

# Principles of lasers

Dr Yoonchan Jeong

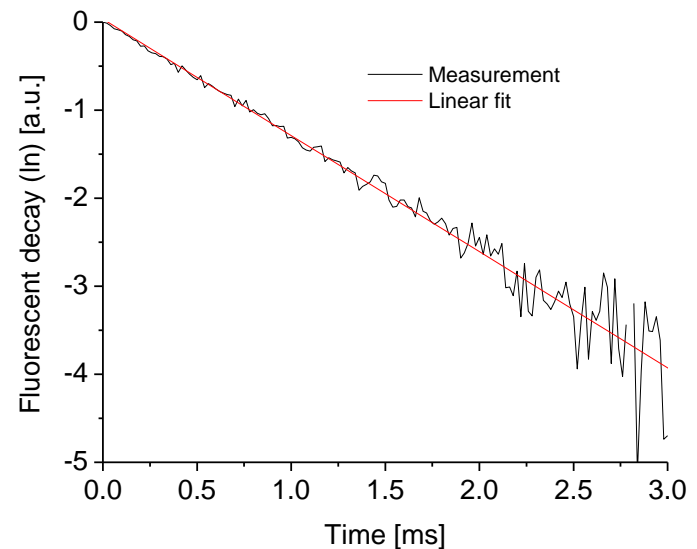
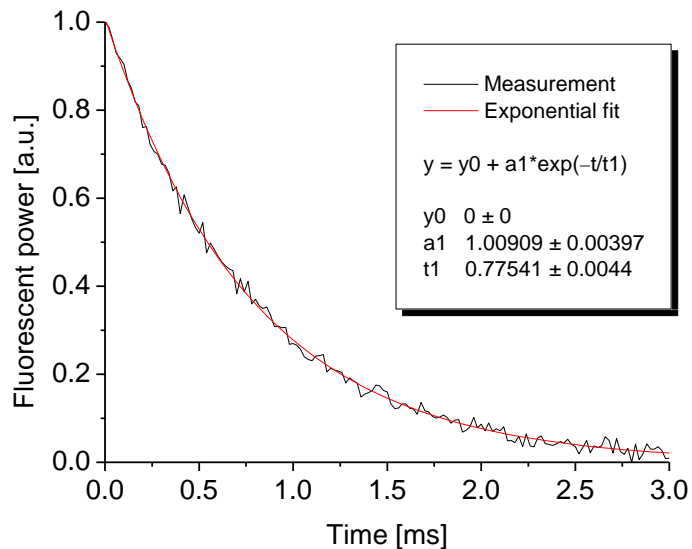
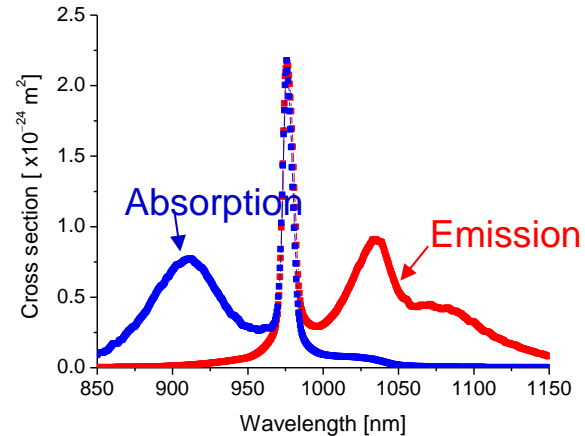
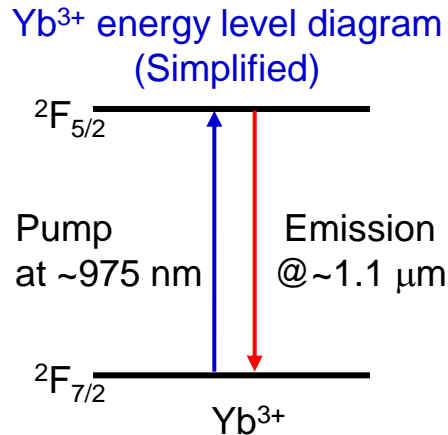
School of Electrical Engineering, Seoul National University

