


I.I.T. Bombay

# Study of Diamond Detector as Alternative for Luminosity Monitor detector


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**with**

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# Outline of talk

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- Quick Review of Simulation Studies
- Diamond as Detector
- Diamond Growth Technology
- Contact Making
- Characterization Setup
- I-V and C-V Characteristics
- Conclusion & Summary
- Future Steps

# Diamond

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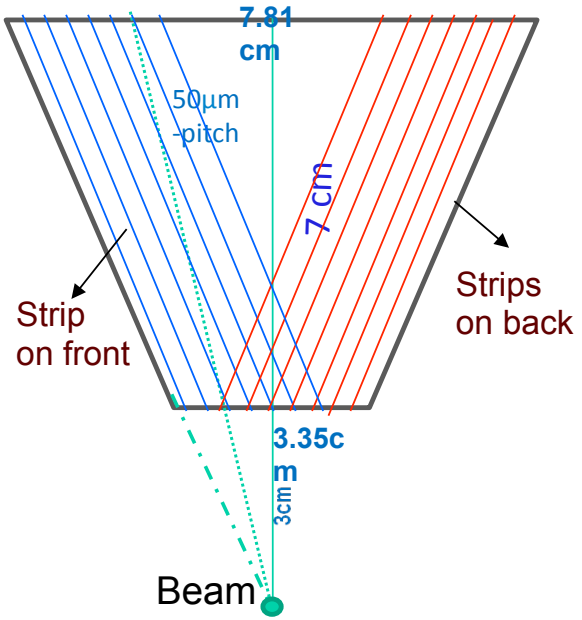
- With Band gap **Eg = 5.5 eV** is an insulator
- Average energy needed to create an $e^-/h$ pair is 13.6 eV. (for Silicon, **3.61 eV** )
- This implies negligible intrinsic carrier densities even at room temperature but less electron hole pairs

## Strip Sensor Specifications:

- Double-sided strip sensor
- Dimension : Trapezoid
  (3.35 cm X 7.81 cm) X 7 cm
- Thickness : 150 µm
- Pitch: 50 µm
- Strip Orientation: parallel to sidewalls of Trapezoid



# Setup used for simulation

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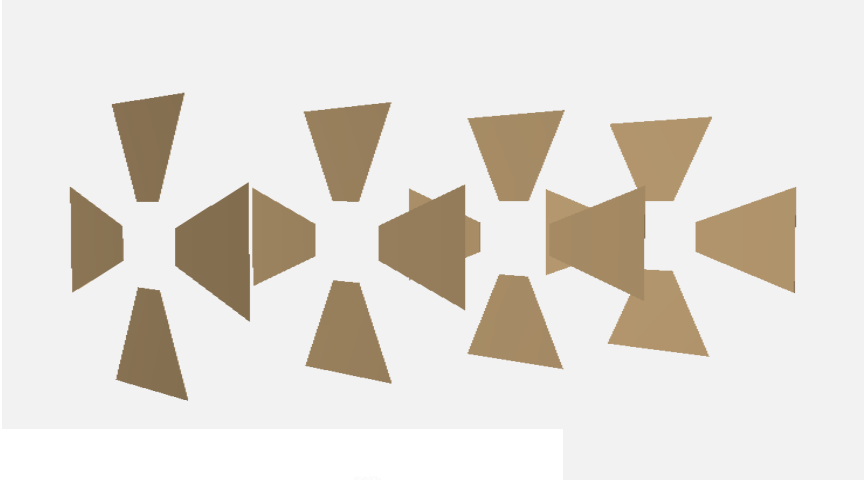
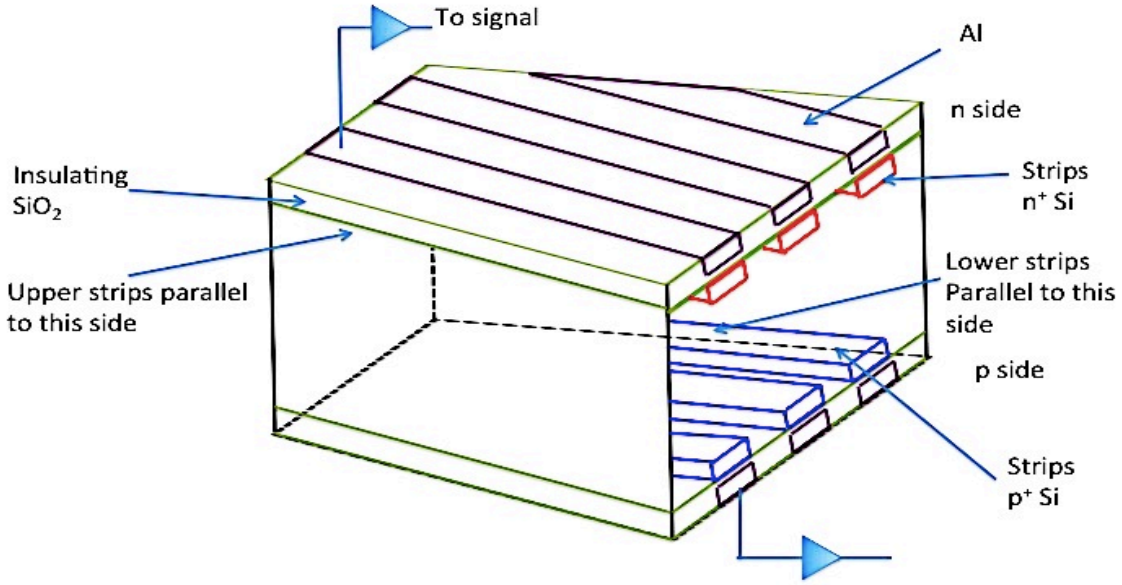
## Tentative Geometry:





