Bulk SiC as a detector material

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Material systems investigated

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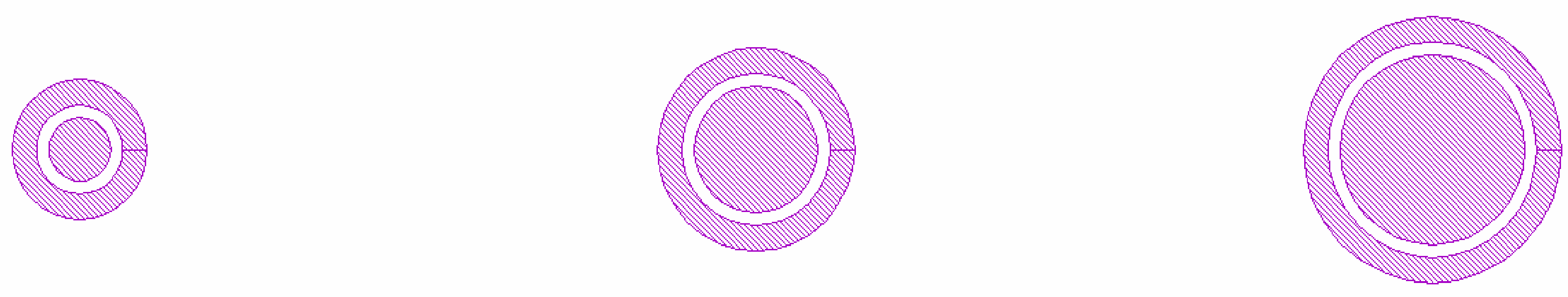
- Cree vanadium (V) doped 4-H SiC
  - V concentration $\sim 10^{18}$ cm^{-3}
- Okmetic semi-insulating 4-H SiC undoped
  - semi-insulating material due to growth process
- Epi-layers of lightly doped 4-H SiC from IKZ

Design of test samples



Close up showing pads and guard rings

I-V Cree material

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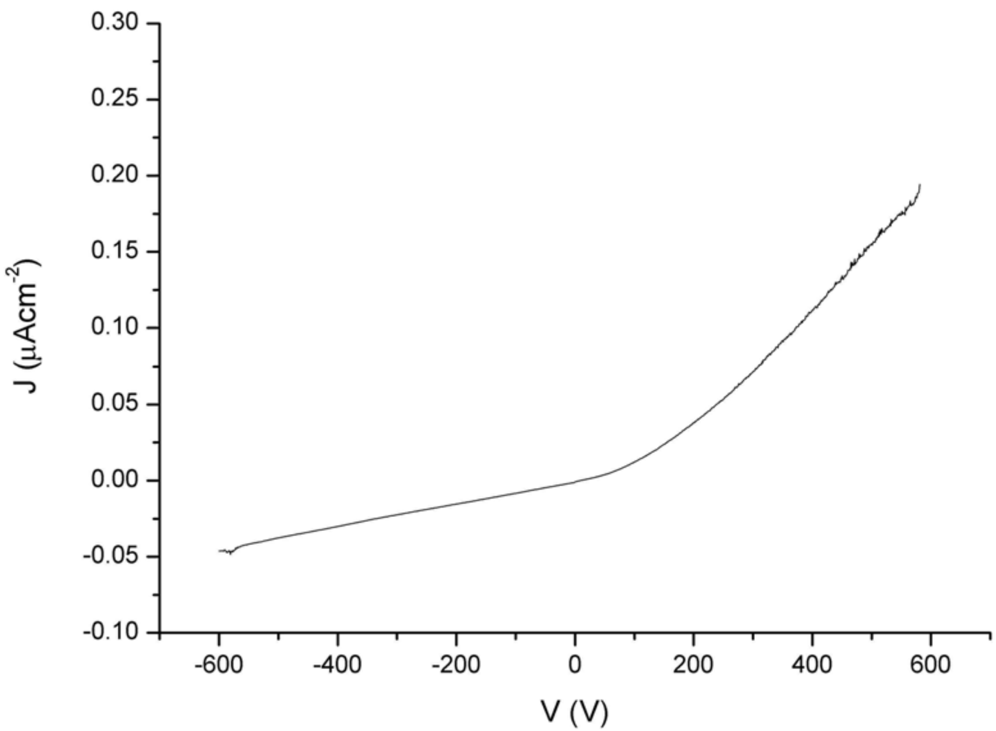
Front contact :100 nm Ti
back contact : 100 nm Ni