Tel: +82 (0)2 880 1623, Fax: +82 (0)2 873 9953

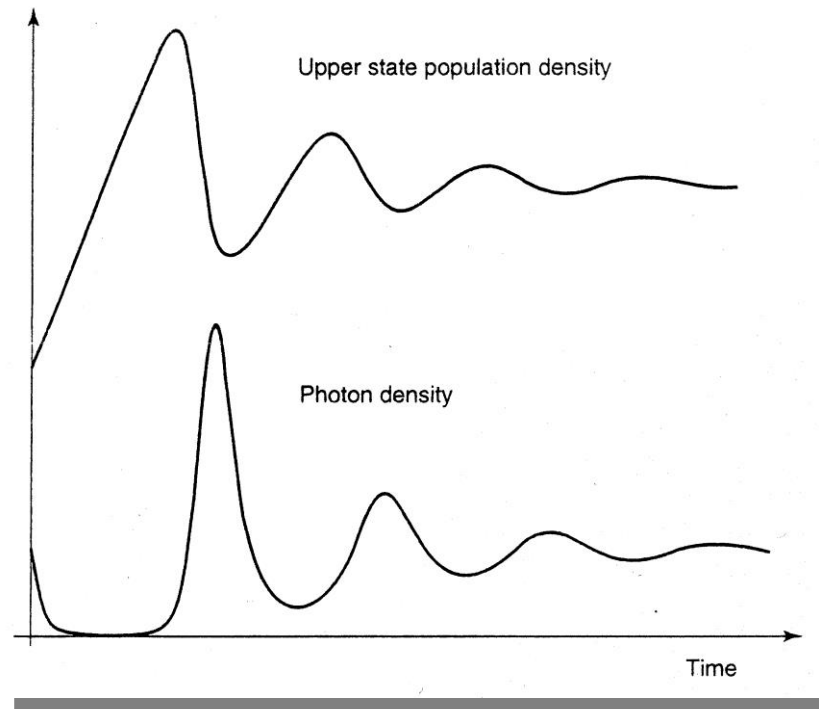
Email: [yunchan@snu.ac.kr](mailto:yunchan@snu.ac.kr)

# Energy levels & upper-state lifetime

e.g.



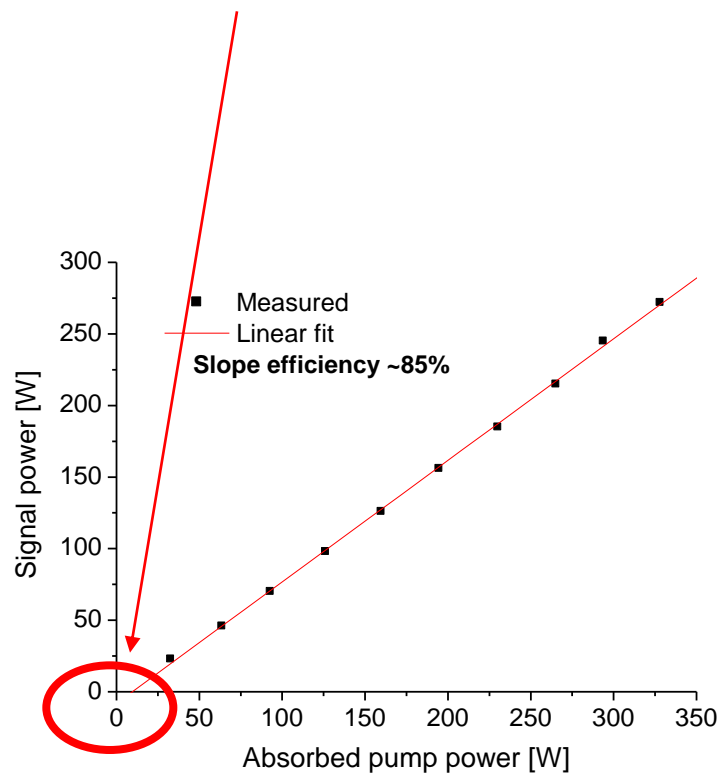
# Relaxation oscillation



Source: Optical Electronic in Modern Communications, A. Yariv

***Relaxation oscillations occurs in lasers when the upper state lifetime is significantly greater than the lifetime of a photon in the cavity.***

# Lasing threshold



Gain = Loss

Gain is proportional to population inversion.

