Course
 (Also Webinar or In-Person Class)**

**SAMPLE SLIDES
 FROM COURSE**

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**Engineering Semiconductor Properties
 Leads to Useful Devices**

Semiconductors Have Electronic Special Properties

We Can Engineer (Control) Those Properties
 During Design & Manufacturing By Applying Voltages During Device Operation

2 Basic Building Blocks of Electronic & Optoelectronics
 Junctions (Semi/Semi, Semi/Metal) MOS Capacitor

Very Useful Devices
 Rectifiers, Transistors, ICs, Photodetectors, Solar Cells, LEDs, Lasers

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**A Voltage Source (e.g., Battery)
 Supplies Energy**

Battery of Voltage, V

- Charges gain energy going through a battery
 - Electrons gain energy from + to – side of battery
- Energy Gained = Amount of Charge x Voltage
 - An electron going through a 1V battery gains 1 eV (electron Volt, 1.6E-19 Joules)

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**Single Energy Levels of Atoms Become
 Bands (Ranges of Energy) in Crystals**

Electron's Energy

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**Replacing a Silicon Atom With Phosphorus
 Makes Silicon n Type (Excess Electrons)**

n Type (Excess Electron) Si
 P substitutionally replaces Si in the lattice. P's 5th valence electron is free to move about crystal.

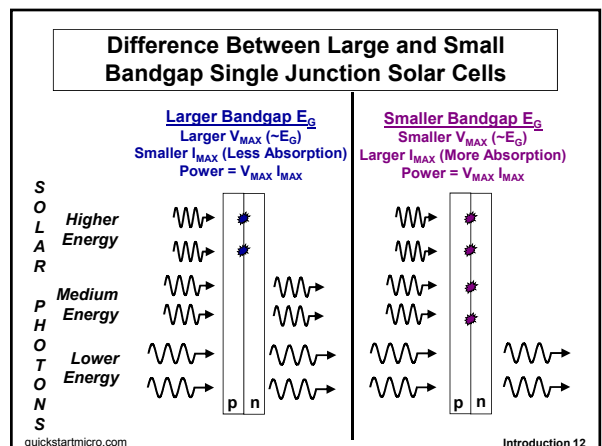
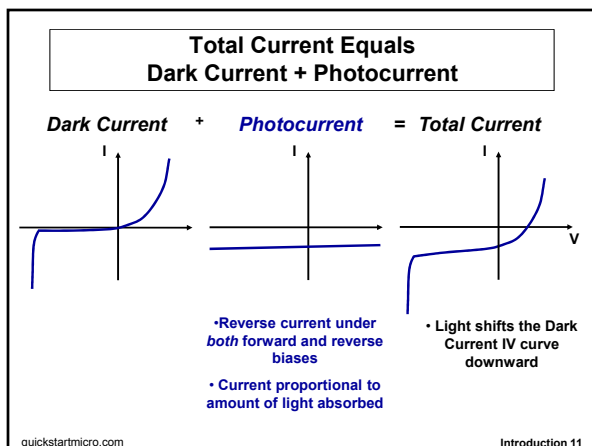
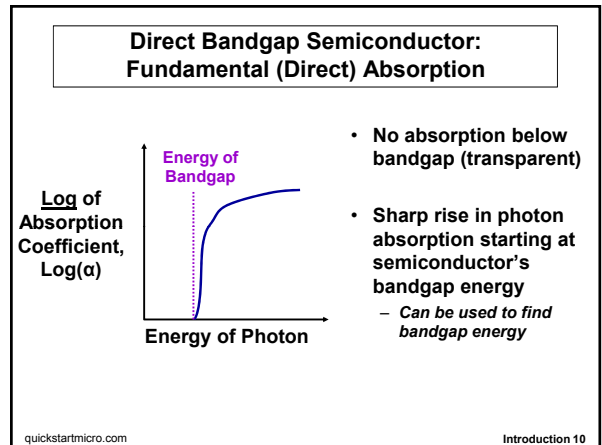
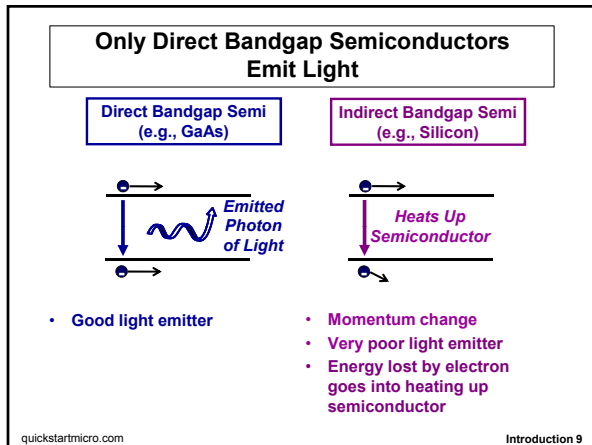
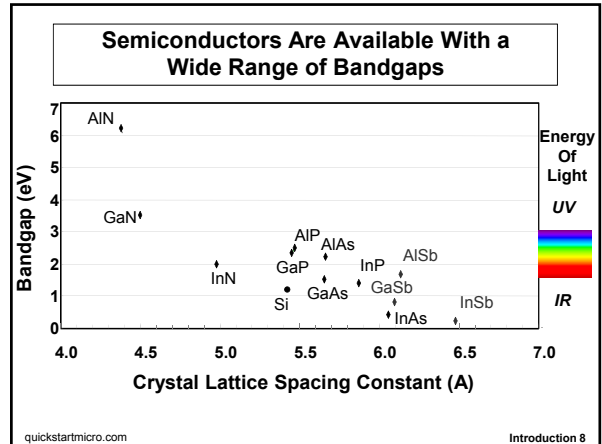
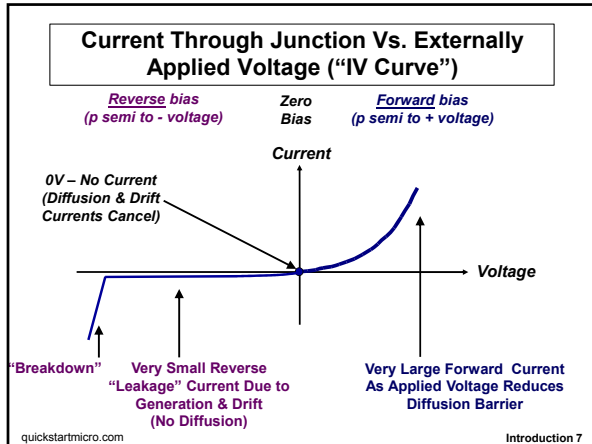
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**A "Junction" Is Formed Whenever Two
 Different Semiconductors Are Joined**

