Preliminary studies on 3D Diamond

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Research Interest

• 3D diamond detectors
  – Grain boundaries
  – Refined Modeling
  – Bulk electrodes
• Radiation Damage
• Spatially resolved measurements of charge transport
  – test beams
Why 3D?

- Silicon results show radiation hardness increases for 3D geometry.
Diamonds at Diamond

- Beamtime 2010
  - Alexander Oh (PI), Cinzia Da Via, Mahfuza Ahmed, Thorsten Wengler, Steven Watts
- Use 15 keV photons to create charge in a diamond detector.
- Two field configurations
- Device is $1 \times 1 \times 3$ mm$^3$
Samples & Data

• Samples provided by DDL
• “dot” electrodes
• Samples investigated
  – pCVD 1mm x 1mm x 3mm, Top Bottom Electrodes
  – pCVD 1mm x 1mm x 3mm, Left Right Electrodes
  – sCVD 1mm x 1mm x 2mm
• Data taken:
  – line scans at different voltages, both polarities
  – full scan, fixed field, both polarities
  – the above for beam parallel and orthogonal to electric field
• pCVD unfortunately excessive leakage current.
Diamonds at Diamond

• Beam-line at the Diamond Synchrotron Light Facility
Beam Line

- Energy: 15 keV
- Absorption length ~3.5mm (total), ~18mm (photoelectric absorption)
- Beam focus: compound refractive lense
- Beam size: 4mum FWHM
- Flux: ~ $10^9$ photons/s
- Very good Beam Line Support!
  - Technician
  - Beamline physicist
  - Fully working DAQ setup (plug & play)
Diamonds at Diamond

- Single Crystal Diamond sample glued to the test PCB
Diamonds at Diamond

- Simple set-up
- Experimental table can move in theta, phi, x, y, z.
- Automatic scans via DAQ system.
Diamonds at Diamond

- Poly-crystalline diamond samples
Results

• Surface scan with 10mum step size.
• Charge collected laterally across grain boundaries.
• Collected lots of data to analyse!
• First preliminary findings:
Results

- Area scans for pCVD-LR, E parallel
- Field E=1kV/cm
- Negative and positive field
Results

- Area scans for pCVD-LR, E orthogonal
- Field E=1kV/cm
- Negative and positive field

[Images of positive and negative field scans]
Results

• Area scans for pCVD-TB, E parallel
• Field E=0.5kV/cm
• Negative field
Results

- Area scans for pCVD-TB, E orthogonal
- Field $E=0.5\text{kV/cm}$
- Negative and positive field
Results

• Response along a line for different voltages for sample B.

• Comparison of sample A and sample B.
  – 40% - 70% less signal for sample B.

• Grain boundaries seem to have a detrimental effect on charge collection.
Results

- Multiple line scans to measure the pumping behavior spatially resolved.
- Is the priming uniform?
- Extract priming parameters as a function of position.

\[ f(n) = a + b \cdot (1 - e^{-\frac{n}{c}}) \]
Results

• Large variations observed with position.
• No clear correlation of priming parameters and signal response

\[ f(n) = a + b \cdot (1 - e^{-\frac{n}{c}}) \]
Outlook

• Analysis ongoing.
• Successfully applied for beam time in 2011
• Further investigations:
  – Angular scans
  – working sCVD
  – varying width samples
  – Graphite electrodes