# Full Simulation Chain Results

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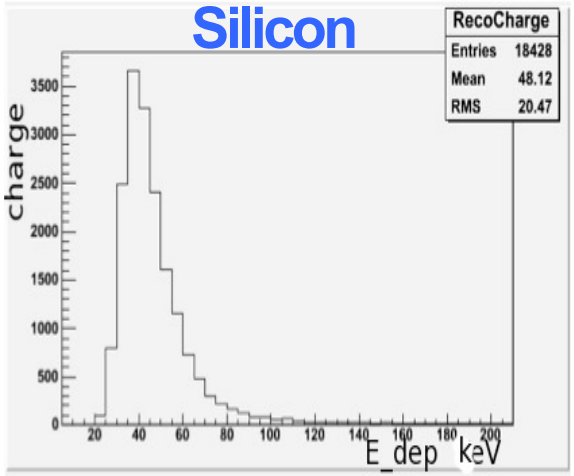
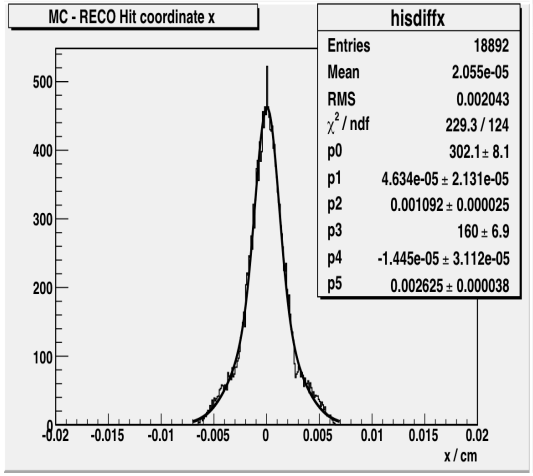
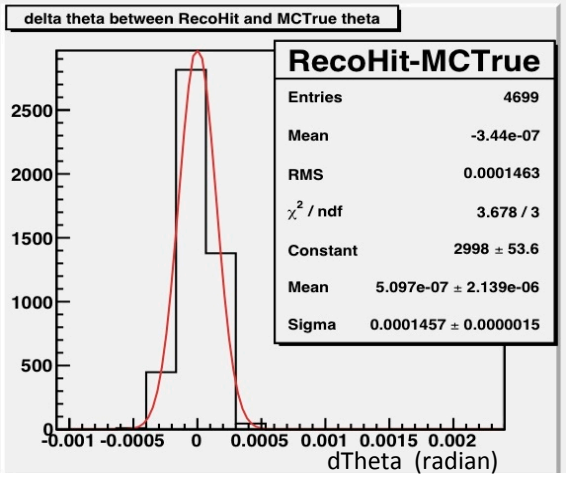
## Silicon




