Diamond Detector Prototyping

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Outline: Recipe “how to make a diamond detector”

1. Buy

2. Clean with various acids/bases

3. Metallize

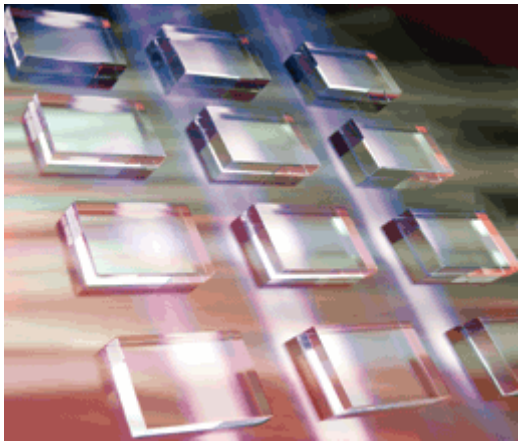
4. Mount in a nice package and wirebond

5. Tests – checks to see if you did a good job

6. Summary

1. Get a “CERN quality diamond from

elementsix™
ADVANCING DIAMOND



Chemical Vapour Deposition (CVD) - method of diamond synthesis that can be compared to frost forming on a window – only the process uses carbon rather than water. A mixture of gases is heated to very high temperatures to produce carbon atoms in the form of a plasma. Out of the gases the diamond crystals can grow on complex, 3D shapes – such as tweeter domes

We bought 10.0 x 10.0 x 0.5 mm CVD diamond

2. Boil in various acids/bases (cleaning)

- Main purpose: to remove all organic and inorganic impurities from the diamond surface and replace H on the surface with O.
- The most time consuming process
- Recipe contains boiling in acids/bases for a few minutes @ ~110°C in:
  - RCA1 ($NH_4OH/H_2O_2/H_2O$) ratio 1/1/5
  - RCA2 ($HCl/H_2O_2/H_2O$) ratio 1/1/5
  - $HCl/NHO_3/H_2O$ ratio 1/1/1
  - H_2SO_4/H_2O_2 ratio 1/1
  - every time rinse with DI

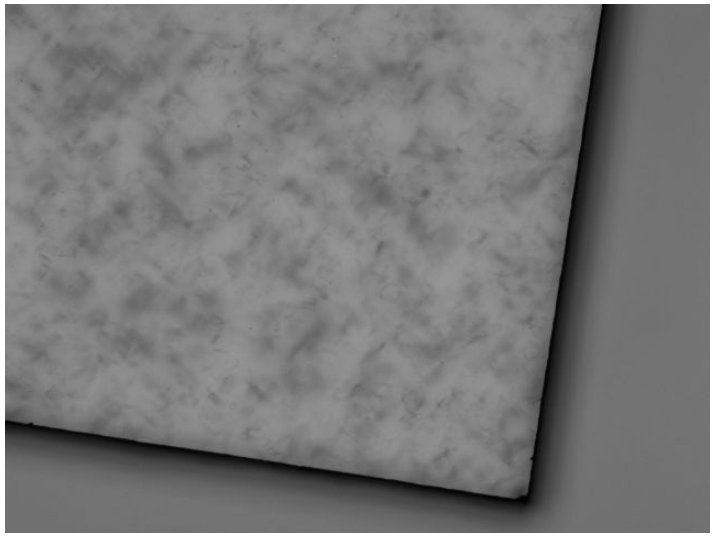
At The University of Manitoba

Nano-Systems Fabrication laboratory

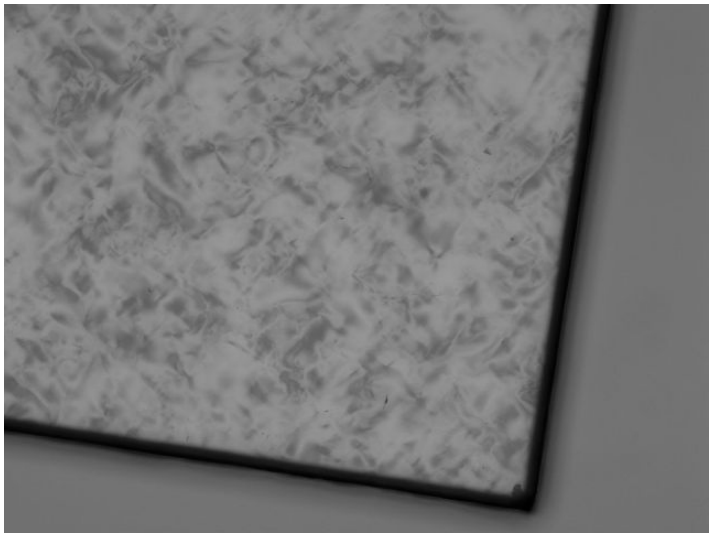
Be careful – things to keep in mind

- Avoid touching diamond with tweezers, To handle sample sapphire or quartz plate should be use, on which diamond is mounted via xtal bond or photoresist.
- To rinse, 2 beakers are used
- No metal tweezers; ceramic or teflon

