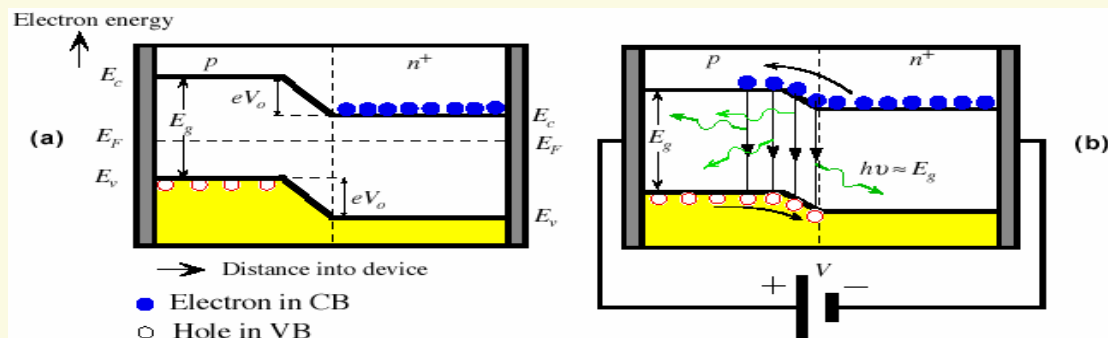
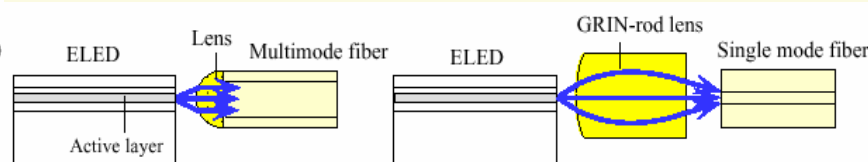
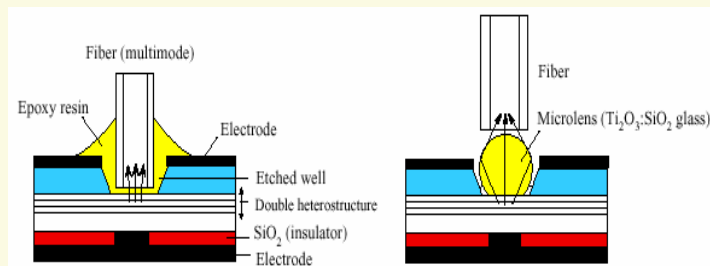
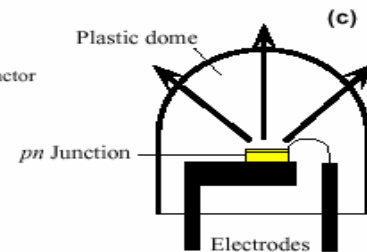
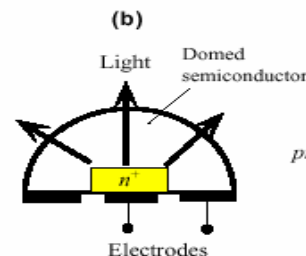
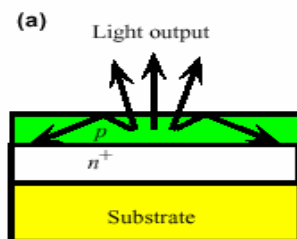
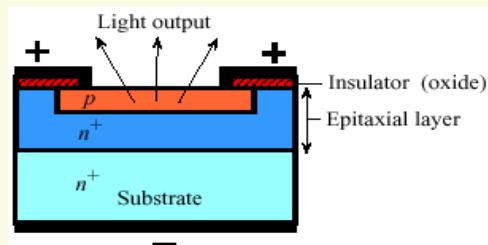


