SECTION - 3

LIGHT EMIITING SOURCE LED

LENS COUPLING

BEHAVIOR AT HIGH FREQUENCIES

LENS COUPLING CONFIGURATIONS

a) SPHERICAL POLISHED STRUCTURES

b) SPHERICALLY ENDED OR TAPERED FIBER COUPLING

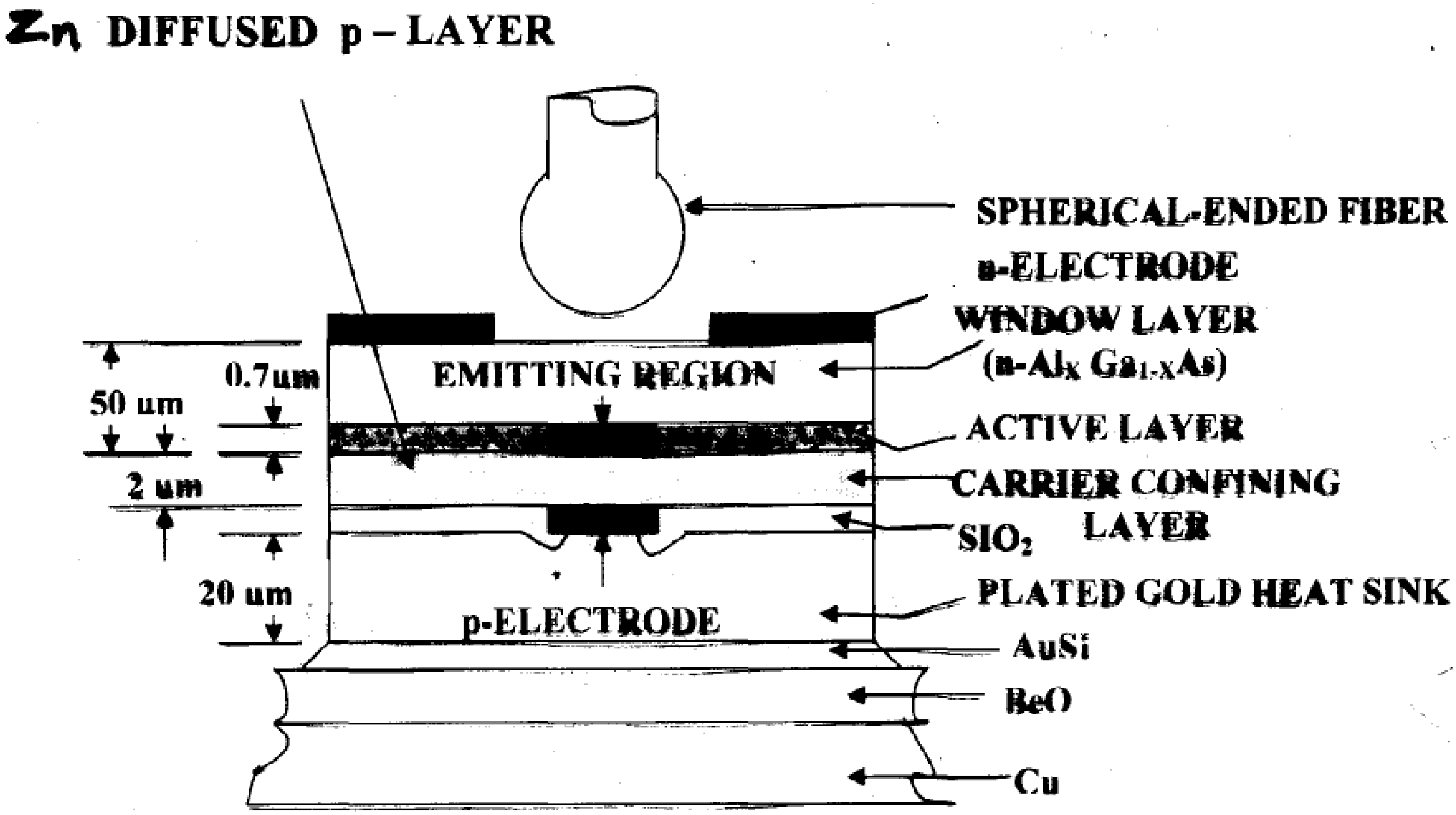
c) TRUNCATED MICROLENSES

d) GRIN-ROD LENSES

e) INTEGRAL LENS STRUCTURE

Note : LED output is not fully coupled into the fiber because of narrow acceptance angle of the fiber.

