Photodiodes

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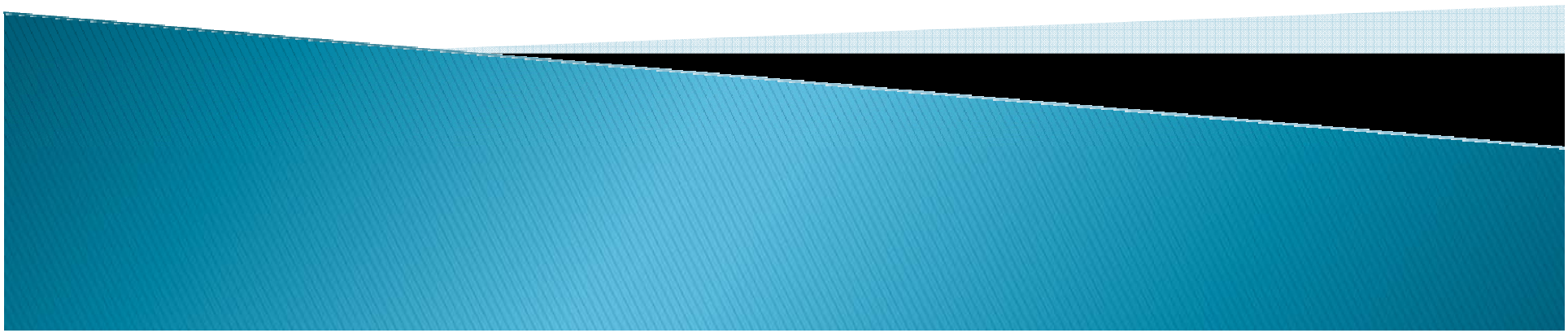
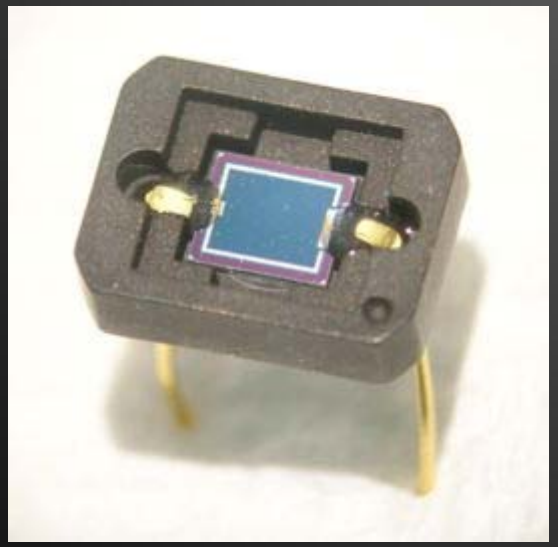
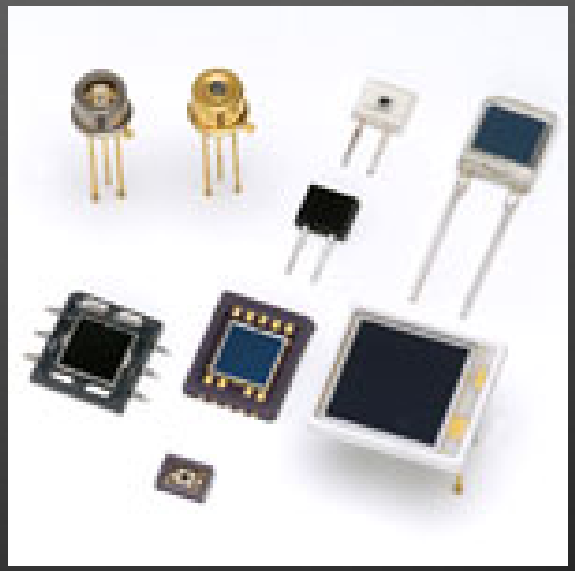


Introduction

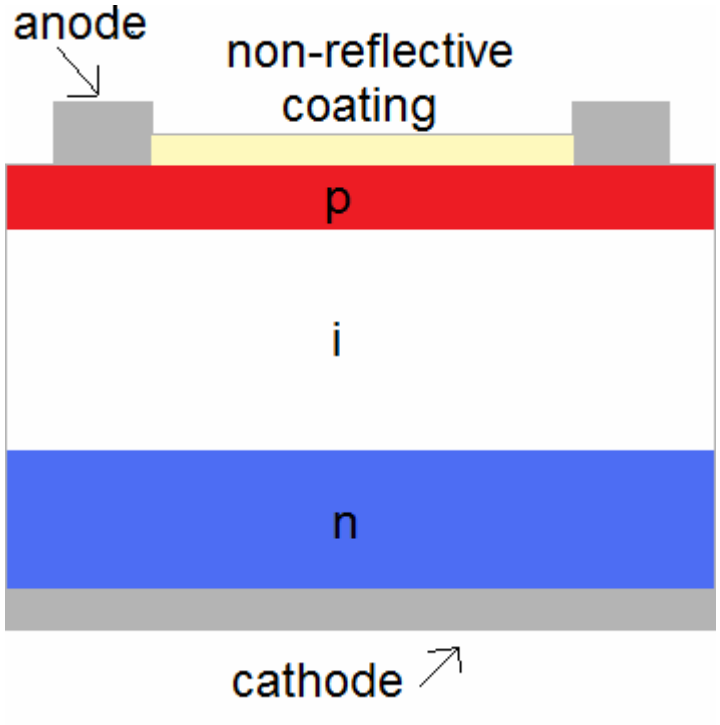
- Photodiode: A light sensing semiconductor that can produce electrical current or voltage from photons.