DIAMOND: Front surface;

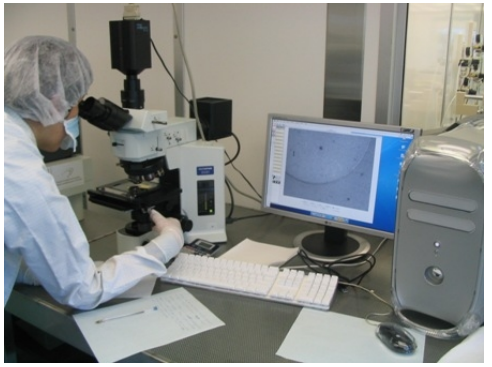


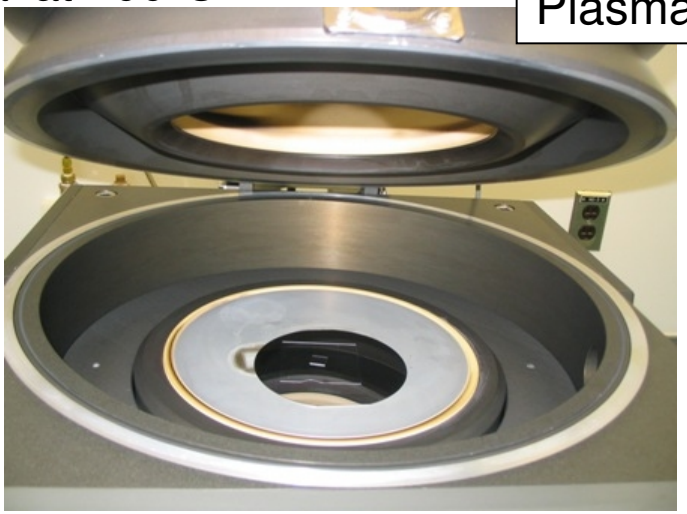
Back surface



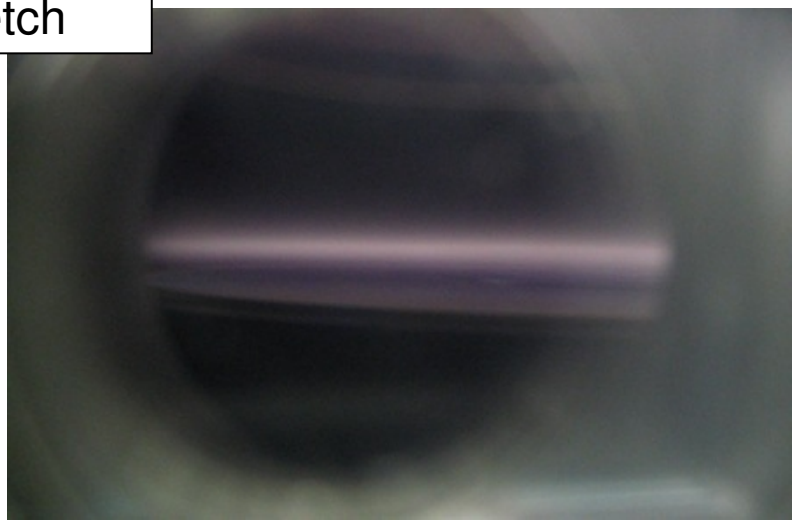
3. Sputter/evaporate on some metal

- Purpose: placing the electrodes on each side of diamond
- Two methods:
  - Shadow mask (out of G10 or Al)
  - Photolitography – layer of photoresist
- O_2 Plasma etch
- Cr(500A)/Au(2000A), or Ti/Au or Ti/Pt/Au, etc (other recipes)
- Anneal at 400°C