Spherical-Ended Fiber Coupled AlGaAs LED



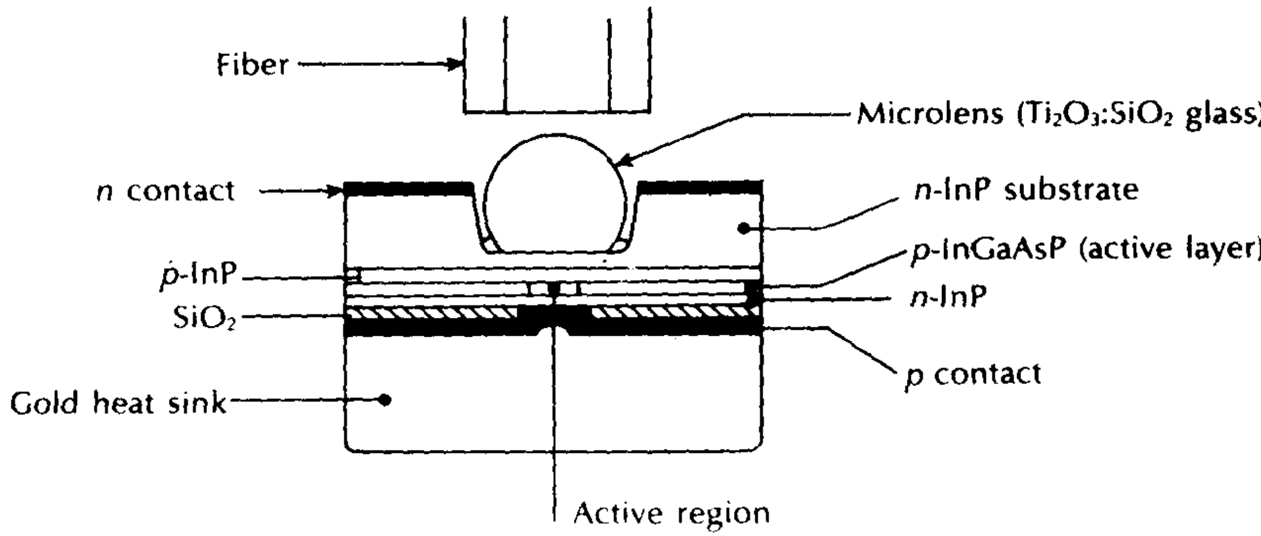
SPHERICALLY ENDED FIBER COUPLED Al Ga As LED

- EMITTING DIA = 35 μm } RATIO OF
- CORE DIA (OF FIBER)= 75 – 110 μm 1: 2 (min)

- **COUPLING EFFICIENCY OF 2 TO 5 TIMES CAN BE ACHIEVED THR THE USE OF SPHERICAL FIBER LENS.**

- THE DEVICE IS A PLANAR SURFACE EMITTING STRUCTURE WITH THE SPHERICAL ENDED FIBER ATTACHED TO THE CAP BY EPOXY RESIN.
- **COUPLING EFFICIENCY = 6 %**

USE OF TRUNCATED SPHERICAL MICROLENS FOR COUPLING THE EMISSION FROM AN InGaAsP surface EMITTING LED



- OPERATING wave length = 1.3 μm
- EMISSION REGION DIA SHOULD BE MUCH SMALLER THAN CORE DIA OF THE FIBER.
- **TYPICAL VALUES (for a step Index fiber**)
- ACTIVE DIA : 14 μm
- CORE DIA : 85 μm

NUM APERTURE : 0.16

COUPLING η INCREASED BY A FACTOR OF 13.

