
Studies of silicon carbide as a radiation hard detector material

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Outline

- **Surface effects - irradiated & unirradiated**
 - **Charge collection**
 - **MEDICI simulation**
 - **SiC 3D structures?**



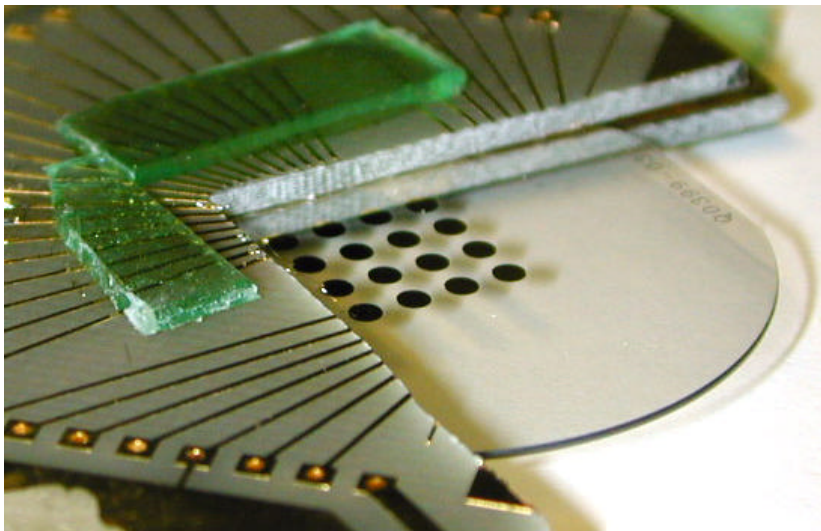
Ideal detector material characteristics

What is desired ideally in a detector medium?

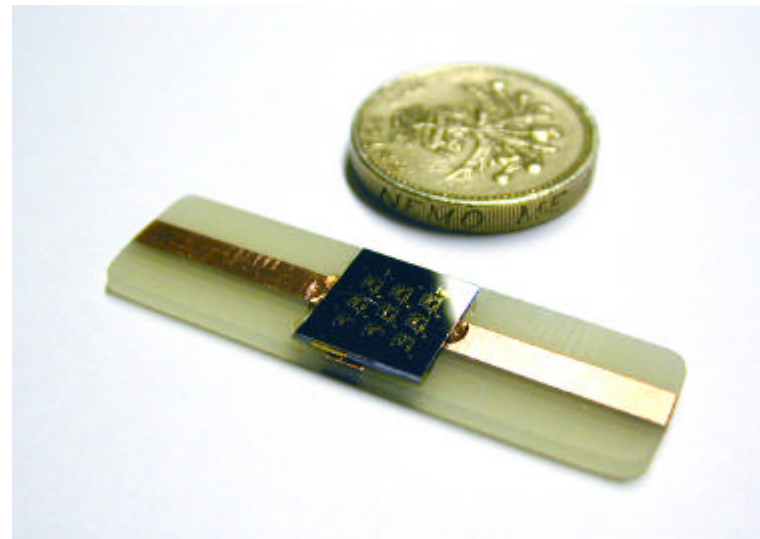
- High purity to enhance CCE – Ge is purest material, owing to low melting point 960°C, background level $\sim 10^9 \text{ cm}^{-3}$
 - Large bandgap to suppressed thermal carriers [$\sim T^{3/2} \exp(-E_g/2kT)$] & defect recombination/generation current [$\sim np - n_i^2$] – SiC is $\sim 3.3 \text{ eV}$, D is $\sim 5.5 \text{ eV}$
 - High μ_n , μ_h , v_{sat} give higher τ_{coll} – GaAs good, SiC & D have higher v_{sat}
 - Low Z number to lessen radiation losses – SiC & D both better than Si, GaAs
 - Low e-h excitation energy to enhance signal – D bad (15 eV), SiC (4.4 eV) like Si (3.2 eV)
 - Low ϵ to reduce capacitance – D (5.7) & SiC (9.7) better than Si (11.9)
 - High bond strength to reduce defect production – SiC and D both good
 - High thermal conductivity to dissipate power – SiC & D are excellent
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SiC detectors