Plasma etch



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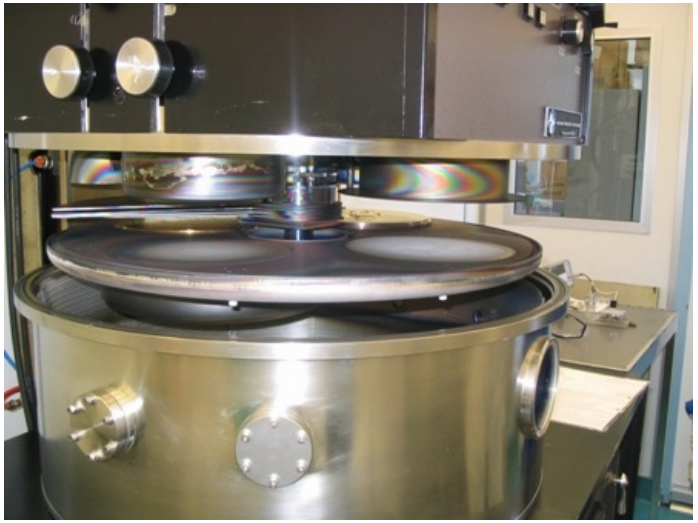
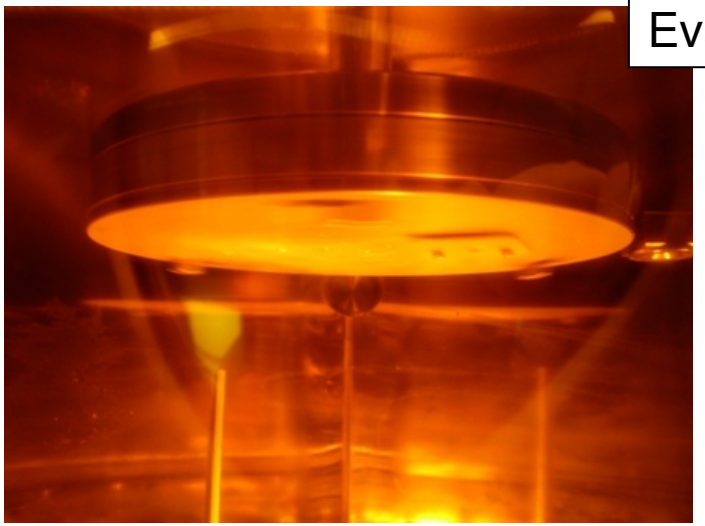
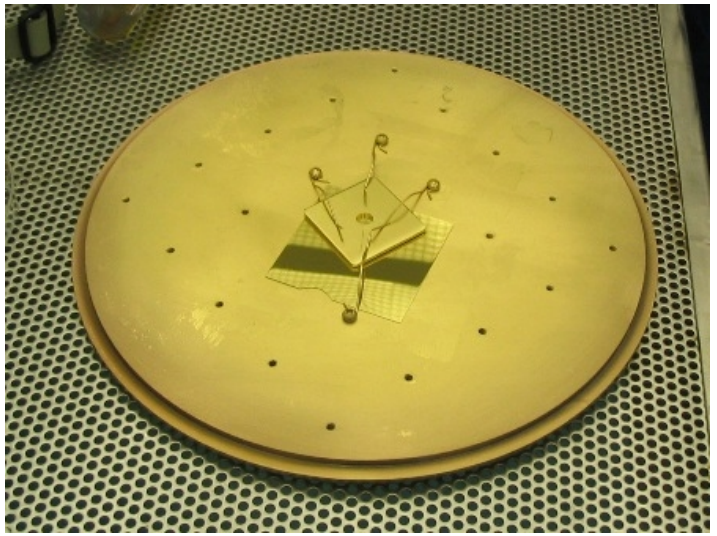
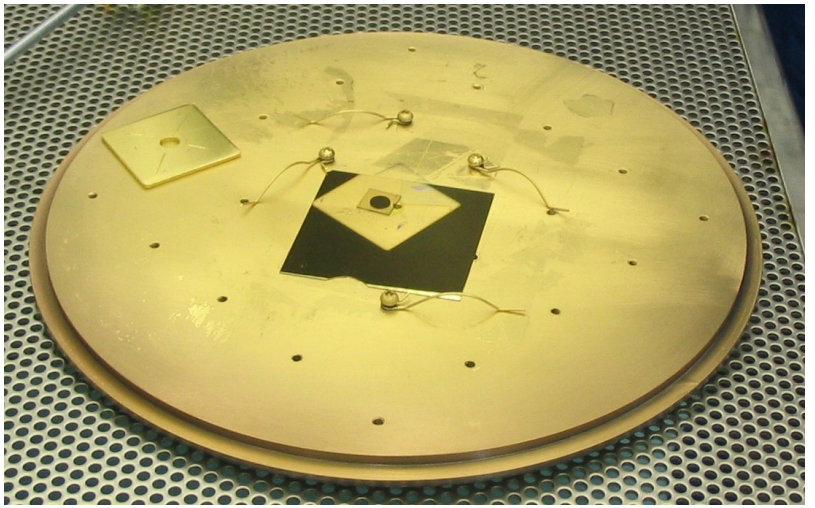