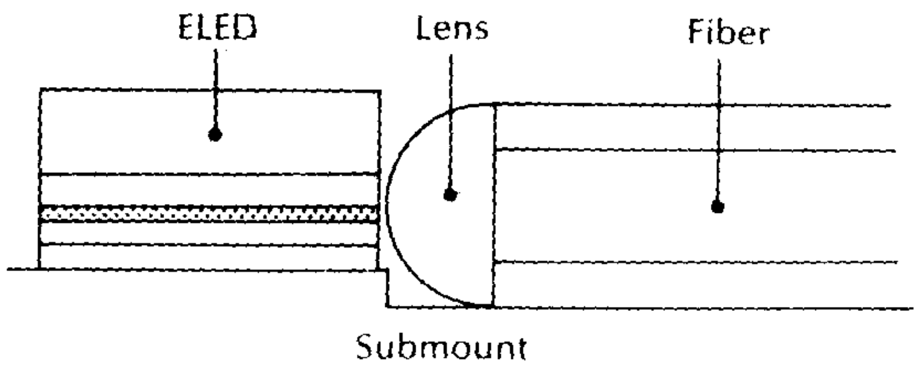
OVERALL POWER CONVERSION EFFICIENCY (η PC)

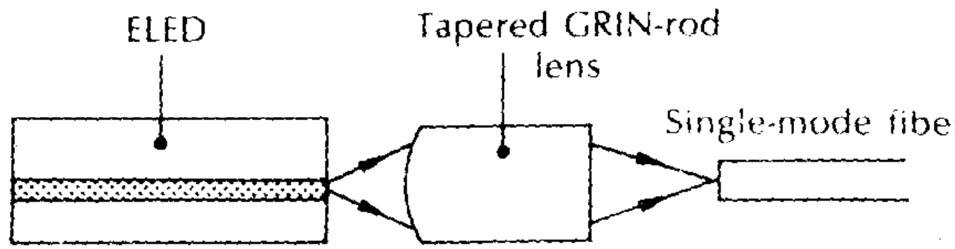
$$\left(= \frac{\text{OPT POWER COUPLED INTO FIBER}}{\text{ELECT. POWER APPLIED AT TERMIALS}} \right)$$

IS STILL LOW= **0.4%**

NOTE : THEORY SUGGESTS POSSIBLE INCREASE OF UPTO 30 TIMES IN THE COUPLING η)

LENS COUPLING WITH EDGE EMITTING LED'S





Lens coupling with edge-emitting LEDs: (a) lens-ended fiber coupling;
(b) tapered (plano-convex) GRI N-rod lens coupling to single-mode fiber.

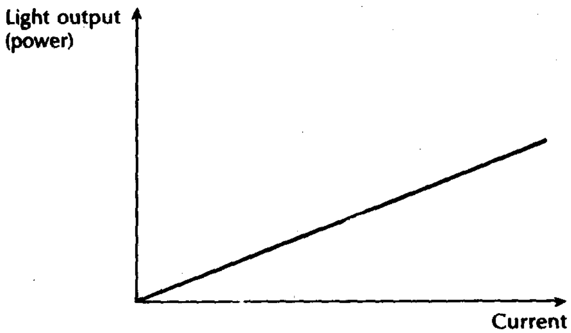
LENS COUPLING WITH EDGE EMITTING LED'S

- HIGHER POWER CAN BE COUPLED INTO SINGLE MODE FIBERS IN CASE OF EDGE EMITTING LED'S THAN SELED'S.
- **TAPERED FIBER – LENSES YIELD A COUPLING EFFICIENCY OF 15%**
- **COUPLING** $\eta = \dfrac{\text{COUPLED POWER}}{\text{TOTAL EMITTED POWER}}$