SiC comes in 47 polytypes, but the 4H semi-insulating is most promising



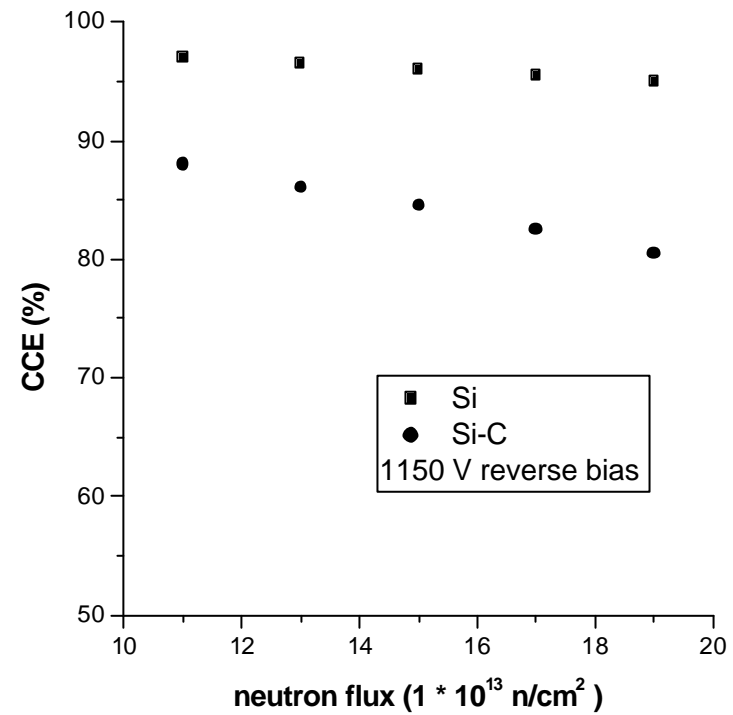
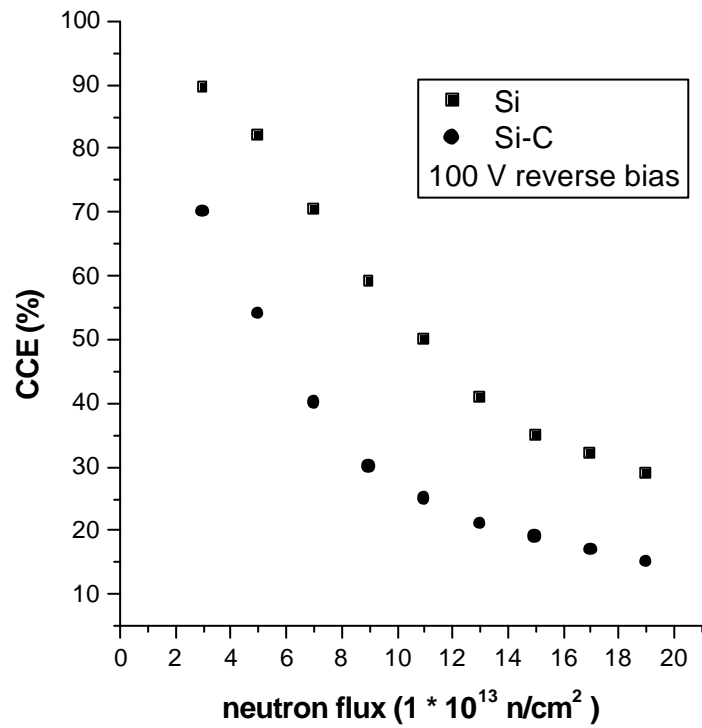
Diode detectors made in semi-insulating SiC



SiC detector ready for testing

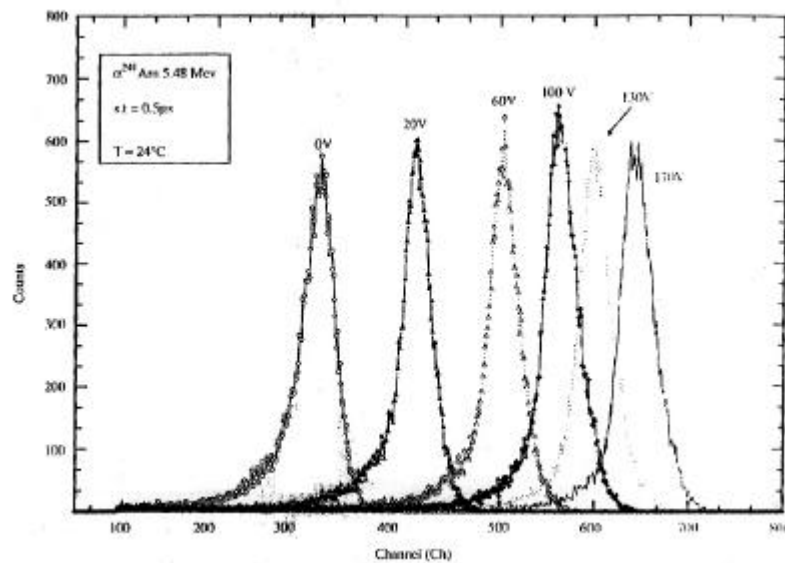
MEDICI simulations

Silicon vs SiC / -100V vs -1150V / neutron irradiation



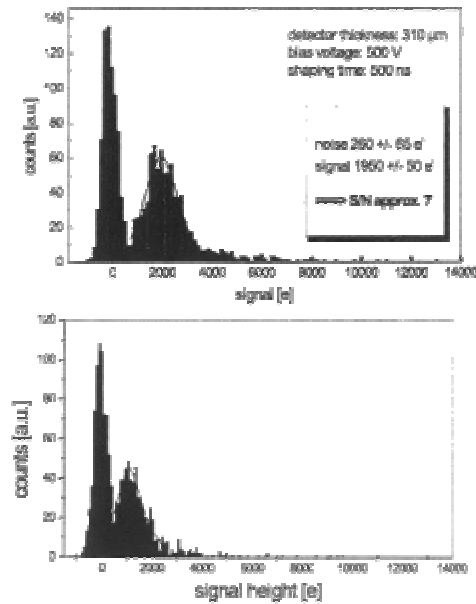
Charge collection in SiC

Charge collection in irradiated and non-irradiated SiC



Nava et al. NIM A **437**, 354 (1999)

30 μm 4H-epi ($2 \times 10^{15} \text{ cm}^{-3}$) SiC
with V_{bias}



Rogalla et al. Nucl Phy B **78**, 516 (1999)

310 μm 4H-SI SiC before & after
 $4 \times 10^{14} \text{ cm}^{-2}$ irradiation

Conclusions

- **SiC material/processing issues**
 - **Sensitive surface properties**
- **Simulations seem to favour silicon**
- **Nevertheless, some evidence for radiation tolerance**