Spectra from test diodes

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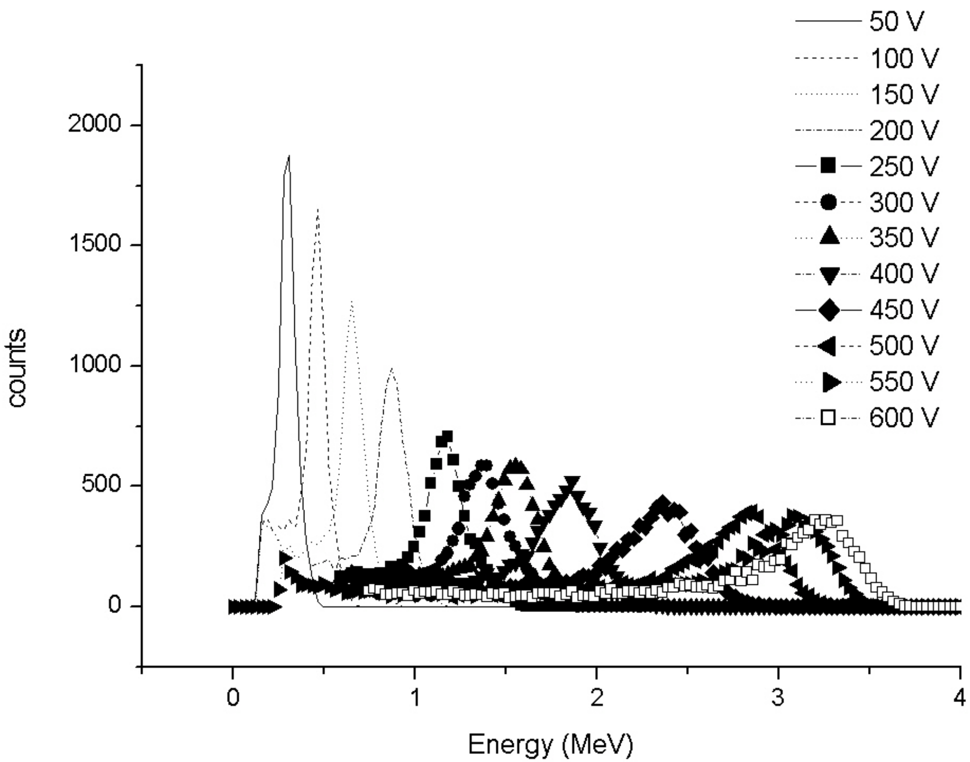
Spectra taken for 5.48 MeV Am^{241} α's in vacuum



CCE vs Voltage unirradiated

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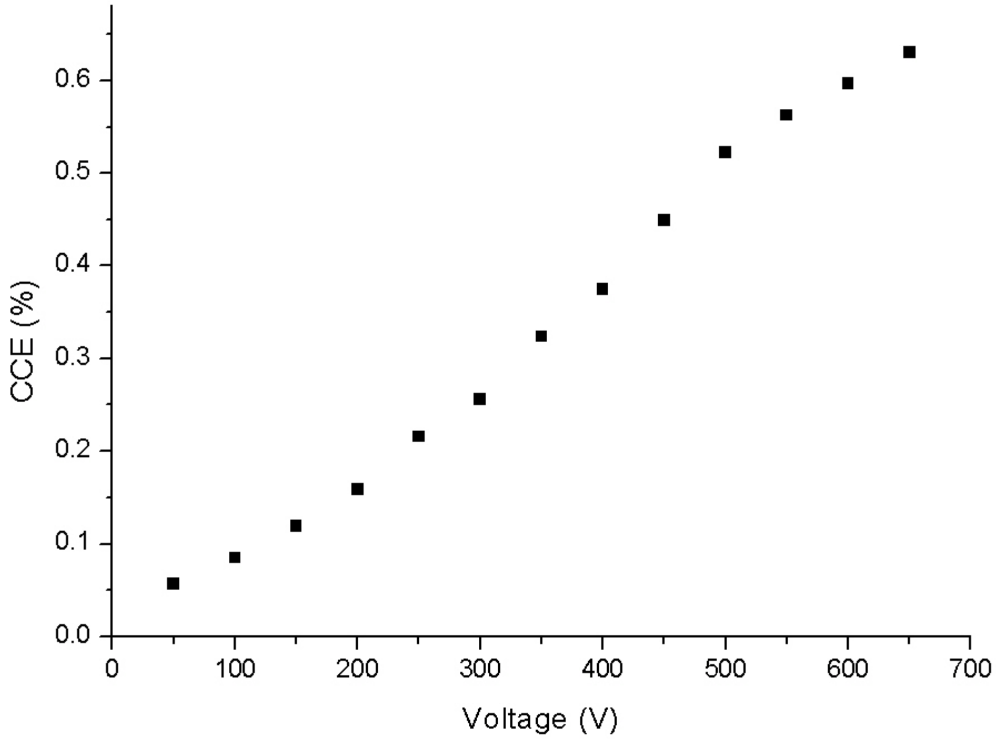
The evolution of the CCE with increasing detector bias



