Motivation

- Since the application of neutron technology in a broad field, the neutrons dose are required to be monitored efficiently. Especially, some harsh environments including Fukushima Daiichi nuclear power plant and high-intensity accelerators such as SuperKEKB produce mixed radiation field.
- There is an urgent need to design a neutron detector that is resistant to high-intensity radiation and can reject high levels of background rays.

- **Advantage**: low leakage current, low capacitance, high electron-hole mobility, radiation resistance, excellent timing resolution
- **Drawback**: low Charge collection efficiency (CCE), low energy resolution

Comparison of Diamond and Silicon Characteristic

<table>
<thead>
<tr>
<th>Properties</th>
<th>Silicon</th>
<th>Diamond</th>
<th>Benefit of Diamond</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandgap (eV)</td>
<td>1.12</td>
<td>5.47</td>
<td>Low Leakage Current</td>
</tr>
<tr>
<td>Breakdown Field [MV/cm]</td>
<td>&lt;1</td>
<td>~20</td>
<td>High Field Operation</td>
</tr>
<tr>
<td>Dielectric Constant</td>
<td>11.9</td>
<td>5.7</td>
<td>Small Detector</td>
</tr>
<tr>
<td>Electron Mobility [cm/Vs]</td>
<td>1350</td>
<td>1900-3800</td>
<td>Capacitance, Less Noise</td>
</tr>
<tr>
<td>Hole Mobility [cm/Vs]</td>
<td>480</td>
<td>2300-4500</td>
<td>Faster Charge Collection</td>
</tr>
<tr>
<td>Thermal Conductivity [W/cmK]</td>
<td>1.5</td>
<td>20</td>
<td>Better Heat Dissipation, Less Noise</td>
</tr>
</tbody>
</table>

- The diamond detector is an ideal choice for monitoring neutron flux and dose in comparison to silicon detector.

Simulation

**PHITS (Particle and Heavy Ion Transport code System)**

What it can do:

- Transport and collision of nearly all particles over wide energy range in 3D phase space with magnetic field & gravity
- 10^4 eV to 1 TeV/u neutron, proton, meson, baryon, electron, photon, heavy ions

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Deposition Energy [MeV]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5μm</td>
<td>500μm</td>
</tr>
<tr>
<td>30μm</td>
<td></td>
</tr>
<tr>
<td>500μm</td>
<td></td>
</tr>
</tbody>
</table>

The simulated deposition energies on diamond detectors with difference thickness for ^137Cs gamma-rays.

- The sensitivity and deposit energy decreased with decreasing the detector thickness.
- The pile-up events will be less impact.
- The maximum deposition energies were significantly less than the expected deposition energies from the neutron-induced ^6Li(n,t)α reaction: Et= 2.73 MeV, Eα= 2.05 MeV.

Diamond Detector:

- Material: sCVD diamond
- Size: 4.5 mm x 4.5 mm
- Thickness: 140 μm
- Thermal-neutron converter: ^6LiF (95% enrichment)
- Active area: 10 mm²

Experimental Setup and Result

- I–V characteristic of the sCVD diamond detector.
- CCE of the sCVD diamond detector.
- TCT pulse for charge carrier in diamond

Experimental Setup:

- Power Supply of Detector: Keithly 2450
- Power Supply of Amplifier: Tektronics P6120A
- Vacuum Chamber
- Diamond

Conclusion

- The deposition energies on diamond detectors with difference thickness for ^137Cs gamma-rays were simulated.
- We did performance tests on the diamond detector.

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†: xxqing@post.kek.jp

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