

### 7.1.3 Double Heterojunctions

We have not paid too much attention to the injection of carriers into the active volume so far. The more simple **LED** structures [shown before](#) employed homo-junctions, i.e., simple **p-n** junctions, but while this may be cheap, it has several disadvantages

- The active volume for the gain coefficient is ill defined. It is not simply given by the **SCR**, but by the diffusion length of the carriers. It is therefore difficult to keep the carriers in a small volume since they can diffuse away.
- The active volume for  $u(v)$  is not defined at all. The photons can go wherever they like in lateral directions; and this will simply not be good enough for laser diodes. Essentially, we would lose a lot of photons and the efficiency of a laser would be low.

Homojunction lasers therefore are only usable at low temperatures. The solution, of course, are [heterojunctions](#). They offer several general advantages:

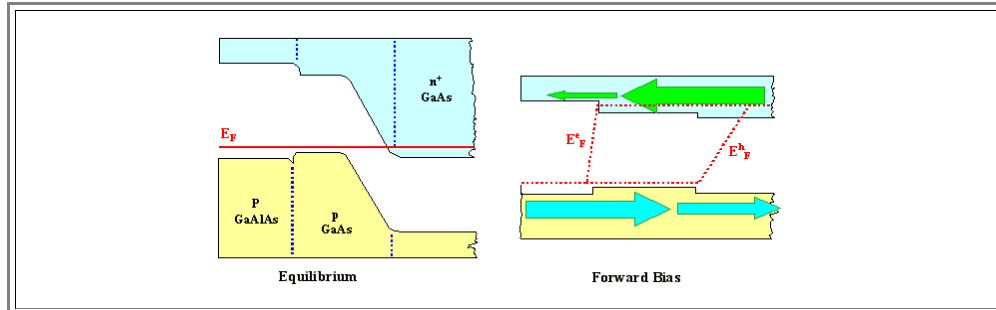
- We may obtain very large injection efficiencies, [essentially only injecting the majority carriers](#) from the wide-gap material into the small-gap material.
- The carriers can be kept confined to the small band-gap material by the energy barriers due to the discontinuities of the band structure. This means that the active gain volume can be well defined.
- If the refractive indices of the material surrounding the active volume is "right", we may achieve light confinement, too.

The problems with heterojunctions are clear, too:

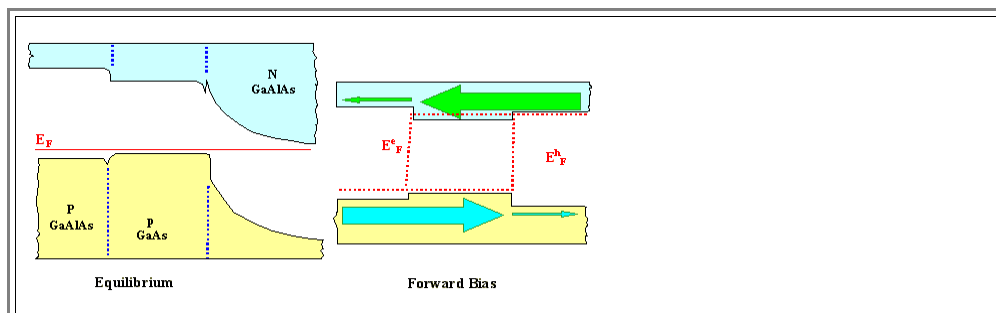
- Only rather perfect heterojunctions will work. If you introduce misfit dislocations or other defects – forget it. This severely restricts the possible combinations of materials.
- Optimizing all parameters at the same time with a limited choice of materials may be tricky, if not impossible. There are good reasons, after all, why there is no blue (or ultraviolet) semiconductor laser at present (the first blue ones are appearing just now = **2002**).
- The technology for making a laser may become quite involved, meaning expensive.

Let's look at some heterojunctions.

- First we consider the case of a single heterojunction of the **P-p-n<sup>+</sup>** type.



- For the example chosen, practically all of the injected electrons from the **n<sup>+</sup>** part are confined in the active **p-GaAs**, while a considerable part of the injected holes can escape (by diffusion in forward direction).
- This will get better with a double heterojunction which necessarily must consist of one diode type and one isotype junction. The same kind of situation as above, but now with a **pN** junction diode on the right is shown below.



- Now the escape of both injected carrier types is blocked by the band offset due to the large band-gap material on the opposite side of the active region.
- Large efficiencies can be obtained in this way, but the technology becomes rather complicated – compare the "index-driven" laser diode [shown in the following sub-chapter](#).