Limitations of V doped material

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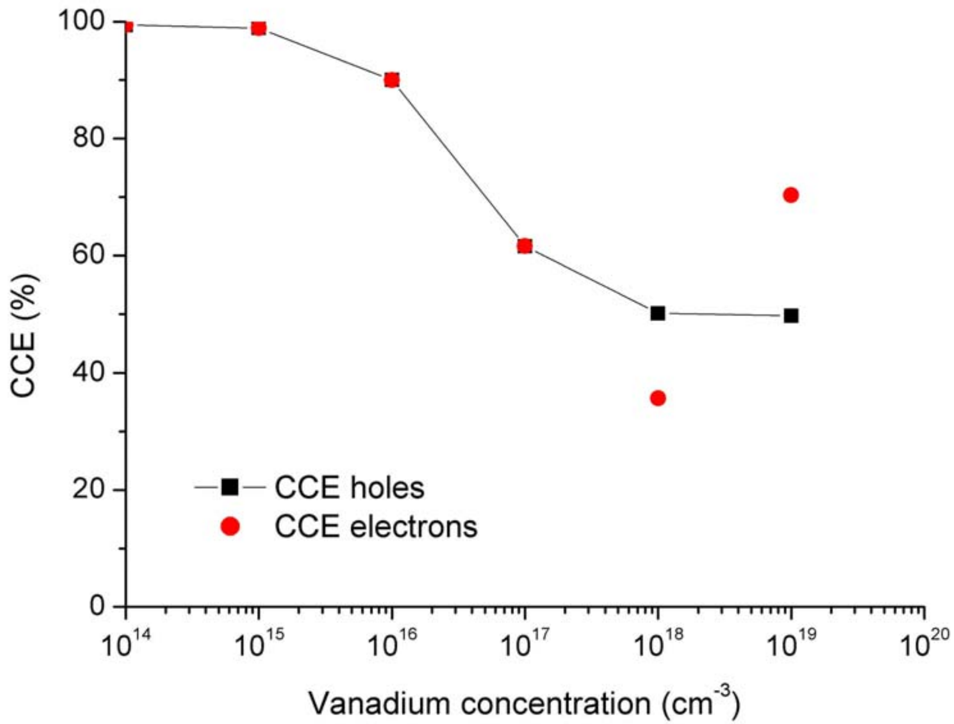
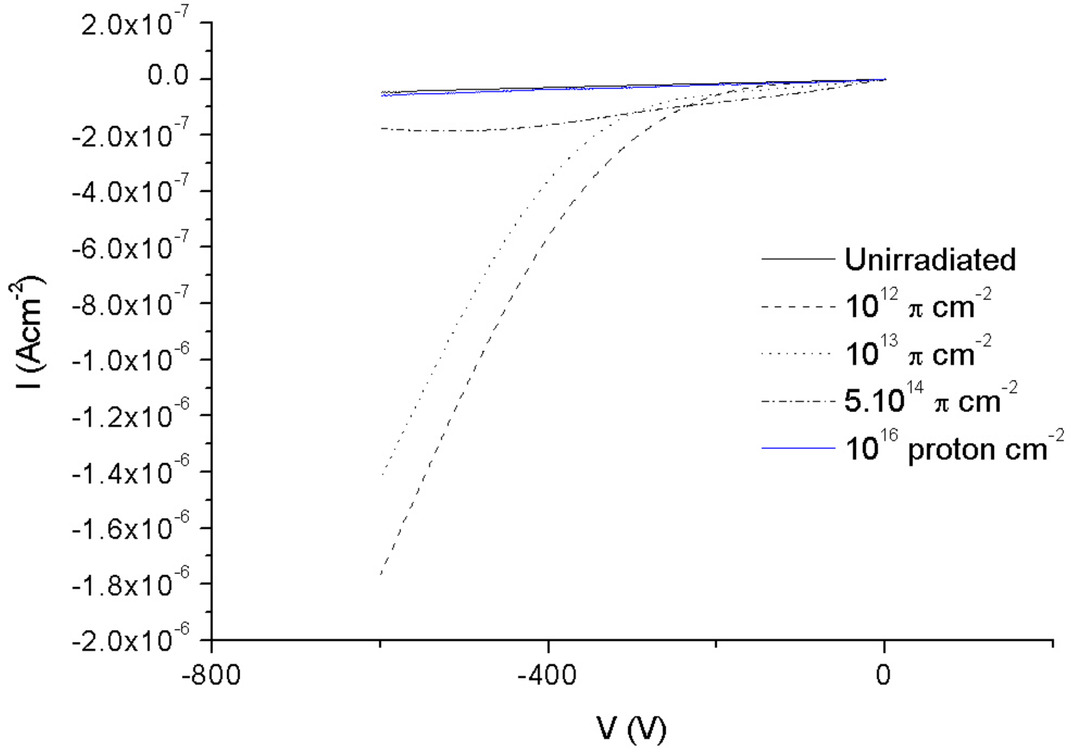
Simulations of CCE with only V dopant as a possible trap



