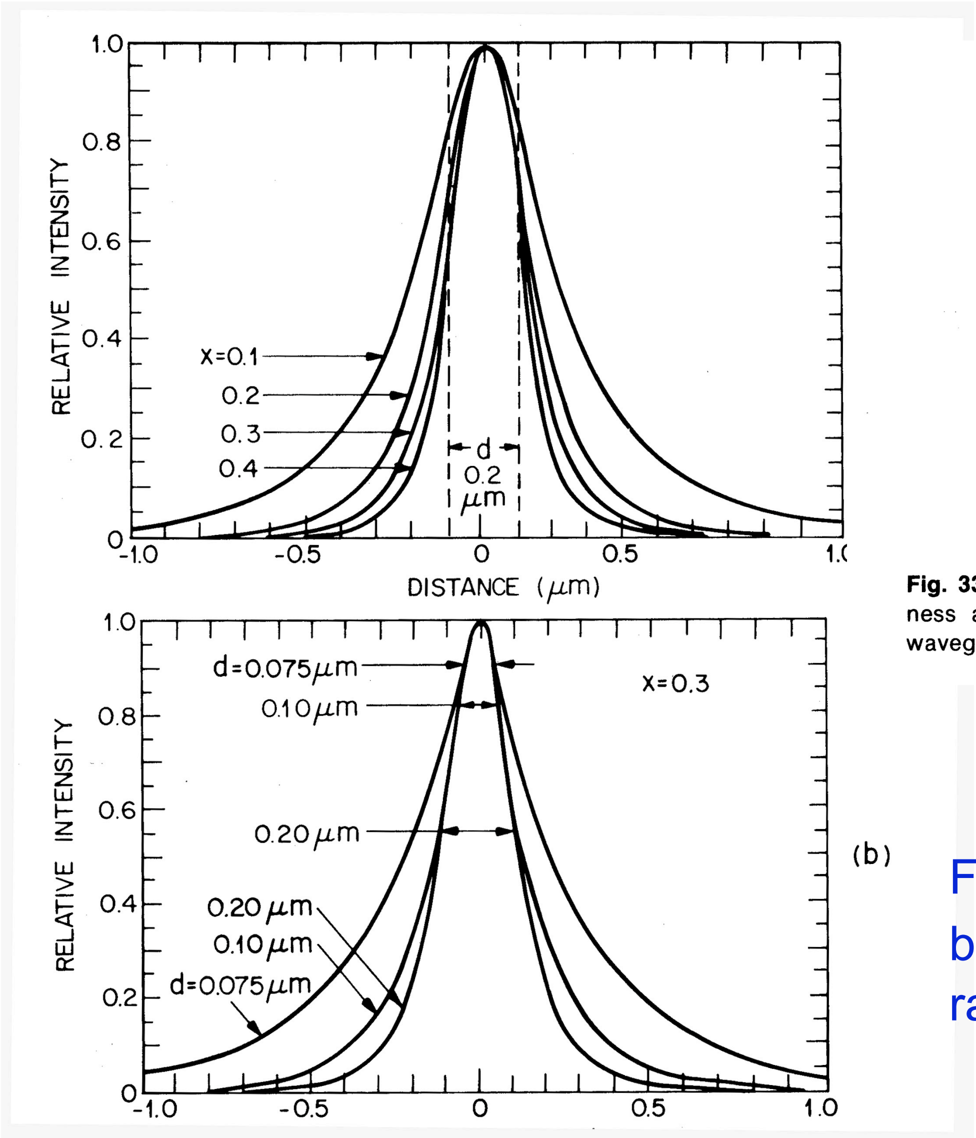
Confinement factor Γ



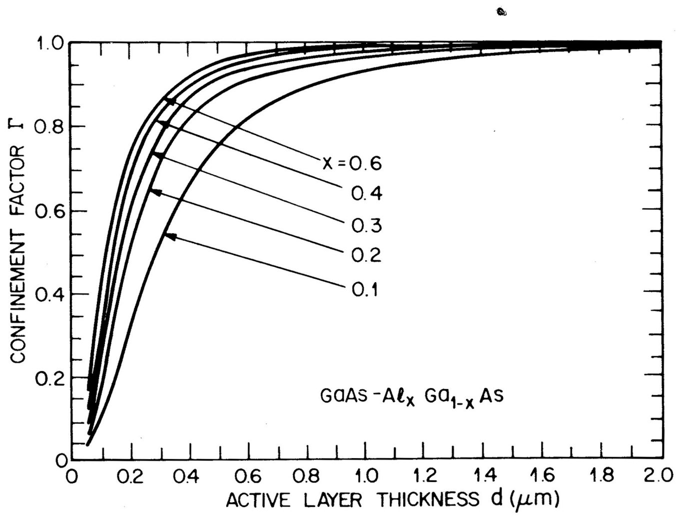


Fig. 33 Confinement factor for fundamental mode as a function of active-layer thickness and alloy composition for a GaAs–$Al_xGa_{1-x}As$ symmetric three-layer dielectric waveguide. (After Casey and Panish, Ref. 20.)