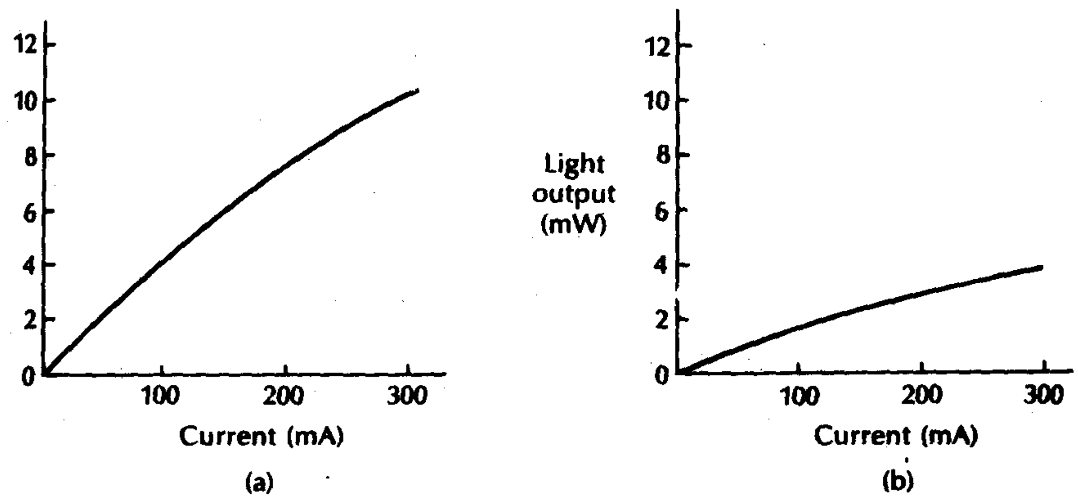
A) LENS – ENDED FIBER COUPLING

B) TAPERED(PLANO - CONVEX) GRIN – ROD LENS COUPLING TO SINGLE MODE FIBER.

LED CHARACTERISTICS



An ideal light output against current

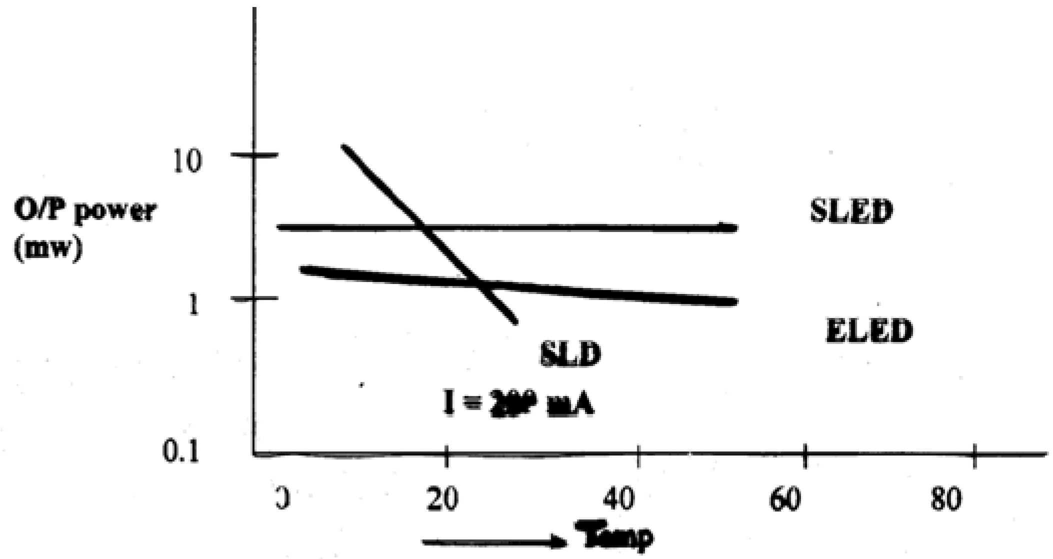


(a) an AIGaAs **surface emitter** with a 50 µm diameter
(b) an AIGaAs **edge emitter** with a 65 µm wide stripe and 100 µm length.

<u>SURFACE EMITTER LED RADIATES SIGNIFICANTLY MORE OPTICAL POWER THAN EDGE EMITTER LED</u>.