# Laser oscillation

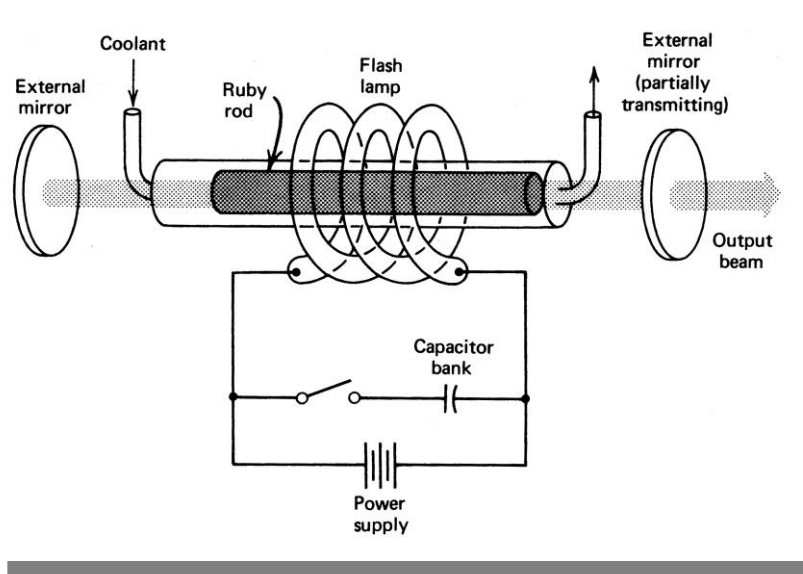
**LASER** stands for

**L**ight **A**mplification by **S**timulated **E**mission of **R**adiation

First operation by the Columbia Univ. group of Gordon, Zeiger, and Townes in 1953  $\Leftarrow$  **MASER**

First visible-light operation (*ruby laser*) by Maiman in 1960  $\Leftarrow$  **LASER**

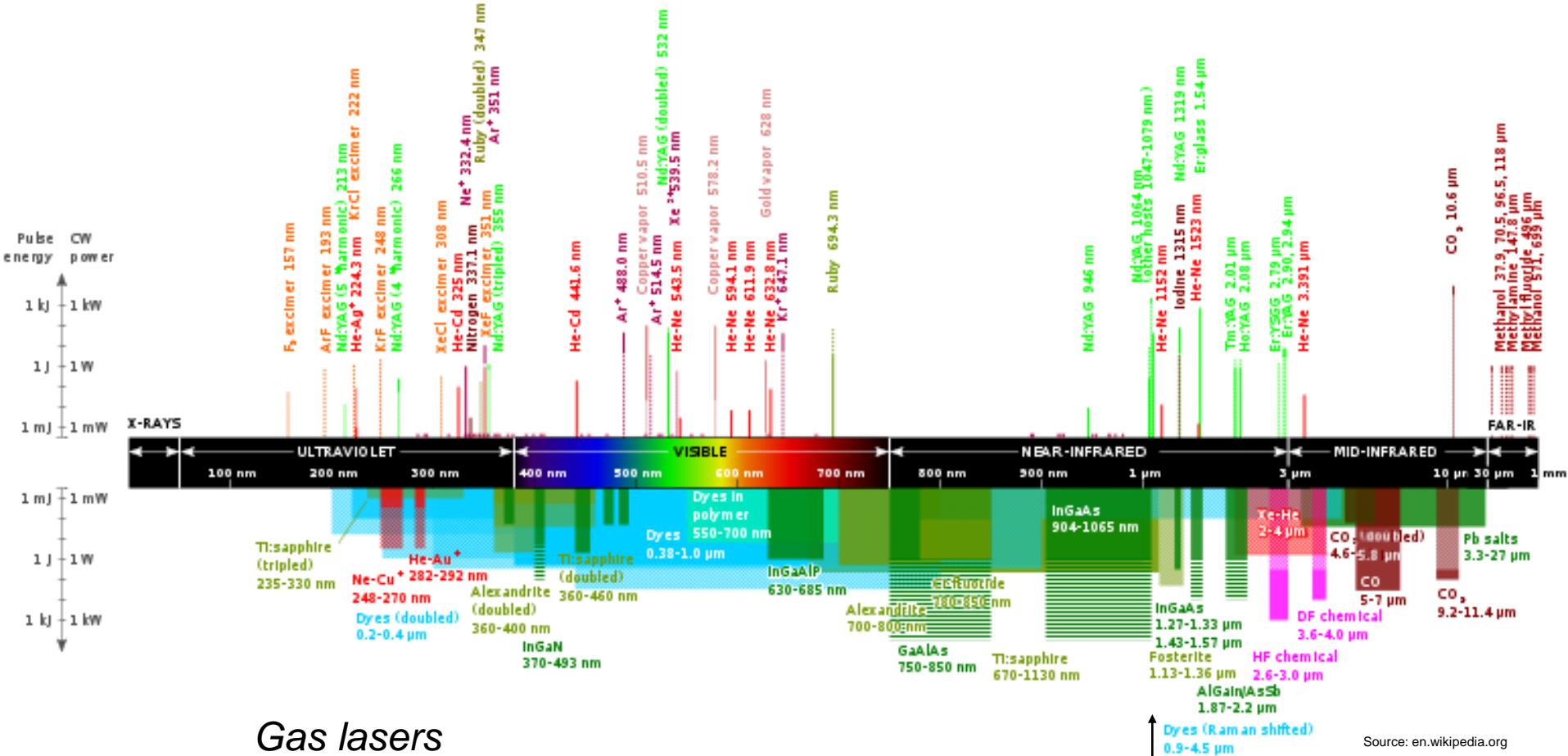
*Pink Ruby?!!*



694.3 nm

Source: Optical Electronic in Modern Communications, A. Yariv

# Wavelengths of commercially available lasers



- Gas lasers
- Chemical lasers
- Solid-state lasers
- Semiconductor lasers
- Fibre lasers