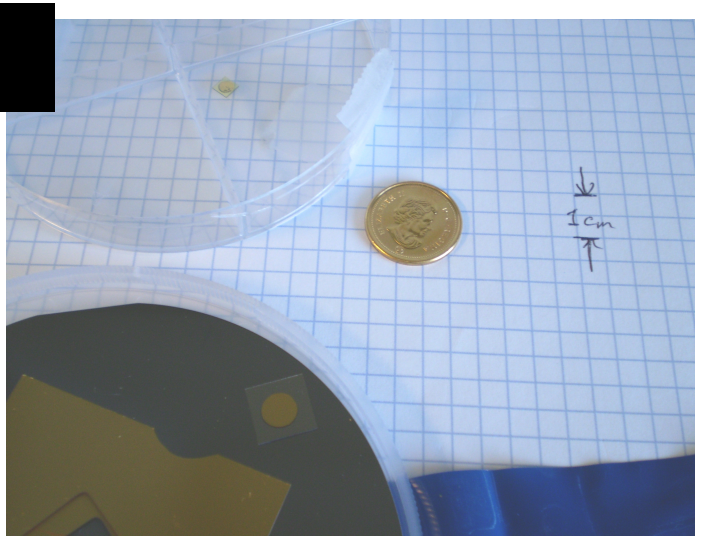
Evaporation





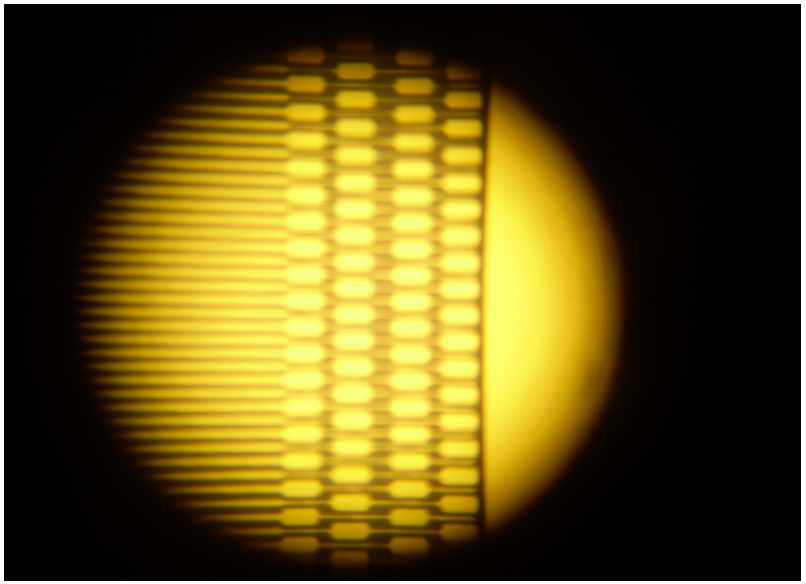
Metallization Results

Via shadow mask

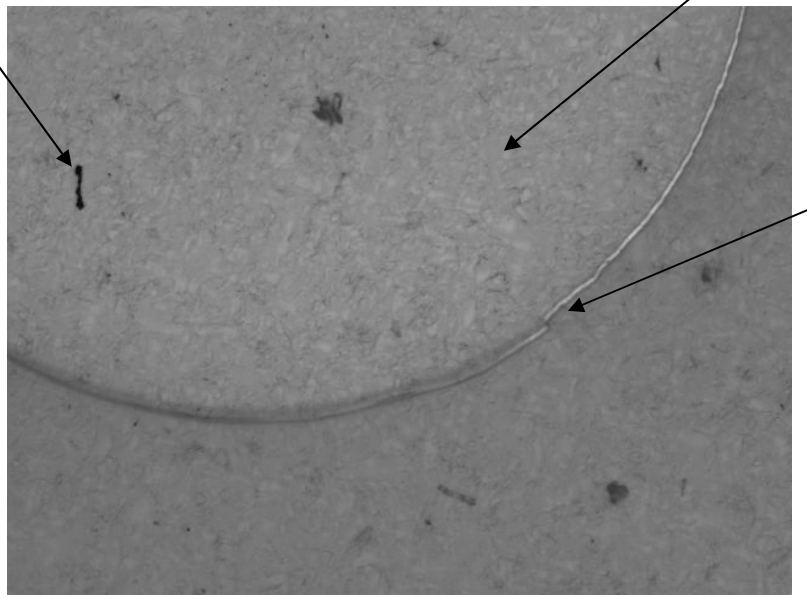