PN结电致发光：发光二极管（LED）

➤ 基本原理

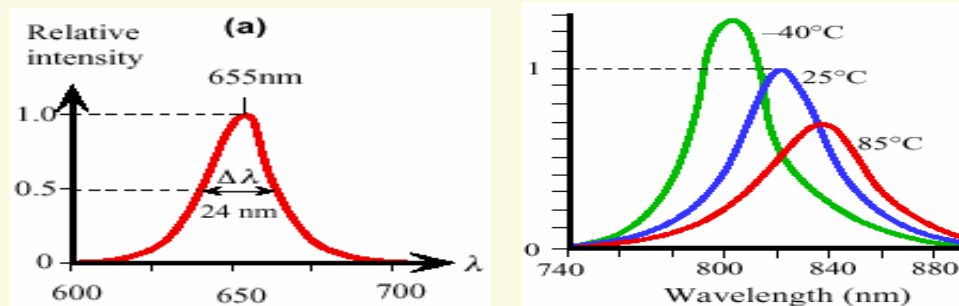


➤ 器件结构



LED的基本特性

➤ 光谱特性

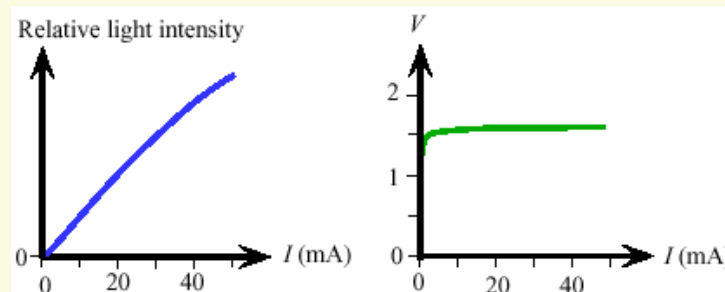


$$\lambda_p(\mu\text{m}) = 1.24 / (E_g + kT) [\text{eV}], \quad \Delta\lambda \approx 3kT \lambda^2 / 1.24, \quad E_g = E_g - \alpha T - \beta n^3$$

➤ 光电流 (L-I) 特性

外部量子效率: $\eta_{\text{ext}} = \frac{P}{IV}$

内部量子效率: $\eta_{\text{int}} = \frac{P/h\nu_p}{I/e}$



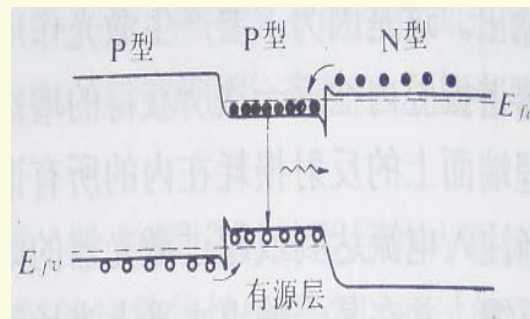
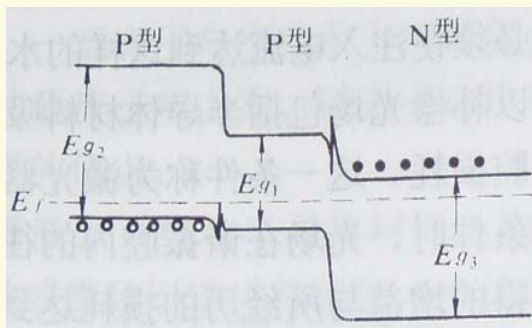
➤ 噪声特性

