#### **Optoelectronics and Optical Communication**

#### FFFN25/FYST50

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<u>Optoelectronics</u> The application of electronic devices that source, detect and control light.

(Electronic devices = semiconductor devices)

<u>Optical Communication</u> The use of light to transport information.

#### Practical Info



Email with instructions for signing up

#### Practical info

#### Literature

- Fundamentals of Photonics, B. E. A. Saleh and M. C. Teich
  - Can be found as e-book via the University library
- Lecture notes
- Hand out material. On website, password protected

#### <u>Exam</u>

- 22/3 MA9, 08.00-13.00
- Book allowed, e-book not allowed!

#### Course Outline



## Semiconductors Ch 16

## Bandstructure



- Bandgap E<sub>g</sub>
- Direct/indirect bandgap
- Effective masses for electrons
  and holes

## Semiconductor materials



- Group IV: Si, Ge Indirect; Detectors, CCD, photovoltaics
- Group III-V: GaP, GaAs, InGaAsP... LEDs, lasers, detectors
- Group III-N: GaN, InGaN...
  Blue (&white) LEDs, UV lasers
- Group II-VI: HgCdTe...
  IR cameras

The periodic table (from a semiconductor physicist's view)

#### How do we produce semiconductor structures?





## Energy Bands



Fermi-function & -level

Boltzmann far from E<sub>f</sub> Step at low T

## Quasi-Equilibrium



• Quasi-Fermi levels  $E_{fc} \& E_{fv}$ 

 Separate Fermi-functions for electrons and holes

# Generation and Recombination

- Thermal generation G<sub>0</sub>+injection R
- Recombination = r n p radiative and non-radiative
- Excess carrier concentration  $\Delta n$
- $\Delta n=injection rate*lifetime=R \tau$
- High and low level injection
- Electrical injection R=current/(e\*volume)



## pn-Junction

- Built-in electric field (used in solar cells and detectors)
- Injection of electrons and holes when forward biased (used for light emitting devices)



## Heterostructures



Heterostructures can:

- Create barrier for charge carriers
- Confine charge carriers
- Accelerate carriers
- Control where emission can take place combining direct-indirect material
- Control where absorption takes place (and not)
- Combine different refractive indexes
- Give quantum confinement

## DOS in Quantum Structures



## Band-to-Band Transitions



Absorption, Spontaneous and Stimulated emission

- Determined by
  - -Optical Joint DOS (combines CB and VB)
  - -Occupation
  - -Transition probability
- Energy and momentum conservation

## Absorption



Absorption also with indirect bandgap but no emission

## Indirect bandgap



• Very weak emission...

• ...but good <u>absorption</u>