Charge

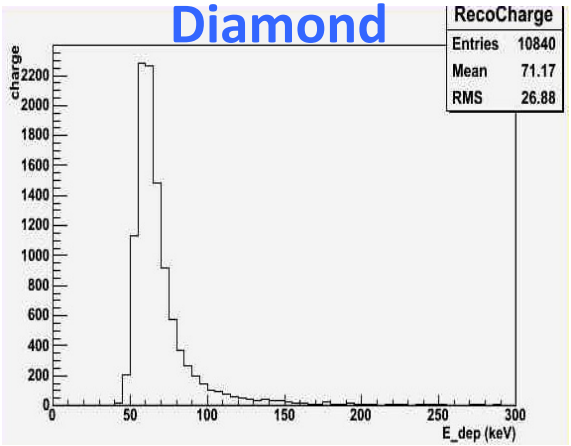


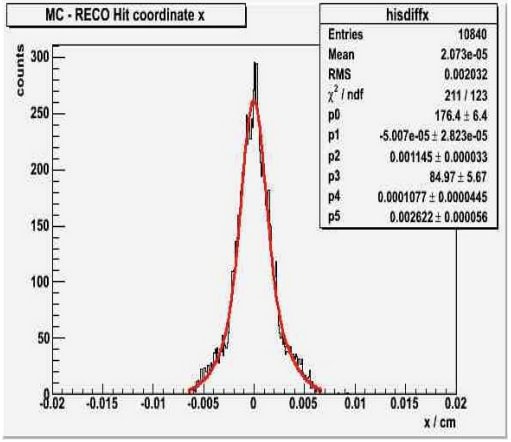

position resolution

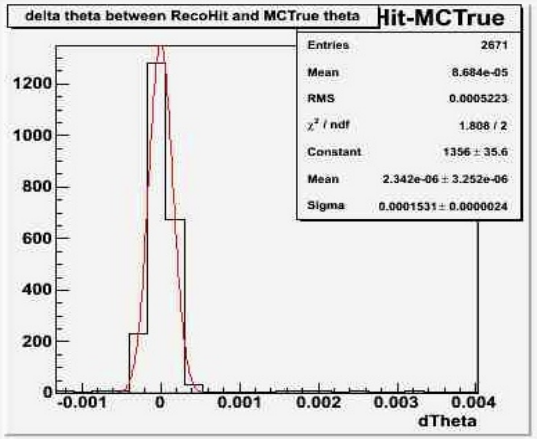



momentum resolution

## Diamond




antiproton@8.9 GeV/c

# Full Simulation Chain Results

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antiproton@8.9 GeV/c

| Material\Results | Energy Deposited | Position Reconstruction Error | deltaTheta/Theta |
|---|---|---|---|
| Silicon | 48.12 keV | 10.92 micron | 0.145 mrad |
| Diamond | 74.56 keV | 11.04 micron | 0.15 mrad |

