UNIT-IV

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OPTICAL SOURCES

* LED } Construction, operating principle
* LASER } and characteristics of their light
* ILD - Injection Laser Diodes.

Light source should have following characteristics (లక్షణాలు)

* optical light has very low losses
* optical light o/p must be stable under different Condition
* o/p light should be highly directive
* o/p light should be modulated easily i.e. by V or by I
* o/p light has small bandwidth and less dispersion
* Size of source should be comparable to optical fiber
* Long life, coherence, Reliability

Imp Facts

* Heterojunction LED and LASERs are mostly used
  Ex GaAs, GaAlAs.
* Source to fiber coupling efficiency depends upon size, angle, alignment, NA, of optical source light
* Si & Ge is not used for LED.
* LED is used as optical source for short distance
* LASER is used for Long distance.
* Direct band Gap materials are preferred for Laser Diodes.

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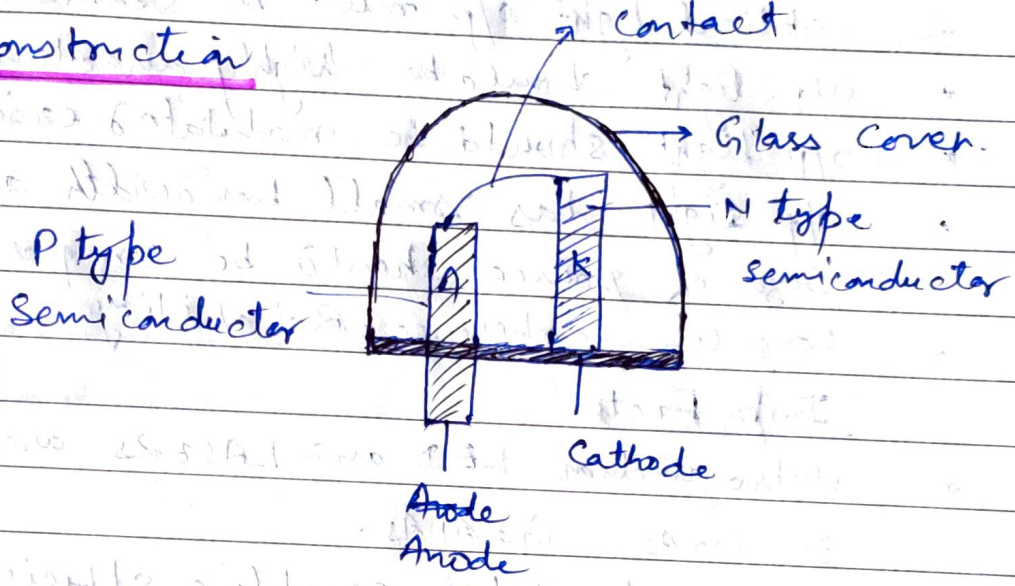
LED - Light Emitting Diodes

* It converts electrical signal to light signal.

Symbol of LED

Basic LED construction



* LED एक PN junction होता है जो कि Forward Biase होता है।
* यह PN junction GaAs, GaAsP, GaP का बना होता है। Si तथा Ge का प्रयोग LED में नहीं किया जाता है। Si तथा Ge प्रकाश के स्थान पर Heat generate करते हैं।
* It has heavily doped P-N junction
* LED junction is made such that emitted light should be in visible Region (λ 750nm to 380nm) $E = hc/\lambda$
* For LED thersold voltage is higher (1.63 to 3.6) It is differ as per o/p colour light

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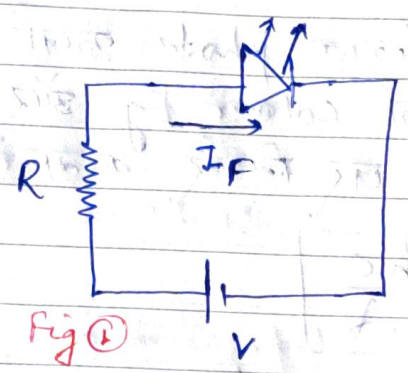