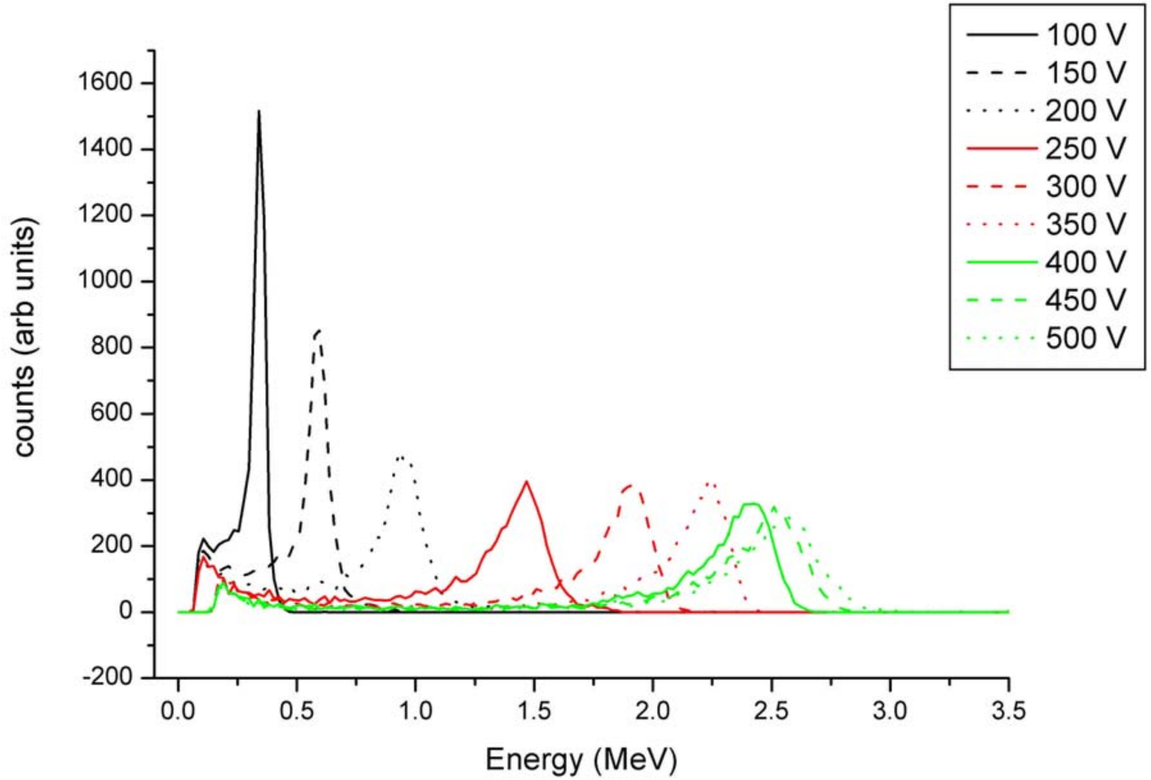
I-V irradiated Cree material

Comparisons of
J-V measurements for
irradiated Cree
V doped SiC



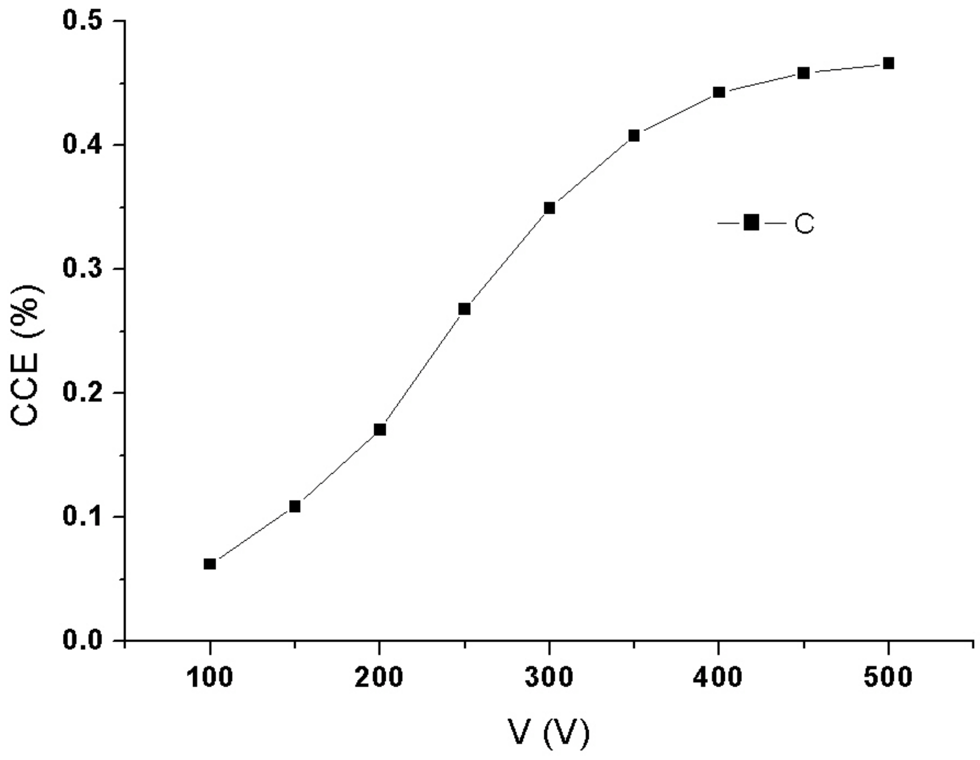
Spectra from irradiated diodes

Spectra taken for 5.48 MeV Am^{241} α's in vacuum after irradiation 10^{12} πcm^{-2}



