Investigation of nitrogen enriched silicon detectors

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Nitrogen doping - effect on silicon

\[ I + V \leftrightarrow 0 \]  
\[ 2N_i \leftrightarrow N_2 \]  
\[ N_s + N_i \leftrightarrow N_2V \]  
\[ N_2 + V \leftrightarrow N_2V \]  
\[ N_2V + I \leftrightarrow N_2 \]

During crystal growth imperfections and defects are formed within the silicon wafer. Nitrogen enrichment replaces some of these defects with more stable defects.

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# Samples and irradiation

<table>
<thead>
<tr>
<th>Wafers</th>
<th>Label</th>
<th>Substrate</th>
<th>Type</th>
<th>Resistivity [Ω·cm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-6</td>
<td>FZ</td>
<td>Floatzone</td>
<td>n-type</td>
<td>2000-2400</td>
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<tr>
<td>7-12</td>
<td>NIT</td>
<td>FZ Nitrogenated</td>
<td>n-type</td>
<td>1500-1900</td>
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<tr>
<td>13-18</td>
<td>DOFZ</td>
<td>FZ Oxygenated</td>
<td>n-type</td>
<td>2000-2400</td>
</tr>
<tr>
<td>19-24</td>
<td>MCZ</td>
<td>Magnetic Czochralski</td>
<td>n-type</td>
<td>800-1000</td>
</tr>
</tbody>
</table>

Irradiation performed at:
- Ljubljana reactor neutrons
- KIT 25 MeV protons
- CERN 24 GeV/c protons

Sensor fluences:
- $1 \cdot 10^{14} \text{n}_{\text{eq}}/\text{cm}^2$
- $3 \cdot 10^{14} \text{n}_{\text{eq}}/\text{cm}^2$
- $6 \cdot 10^{14} \text{n}_{\text{eq}}/\text{cm}^2$
- $1 \cdot 10^{15} \text{n}_{\text{eq}}/\text{cm}^2$. 
RESULTS
Nitrogen concentration measurements

- Samples are measured using the secondary-ion mass spectrometry (SIMS) technique to determine nitrogen concentration, before and after processing.
- Wafer processing lowers nitrogen content to or below detection limit.
Field configuration

Results obtained from laser measurements with a laser illuminating the sensor edge (EdgeTCT).

Plots show E-field calculated at 40 V bias voltage. NIT and DOFZ show similar behaviour, while FZ E-field is growing almost exclusively back to front.

Strip sensor irradiated to $10^{14}$ n$_{eq}$/cm$^2$ with protons (CERN 24 GeV/c) measured @ -20 °C.

This effect was not present under irradiation with neutrons! NIT and DOFZ behave similarly across the measurements.
Much more to see …

Source measurements

TSC measurements

Electrical testing

Investigation of nitrogen enriched silicon detectors

Laser measurements