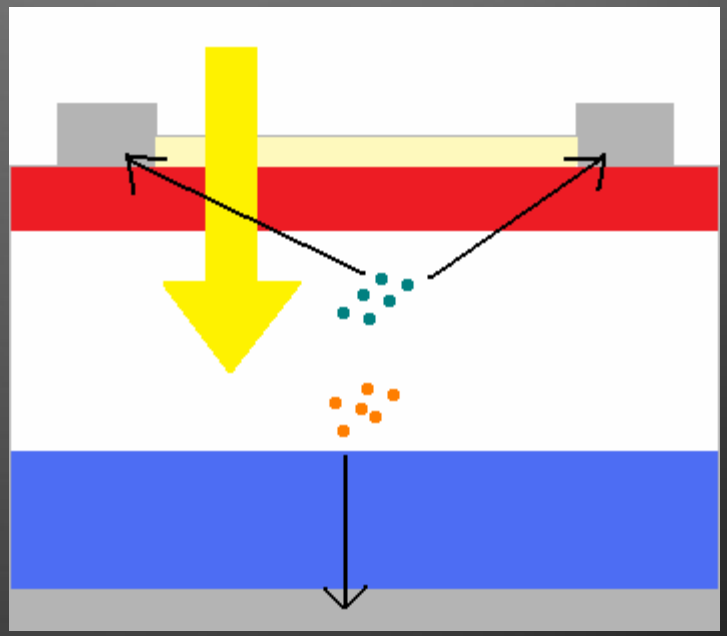
Inside A Photodiode

- Non-Reflective Coating
  - Non-reflective layer made of silicon monoxide or silicon dioxide
  - High refractive index between air and most semiconductors
- P-Type Material
- Intrinsic Material
- N-Type Material



How Do Photodiodes Work?

- Photons enter the diode through the non reflective coating and p layer into the depletion region
- Photons excite free electrons and holes
- Carriers move to cathode and anode creating current



How Do Photodiodes Work?

- Photocurrent due to absorption in the depletion region

$$I_{ph} = -\frac{q(1-R)P_{in}}{h\nu}(1-e^{-\alpha d})$$

- Photocurrent due to absorption in the quasi-neutral region

$$I_{ph} = -\frac{q(1-R)P_{in}e^{-\alpha d}}{h\nu}\frac{\alpha L_p}{1+\alpha L_p}(1-e^{-\alpha d}) - \frac{qD_p p_{n0}}{L_p}$$

- Dark Current

Modes of Operation

- Photovoltaic
  - Allows dark current to flow
  - Used for solar cells
- Photoconductive
  - Faster response times
  - Low noise
- Avalanche Photodiode
  - High reverse bias voltage
  - Increases the effective responsivity

Controlling Wavelength

- The Material Used Determines the Wavelength
  - Because of this unwanted spectrums can be ignored by design
  - Unfortunately this also means that desirable materials that produce less noise, such as silicon, cannot be used for photodiodes designed for wavelengths outside of their range.

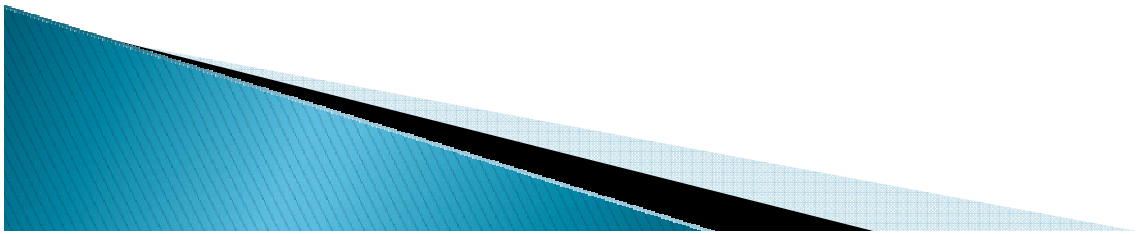
Material	Wavelength range (nm)
Silicon	190–1100
Germanium	400–1700
Indium Gallium Arsenide	800–2600
Lead Sulfide	<1000-3500

Alternative

- Photomultiplier
  - Very sensitive
  - Fast response time
  - Up to 100million gain
  - Requires 1-2k Voltage
  - Short life
  - Fragile
  - Big
  - Expensive

Photodiode Products

- Solar Cells
- Nintendo (NES) Zapper
- Motion Sensors
- Light Sensors
- Optical Communication



References

1. “Photodiodes: Construction, Hamamatsu.” Hamamatsu Corporation. April 2008. <http://sales.hamamatsu.com/assets/html/ssd/si-photodiode/index.htm>
2. Zeghbroeck, Bart. “p-n Junctions.” University of Colorado at Boulder. April 2008. <http://ece-www.colorado.edu/~bart/book/book/chapter4/ch4_7.htm>
3. “Molecular Expressions Microscopy Primer: Photomicrography - Interactive Java Tutorials - Avalanche Photodiodes.” Molecular Expressions. April 2008. <http://micro.magnet.fsu.edu/primer/java/digitalimaging/avalanche/index.html>
4. “Photodiode.” Wikipedia. April 2008. <http://en.wikipedia.org/wiki/Photodiode>

Questions?