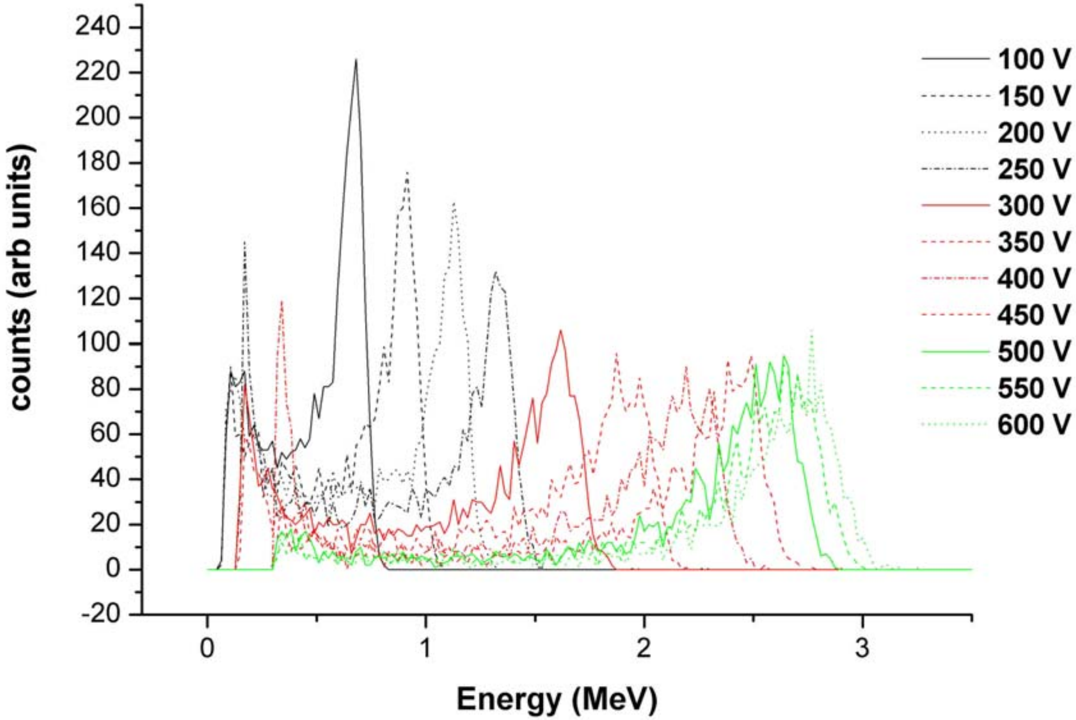
CCE vs Voltage 10^{12} pions cm^{-2}

The evolution of the CCE with increasing detector bias



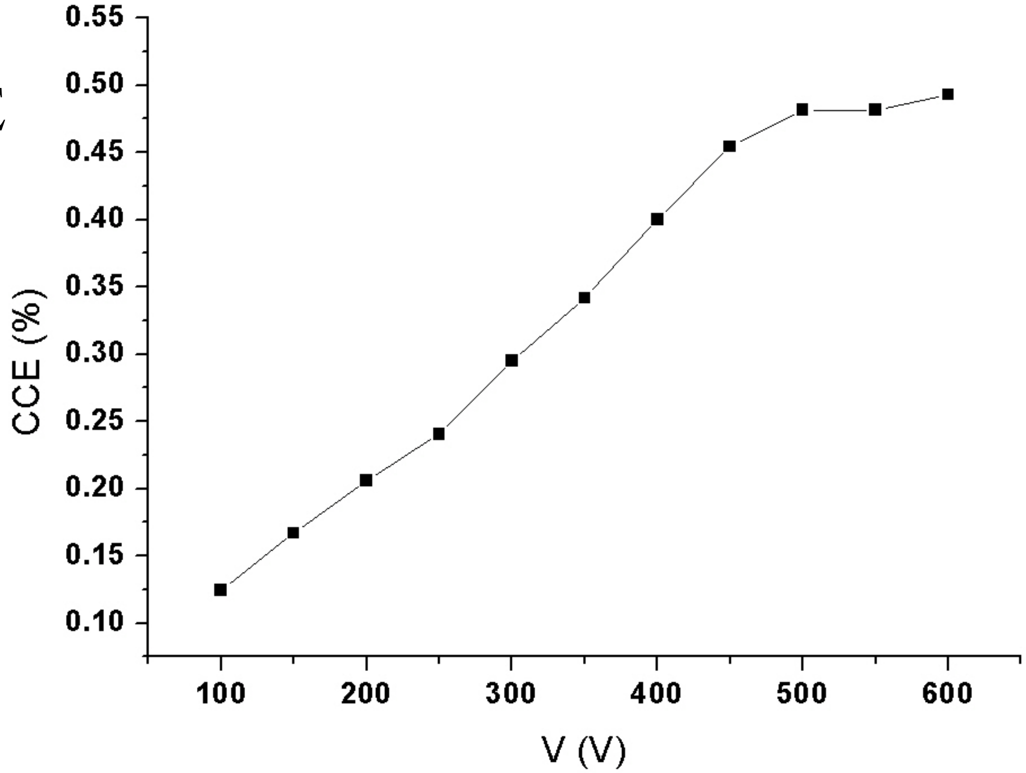
Spectra from irradiated diodes

Spectra taken for 5.48 MeV Am^{241} α's in vacuum after irradiation 10^{13} πcm^{-2}



