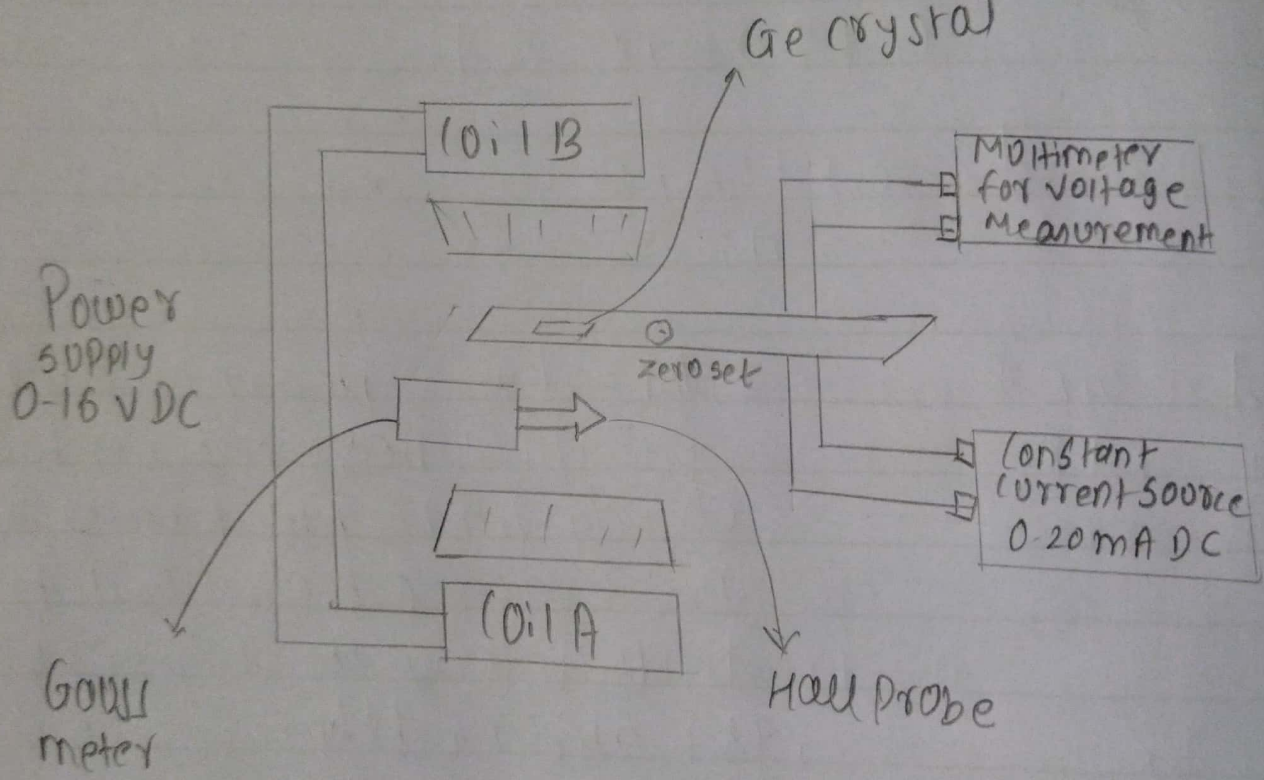
Ge crystal
Coil B
Multimeter for voltage Measurement
Power supply 0-16 V DC
zero set
Constant Current Source 0-20mA DC
Coil A
Gauss meter
Hall Probe

Aim:- 1) The Hall Coefficient RH
2) The concentration of charge carrier n

Apparatus:- Power supply for electromagnets, Gauss meter with hall probes, P type Ge semicon
Multimeter, electromagnets

Theory:- A current carrying conductor is placed i
magnetic field perpendicular to direction of cur
A voltage is developed across conductor in direction ⊥r to current and magnetic field.
It is useful to determine -
1) Nature of charge carries
2) Carrier concentration or no of density charge car
3) Mobility of charge carriers

$$\text{Hall Coefficient } (R_H) = \left(\frac{V_H}{I}\right) \cdot \frac{w}{B}$$

$$\text{Carrier concentration } (n) = \frac{1}{e R_H}$$

Observation Table

Sr	Current through specimen (mA)	V_H (Voltage) (mV)	Hall coefficient $[R_H] \times 10^r$ $(cm^3 C^{-1})$
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Thickness of Specimen $(w) = 5 \times 10^{-2}$ cm

Conductivity $(\sigma) = 0.1\ (V^{-1} sec^{-1} cm^{-1})$

Hall coefficient $R_H = \left(\frac{V_H}{I}\right)\frac{w}{B}$

Carrier concentration $\Rightarrow n = \frac{1}{eR_H}$

Carrier Mobility $\mu = R_H \sigma$

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⇒ Procedure

- Connect one pair of contact of specimen on opposite fac to current source and other pair to moltmeter
- Switch on power supply of electromagnet and measure magnetic flux density
- Place the specimen at centre b/w pole faces such that magnetic field is ⊥r to strip
- Pass the current from current source through specimen and measure resulting hall voltage
- Increase current through specimen gradually and measure corresponding hall voltages.