**Implies Diamond can be used as LMD with same performance as Silicon plus advantage of Radiation Hardness**

# Diamond Detector

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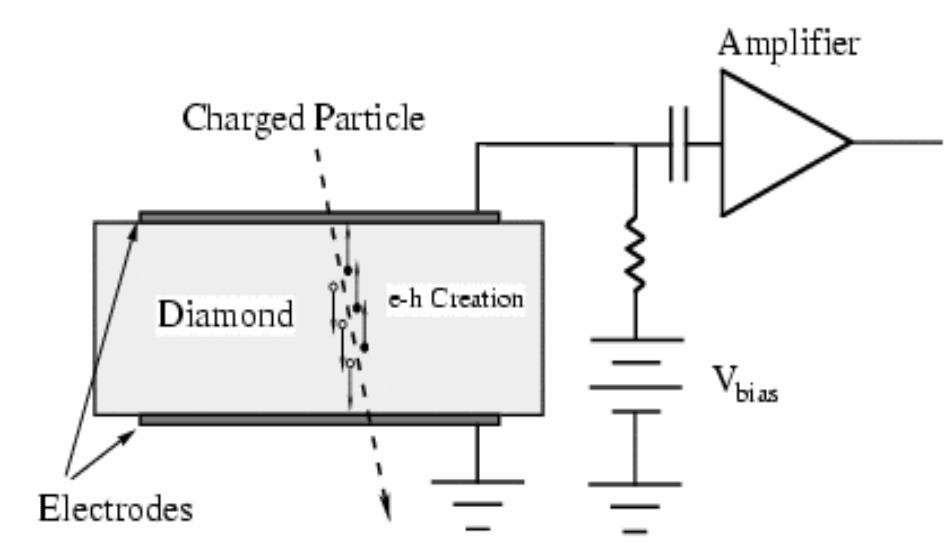
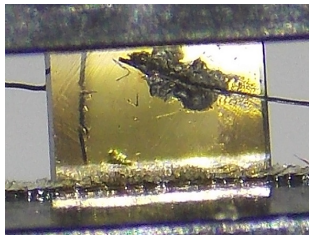
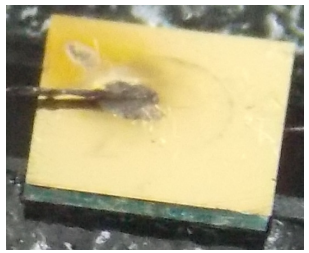
- SC-CVD diamond film: 300 µm thickness (3.5 mm × 3.5 mm)
- Contact: Cr (30 nm) / Au (200 nm)
- One Side fully coated & other side, no coating at edges
- Capacitance of device 2.2 pF
- Copper wire bonded with silver epoxy
- Sensor is mounted on IC mounter

