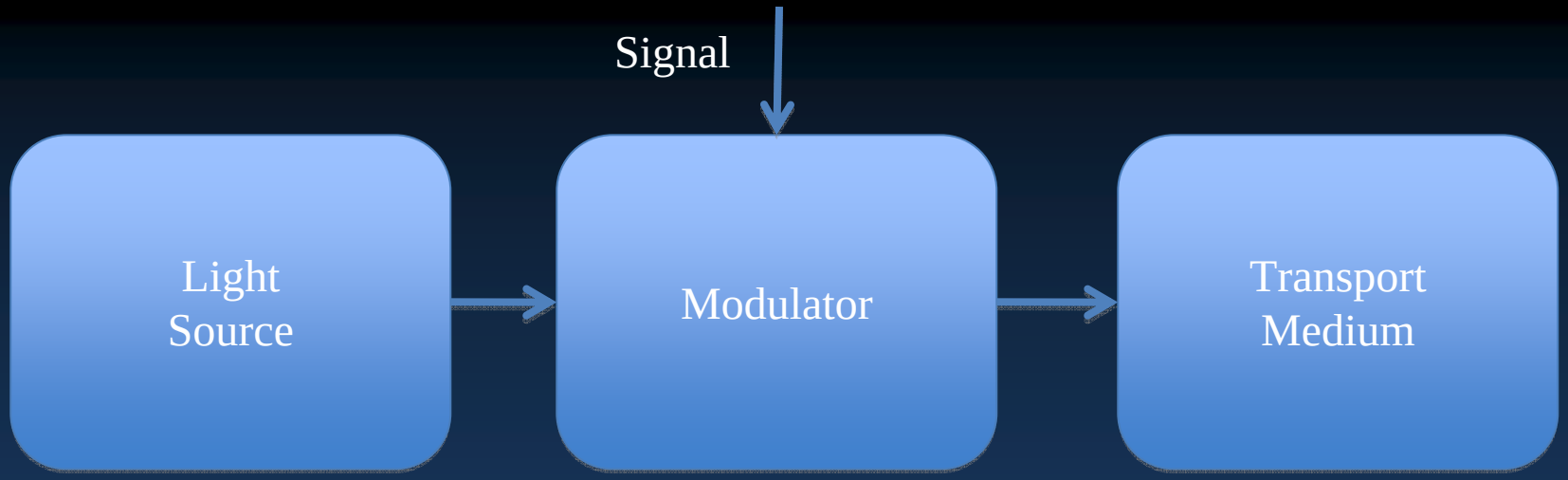
# Fiber Optics

Light Modulation by Electroabsorption

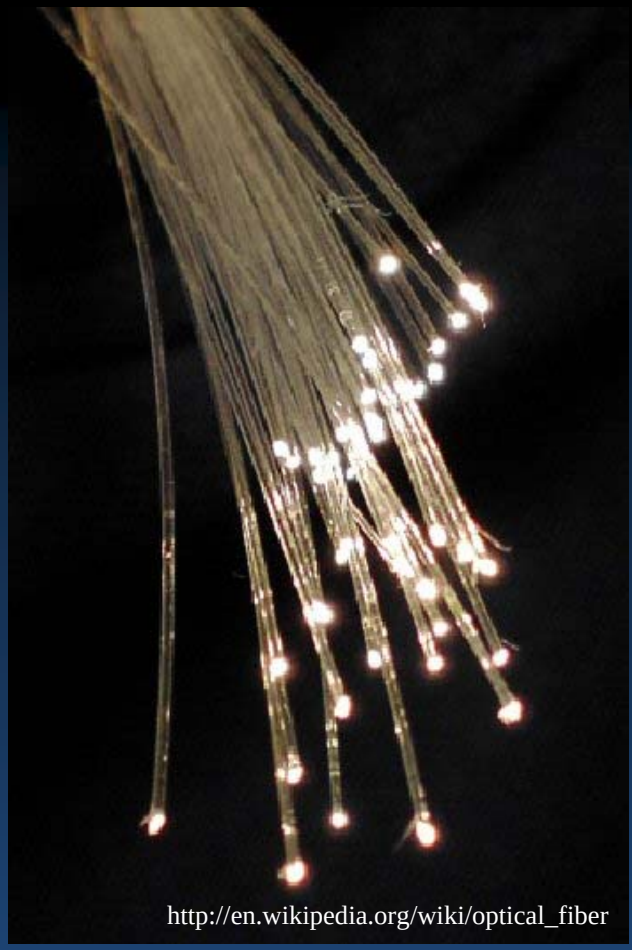
Mark McCarthy

# Basics of Fiber Optics



# Basics of Fiber Optics