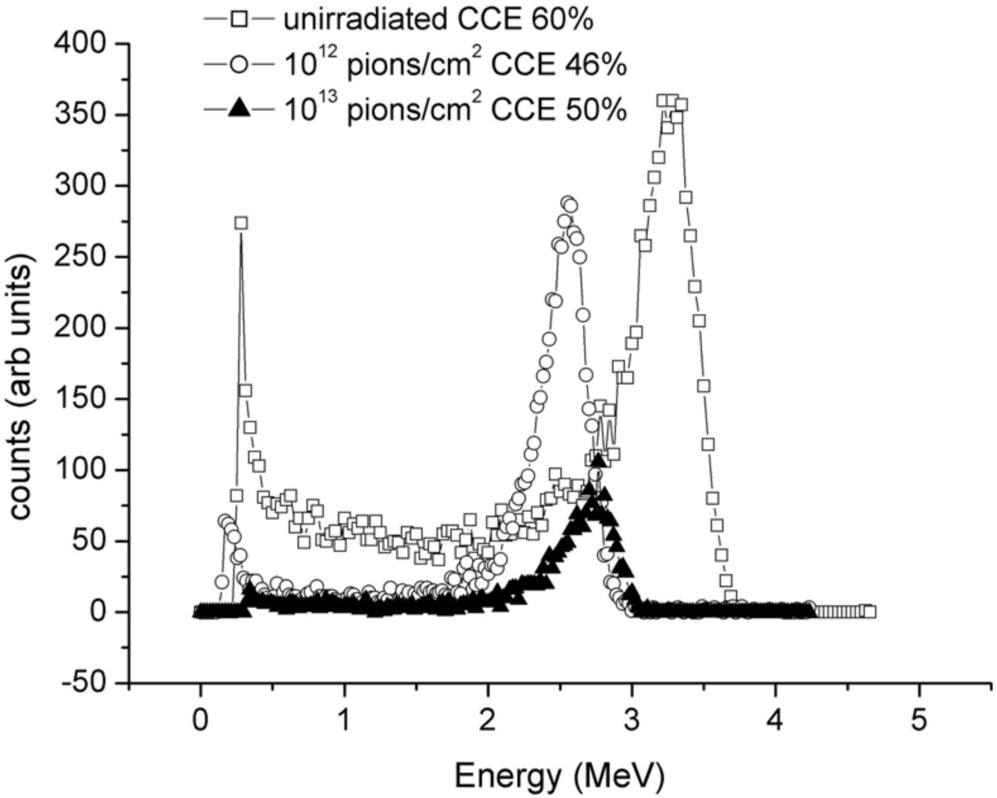
CCE vs Voltage
10^{13} pions cm^{-2}

The evolution of the CCE with increasing detector bias



Comparisons of pulse-height spectra

Comparison of spectra for 5.48 MeV Am^{241} α's in vacuum for irradiated diodes



Summary of V doped samples

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- High resistivity gives low leakage current
- V dopant reduces maximum CCE due to trapping effects
- Has good radiation hard properties compared to GaAs and Si
  - SiC CCE reduced 15% after pion irradiation
    - GaAs CCE reduced 50 % after similar dose
    - Si CCE reduced 30 % after similar dose
  - both had increased bias voltages to achieve lower CCE
- Reasonably promising initial results

Okmetic (non-V doped) semi-insulating material

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- Grown by MOCVD method.
  - Specialised growth process reduces unintentional dopants
- Has no added vanadium
  - should remove limitation on CCE
- High resistivity
  - low leakage current, high field build up possible

I-V Okmetic material

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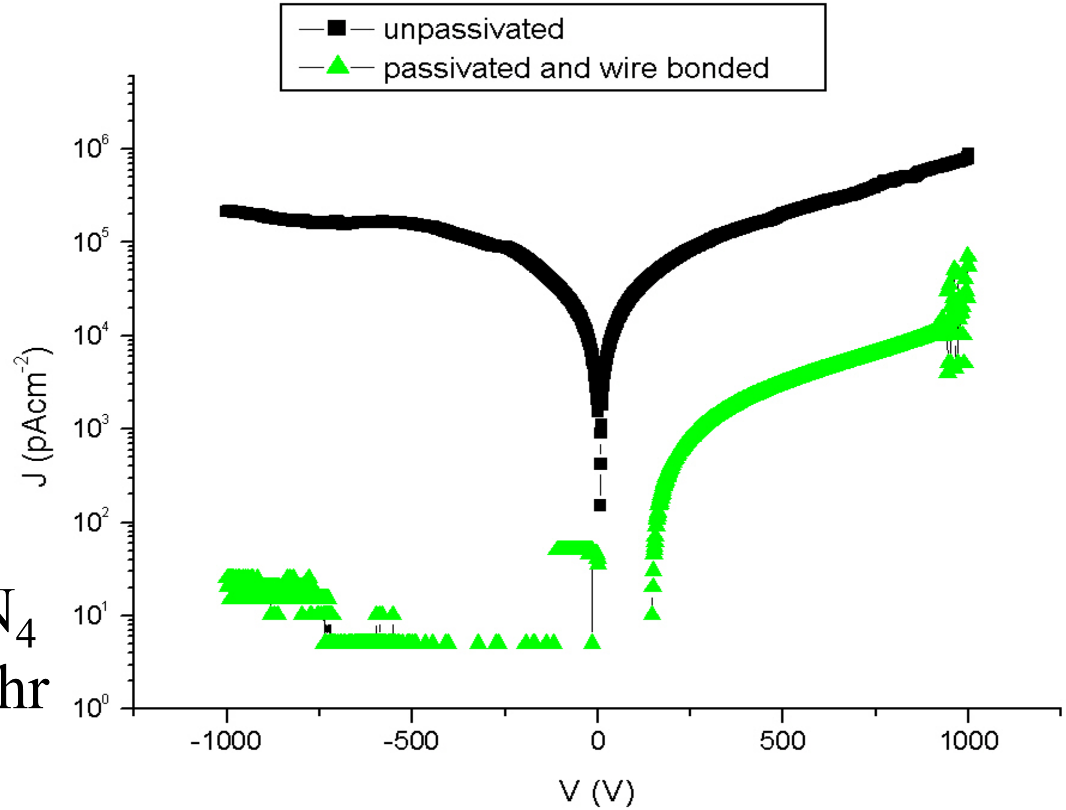
Current density measurements of diodes fabricated on Okmetic S.I. SiC