面发射LED: 纯粹的自发辐射, 无相干性, 无方向性。

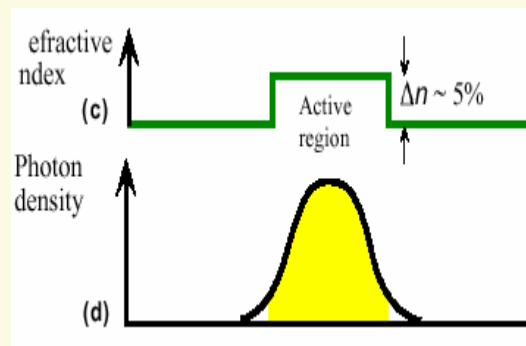
边发射LED: 放大的自发辐射, 具有部分相干性和方向性。

双异质结

载流子限制

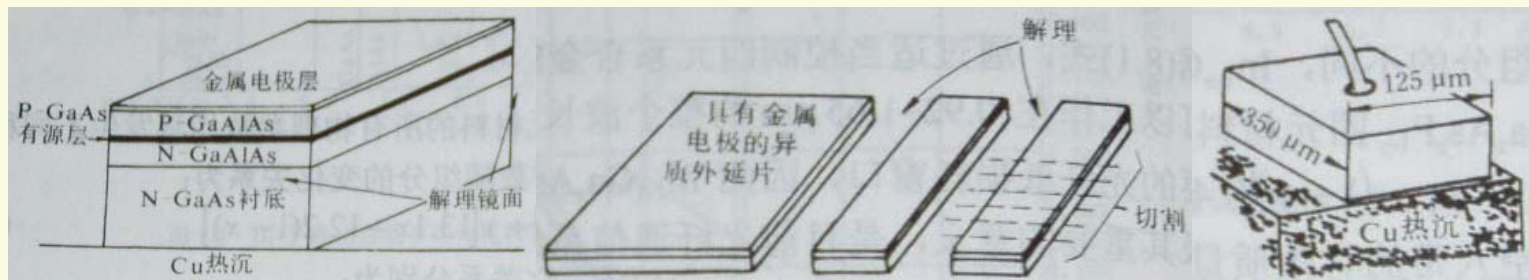


光限制



双异质结构激光二极管 (LD)

➤ 宽接触LD的器件结构与制作工艺

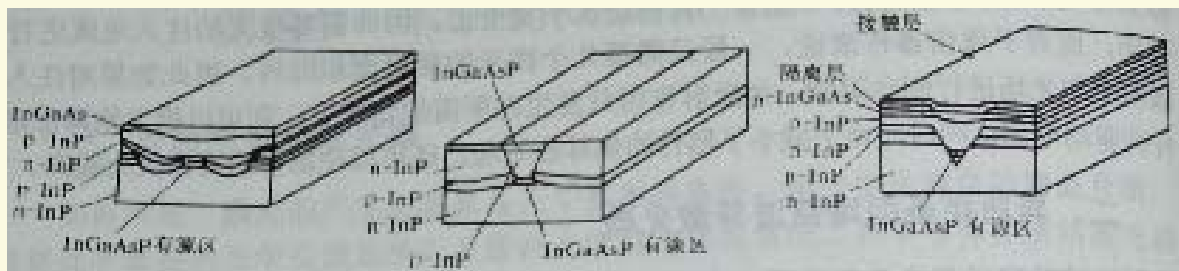
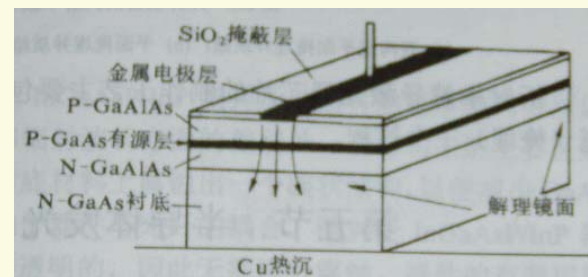


外延技术: LPE, MOCVD, MBE...