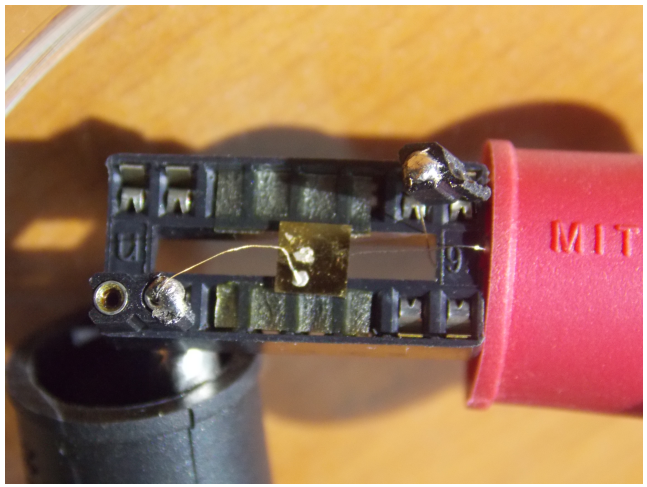



Down side



Up side





# Diamond Growth in our Lab @ IIT Bombay

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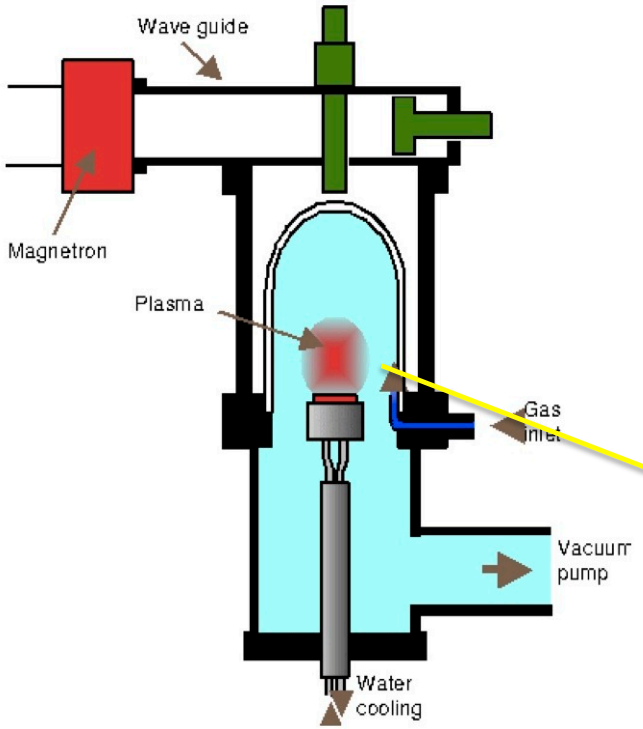
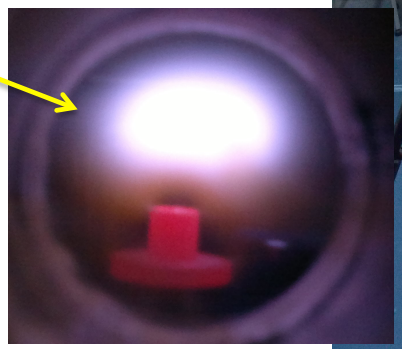
- MP-CVD Process
- Single crystal diamond & polycrystalline diamond
- Methane (1%)+ Hydrogen (99%)
- At pressure, 70-80 mbar