Back contact annealed 950° C 2 min

passivation 200 nm Si_3N_4 applied at 300° C over 1hr



Pulse height spectra Okmetic material

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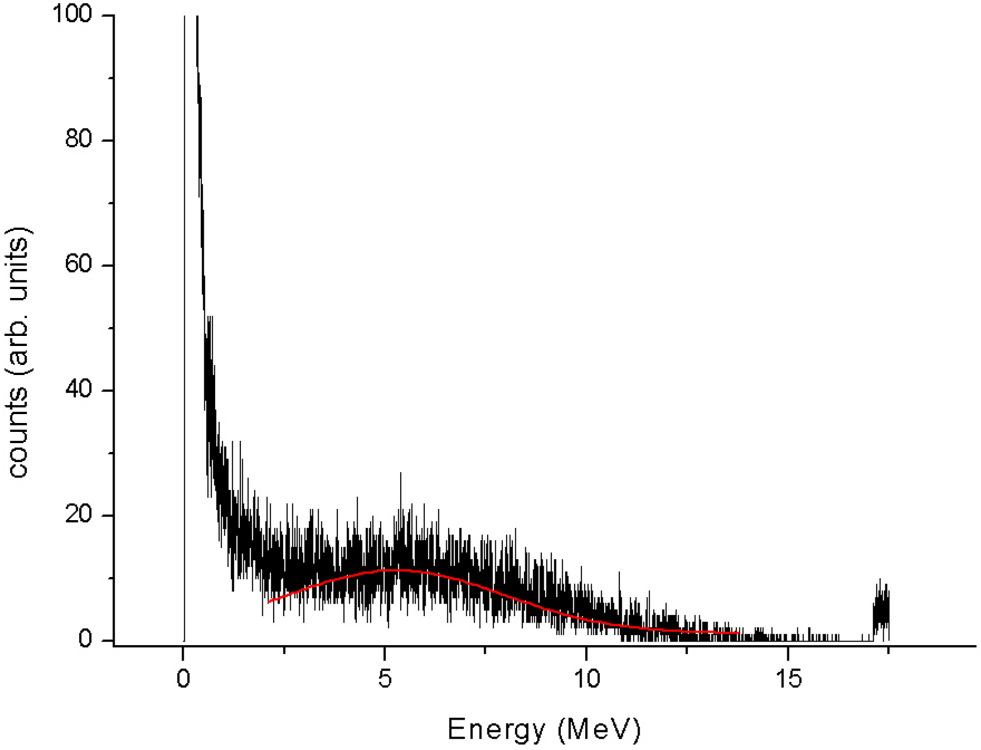
Initial work spectra measurements showing an approximated Gaussian curve over pulse height spectra, peak energy approx. 5.4 MeV



Design of RD50 test mask

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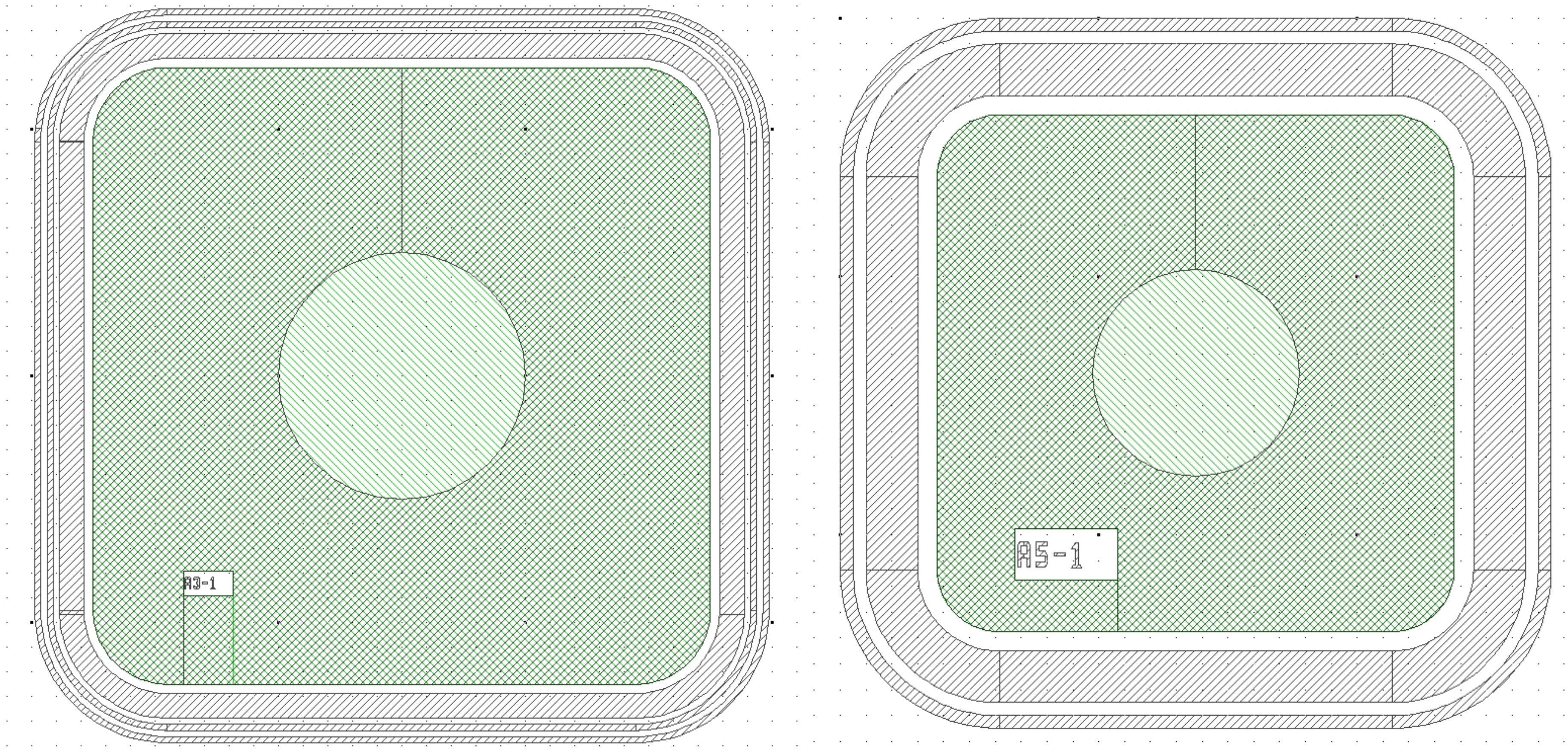