For $d<\lambda/n_2$, where the active layer thickness becomes less than the wavelength of the radiation the Γ factor decreases rapidly.

Laser Characteristics

Optimal laser performance: low threshold current, by decreasing the active layer thickness (0.5kA/cm^2)

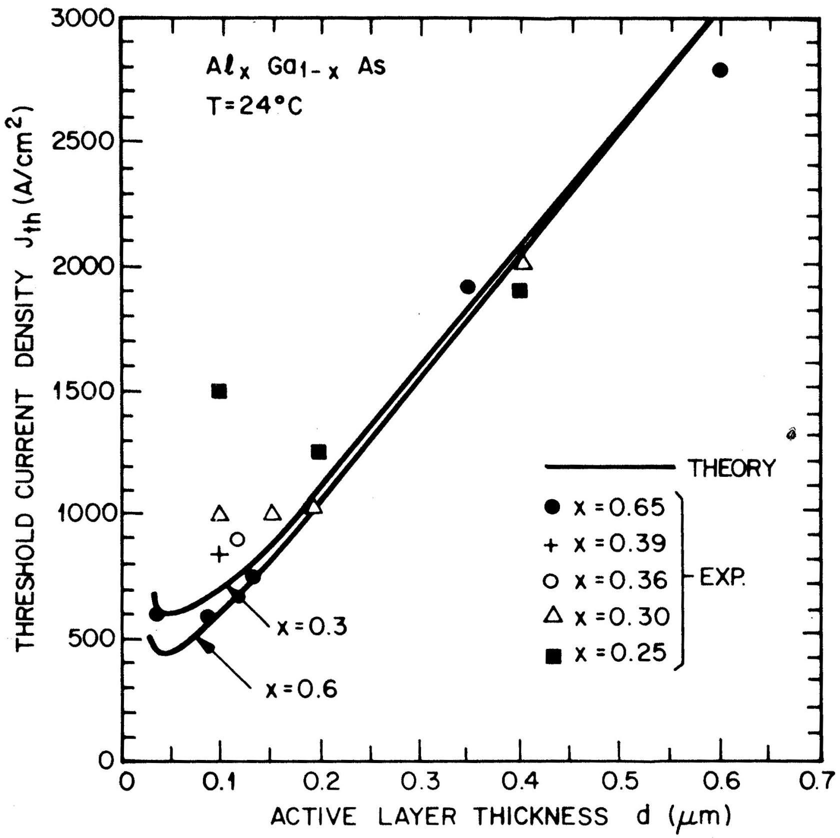


Fig. 42 Comparison of experimental J_{th} and J_{th} calculated from Eq. (55). (After Casey, Ref. 57.)