Chromium

Via photolitography

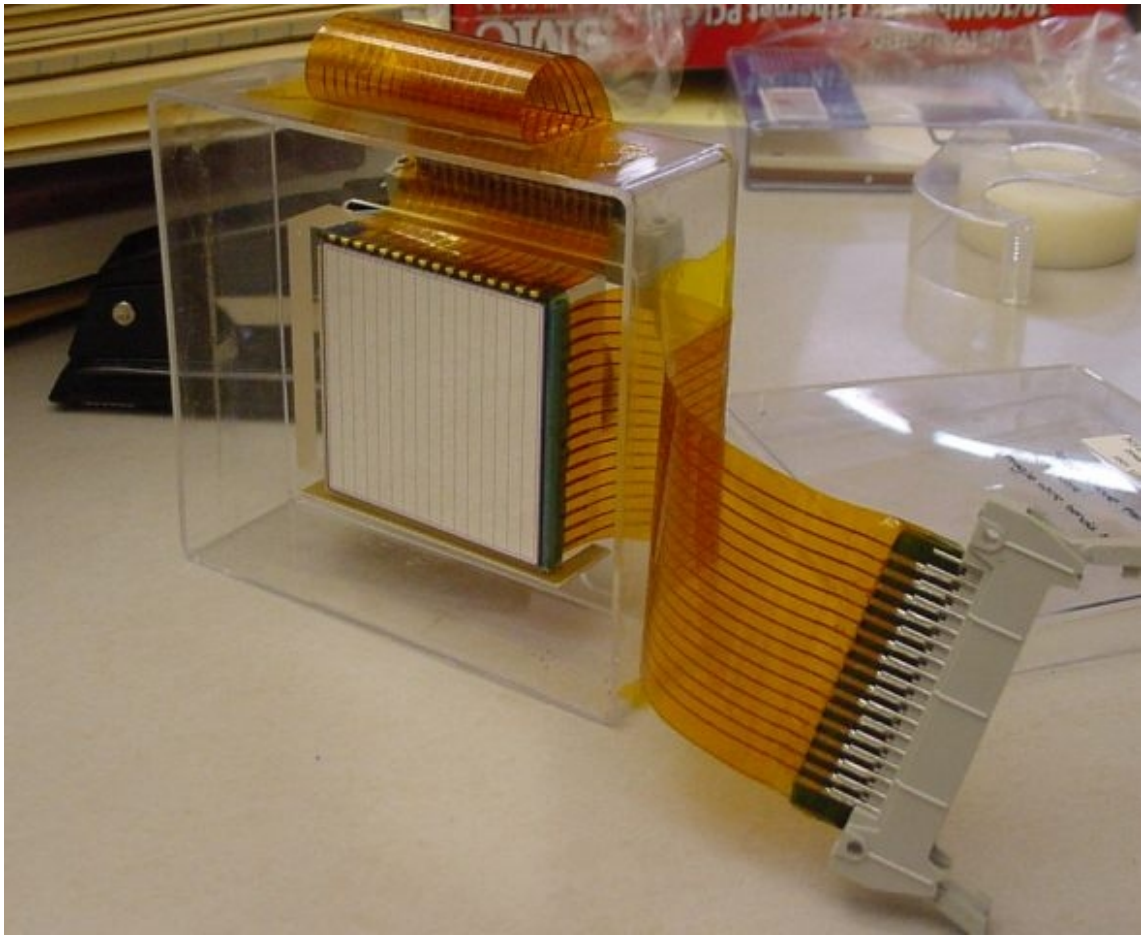


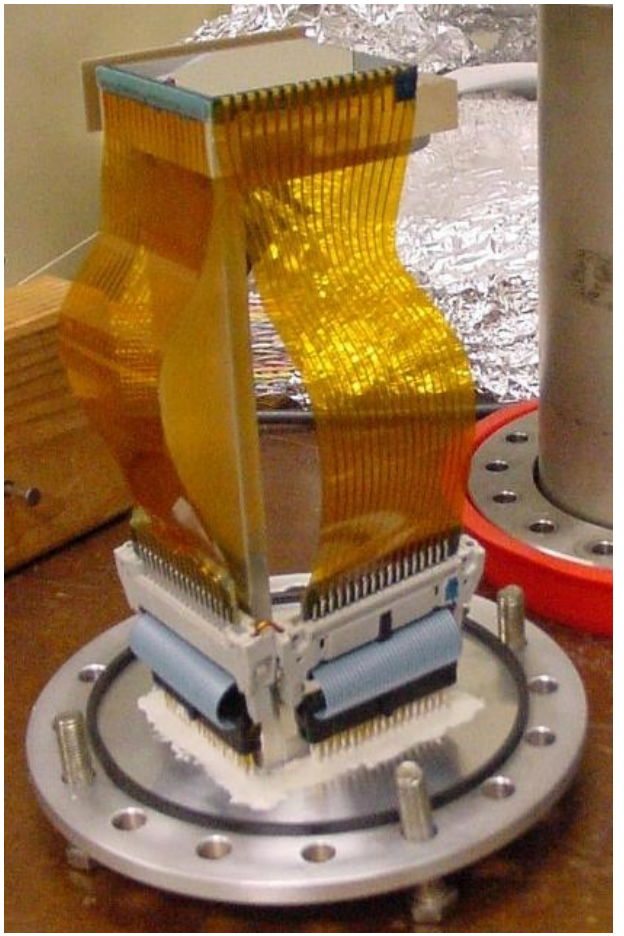
dust



Gold

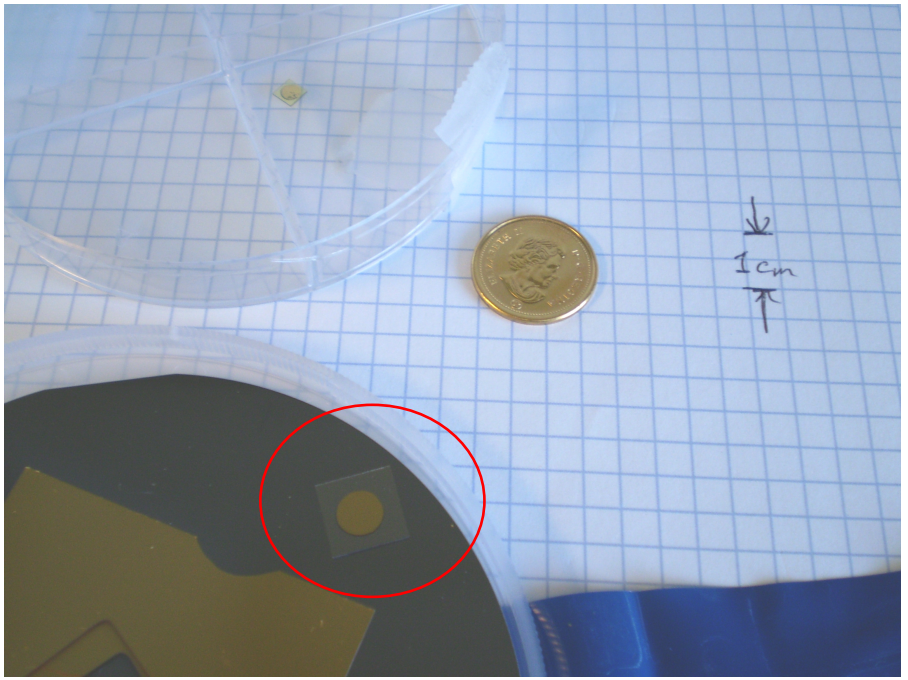