BOTH ARE REASONABLY LINEAR AT MODERATE CURRENTS

LIGHT OUTPUT TEMP DEPENDENCE-LED

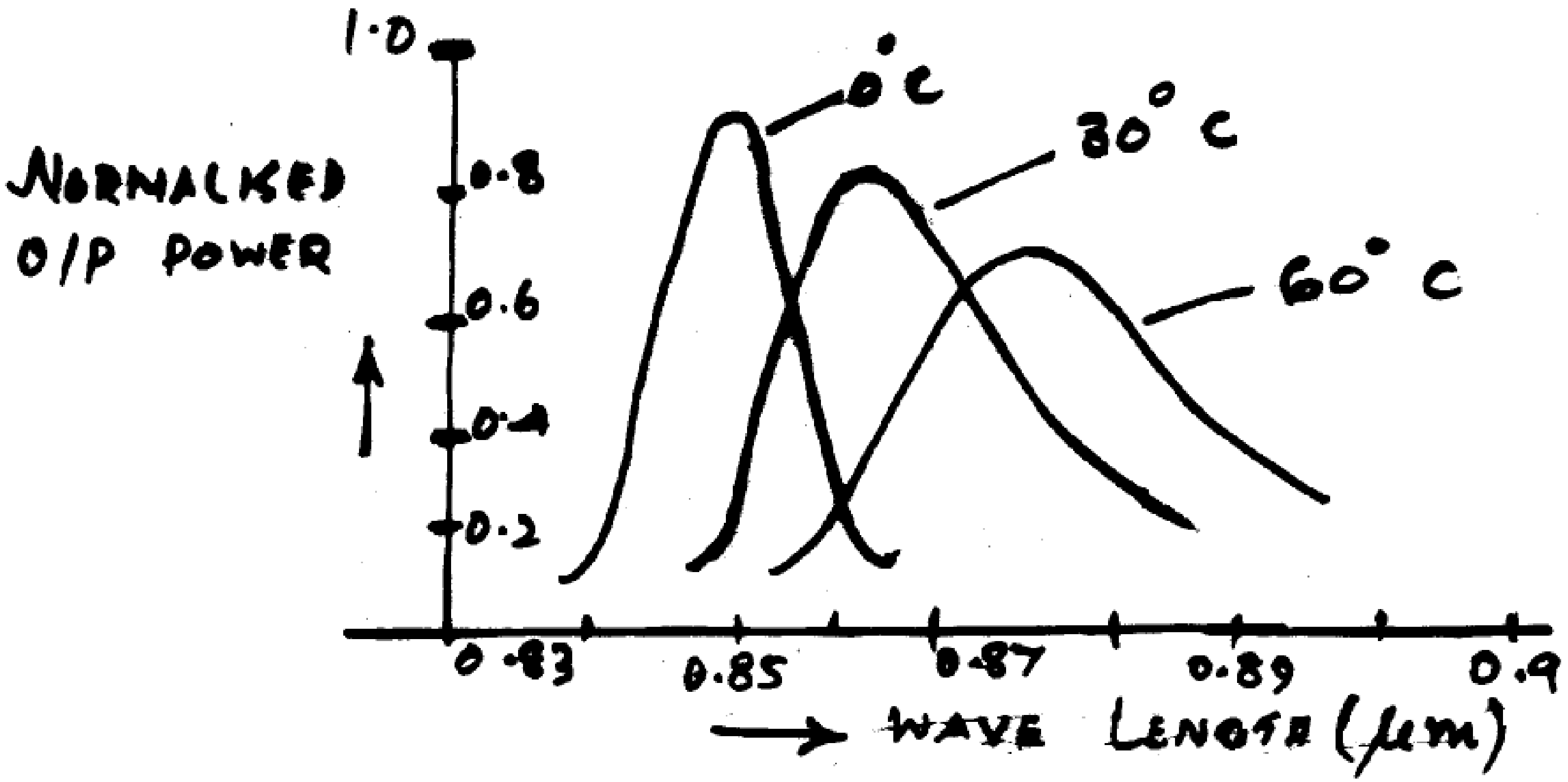


• THE INTERNAL QUANTUM EFFICIENCY OF LED'S DECREASES EXPONENTIALLY WITH INCREASING TEMPERATURE & SO THE LIGHT OUTPUT DECREASES AS P-N JUNCTION TEMPERATURE INCREASES.