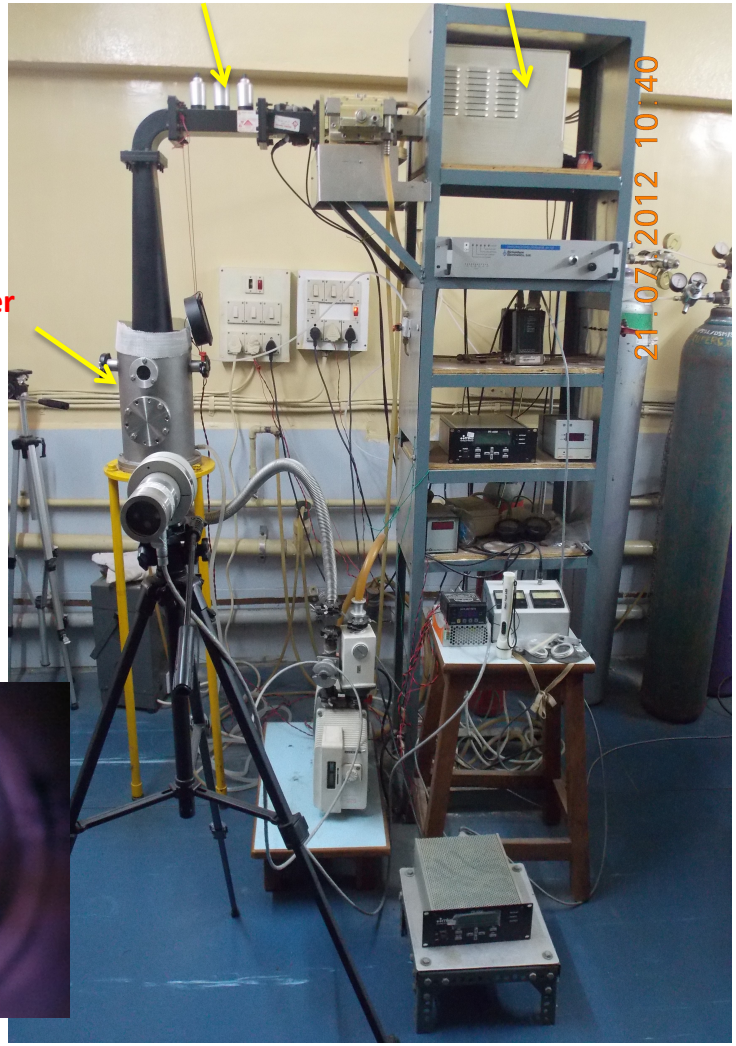

Plasma



Rectangular waveguide

Microwave Generator

Vacuum chamber



# Contact Making

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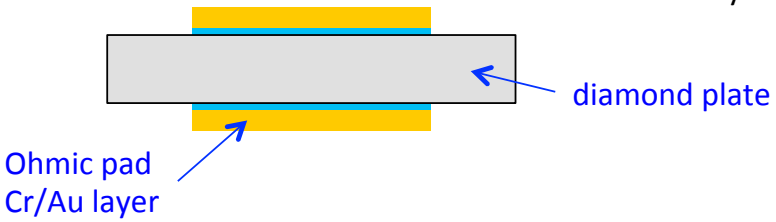
## Ohmic Contact Pads

- Oxygen terminated surface
- Pad size 3 mm in diameter
- Layers Au 200nm /Cr 30nm




**Oxygen Plasma treatment for cleaning**

**Oxygen Plasma chamber**

**Deposits Cr and Gold on sample using evaporation technique**

**Gold-Chrome evaporator**

# Characterizations

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- characterization setup
- To measure voltage, Keithley 2410 Source meter is used.
- To measure Capacitance, Keithley 4200 SMU setup used.

Studied I-V characteristics
from -1000 V to +1000 V and current range found is in pA

Studied C-V characteristics from
0 V to 30 V (due to limitations of measuring setup)

**Vega: I-V Characterization setup**

# I-V Characteristics

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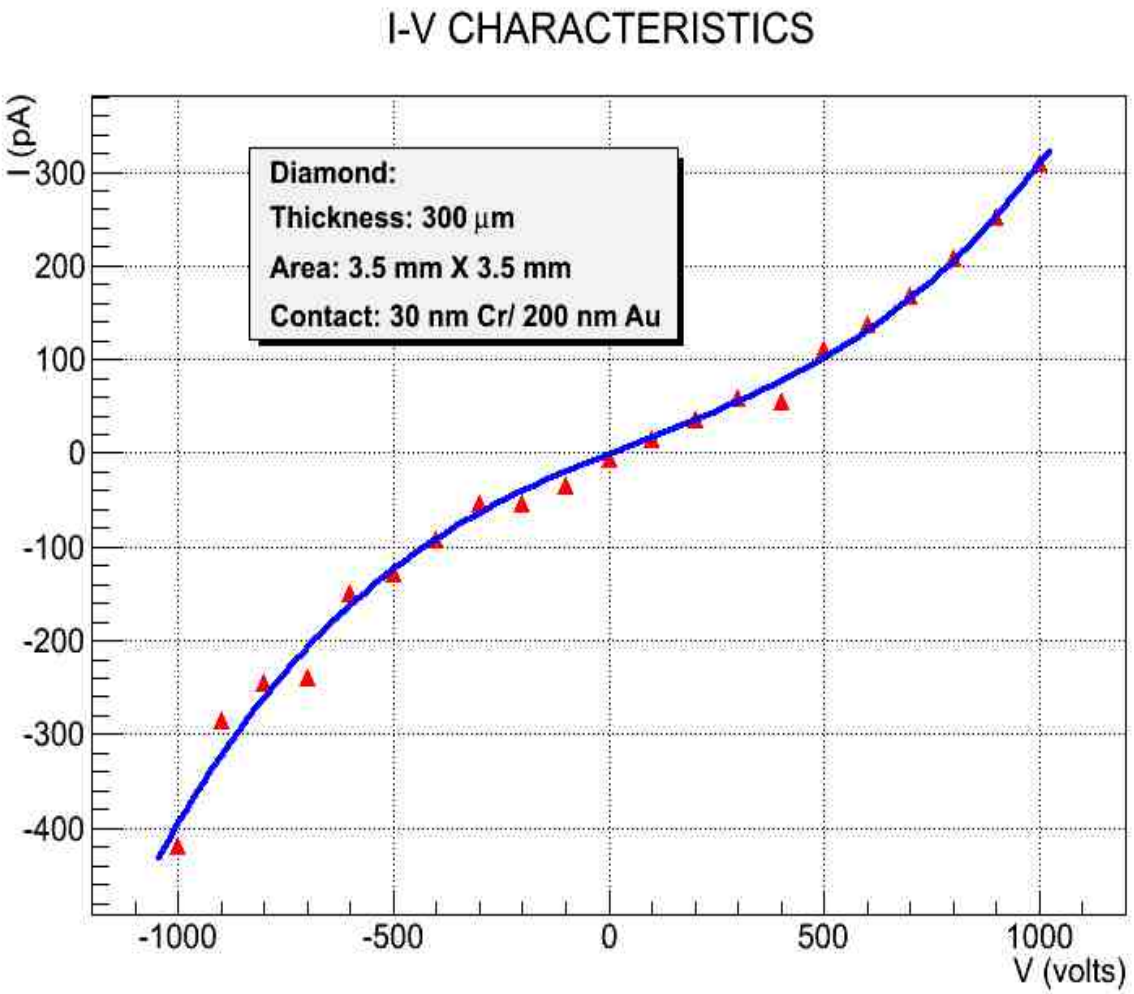