Fig ①

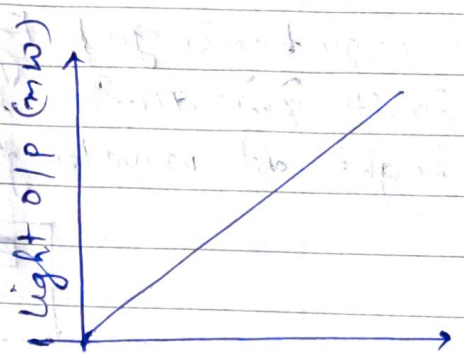

Fig ② Forward Voltage Current

$I_F \rightarrow$ (mA)

as V ↑ I_F ↑

light Intensity ↑

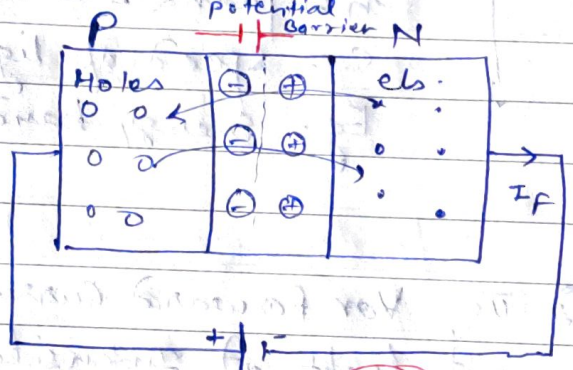

Fig-3

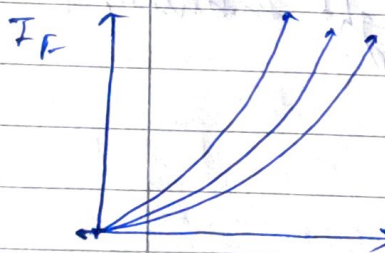

Fig ⑤

curve is different for different colour

$E = \frac{hc}{\lambda}$

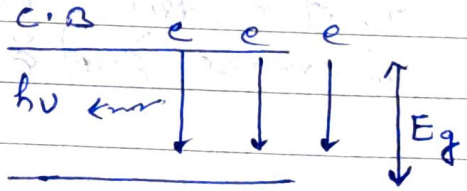

Fig ④

Working Principle of LED

जब किसी GaAs, GaAsP के PN Junction को forward Biased किया जाता है तो P type के holes और N type के els एक दूसरे की तरफ attract होकर recombine हो जाते हैं। recombination पर els और holes vanish (विलुप्त) हो जाते हैं। तथा light emitt करते हैं। els जो कि higher Band C.B से निचले Band V.B के holes पर जाते हैं

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energy band gap E_g के संगत photon ऊर्जा emitt करता है। Emitt होने वाली light का colour E_g और निकलने वाली light की wavelength (λ) पर निर्भर करता है।

$$E_g = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E_g}$$

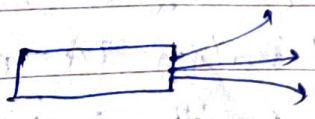
h = plank's cost.
c = speed of light
E_g = Energy band gap

Forward Voltage V_F बढ़ाने पर Forward Current I_F बढ़ती है तथा Emitt होने वाली light की Intensity भी increase होती है $V_F \uparrow$ $I_F \uparrow$ light Intensity $\uparrow$

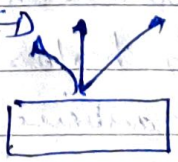
GaAs → Infrad Region (IR)
$GaAs_{1-x}P_x$ → For different colour

Types of LED

① Edge LED



② Surface LED



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LED की विशेषताएं

① Durable ② Small size ③ Easy fabrication
④ Less costly ⑤ Driven ckt is simple ⑥ Silent operation
⑦ low power consumption ⑧ Long life ⑨ less heating effect

Application → 7 Segment Display
In optical source
As Indicator
As light source
LED TV.