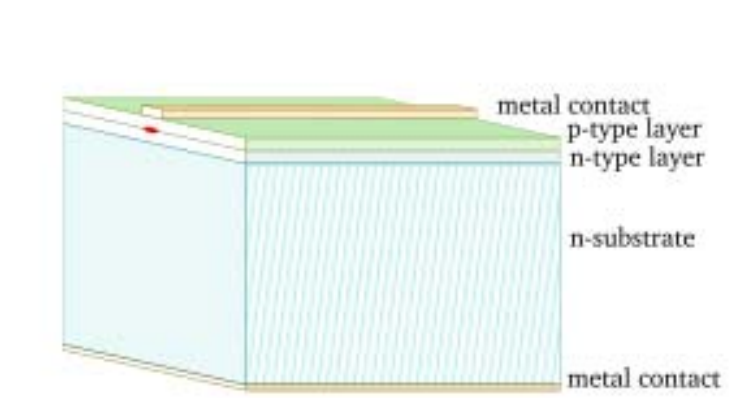
- Light Source
  - LED
  - Laser
- Transport Medium
  - Plastic
  - Glass



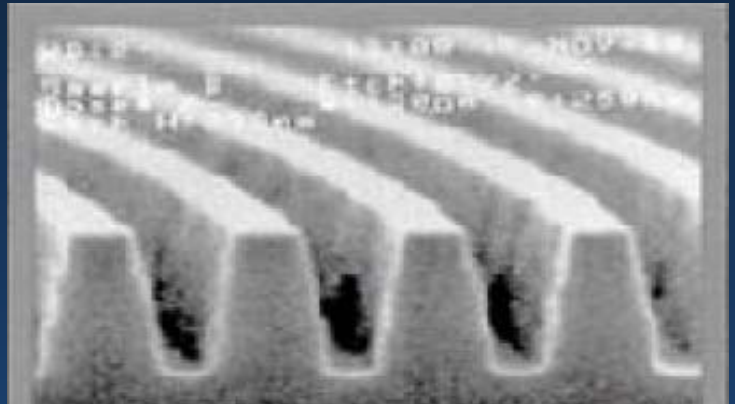
http://en.wikipedia.org/wiki/optical_fiber