激光要素: 增益介质: 窄带隙有源层; 泵浦方式: 电流注入;
反馈机制: 解理镜面。

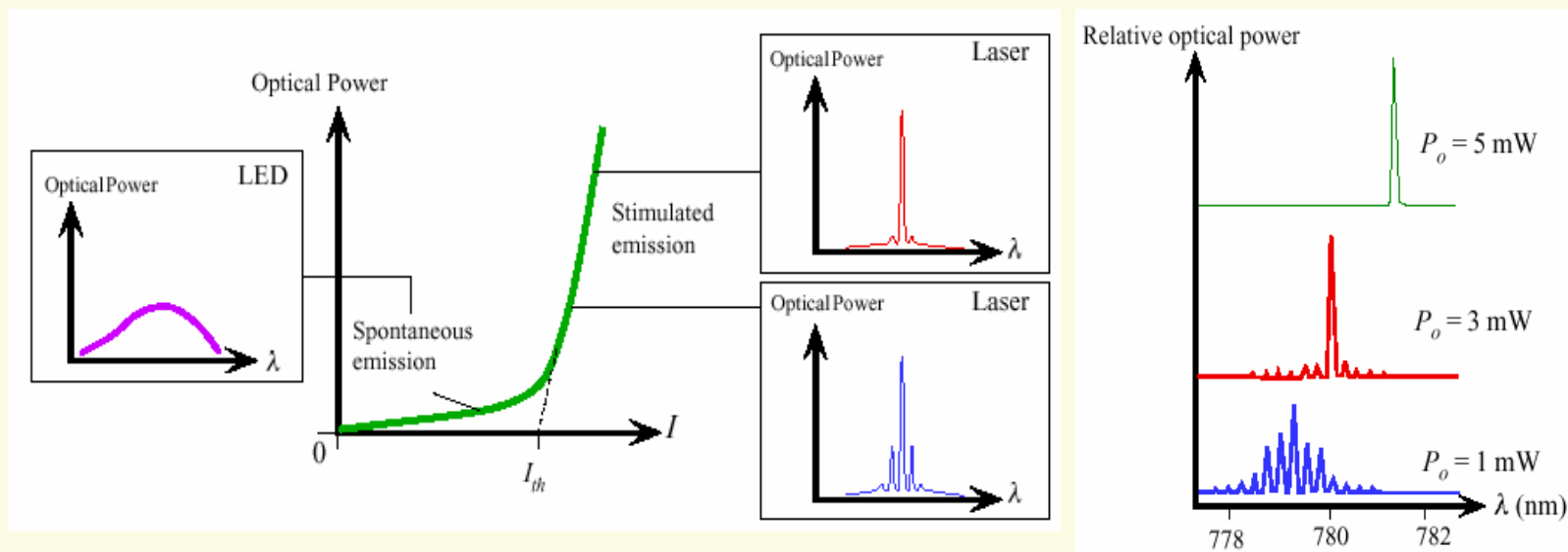
➤ 条形接触LD

➤ 折射率波导激光器: 横模控制



半导体激光器的静态特性

L - I 特性和光谱特性



动态特性

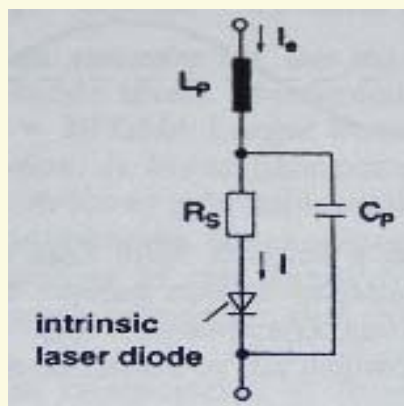
➤ 时间延迟

$$\frac{dN}{dt} = \frac{J}{ed} - \frac{N}{\tau} \quad \rightarrow \quad \tau_d = \int_0^{N_{th}} \left[\frac{J}{ed} - N \right]^{-1} dN = \tau \ln \frac{J}{J - J_{th}}$$