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LASER :

- Introduction
- Absorption, Spontaneous & Stimulated Emission
- Ruby laser, He+Ne laser
- Semiconductor Injection Laser.
- Population Inversion
- Maser (Full Form and Introduction)
- Properties of LASER and Application

* **MASER** - Microwave Amplification by Stimulated Emission of Radiation - First Maser - 1954
It is just like LASER but rays or signal is in Microwave Invisible format

* **LASER** : "Light Amplification by stimulated Emission of Radiation"
First LASER - 1960 (Ruby LASER)

Introduction → LASER is a coherent, Monochromatic, unidirectional, Intense optical light source. It works on Stimulated Emission of Radiation

Properties of LASER Light →
* Monochromatic (एकवर्णी)
* Narrow and parallel ray Beam (समान्तर एवं संकीर्ण)
* High Intensity light (can produce 10⁴°c temp.)
* Unidirectional (एकदिशीय)
* Coherent ray (कला समान है)
* Do not spread

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	Application of LASER :-			
*	Use as a cutting tool for metals sheets			
*	Drilling Machine and Soldering			
*	Laser Welding			
*	In Medical field Ex To damage Cancer cell			
	For kidney stone operation			
	To damage tumer cell			
	For Surgery			
*	War Weapons. Laser Rifles			
	Guided Missiles			
*	Metal Processing →			
*	For 3D photography			
*	optical source for long distance in OFC			
*	Satellite and space Research			
*	Nuclear Research.			

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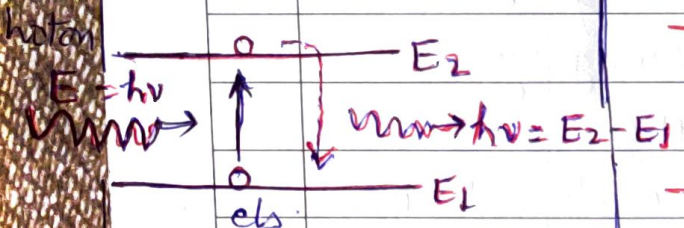
Types of LASER,

- Ruby Laser
- He. Ne Laser
- Semiconductor Laser

First we study these basic operation in LASER action

Absorption of photon



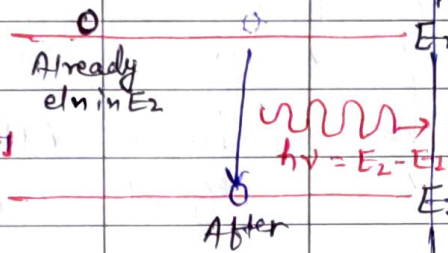
absorption of a photon will occur when the quantum energy of the photon precisely matches the energy gap ($E_2 - E_1$)

els absorbs photon energy Goes to E_2 Energy level

life time in Excited state E_2 is less. eln jumps Back to E_1 and emits

Corresponds energy in form of photon $E = h\nu = E_2 - E_1$

Spontaneous Emission



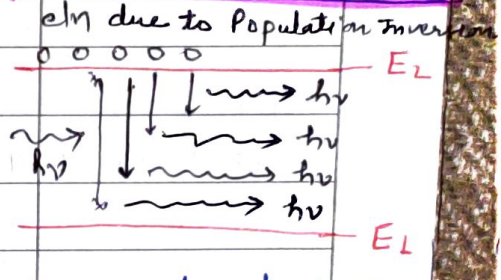
eln may already in E_2 energy level with Excited state for very short time i.e = 10^{-8} s

After 10^{-8} s time this eln jumps to energy level E_1 and realsing Random Energy photon

$E_p = E_2 - E_1$

All such transistation give rise to emission of photon which are out of phase

Stimulated Emission



eln are already in E_2 state by population Inversion

External Photon Stimulate E_2 energy level eln to jump back to E_1 and realsing new photons.

All such photon emitted has same polarization, phase, direction and are coherent. so Intense light ray occur at o/p. This is laser operation.

