ABSTRACT: A lot of R & D work is carried out in the CERN RD50 Collaboration to find out the best material for the Si detectors that can be used in the harsh radiation environment of HL-LHC. n-and p-MCz Si was identified as one of the prime candidates as a material for strip detector that can be chosen the phase 2 upgrade plan of the new Compact Muon Solenoid tracker detector in 2026. For the very first time, in this work, an advanced four level deep trap mixed irradiation model for p-MCz Si is proposed by the comparison of experimental data on the full depletion voltage and leakage current to the Shickley Read Hall recombination statistics results on the mixed irradiated p-MCz Si PAD detector. In this work, we have determined the effective introduction rate \( n_{\text{eff}} \) of shallower donor deep traps E30K using SRH theory calculations for exp. MCz Si and that can show the behavior of space charges and electric field distribution in the p-MCz Si strip detector and compared its value with the \( n_{\text{eff}} \) of shallower donor deep trap E30 K in the n-MCz Si microstrip detector. Prediction uncertainty in the p-MCz Si radiation damage mixed irradiation model considered in the full depletion voltage and leakage current. A very good agreement is observed in the experimental and SRH results. This radiation damage models also used to extrapolate the value of the full depletion voltage at different mixed (proton + neutron) higher irradiation fluences for the thin p-MCz Si microstrip detector.

**Table 1. List of Physical Parameters**

<table>
<thead>
<tr>
<th>Physical Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doping concentration ( N_D )</td>
<td>2.87 x 10^{13} cm^{-3}</td>
</tr>
<tr>
<td>Oxide thickness ( t_Ox )</td>
<td>0.5 µm</td>
</tr>
<tr>
<td>Junction Depth ( D )</td>
<td>1 µm</td>
</tr>
<tr>
<td>Guard ring spacing ( G )</td>
<td>10 µm</td>
</tr>
<tr>
<td>Guard ring width ( W )</td>
<td>100 µm</td>
</tr>
<tr>
<td>Device depth ( W_{Si} )</td>
<td>300 µm</td>
</tr>
<tr>
<td>Fixed oxide charge ( Q_{f} )</td>
<td>1x 10^{-4} cm^{-2}</td>
</tr>
<tr>
<td>Resistivity ( \rho )</td>
<td>1.5 KΩ-cm</td>
</tr>
</tbody>
</table>

**SRH Calculations**

\[
N_{\text{eff}} = N_D + \sum_{\text{donor}} n_T - \sum_{\text{acceptor}} n_T,
\]

\[
\frac{d}{dN} \left( \sum_{\text{donor}} n_T \right) \left( e^{D} + e^{-D} \right) = \frac{n_T}{N_D + \sum_{\text{donor}} n_T},
\]

\[
\text{Introduction rate of E30K for the comparison of experimental data with theoretical SRH data}
\]

\[
\text{Introduction rate of E30K in n-MCz or in p-MCz Si plays an important role and that can be a key trap to explain the macroscopic performance of the n-p-MCz Si pad detector}
\]

**Conclusions**

†First time within the detector consortium in the world, we have proposed a four level deep trap mixed irradiation damage model for the p-MCz Si strip detector.
†Good agreement in experimental and SRH value of Full depletion voltage observed.
†Introduction rate of E30 K extracted from our mixed irradiated radiation damage model.
†The \( V_{fd} \) is the main macroscopic parameter that can determine the space charge behavior of the mixed irradiated detectors and <3000 V observed for 200 micron p-MCz Si strip detector for the mixed irradiation fluence of 4.5 x 10^{11} cm^{-2}.
†Leakage current increases with fluences at 297 K as per [4].

**Acknowledgements**

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**References**

3. CMS collaboration, "I - D plot covering CMS tracker, showing FLUKA simulated 1 MeV neutron equivalent in Silicon including contributions from various particle types", CMS-DP-2015-02.