• **ELED EXHIBITS GREATER TEMPERATURE DEPENDENCE THAN SLED**

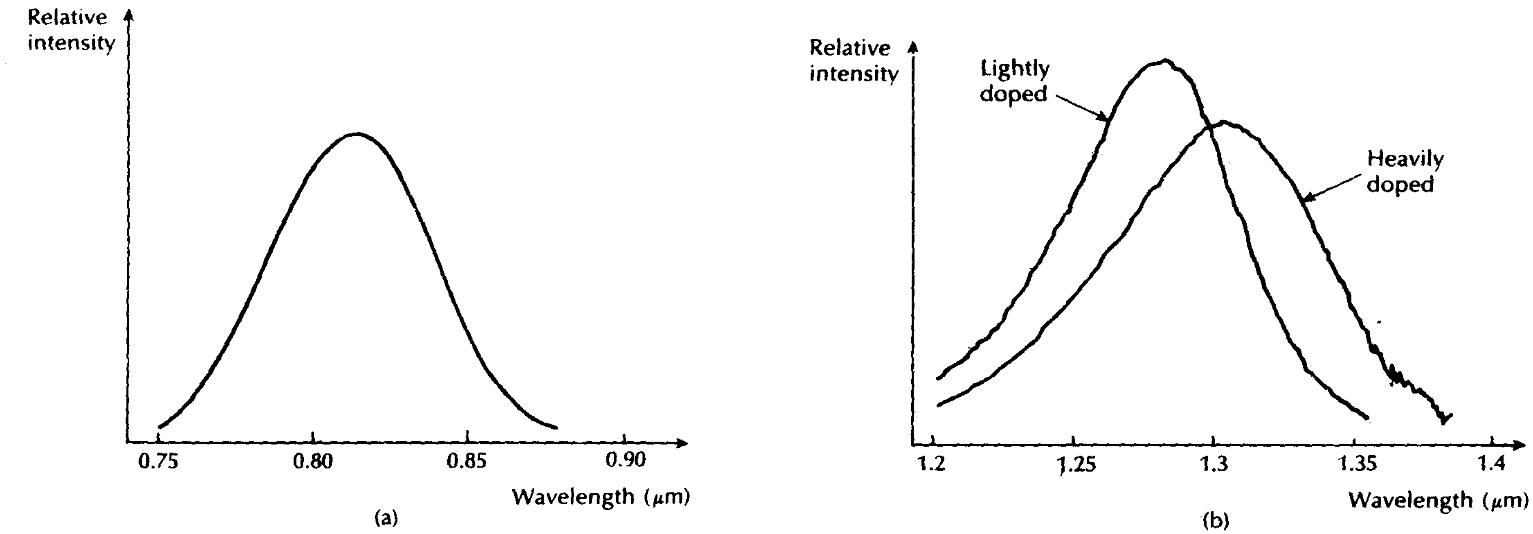
• **OUTPUT OF SLD WITH ITS STIMULATED EMISSION IS STRONGLY DEPENPANT ON THE JUNCTION TEMPERATURE**.

CURVES FOR AN Al Ga AS SURFACE EMITTING LED



OUTPUT SPECTRA TENDS TO BROADEN AT A RATE **0.1 TO 0.3 nm/deg** INCREASE IN TEMP. (DUE TO GREATER ENERGY SPREAD IN CARRIER DISTRIBUTIONS)

OUTPUT SPECTRUM



LED output spectra: (a) for an AlGaAs surface emitter with doped active region .(b) for an lnGaAsP surface emitter showing both the lightly doped and heavily doped cases.