⇒ Precautions

- Before starting the experiment, check gaussmeter is showing zero value.
- Ensure that specimen is located at centre b/w pole faces and exactly ⊥r to magnetic fie
- To measure magnetic flux the hall probe should placed at centre the pole faces, parallel to crystal.
- check the direction of electromagnet coils so that generates max magnetic field this can be check by placing soft iron near generated magnetic field.

⇒ Result :-

⇒ Conclusion :-

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Aim: - To determine the energy band gap of semiconductor (germanium) for four probe method

Apparatus: - Probes arrangement, sample, A constant current generator (open circuit voltage about 20v current range 0 to 10 mA), Oven (for variation of temperature of crystal from room temperature to about 2000 C), Millivoltmeter, power supply for oven, thermometer.

Theory: -

- Many conventional methods for measuring resistivity are unsatisfactory for semiconductors because metal semiconductor contacts are usually rectifying in nature. Also there is generally minority carrier injection by one of the current carrying contacts.

The method described here overcomes the difficulties mentioned above and also offers several other advantages. It permits measurements of resistivity in samples having wide variety of shapes including resistivity of small volume within bigger pieces of semiconductor. In this manner the resistivity of both sides of p-n junction can determined with good accuracy before the material is cut in to bar for making devices

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- for share probes are placed on a flat surface of the material to measured. Current is passed through the two outer electrodes and floating potential is measured across the inner part. If the flat surface on which the probes rest is adequately large and the crystal is big the semiconductor may be considered to semi-infinite volume. This permit measurement with reasonable current of n type or p-type semiconductor from 0.001 to 50 ohm cm. In order to use this four probe method in semiconductor crystals or slides it is necessary to assume that

1) The resistivity of material is uniform in the area of measurement
2) If there is a minority carriers injection into semiconductor by current-carrying electrodes most of carriers recombine near the electrodes so that their effect on conductivity is negligible
3) The surface on which the probes rest is flat with no surface leakage
4) The four probes used for resistivity measurements contact the surface at points that lie in straight line
5) The diameter of contact b/w the metallic probes and semiconductor should be small compared to distance b/w probes
6) The boundary b/w the current-carrying electrode and bulk material is hemi-spherical and small in diameter

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→ Procedure:-

1) put the sample on base plate of four probe arrangement. unscrew the pipe holding the four probes and let the four probes rest in the middle of sample. Apply a very gentle pressure on the probes and tighten the pipe in this position. chek the continuity b/w probes for proper electrical contacts

2) Connect the outer pair of probes leads to the constan current power supply and inner pair to the probe voltage terminals

3) place the four probe arrangement in the oven and fix thermometer in oven through the hole provided

4) Switch on the A C mains of four probe setup and the digital panel meter in current measuring mode through the selector switch. In this position LED facing mA would glow

5) Now put the digital panel meter in voltage measur mode. In this position LED facing mV would glow and the meter would read the voltage b/w probes.

Aim:- To calculate the beam divergence and spot size of given laser beam

Apparatus:- The light emitted by laser is confined to rather narrow cone. laser, detector, optical bench photodiode, micrometer

Laser:- It is mechanism for emitting electromagnetic radiation via process of stimulated emission. The laser was first device capable of amplyfying light waves themselves. The emitted laser light is a spatially coherent, narrow long divergence beam when waves of beam of light have same frequency phase and direction it is said to be coherent.
A laser beam with narrow beam divergence is greatly used to make laser point devices. Generall beam divergence of laser beam is measured using beam profiler

Beam divergence
The light emitted by laser is confined to rather narrow cone. But, when the beam propagates outward, it slowly diverges or fans out. for an electromagnetic beam, beam divergence is angular measure of increase in radius or diameter with distance from optical aperture as beam emerges

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The divergence Of laser beam can be calculated if beam diameter d1 and d2 at two separate distances are known. let z1 and z2 are distances along the laser axis from end of laser to points 1 and 2

Usually, divergence angle is taken as full angle of Opening of beam

$$\theta = \frac{d_2 - d_1}{z_2 - z_1}$$

Half of divergence angle can be calculated

$$\theta = \frac{w_2 - w_1}{z_2 - z_1}$$

w1 and w2 are radii of beam at z1 and z2

⇒ Spot size

Spot size is nothing but the radius of beam itself. The irradiance of beam decreases gradually at edges