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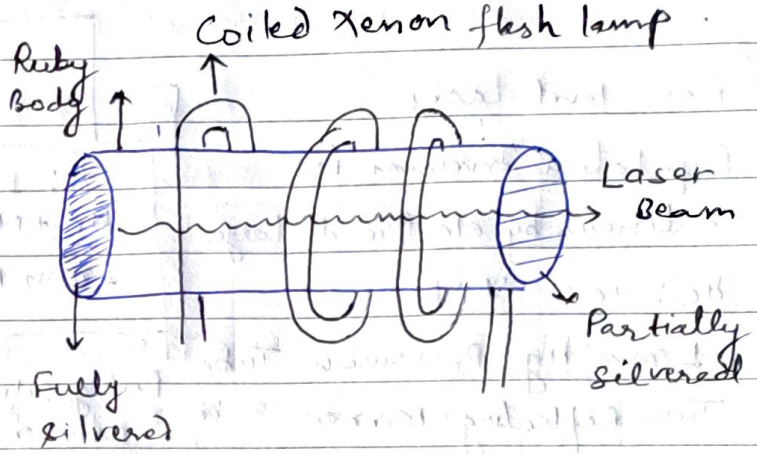
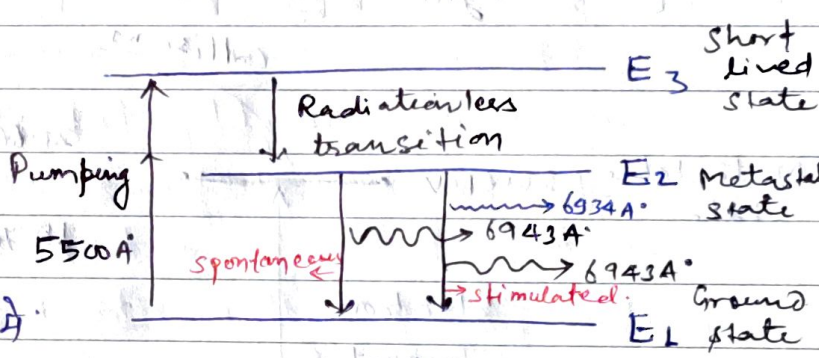
Ruby LASER →



* First Laser - 1960. Ruby laser
* It is solid state laser
* It is three state Laser.

Working → Ruby Body is made of $Al_2O_3 + 0.05\% Cr_2O_3$ crystal.
इसका colour गुलाबी होता है।
जब Xenon flash lamp के द्वारा 1 ms तक flash दी जाती है तो 5500 Å के Radiation (Cr ions के द्वारा absorb कर लिए जाते हैं। अतः इनकी pumping E_3 अवस्था में हो जाती है। यहाँ इनका (Cr ions का) life time 10^{-9} s होता है अतः ये Radiationless transition कर E_2 metastable state में आ जाते हैं। यहाँ इनका life time 10^{-3} s होता है। E_2 energy level में आयन की संख्या बढ़ती जाती है इसे pupulation Inversion कहते हैं। E_2 level से कोई भी आयन spontaneously E_1 level पर आता है। और यह आयन Ruby Crystal body के Silvered part से टकराकर अन्य आयनों को E_2 level से stimulate करता है। यह क्रिया बार-बार होती है जिस कारण Crystal के अन्दर उत्पन्न होने वाले stimulated ions crystal की faces से टकराकर Intense photon ray के रूप partially silvered face से बाहर laser ray की form में आते हैं।



Disadvantages of Ruby LASER

* It requires high pumping power
* Some energy of 6943 Å is absorb by E_1 stations.
* ये कमियां He-Ne Laser में दूर करी गयी