Light Output

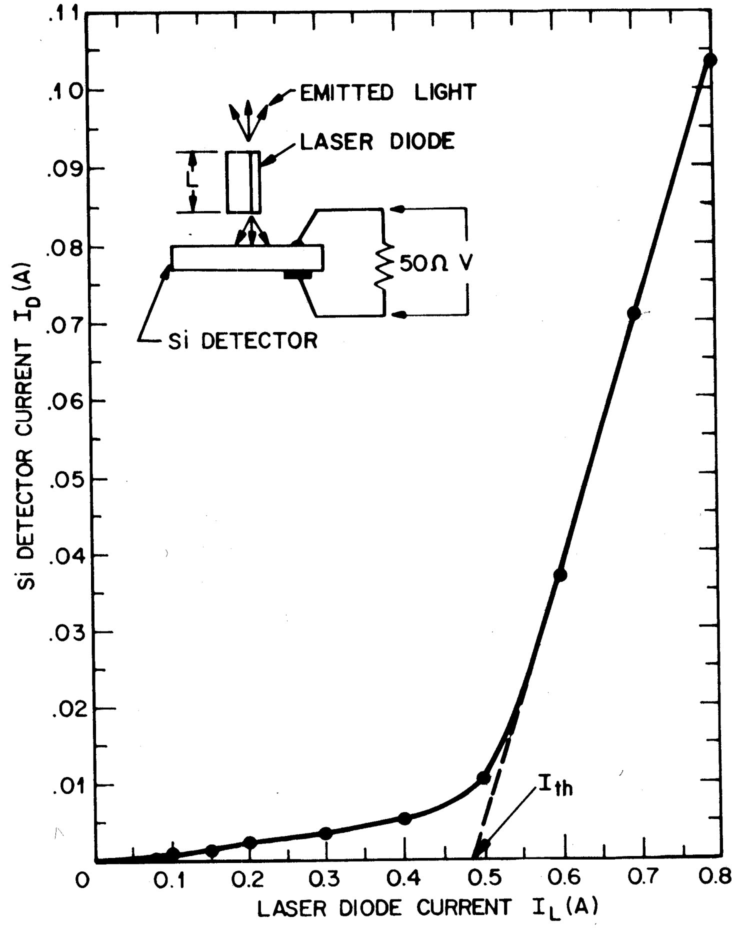


Fig. 47 Light output versus diode current for a GaAs–$Al_xGa_{1-x}As$ DH laser at room temperature. The insert shows the measurement setup. (After Casey and Panish, Ref. 20.)

The extrapolation of the curve to zero gives the threshold current I_{th} ($J_{th}=I_{th}/A$)

Light Output vs T

The light outputs versus injection current at various heat-sink temperatures for GaAs-AlGaAs heterostructure laser. The threshold current increases exponentially with temperature $I_{th} \approx \exp(T/T_0)$. It is desirable to have a value of T_0 as high as possible.

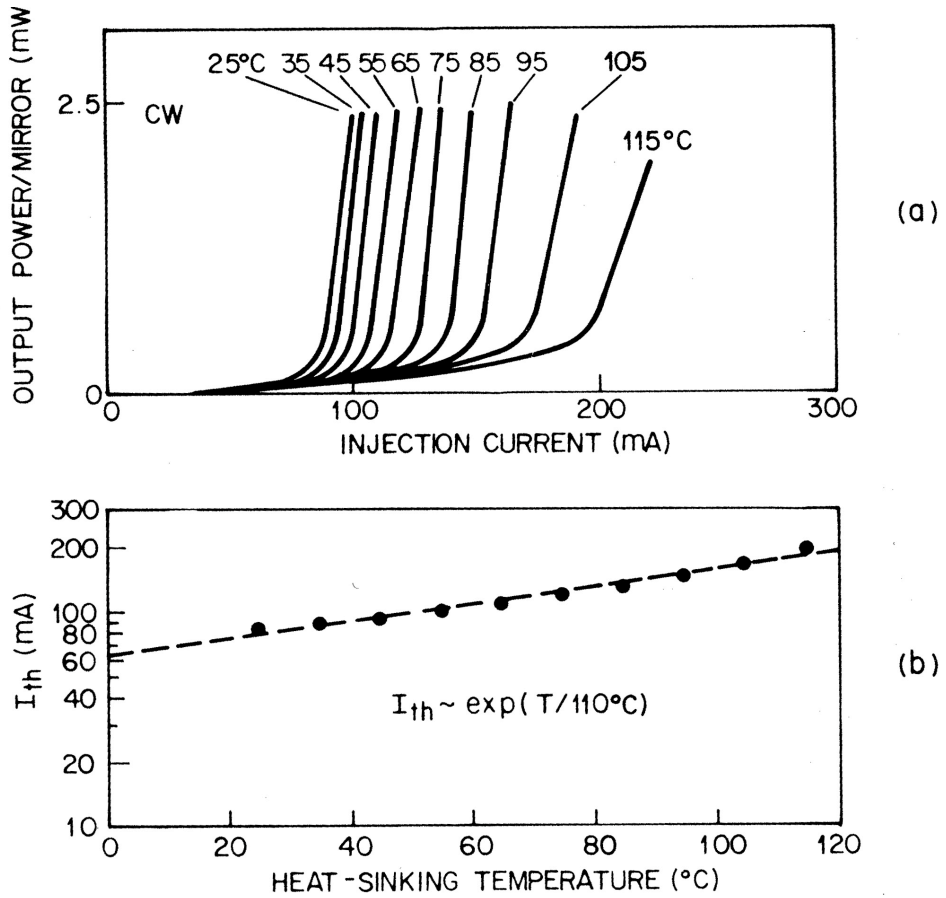


Fig. 48 (a) Light output versus diode current for GaAs–$Al_xGa_{1-x}As$ stripe-buried heterostructure laser. (*b*) Temperature dependence of cw current threshold. (After Tsang, Logan, and Van der Ziel, Ref. 65.)