4. Mount in a nice package and wirebond





5. Check if we did good job

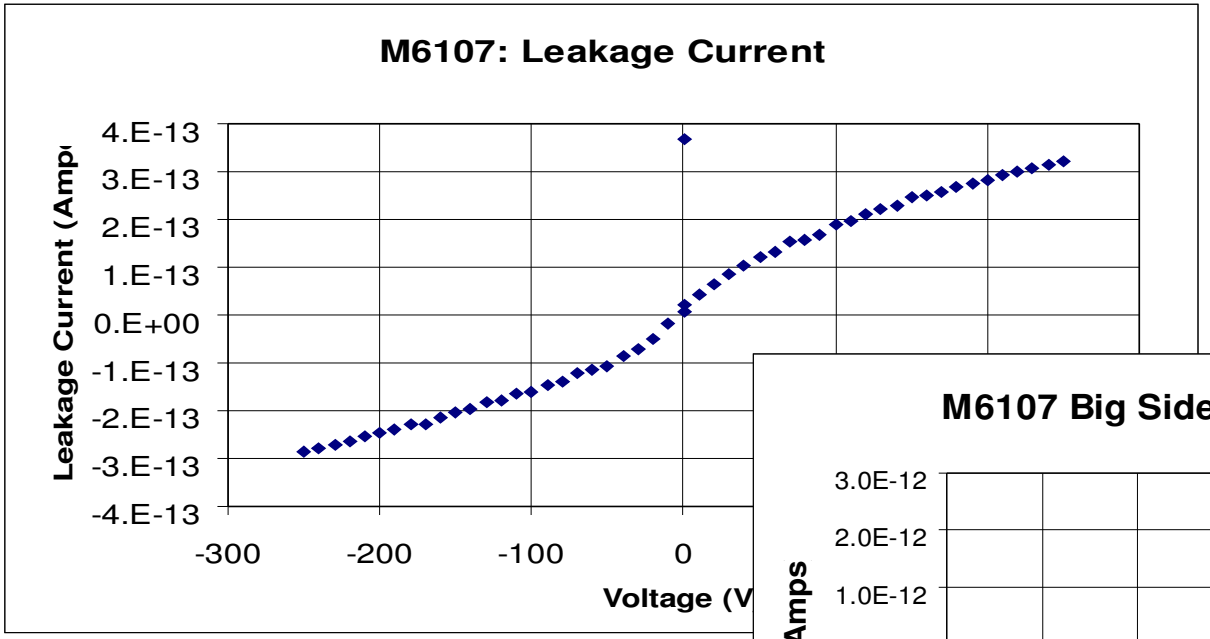
- Tape test - the most brutal, but gives the fastest answer