This shows that the device is resistive and capable of giving signal from radiation source

# C-V Characteristics

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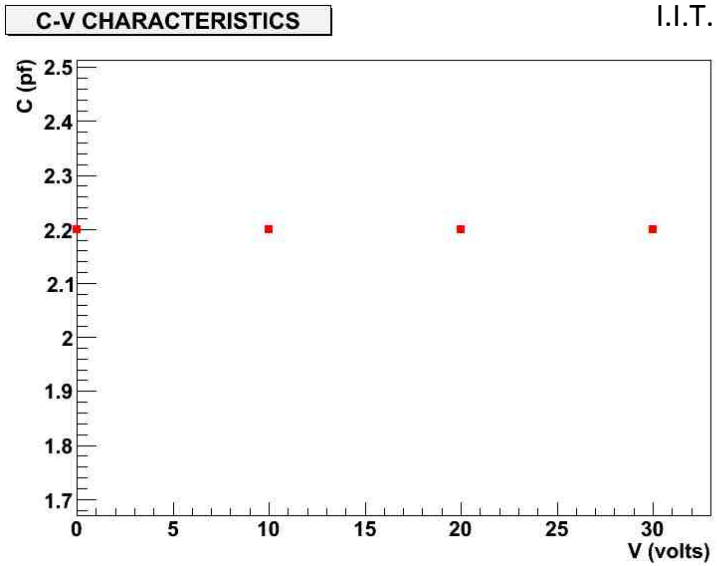


- CV characteristic is studied for 0-30 V
- To produce reasonable output CV measurement this much of voltage range is not sufficient And for range of 0 to 30 V capacitance is constant (~2.2 pf).

$$t_e = \frac{d^2}{2\mu_e V_{dep}} \ln\left[\frac{V + V_{dep}}{V - V_{dep}}\left(1 - \frac{x_0}{d}\frac{2V_{dep}}{V + V_{dep}}\right)\right]$$

- Considering 70-80 volts of operating voltage using above formula we get detector timing of peco Sec.
- Ordered higher range LCR measurement unit.

# Conclusion & summary

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- Developed Diamond growth set up
- Made contact Cr/Au
- Studied IV and CV characterization
- IV curve is in agreement with theoretical understanding
- CV  needs to be measured for higher voltage range
- We are proceeded to make detector from Diamond
- I-V & C-V characterization setup is built
- For operating voltage of 70-80 Volts, timing of detector is of the order of few pico-Sec

## Further Steps

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- ✓ CV characterization for higher voltage range
- ✓ Put source and study collection charge, charge collection distance, CCE measurement
- ✓ Readout electronics
- ✓ Make strip detector with Silicon
- ✓ Try to make larger size diamond films
- ✓ Make single sided diamond strip detector