-SPECTRAL LINEWIDTH OF LED OPERATING AT ROOM TEMP IN THE 0.8 TO 0.9 μm WAVELENGTH BAND IS 25 – 40 nm AT HALF POWER POINTS .
LINE WIDTH INCREASES DUE TO INCREASED DOPING LEVELS.
-TYPICAL VALUES FOR ELED & SLED IS 75 nm & 125 nm RESP at 1.3 μm

MODULATION

- TO TRANSMIT INFORMATION ,IT IS NECESSARY TO MODULATE A PROPERTY OF THE LIGHT ,WITH THE INFORMATION SIGNAL.
- **PROPERTY : INTENSITY , FREQUENCY, PHASE , POLARISATION (DIRECTION)**

INTENSITY MODULATION (IM) OF THE SOURCE IS THE MAJOR MODULATION STRATEGY.

- IM IS EASY TO IMPLEMENT (variation of drive current of the source)
- ANALOG INTENSITY MODULATION IS USUALLY EASIER TO APPLY BUT REQUIRES LARGE S/N RATIO , AND HENCE LIMITED TO SHORT DISTANCE APPLICATIONS (NARROW BW).
- **DIGITAL INTENSITY MODULATION GIVES IMPROVED NOISE IMMUNITY , BUT REQUIRES WIDER BW'S.** IDEALLY SUITED FOR OFC, AS LARGE BW IS AVAILABLE .

MODULATION BANDWIDTH

ELECTRICAL DEFINITION :

ELECT SIGNAL POWER HAS DROPPED TO HALF ITS CONSTANT VALUE DUE TO MODULATED PORTION OF THE OPTICAL SIGNAL (3 DB DOWN). **THIS CORRESPONDS TO THE FREQ AT WHICH ELECT POWER IS REDUCED BY 3 db wrt I/P ELECT POWER ie WHEN OUTPUT CURRENT HAS DROPPED TO 0.707 OF INPUT CURRENT.**