- I-V curve - 1 day measurement,
- Charge Collection Depth (CCD) measurement – 1 day measurement



I-V curve

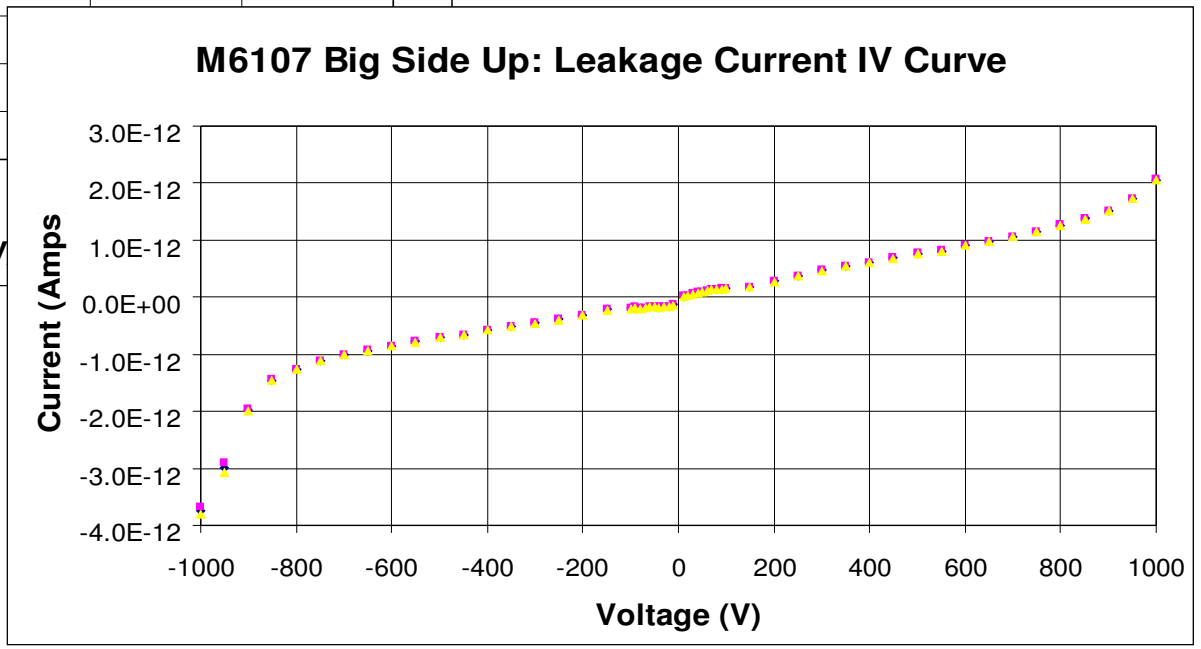
Our sample crystal 250µm thick, 5 x 5 mm,