The distance across the center of beam for which the Irradiance equal to $\frac{1}{e^2}$ of maximum Irradiance is defined as beam diameter. The spot size Of beam is defined as radial distance from center point of maximum irradiance to $\frac{1}{e^2}$ point

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Gaussian laser beams are said to diffraction limited when their radial beam divergence is close to min possible value

$$\theta = \frac{\Theta}{2} = \frac{\lambda}{\pi w_0}$$

$w_0 \rightarrow$ Radius of beam at narrowest point

$\lambda \rightarrow$ wavelength of given laser

⇒ procedure

- Arrange the laser and detector on optical bench
- The laser is switched on and is made to incident on photodiode
- Fix the distance, z b/w detector and laser source
- By adjusting micrometer of detector, move spot in horizontal direction left to right
- Note output current for each distance, x from measuring device
- The experiment is repeated for different detector distances

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Aim:- To find Numerical aperture of given optical fibre and hence to find its acceptance angle

Apparatus:- Output unit, Detector, fibre stand, Fiber, concentrator, Emitter

Optical fibre:- Optical fibers are fine transparent glass or plastic fibers which can propagate light. They work under the principle of total internal reflection from diametrically opposite walls. In this way light can be taken anywhere because fibers have enough flexibility. This property makes them suitable for data communication, design of fine endoscopes, micro sized, microscopes etc. An optic fibre consist of core that is surrounded by cladding which are normally made of silica glass or plastic. The core transmits an optical signal while the cladding guides the light within the core since light is guided through the fiber it is sometimes called an optical waveguide.

- In order to understand the propagation of light through an optical fibre, consider the figure(2). consider a light ray i) entering the core at a point A, travelling through the core until it reaches the core cladding boundary at a small angles the ray will be reflected back in to core to travel on to point C where the process of reflection is repeated

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Total Internal reflection occurs only when the angle of incidence is greater than critical angle.
If a ray enters an optical fiber at a steep angle when this ray Intersects the core-cladding boundary the angle of intersection is too large. So, reflection back in to core does not take place and light ray is lost in the cladding. This means that to be guided through an optical fibre, a light ray must enter core with an angle less than a particular angle called acceptance angle of fibre.

Consider an optical fibre having a core of refractive Index n_1 and cladding of refractive index n_2 let the Incident light makes an angle i with the core axis as shown in figure (3). Then the light gets refracted at an angle θ and fall on the core-cladding Interface at an angle where,

$$\theta' = (90 - \theta) \rightarrow (1)$$

By snell's law at point of entrance of light in to optical fiber we get

$$n_0 \sin i = n_1 \sin \theta \rightarrow (2)$$

n_0 - Refractive index of medium outside the fiber

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when light travels from core to cladding it moves from denser to rarer medium and so it may be totally reflected back to the core medium if θ' exceeds the critical angle θ'_c. The critical angle is that angle of incidence in denser medium (n_1) for which angle of refraction become $90°$

Using snell's laws

$$n_1 \sin\theta'_c = n_2 \sin 90$$

$$\sin\theta'_c = \frac{n_2}{n_1} \rightarrow (3)$$

Therefore, for light to be propagated within the core of optical fiber as guided wave, the angle of incidence at core cladding interface should be greater than θ'_c. Also i increases, θ increases and so θ' decreases. There is maximum value of angle of incidence beyond which it does not propagate rather it is refracted into cladding medium.

$$NA = n_0 \sin i_m = n_1 \sin\theta$$

$$= n_1 \sin(90 - \theta_c)$$

$$\text{or } NA = n_1 \cos\theta'_c$$

$$= n_1 \sqrt{1 - \sin^2\theta'_c}$$

from eq(2) $\sin\theta'_c = \frac{n_2}{n_1}$

$$NA = n_1 \sqrt{1 - \frac{n_2^2}{n_1^2}}$$

$$NA = \sqrt{n_1^2 - n_2^2}$$

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- The significant of NA is that light entering in cone of semivertical angle im only propagate through fibre The higher the value of im or more is the light collected for propagation in the fibre. Numerical aperture is thus considered as light gathering capacity of an optical cone angle

$$\sin\theta = \frac{r}{\sqrt{r^2+a^2}} \rightarrow (4)$$

⇒ Procedure

- Start button - To start experiment
- Switch on - To switch on laser
- select fiber - To select type of fiber
- select laser - To select different laser source
- Detector distance(z) - Use the slider to vary the distance b/w the source and detector
- Detector distance(x) = Use the slider to change detector distance
- Show Graph:- To displays the graph
- Set the detector distance z.
- Vary the detector distance x by an order 0.5mm Using screw gauge
- Measure the detector reading from output reading
- find the radius of the spot r, which is corresponding to Imax

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