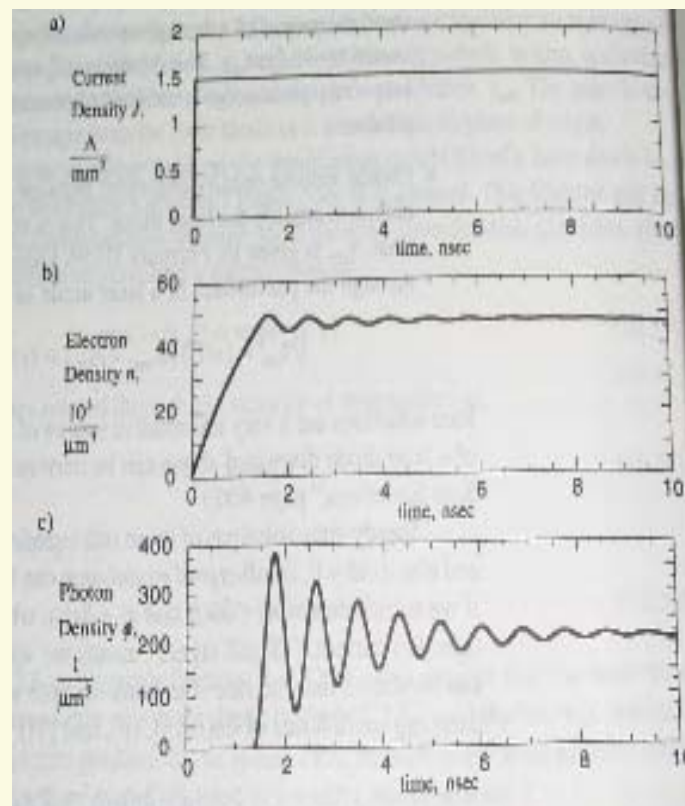
➤ 瞬态过程：弛豫振荡和振荡阻尼

增益压缩因子 ϵ 、自发辐射系数 β 和纵模数目均对激光器的弛豫过程具有阻尼作用

➤ 等效电路和调制谱宽

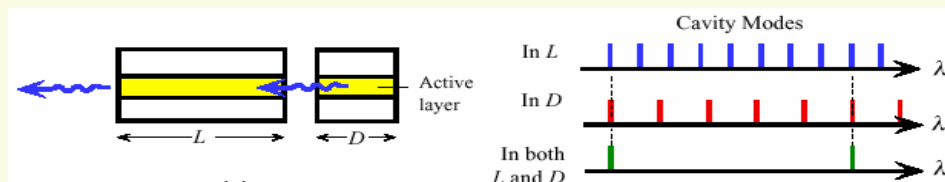


$$\omega_m = \frac{1}{R_s C_p}$$

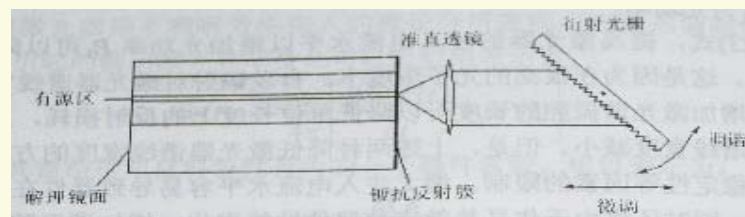
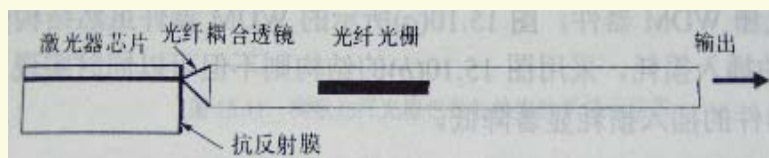


动态单纵模激光器 (纵模控制技术)

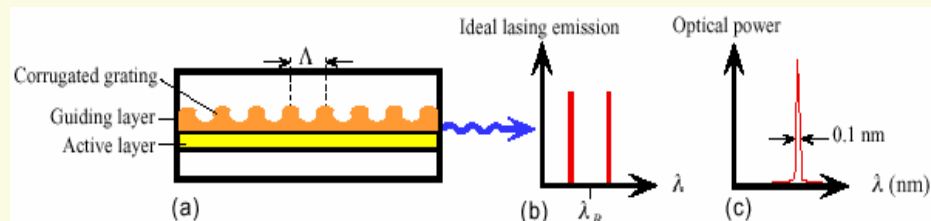
➤ 解理耦合腔 (C³) 激光器



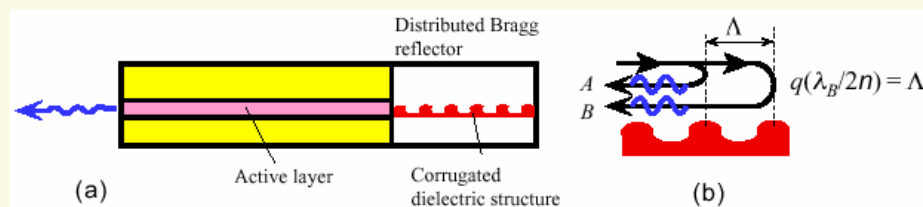
➤ 外腔激光器



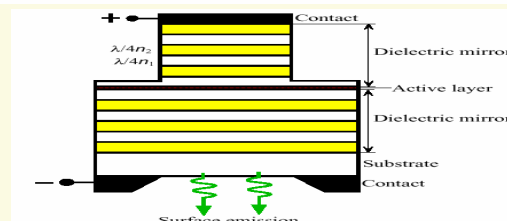
➤ 分布反馈 (DFB) 激光器



➤ 分布布拉格反射 (DBR) 激光器



➤ 垂直腔面发射激光器 (VCSEL)



半导体激光器的温度特性

➤ 阈值随温度的变化

载流子的非辐射复合速率和热载流子泄露均随温度升高而增加，导致阈值电流密度增加：

$$J_{th} = J_0 e^{T/T_0} \quad T_0: \text{特征温度}$$

加： $T_0 = 50 \sim 70\text{K}$ for InGaAsP LD's, $T_0 = 150 \sim 180\text{K}$ for GaAs LD's