Emission Spectra

At low currents the spontaneous emission has broad spectral distribution with a typical spectral width at half power 100 to 500Å. As the current approaches the threshold, the distribution becomes narrower.

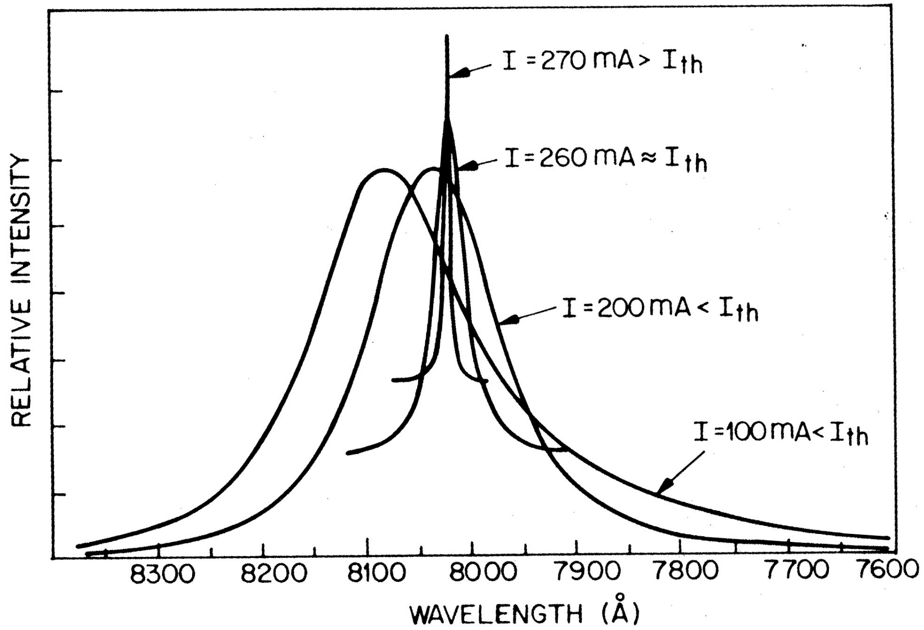
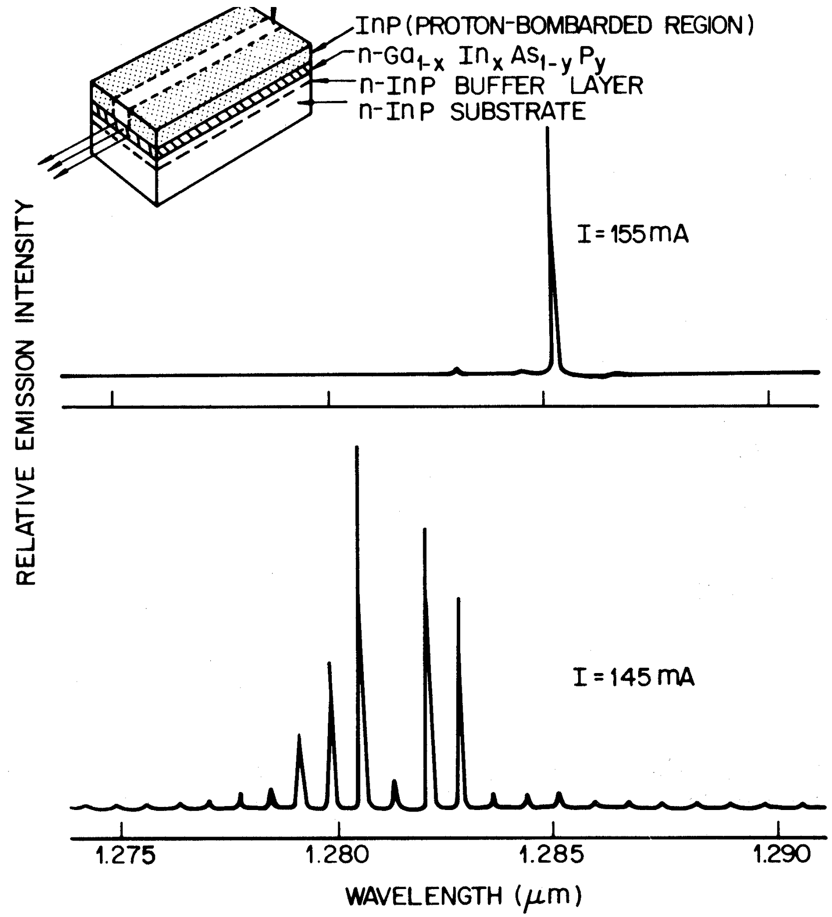