- "Bulk" regions of the semiconductors remained essentially unchanged
- Inside the junction many interesting effects can occur
 - E.g., built-in voltage and electric field and diffusion barriers

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There Are Two Recombination Process That Produce a Photon

Spontaneous Emission

1 Photon

Stimulated Emission

1 Photon → 2 Photons

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Double Heterostructures Are Good For Photon Emission

+V **Wide Bandgap p** **Narrow Bandgap p** **Wide Bandgap n** -V

1. High concentrations of electrons and holes in narrow bandgap material increases the recombination rates
2. Wide bandgap materials will not absorb lower energy photons from narrow band gap

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Different Semiconductors Are Needed For Different Colors of Light

- LEDs and Lasers produce a essentially a single color of light (monochromatic)
- The bandgap energy of the semiconductor must match the energy (color) of the light
 - For lower-energy infrared light need a smaller bandgap semiconductor like InGaAsP
 - For higher-energy blue light need a larger bandgap semiconductor like GaInN

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Optical Effects Are A Major Factor in The Performance of LEDs

Photon That Escapes Into Air

Photons That DO NOT Escape Into Air

- Due to the high index of refraction of semiconductors relative to air only a small fraction of the light generated in the LED junction escapes into the air

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To Make a Laser Diode Add An Optical Cavity to an LED

Laser Diode = **LED** + **Two Parallel Reflecting Surfaces**

Lots of electrons and holes that can recombine to make photons within junction (gain region)

Sets up beams of photons all moving in the same direction. Photons make multiple passes through junction

Need lots of both electrons/holes and photons to have lots of stimulated emission

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