# Laser Basics

- P-N Diode
- Quantum Wells
- Distributed Feedback

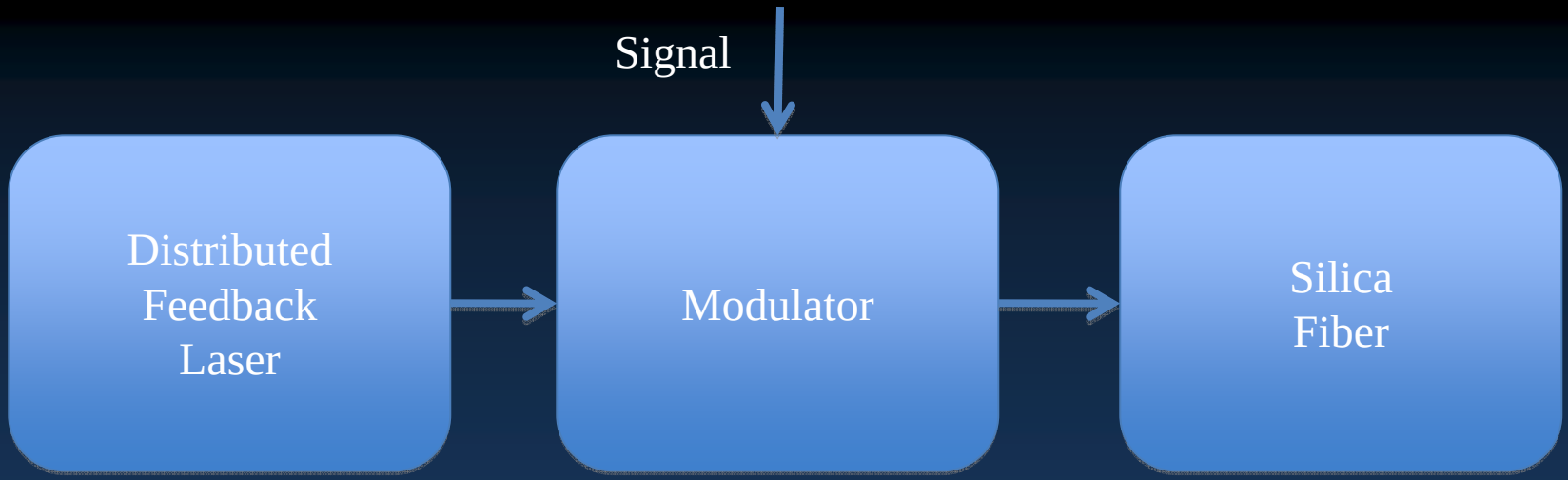



http://en.wikipedia.org/wiki/Laser_diode



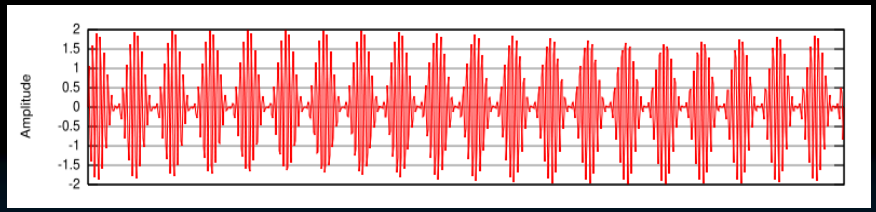

http://cqd.eecs.northwestern.edu/research/ebeam.php

# High Speed Fiber Optics

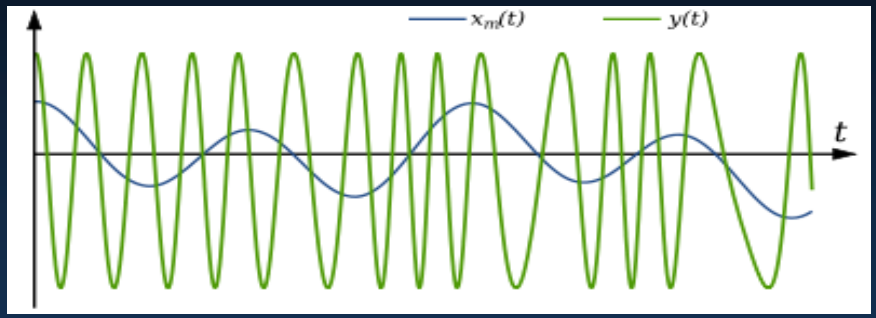