➤ 量子效率随注入电流的变化

随注入电流增加，结温升高，导致载流子泄露和非辐射复合速率增加，从而引起量子效率降低。

➤ 激射波长随温度的变化

随注入电流增加，结温升高，导致有源区带隙减小，从而引起激射波长的增大。

$$\lambda_m(T) = 2n_{eff}(T)L(T)/m$$

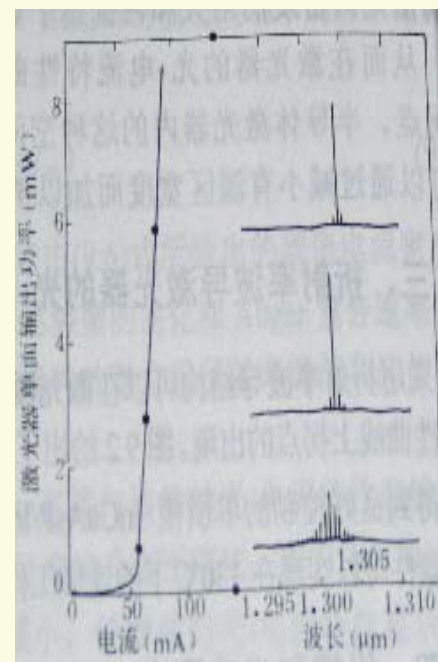
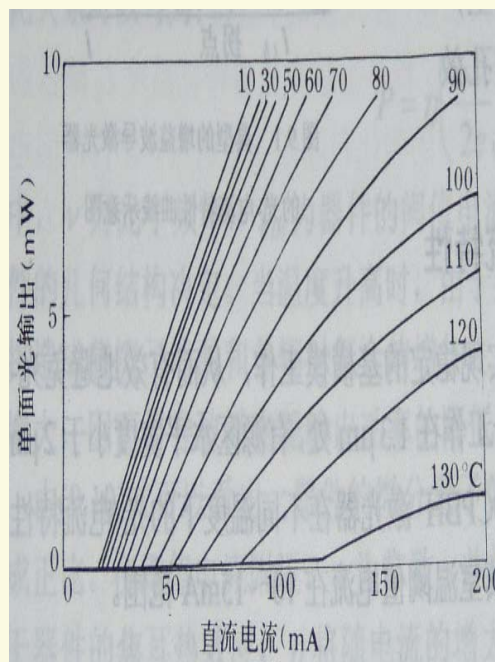
0.07nm/K for GaAs; 0.1nm/K for InGaAsP

$$\lambda_{peak}(T) = 1.24/[E_g(T) + kT]$$

0.35nm/K for GaAs; 0.5nm/K for InGaAsP

➤ 一个实例

1.3um InGaAsP DCPBH LD



输出发散角

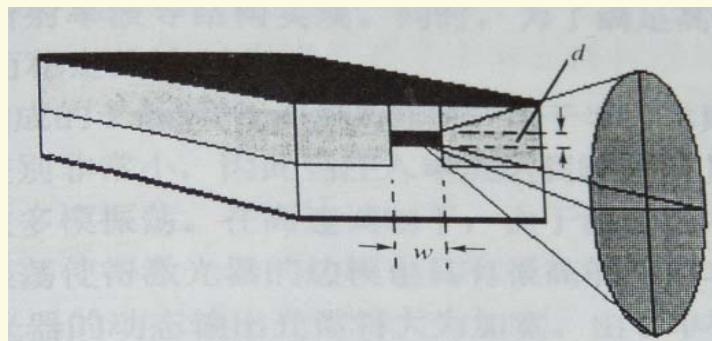
➤ 一般情形

$$\theta_{\perp} \sim 2 \sin^{-1}(\lambda/d_{\text{eff}})$$

$$\theta_{\parallel} \sim 2 \sin^{-1}(\lambda/w_{\text{eff}})$$

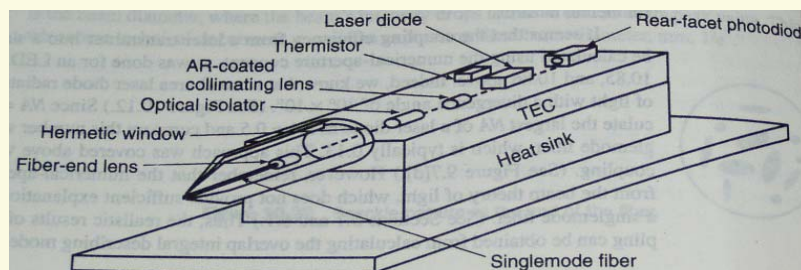
典型值:

$$\theta_{\perp} \sim 30 \sim 40^{\circ}, \quad \theta_{\parallel} \sim 10 \sim 20^{\circ}$$

