In-house developed (1100) and (1120) oriented 4H-SiC wafers, and a reference wafer were used to evaluate the impact of the SiC structural defects on the degradation phenomenon of bipolar pn diodes. Evaluation of the crystal quality and the degraded devices was performed by comparing the results of etch pit densities, electroluminescence, Berg-Barrett topography, HRXRD and HRTEM analysis. Our data demonstrate that the degradation phenomenon is strongly related to the SiC structural crystal defects of the starting material. DENSO (HQ) wafers are less susceptible to the forward current degradation, which we attributed to comparatively much lower etch pit densities, specially the slip/stacking fault defects.

Key words: Bipolar pn diode, Degradation, Stacking faults, Carrier recombination, Berg-Barrett topography, HRXRD, Electroluminescence, HRTEM
### Table 2 Summary of Berg-Barrett topography and HRXRD extracted parameters

<table>
<thead>
<tr>
<th>4H-SiC wafers</th>
<th>DENSO HQ (1120) off-oriented</th>
<th>DENSO STD (1100) off-oriented</th>
<th>Reference (1120) off-oriented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curvature type</td>
<td>-</td>
<td>Convex</td>
<td>Concave</td>
</tr>
<tr>
<td>Radius [nm]</td>
<td>3000</td>
<td>9.3</td>
<td>11.5</td>
</tr>
<tr>
<td>FWHM [arcsec]</td>
<td>8</td>
<td>11.2</td>
<td>14.9</td>
</tr>
</tbody>
</table>

![HRXRD rocking curve of high quality of DENSO (HQ) wafers](image)

**Fig. 1 HRXRD rocking curve of high quality of DENSO (HQ) wafers**

### Table 1 Measured etch pit densities of 4H-SiC wafers (ø15mm size) used in the present investigations

<table>
<thead>
<tr>
<th>4H-SiC Wafers</th>
<th>Defect Type</th>
<th>DENSO HQ (1120) off 8deg.</th>
<th>DENSO STD (1100) off 8deg.</th>
<th>Reference (1120) off 8deg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etch pit density [cm(^{-2})]</td>
<td>8.0x10(^2)</td>
<td>1.6x10(^3)</td>
<td>3.2x10(^4)</td>
<td></td>
</tr>
<tr>
<td>(i) Micro-pipe density [cm(^{-2})]</td>
<td>5</td>
<td>30</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>(ii) Screw dislocations [cm(^{-2})]</td>
<td>2.9x10(^2)</td>
<td>2.7x10(^4)</td>
<td>6.7x10(^2)</td>
<td></td>
</tr>
<tr>
<td>(iii) Edge dislocations [cm(^{-2})]</td>
<td>7.3x10(^3)</td>
<td>1.1x10(^4)</td>
<td>1.6x10(^4)</td>
<td></td>
</tr>
<tr>
<td>(iv) Slip/stacking faults [cm(^{-2})]</td>
<td>3.8x10(^2)</td>
<td>2.5x10(^4)</td>
<td>1.6x10(^4)</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 2  Forward characteristics of pn junction diode fabricated on the DENSO HQ 4H-SiC wafers

Fig. 3  EL images of pn diodes before and after the forward current stress at current densities of about 200 A/cm$^2$ and 600 A/cm$^2$

The images (a) and (b) were acquired using the image intensifier module and a CCD camera at the current densities of 10 µA/cm$^2$ and 600 A/cm$^2$, respectively.

Fig. 4 (a) Forward characteristics degraded pn diode fabricated on reference wafer in (a) log, and (b) linear scale
Fig. 5 Cross-sectional images of degraded pn diodes fabricated on DENSO (STD) wafers
(a) Marked straight line corresponds to the stacking fault (SF1) nucleated near the implanted region/epilayer interface, and
(b) Another stacking fault (SF2) terminated in the drift epilayer region

Fig. 6 Cross-sectional images of degraded pn diodes fabricated on 4H-SiC DENSO (STD) wafers
(a) Low magnification, and (b) High magnification TEM images of stacking fault (SF2) edge in the drift epilayer region
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