Not good, contains N:



Dipangkar's diamond:

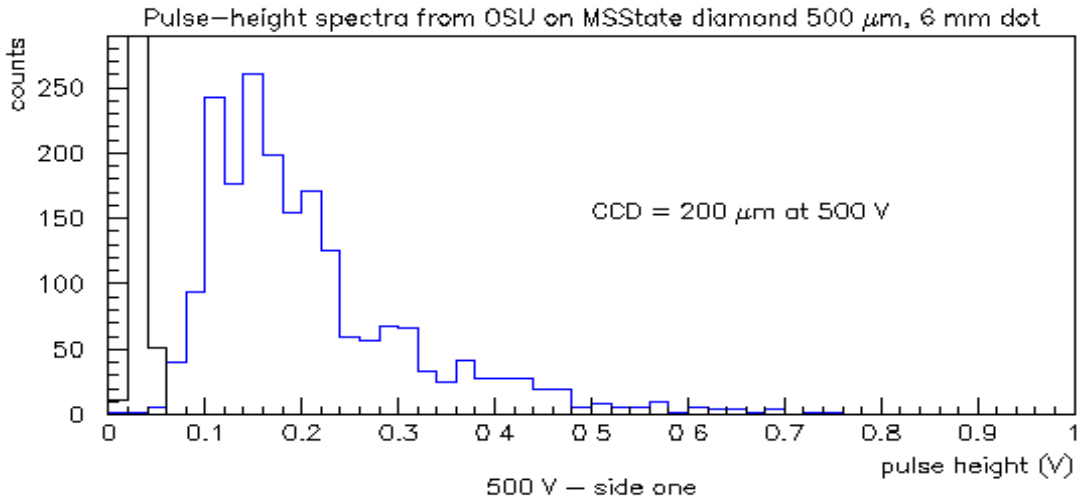
530 µm thick, 10 x 10 mm

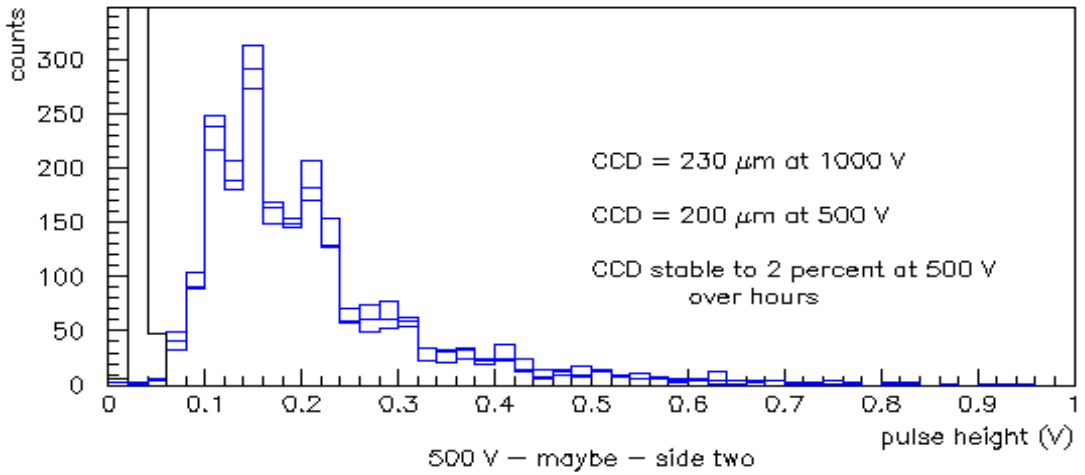


Charge Collection Depth (CCD) results from Dipankars's prototype diamond

Sample

thickness: 530µm





Summary

- Coated first test diamond at NSFL (University of Manitoba EE)
- Visited Ohio State University (Harris Kagan group)
  - learned diamond preparation/metallization in context of a second diamond (D. Dutta's)
  - learned multi-strip detector fabrication
  - learned test procedures
    - CCD measurement
    - I-V curve
- Coated third diamond (hopefully did it right) at NSFL