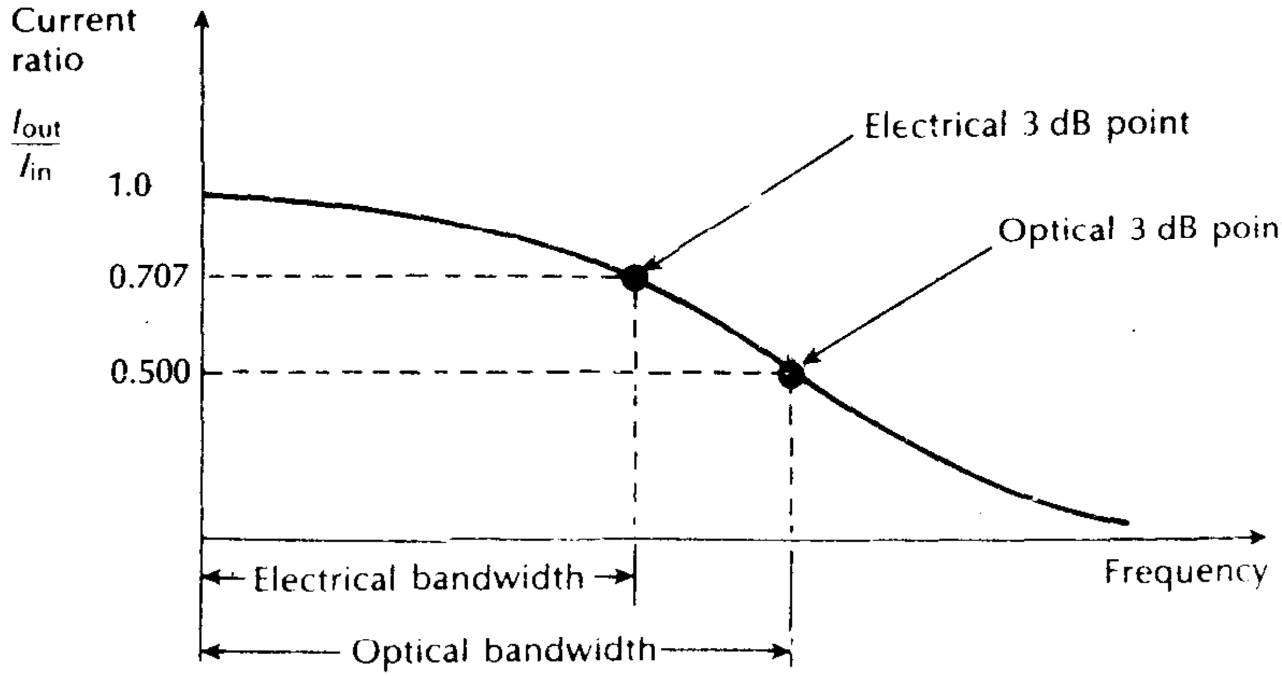
MODULATION BANDWIDTH

MODULATION BANDWIDTH (OPTICAL) :

FREQUENCY RANGE BETWEEN ZERO AND THIS HIGH FREQUENCY 3 DB POINT **WHEN OUTPUT CURRENT HAS DROPPED TO 0.5 OF THE INPUT CURRENT**.

OPTICAL BANDWIDTH IS NORMALLY $\sqrt{2}$ TIMES GREATER THAN THE ELECTRICAL BANDWITH.

MODULATION BANDWIDTH (ELECT & OPTICAL)



RATIO OF ELECT. O/P POWER TO ELECT I/P POWER IN db = RE db

R E db = 10 Log_{10} Elect POWER OUT (DET)/ Elect POWER IN(SOURCE)
α10 Log_{10} $[Iout/I\ in]^2$ AT 3db (Iout/I in $)^{2}=$ ½
Iout/I in = 1/√2 = 0.707

$$RO = 10 \log_{10} \frac{\text{OPT power out (DET)}}{\text{OPT power in (SOURCE)}}$$

$$= 10 \log_{10} \frac{I\ out}{I\ in} \qquad \text{At 3 db} \qquad \frac{I\ out}{I\ in} = 1/2$$

(Due to linear light/ current relationship) of the source and detector

Opt. BW = √ 2(Elect BW)

RELIABILITY OF LED’S

- LED’S EXHIBIT **GRADUAL DEGRADATION** IN ADDITION TO **RAPID DEGRADATION**.
- **RAPID DEGRADATION IS DUE TO GROWTH OF DISLOCATIONS AND PRECIPITATE – TYPE DEFECTS IN ACTIVE REGION** (CALLED **DLDs & DSDs**)
- **THESE DEFECTS DEPEND UPON INJECTION CURRENT DENSITY, TEMP & IMPURITY CONCENTRATION** .
- **LONG TERM DEGRADATION COULD BE DUE TO MIGRATION OF IMPURITIES INTO THE ACTIVE REGION**.

RELIABILITY(contd)

- <u>Output power</u>

Pout : INITIAL O/P POWER

β_r : DEGRADATION RATE = β_0e-Ea/KT

Where β_0 – PROPORTIONALITY CONSTANT

K- BOLTZMAN'S CONSTANT

OPT. POWER O/P Pe(t) = Pout $e^{-\beta_r t}$

T- ABS. TEMP. OF THE EMITTING REGION.

Ea – ACTIVATION ENERGY ≈ 0.56 TO 1.0 ev FOR SLED'S (dependant upon material and structure of device)

AVG. LIFE OF SLED’S

-**10^6 TO 10^7 HOURS(100 TO 1000 YRS**)

(FOR CW OPERATION AT ROOM TEMP FOR AlGaAs DEVICES)

- IN EXCESS OF 10^9 HRS FOR SURFACE EMITTING InGaAsP LED’S.

- **DEVICE LIFE TIME IS OFTEN DETERMINED FOR A 50% DROP IN LIGHT OUTPUT FROM THE DEVICE**

- **JUNCTION TEMP, EVEN FOR A DEVICE OPERATING AT ROOM TEMP. IS LIKELY TO BE WELL IN EXCESS OF ROOM TEMP, WHEN SUBSTANTIAL DRIVE CURRENTS ARE PASSED**