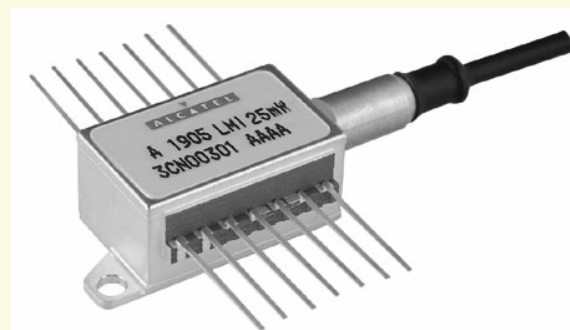


激光二极管组件

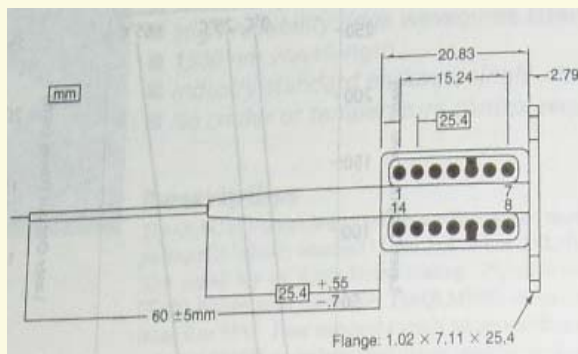
➤ 器件封装



➤ 组件外观



➤ 管脚连接

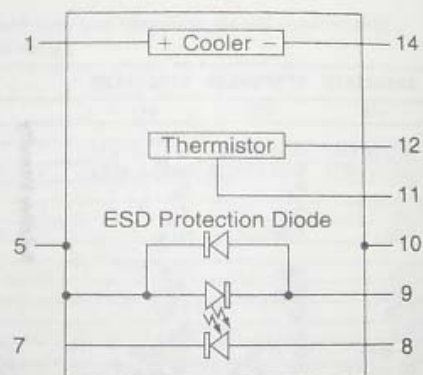


Pin Connections

- 1 Cooler*
- 2 NC
- 3 NC
- 4 NC
- 5 Case Ground
- 6 NC
- 7 Monitor Cathode (Lasers only)
- 8 Monitor Anode (Lasers only)
- 9 Source Cathode
- 10 Source Anode, Case Ground
- 11 Thermistor*
- 12 Thermistor*
- 13 NC
- 14 Cooler*

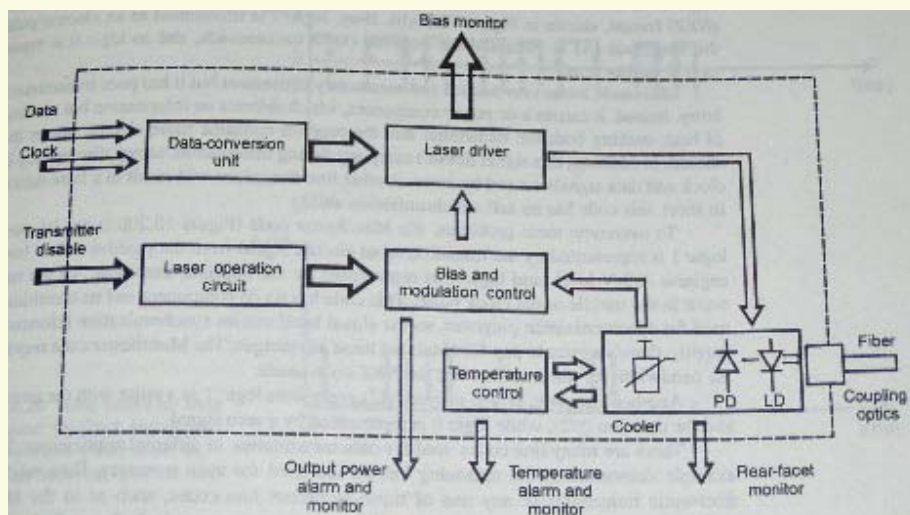
* NC for uncooled modules

Schematic Diagram



光发送机组件

➤ 功能模块



➤ 组件实例

