VIT, Vellore Campus PHY 1701 (Engineering Physics). Lab Manual and Records.
Date:- 1st April 2021 Reg:-20BDS0405

Date
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# Electron Diffraction.

## Apparatus Required

1. Electron diffraction tube with stand.
2. High voltage power supply (upto 10 KV).
3. Connecting wires.
4. Plastic measuring scale.

## OBJECTIVE:-

To calculate the interplanar spacing in graphite from the diffraction pattern.

## BASIC INFORMATION:

In this experiment, electrons get transmitted through a very thin polycrystalline graphite sheet. The schematic sketch is shown in fig 1. Graphite has two independent lattice spacings ($d_1$ and $d_2$) and these are shown in Fig. 2 The two diffraction rings that will be seen at each voltage are due to these planes.

Applying the diffraction formula for first order, we get,

$$\lambda = d\sin\theta.$$

where $\lambda$ is the de-Broglie wavelength of $e^-$, d is interplanar spacing and $\theta$ is the angle of diffraction. Electrons are accelerated through a p.d. of V Volts and hence their de-Broglie wavelength is:,

$$\lambda = \frac{12.3}{\sqrt{V}} \text{Å}$$

From the geometry of Fig. 1 we have,

$$\sin\theta = \frac{R}{\sqrt{R^2+L^2}}$$

Upon simplifying and using the fixed value of $L = 13.5$ cm and $R$ is expressed in cm,

$$\sin\theta = \frac{1}{\left(1+\left(\frac{13.5}{R}\right)^2\right)^{0.5}}$$

Interplanar spacing can be calculated from equation (1) by substituting equations (2) and (4) into it.

SAFETY GUIDELINES AND PRECAUTIONS:-

1. Never accelerate beyond 5KV.
2. Never touch any controls on the power supply other than the 'on-off' switch and voltage varying knob.
3. Never use force to measure the ring diameters. Keep a plastic scale very gently over the tube to measure the diameters. Metal scales are not allowed.
4. You are working with a very high energy source (>5KV) and hence touching any part of the entire setup other than what is mentioned in point 3 (just for the purpose of measurement) is prohibited. This is for the purpose of your own safety and the safety of the Lab.

Procedure:-

1. Set the accelerating voltage at 4 KV.
2. For the inner ring, measure the diameter ($2R_1$).
3. Fill up the radius ($R_1$) in the tabular column.
4. For the outer ring, measure the diameter ($2R_2$).
5. Fill up the radius ($R_2$) in the tabular column.
6. Calculate $\lambda$, $\sin\theta$ and d from the equations (2), (4) and (1) respectively and fill up the corresponding cells in the tabular column.
7. Repeat steps 2 to 6 for accelerating voltages 4.5 and 5 KV.
8. Calculate the average 'd' for both inner and outer rings.

~~RESU~~

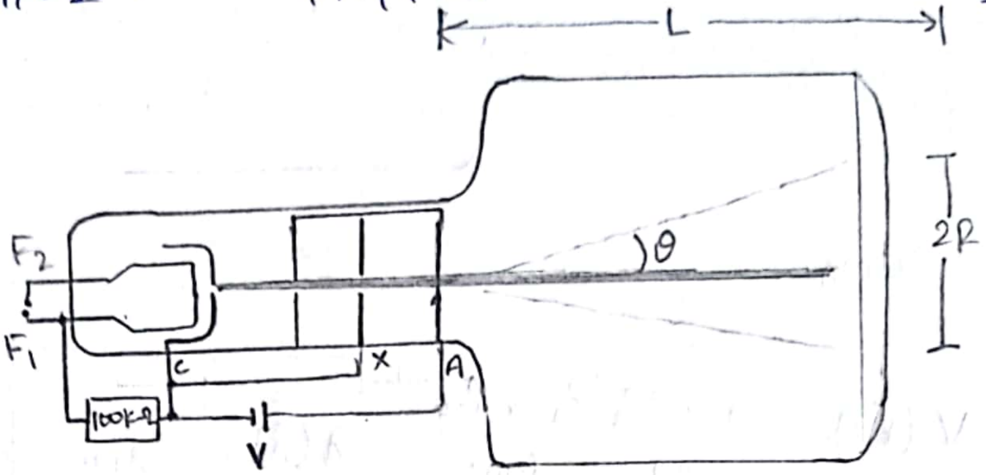
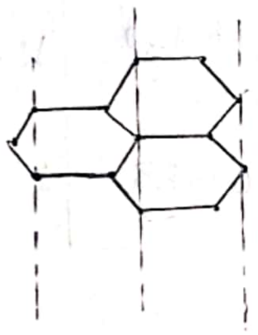



Fig:- Schematic diagram of experimental setup.