# Types of Modulation

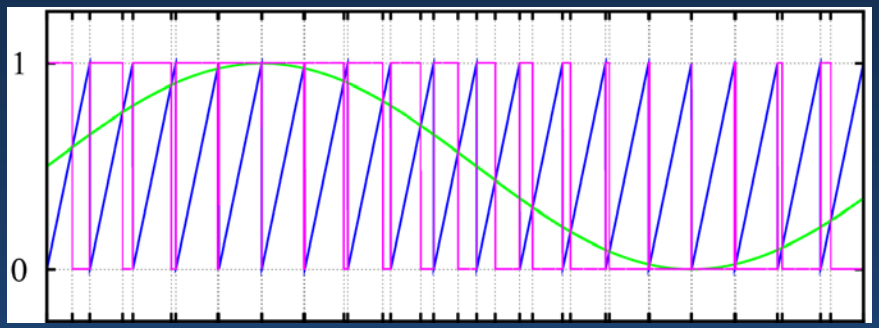
AM

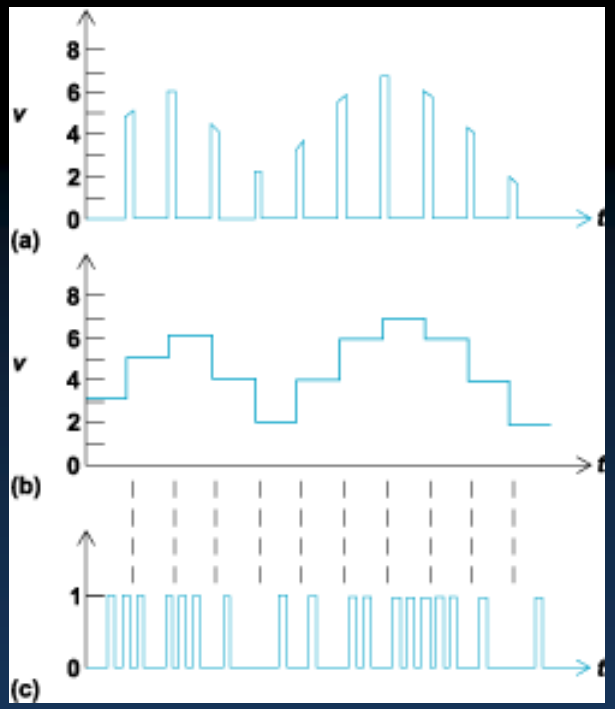



FM



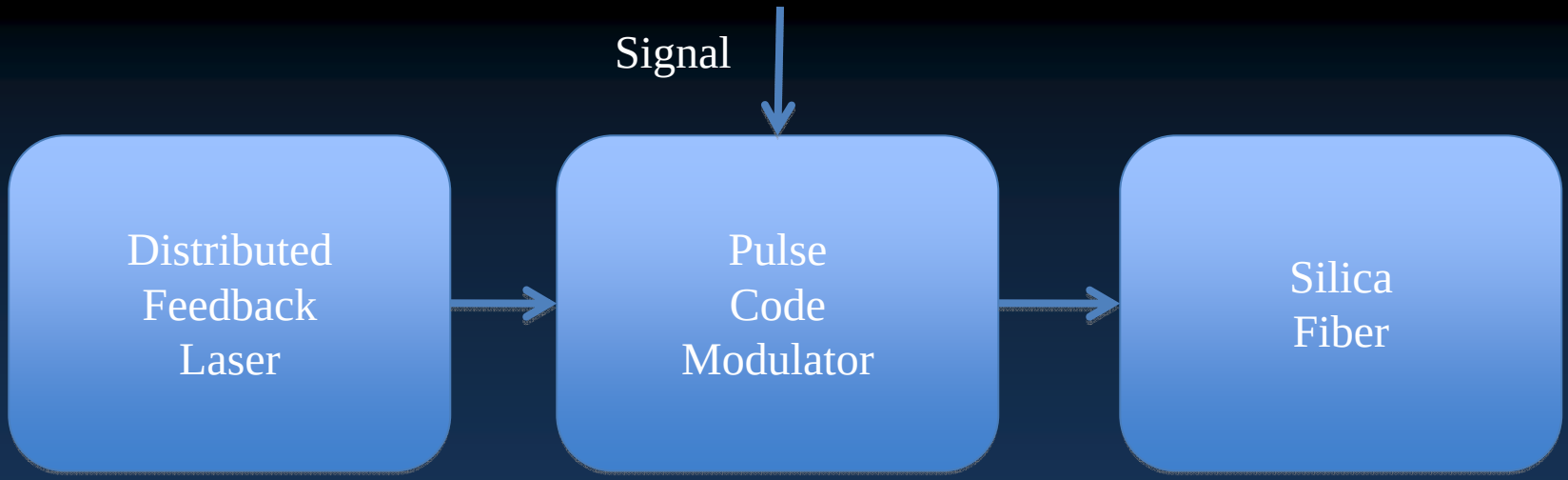

PWM




PCM
Pulse Code
Modulation

# High Speed Fiber Optics



# Modulating Light

- Stark Effect
  - $E_{atom}$ – atomic energy
  - d – eccentricity of orbit, tunnel distance
  - E – applied electric field