Fig. 49 Emission spectra of a diode laser below, just at, and above threshold, indicating the narrowing of the emission when lasing is initiated. (After Kressel and Butler, Ref. 21.)

Spectral distribution



Single mode

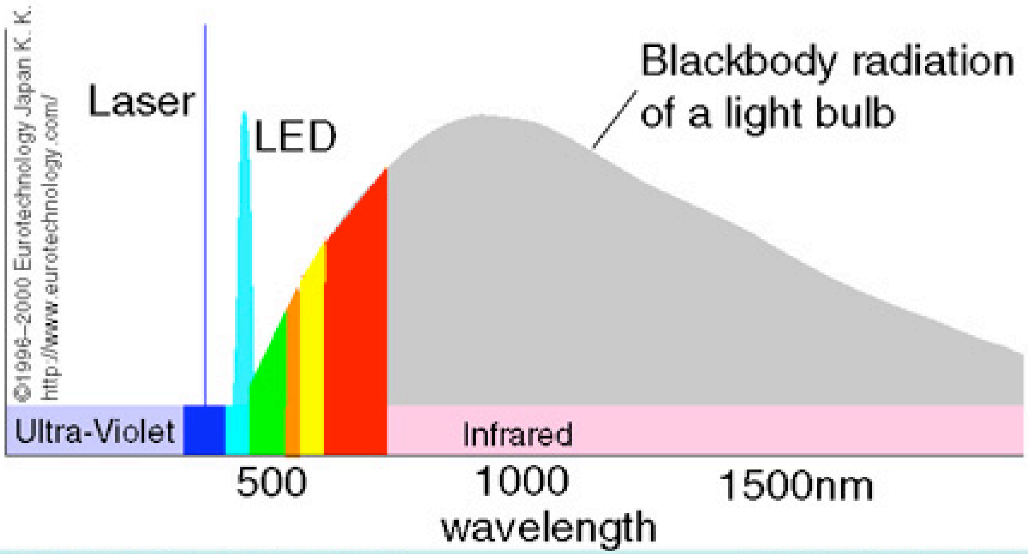
Just above I_{th}

$m(\lambda/2n)=L$

Light spectrum

LIGHT SPECTRUM OF AN LED, A LIGHT BULB AND A LASER

- **Light bulb:** tungsten filament heated to about 3000 C emits "black body" radiation over a broad spectrum. Most emission is invisible infrared heat radition. The efficiency is low, because most input energy is converted into heat, not into light.
- **LED:** Light is emitted by the transition of electrons between energy levels, and therefore within a relatively narrow range of wavelenghts
- **Laser:** the emission of a laser is determined by the resonance of an "optical amplifier" and an optical cavity. The light emitted is coherent (this means that the light waves are continuous without break in phase over a considerable range in time and space). Lasers can emit light in a very narrow beam in a very narrow wave length spectrum



Semiconductor Laser Design Issues

Since one of the most important applications od semiconductor lasers is in the area of optical communications, a key driving force for superior laser design is low threshold current (<1mA) and emission frequencies depending of a particular application (wavelength tunability): long wavelength lasers for communications, short wavelength lasers for high density optical memory application.

Narrow bandgap (λ>5 μm) lasers are also interested for a variety of applications involving communications. These type of materials they present strong Auger processes (non radiative recombination transition) therefore it is difficult to have laser operation at RT.

Short wavelength lasers (λ<0.5 μm) or large bandgap materials have become widely available. They offer large problems for doping and processing.

Why blue (GaN) Laser are important?

Why are blue GaN lasers important?

- Blue (violet) GaN based semiconductor lasers allow to store information with approx. 4 times higher density and therefore are the basis for the next generation DVDs
- Blue (violet) GaN based lasers have many other applications in medicine, printing, copying machines and other areas

Blue LASER

Enormous technological impact of wide gap LASER for large device applications: optical communications, CD players etc.

