Exercise 9.3-1

All Quick Questions to

9. Optoelectronics

General Concerns

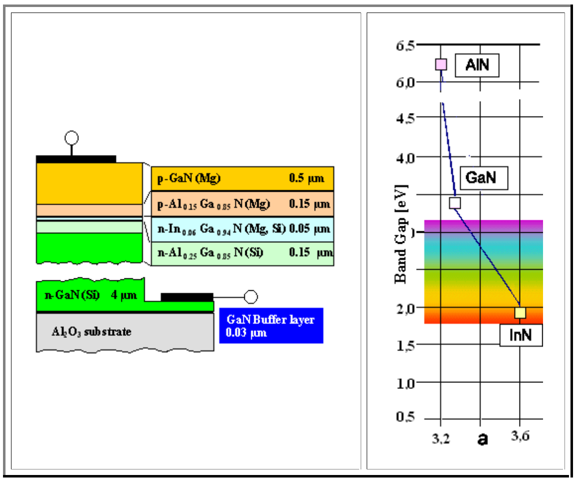
- Name some optoelectronic devices. List their strengths and weaknesses in comparison to competing products / technologies
- Identify and discuss specific properties of some optoelectronic materials.
- Why is the index of refraction an important property of optoelectronic semiconductors? How is it defined and what kind of numbers can you give?
- Compare the operation of a **CMOS** processor and an optoelectronic device in terms of power. What follows for some material properties?
- Why do we still use light bulbs or fluorescent light for general lighting? What are the prime conditions that optoelectronics has to meet in order to impact the lighting market?
- List and briefly discuss the advantages and disadvantages of semiconductor Lasers
- Describe some recombination mechanisms, how they impact optoelectronic devices and what can be done to optimize recombination.
- What are **OLED's**? For what kinds of products are they of prime importance and why?

Important Principles and Technologies

- Describe some measures necessary of you want to produce a high-efficiency **LED**. Use hand drawings to illustrate (at least) three major points.
- How can you best define a recombination volume?
- Draw the band diagram of an **Np** junction in equilibrium with the bandgap of the **N**-type semiconductor about twice the size of the **p**-type material. Discuss choice you make if necessary.
- Discuss advantages an problems of hetero junctions for light emitting devices
- Describe the working principle of **MBE** and what it means in terms of realization.
- Describe the mechanisms of *fundamental absorption* (**FA**) and *stimulated emission* (**SE**) with the aid of a band diagram. What kind of relation between the rates R_{SE} and R_{FA}, i.e. the number of events per second (and cm^2) must you have if amplification of light is to take place?
- What is the meaning of "inversion" in the context of a semiconductor Laser?
- What is "pumping" in the context of a Laser and why is a semiconductor very well suited for efficient "pumping"?
- How can you turn a light amplifier into a Laser? What does it mean technically for processing your semiconductor?

Here is a somewhat "longer" question:

The picture shows a schematic "to scale" drawing of a simple blue Laser diode and the relevant material parameters in the "master" diagram.



- What kind of approximate band gap energy can you assign to the various layers? Draw a schematic band diagram of this kind of situation.
- Which layer is the light-producing one?
- What is the function of the three relatively thin layers in the center region?
- What could be the function of the two thicker pure **GaN** layers?
- Why is the whole structure on an Al_2O_3 substrate (= sapphire) and what is the *electrical* problem encountered?
- What might be the problem necessitating a "buffer" layer between the Al_2O_3 substrate and the stack of functional layers?

- Where are the mirrors necessary for a Laser?
- What is obviously used for **n-** or **p-**doping? Make a guess as to why the very thin central layer contains **Mg** *and* **Si** as dopants