Yb<sup>3+</sup>-doped fibre laser

Source: en.wikipedia.org

# Light-emitting diodes

- A light-emitting diode is a p-n junction that emits light when forward-biased.
- In some semiconducting materials, free electrons in the conduction band can recombine with free holes in the valence band and release a photon in the process. ⇒ **Spontaneous emission** ⇐ **Incoherent light**
- GaP, GaAsP, SiC, GaAs, AlGaAs, InGaAs, InGaAsP

# Laser diodes

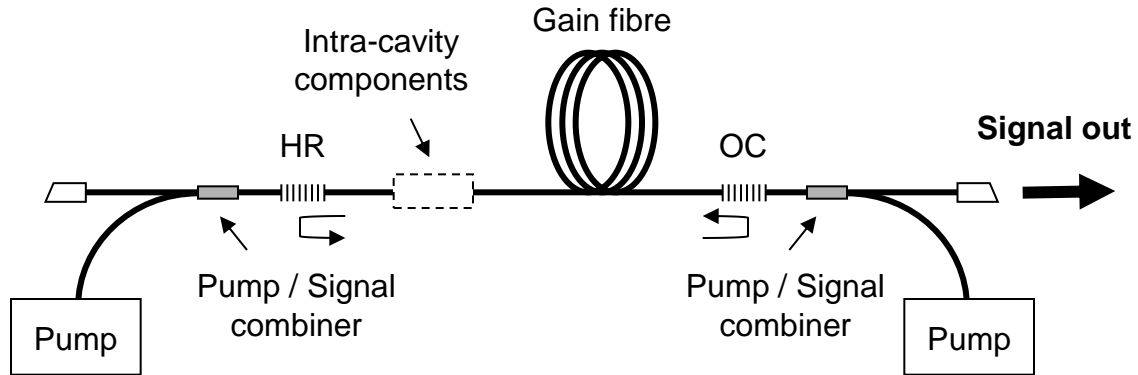
- Laser diodes are light-emitting diodes with two mirrors on the surface of the diode to create a laser cavity and, hence, emit **coherent light**.  
⇒ **Spontaneous emission** + **Stimulated emission** ⇐ **Coherent light**

# High-power fibre lasers

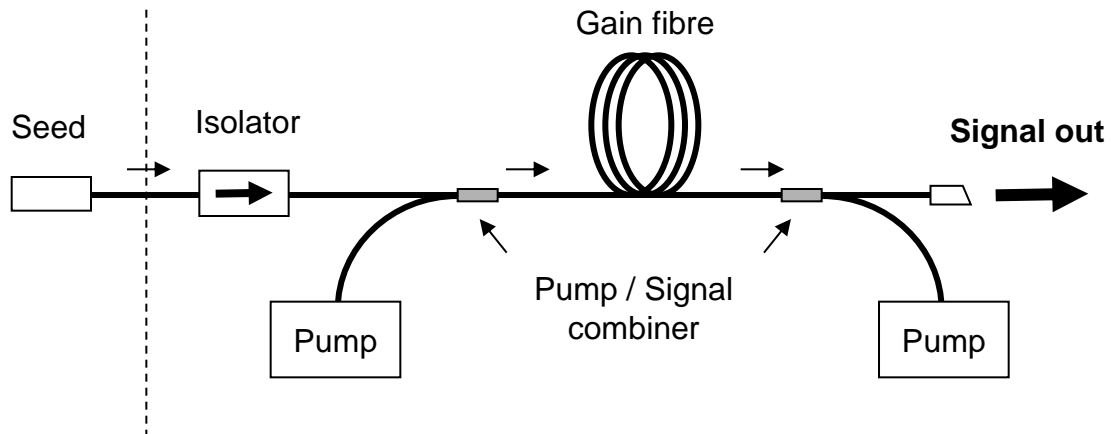
The RE-doped core converts the multimode pump to a high brightness, even diffraction-limited, signal beam.

# Oscillator vs amplifier

## Laser (oscillator) configuration



## Amplifier configuration





# Applications

- Various immediate and potential opportunities

Materials processing, defence, remote sensing, range-finding, free-space communication, display (visible), lithography (UV), medical, telecoms, etc.