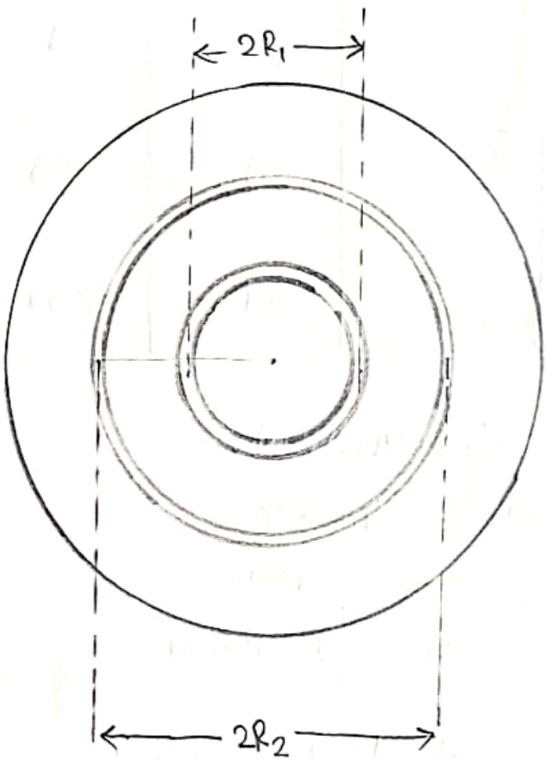



Fig:- Left ( Two independent types of lattice planes in polycrystalline.

Tabular Column:

| Ring | V (kV) | $2R_1$ or $2R_2$ (cm) | $R_1$ or $R_2$ (cm) | $\lambda$ (Å) | $\sin\theta$ | d (Å) |
|---|---|---|---|---|---|---|
| Inner | 4.0 | 2.4 | 1.2 | 0.1945 | 0.0885 | 2.198 |
| | 4.5 | 2.2 | 1.1 | 0.1834 | 0.0812 | 2.259 |
| | 5.0 | 2.0 | 1.0 | 0.1739 | 0.0739 | 2.353 |
| Outer | 4.0 | 4.2 | 2.1 | 0.1945 | 0.1537 | 1.265 |
| | 4.5 | 3.9 | 1.95 | 0.1834 | 0.1430 | 1.282 |
| | 5.0 | 3.7 | 1.85 | 0.1739 | 0.1358 | 1.280 |

SAMPLE CALCULATION:-

For Inner radii, V = 4.0 kV

$2R_1 = 2.4\,cm$

$R_1 = \frac{2.4}{2} = 1.2\,cm$

$\lambda = \frac{12.3}{\sqrt{V}}\,Å = \frac{12.3}{\sqrt{4000}}\,Å = 0.1945\,Å$

$\sin\theta = \frac{1}{\left(1+\left(\frac{13.5}{R}\right)^2\right)^{0.5}} = \frac{1}{\left(1+\left(\frac{13.5}{1.2}\right)^2\right)^{0.5}} = 0.0885$

$d = \frac{\lambda}{\sin\theta} = \frac{0.1945}{0.0885}\,Å = 2.198\,Å$

For outer ring,

Averaged d $= \frac{2.198+2.259+2.353}{3}$

$= 2.27\,Å$

For inner ring,

Averaged d $= \frac{1.265+1.282+1.280}{3}$

$= 1.276\,Å$

Similarly, inner diameter and outer ones were calculated and observed by mean that the interplanar spacing are $d_1 = 2.27\,Å$

$d_2 = 1.276\,Å$

Date:- 2021/04/01.

RESULT:-

The interplanar spacings in graphite were measured as $d_1 = 0.227$ nm and $d_2 = 0.1276$ nm.