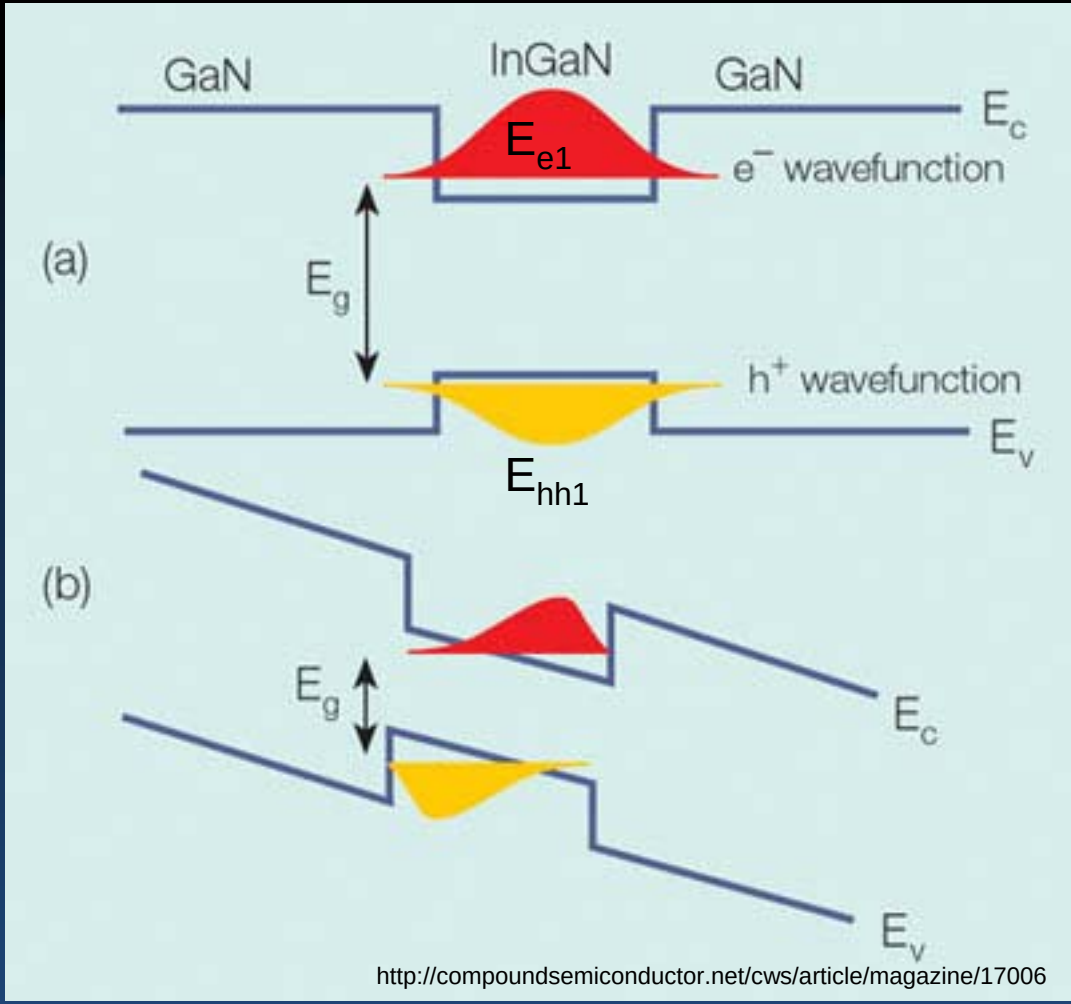
$$\Delta E_{atom} = qdE$$

$$d = E_g / qE$$

- Quantum-Confined Stark Effect
  - Hv – photon energy
  - $E_{gw}$ – bandgap of the well
  - $E_{e1}$ – electron energy
  - $E_{hh1}$ – hole energy
  - $E_{ex}$ – exciton energy

