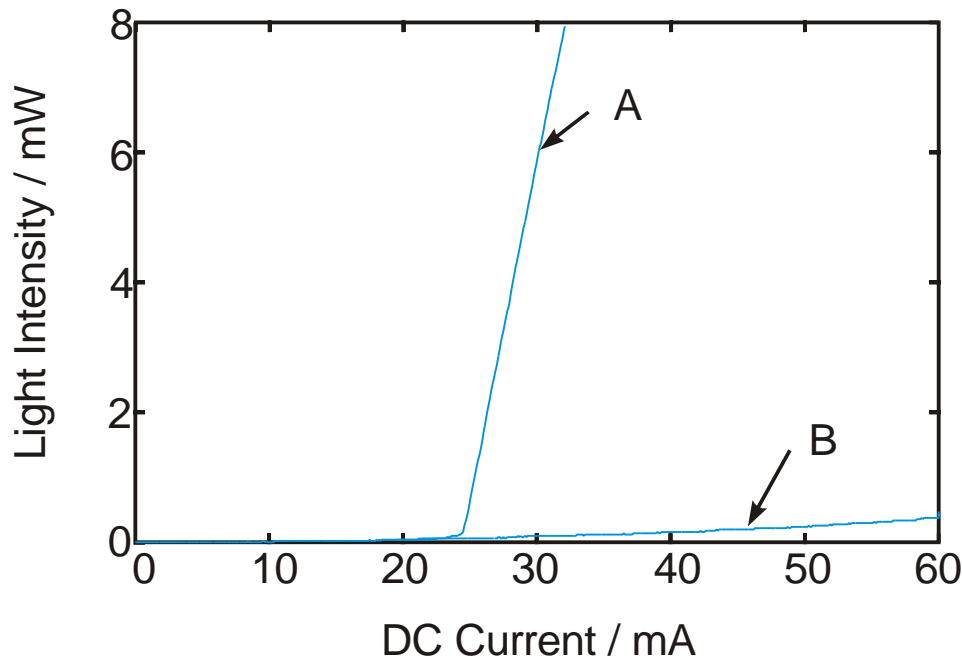


## Technical Note – No. 5

### Effect of AR-Coatings on the Emission Wavelength of Diode Lasers

AR-coatings strongly enhance the total tuning range of diode lasers. The origin of this positive effect can be explained in terms of the band structure  $E(k)$  of the semiconductor material.



**Fig. 1** Light Intensity – Injection Current – Characteristic of a diode laser before AR-coating (trace A) and with AR-coating (trace B). One of the most obvious effects of the AR-coating is the shift of the threshold current to much higher current values.

#### 1.) Effect of AR-coatings on the Carrier Density $N$

Increasing the injection current of a diode laser causes an increase of the number of injected electrons and holes into the active area of diode lasers. Below threshold, this causes an increase of the carrier density  $N$  within the active region. Above threshold, the carrier density  $N$  remains constant and the increase of the injection current only causes an increase of the optical power which is proportional to increase of the injection current. This effect is referenced in literature as gain saturation.

One of the most obvious effects of AR-coatings on diode lasers is found to be the shift of the threshold current to high current values as seen in Fig. 1. This is the reason why the carrier density  $N$  rises to significant higher values above the original saturation value at the original threshold.

Document: <http://data.sacher-laser.com/techdocs/wavelength.pdf>

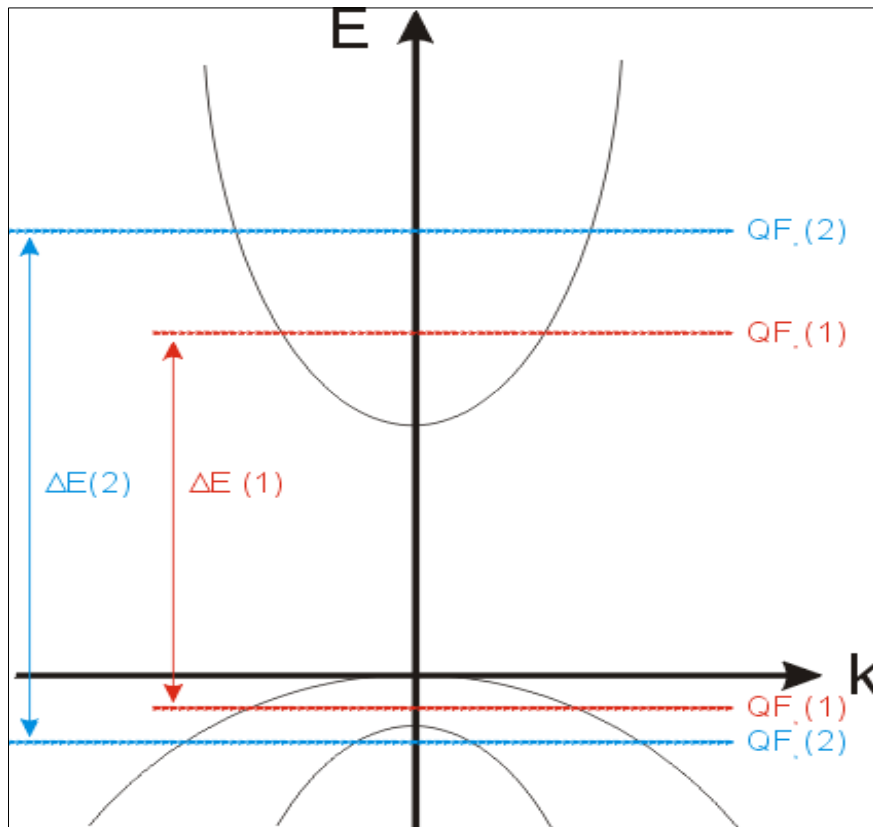
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**Fig.2** Band Structure of a direct semiconductor in a non-equilibrium case. The Fermi level splits up into a Quasi-Fermi level for electrons (QFe) and a Quasi-Fermi level for holes (QFh). The spectral maximum of the luminescence of the semiconductor material is defined by the energy difference  $\Delta E$  between QFe and QFh. A higher value of the carrier density causes a higher value of the energy splitting  $\Delta E$  and the luminescence shows a blue-shift.

## 2.) Effect on the Spontaneous Emission Wavelength

Diode lasers are non-equilibrium semiconductor devices. Formally, this is described by a splitting of the Fermi level into Quasi-Fermi levels which describe the distribution of electrons and holes individually. Fig. 2 shows the well known band structure of GaAs in this case. Higher values of the carrier density cause an increase of the energy splitting of the Quasi-Fermi levels  $\Delta E$  which results in a blue-shift of the spontaneous emission spectrum of a diode laser with increasing injection current.

## 3.) Effect on the Total Tuning Range of Diode Lasers

The tunability of AR-coated diode lasers with an external cavity in Littrow- and in Littman-cavity benefits of the described blue-shift of the spontaneous emission. Especially, the tuning range is enlarged at the low-wavelength side of the total total tuning range in comparison with a non-AR-coated diode laser as they are used by some companies. For further benefit of AR-coatings, please compare <http://data.sacher-laser.com/techdocs/Classes.pdf>.

Document: <http://data.sacher-laser.com/techdocs/wavelength.pdf>

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