II-VI

II-VI/III-V heterojunctions are crucial elements for II-VI blue-green LASERS (ZnSe/ZnCdSe).

Native stacking faults control the LASER degradation.

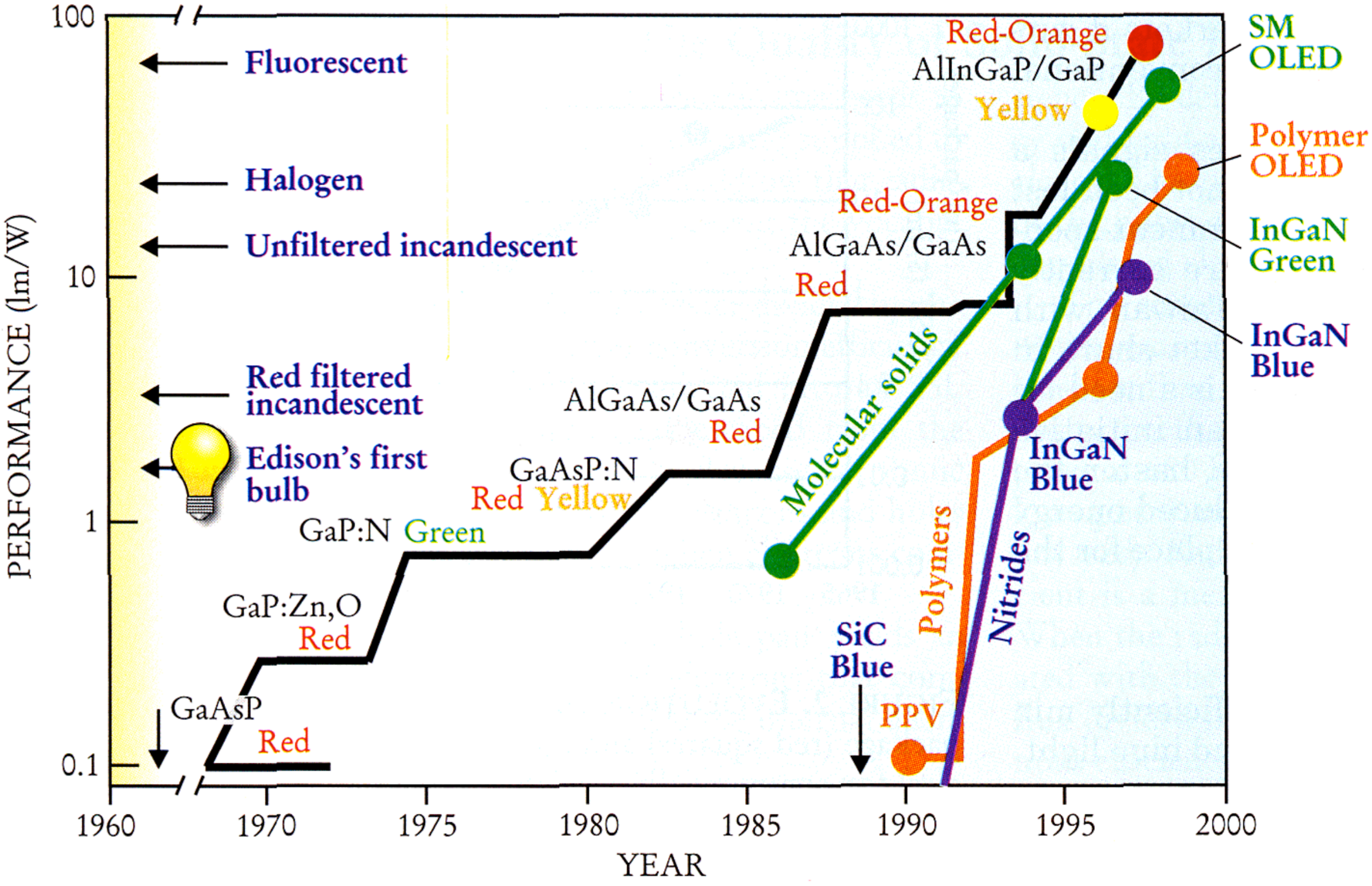
GaN-AlGaN

Very high efficiency.

Lack of substrates: SiC(3.5%), Sapphire (14%), GaN.

Large number of threading dislocations (1×10^8 to 1×10^{12} cm^{-2}).

Laser: III-Nitrides



Electronic and structural properties