$$hv = E_{gw} + E_{e1} + E_{hh1} - E_{ex}$$

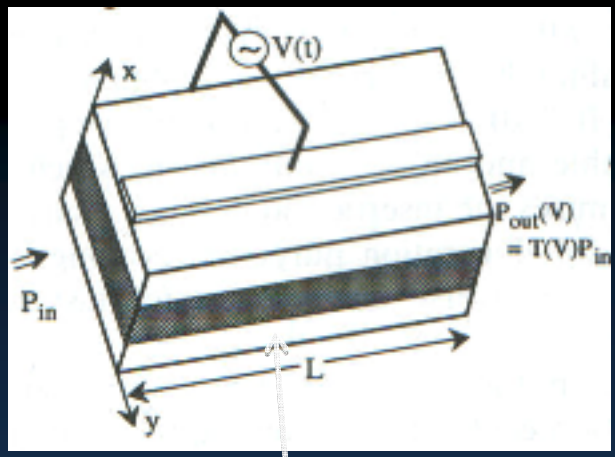
# Absorbing Light




http://compoundsemiconductor.net/cws/article/magazine/17006

# Electroabsorption Modulator

- Similar Structure of DFB
  - waveguide
- Made with III / V elements
- InGaAs / InAlAs
  - 1300 and 1550 nm




P-ohmic contact
P+
P-
MQW
N-
N+
N ohmic contact

# Limitations

- Charge dissipation in quantum wells
  - G – photon generation rate
  - $\tau$ – recombination lifetime
  - $\tau_{es}$ – escape time

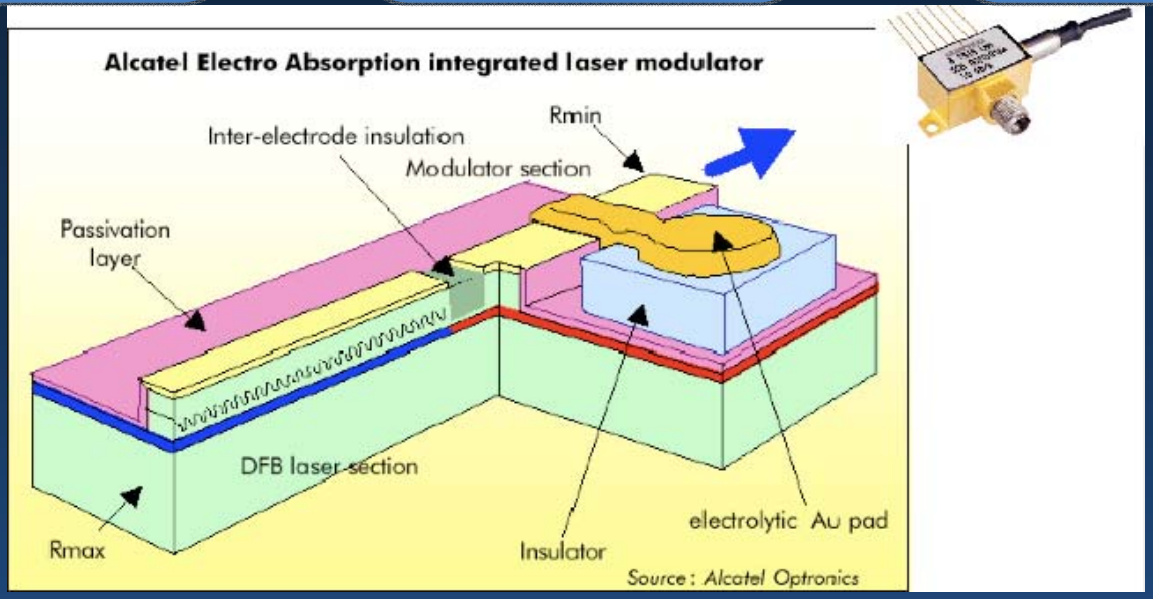
$$\frac{dn}{dt} = G - \frac{n}{\tau} - \frac{n}{\tau_{es}}$$

- Large signal voltage
  - $10^4$ V/cm for 10s meV $E_g$ change

# Complete Device

Signal

Distributed Feedback Laser → Pulse Code Modulator → Silica Fiber



# Questions?