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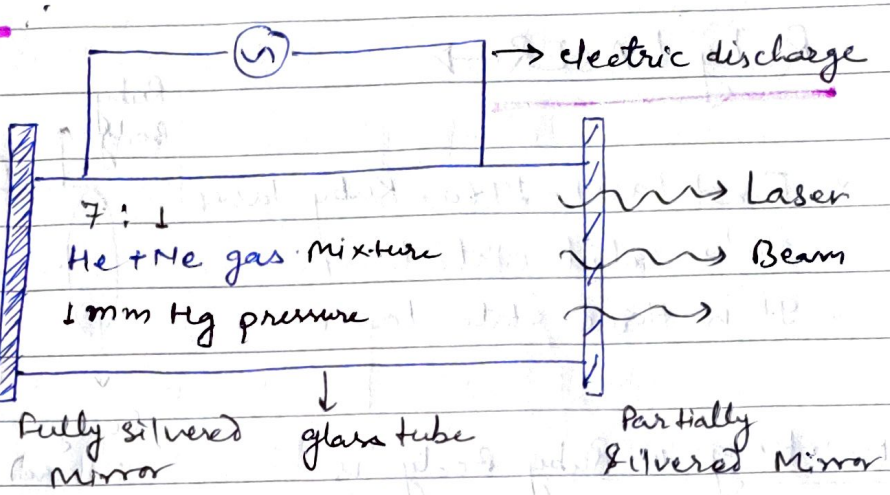
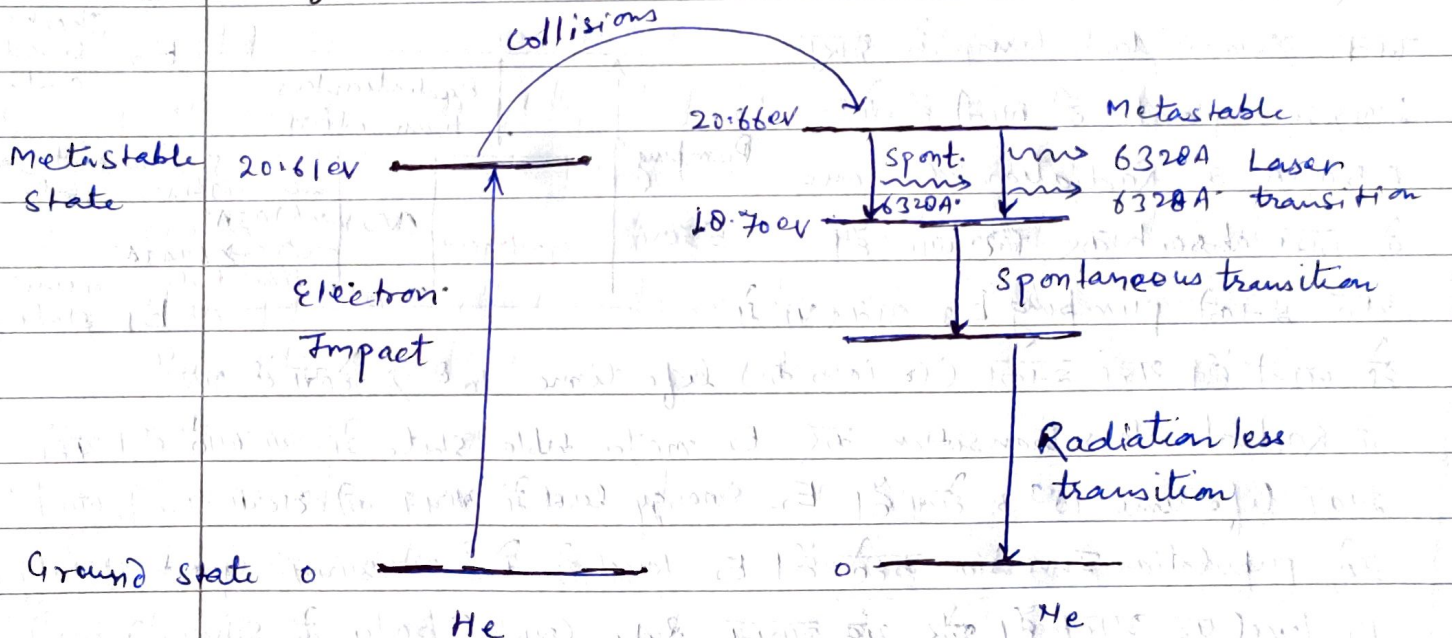
Helium-Neon LASER :

* Four level Laser
* Population Inversion is continous by electric discharge
* He : Ne = 7 : 1
* 1 mm Hg Pressure in Tube
* Two Reflecting Mirrors.
* Spacing between Mirror is multiple of λ of laser light





A Four level LASER :