Potential problems

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- Large pads increase the leakage current
  - increases noise
- Greater possibility of defects under the pad
  - possibly reducing Schottky barrier height
- Reduces number of pads available for testing from a single wafer, especially epi-layers
  - more wasted material, not cost effective

Proposed solution

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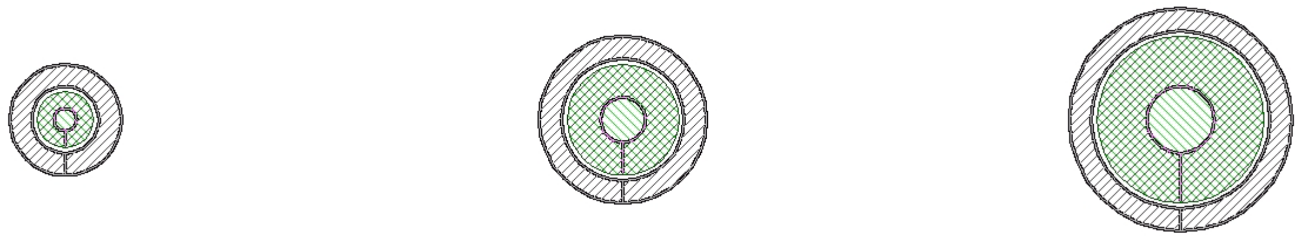
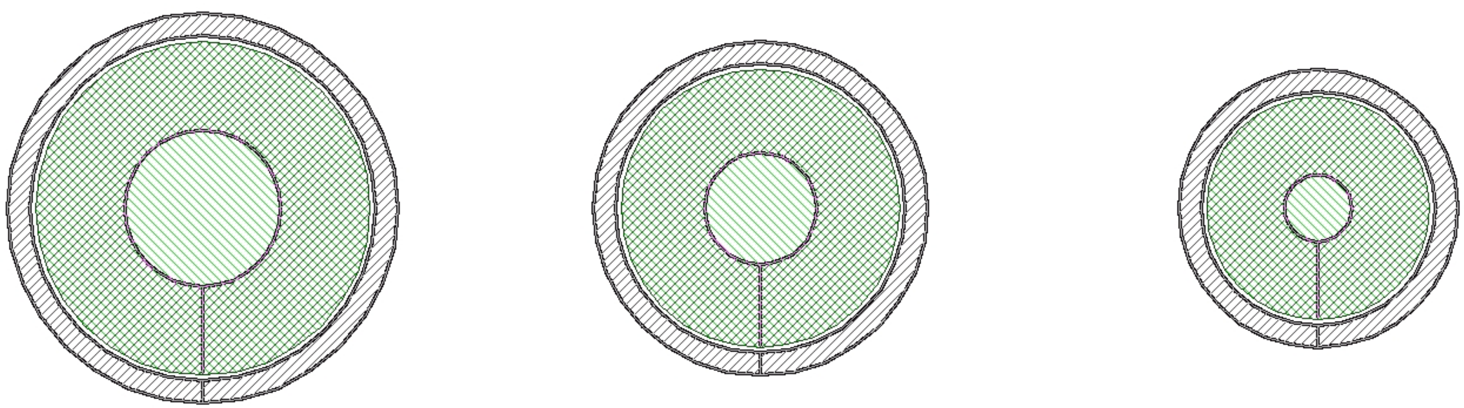
- Reduce pad size
  – ranges of 250 -1500 μm
- Vary pad geometry
  – groups of circular and square pads
  – number of guard rings to be discussed 1,2,3 etc
- This increases used area and number of potentially successful devices from better epi-layer material

Alternative design (initial ideas)



Circular pads 250- 1500 μm diameter
optical windows and single guard ring



Conclusions

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- Bulk SiC has been shown to be more resistant to radiation than Si, GaAs
- Initial tests using the Okmetic non-doped S.I. material promising.
- Current mask design has not met expectations.
- Alternative mask structure proposed