* He and Ne gas Mix. is electrically pumped to Metastable level.
* Ne ions are populated Inversion by Kinitic Energy of He ions.
* Excited Ne atom jumps to 18.70 ev level and spontaneously and emit Light 6328Å photon. यह photon Mirror से तब तक टकराता है जब तक यह Stimulated Emission के द्वारा अन्य Inphase photon (6328Å) न निकाल दे। यह process लगातार चलती है और light ray strong Intensity की हो जाती है तो यह Laser Beam के रूप में partially Silvered face से निकलती है।

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* He atom 1S. Hoer level से spont. transition के द्वारा Metastable state में आता है और फिर Radiationless transition के द्वारा Ground level पर पहुंच जाता है।

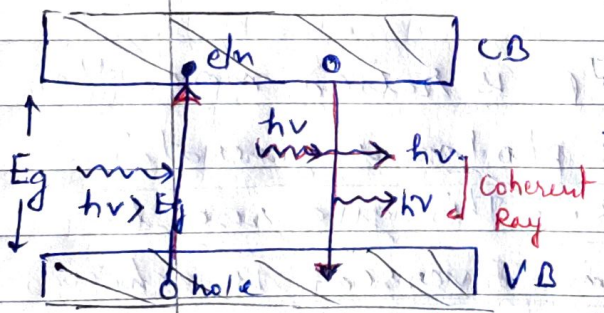
Advantage → × Last transition is Radiationless so no absorption by ground level atoms.

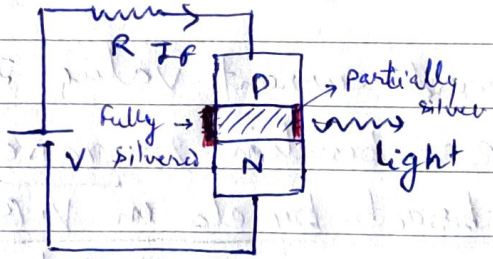
* He-Ne laser Beam is continous as electric discharge is continous process. (Ruby laser - Flash lamp)

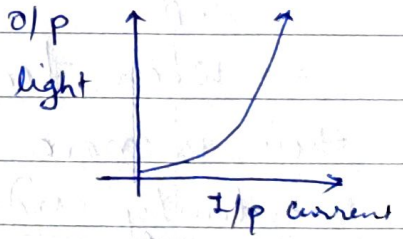
* It needs less excitation power.

Semiconductor Injection LASER Diode (ILD)

* First ILD - GaAs * Eg ~ 1eV (Energy Band Gap)







PN Middle region is work as resonator as its one side is fully silverd and other side Partially silvered

Working. GaAs का PN junction को की forward Biased में प्रयोग किया जाता है इसमें P तथा N type highly dopped होते हैं जैसे ही PN junction of forward Biased किया जाता है तो forward current If बहने लगती है तथा els और holes का Recombination होता है. If का मान अधिक

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होने पर C.B में els की संख्या बढ़ती जाती है।
तथा I_F के अधिक मान के लिए population Inversion प्राप्त हो जाती है।

population Inversion से पहले की क्रिया Spontaneous Emission होती है।

population Inversion के बाद eln और hole के Recombination से उत्पन्न photon Stimulated Emission क्रिया करता है। तथा उत्पन्न होने वाले photon same phase में होकर laser o/p देते हैं।

Steps में इस क्रिया को निम्न प्रकार समझा जा सकता है।

* p N (GaAs) Highly doped and Forward Biased.
* Small I_F current flows as movement of els and holes.
* els and holes recombination give rise to photon.
* This photon either absorb by eln in V.B and raise this eln to C.B or stimulate already exist els in C.B.
* When forward current value I_F is raised more then their is more recombination so more photons is generated randomly and absorb by els in V.B. This give rise to els to come to C.B. i.e population Inversion is achieved.
* Now emitted photon stimulate els in C.B to fall back to V.B and release energy (C.B - V.B = Eg) in form of photon.
* Such photon has equal phase as of incident photon.
* This process happens repeatly and LASER action started.

advantages of ILD. ① Small size ② Easy Modulation by I_F ③ Easy construction ④ cost is less.