MECHANICAL PROPERTIES OF DIRECTLY SLICED MEDIUM GRAIN NIOBIUM FOR 1.3 GHz SRF CAVITY

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Introduction

• LIC-250 is an electron-positron collider that requires 7800 1.3 GHz cavities.
• The TDR is already published but the cost of its construction is a major hurdle.
• High purity Niobium (cont.) is used to manufacture 9-Cell 1.3 GHz SRF cavity.

FG Nb
- Grain size < 50 μm
- isotropic mechanical properties
- High Cost

LG Nb
- Grain size > 1 cm
- Anisotropic mechanical properties
- The Cost

ATI MG Nb
- Grain size = 200-300 μm, occasionally 1-2 mm grains.
- New material, no data.
- High cost properties?
- Viable for SRF cavity?
- Cost reduction w/ ATI Nb

MOPCAV004

Results and Discussion

• ATI Mg Nb billet was sliced into 65 disks and specimens from top two and bottom two disks were cut for tensile testing.
• All disks were chemically polished, specimens were wire EDM cut and then chemically polished again (see fig below).
• A set specimens were annealed at 800 °C for 3 hrs and the remaining ones were not, considered as in as-received condition (ASR).
• Tensile tests were performed in room temperature and in liquid helium.

Mechanical properties are uniform throughout the billet with minimal deviation between annealed specimens (see table below).
• MG Nb initially thought to be isotropic, but it is likely anisotropic as grain size is non-homogeneous radially.

Table: Mechanical properties at room temperature

<table>
<thead>
<tr>
<th>Position (sample no.)</th>
<th>V5 [MPa]</th>
<th>V5 ± [MPa]</th>
<th>Elongation [%]</th>
<th>Elongation ± [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top [8]</td>
<td>38.1±2.7</td>
<td>37.2±2.7</td>
<td>26.4±0.7</td>
<td>38.0±0.7</td>
</tr>
<tr>
<td>Bottom (8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top [4]</td>
<td>49.3±2.2</td>
<td>50.0±1.7</td>
<td>30.8±0.7</td>
<td>38.7±0.7</td>
</tr>
<tr>
<td>Bottom (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table: Mechanical properties in liquid helium

<table>
<thead>
<tr>
<th>Position (sample no.)</th>
<th>V5 [MPa]</th>
<th>V5 ± [MPa]</th>
<th>Elongation [%]</th>
<th>Elongation ± [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top (3)</td>
<td>131.8±13</td>
<td>131.0±13</td>
<td>25.0±0.7</td>
<td>25.0±0.7</td>
</tr>
<tr>
<td>Bottom (3)</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Average T5 is approximately 378 MPa.
• V5 print couldn’t be attained for most specimens.

Viability of MG Nb for 1.3 GHz SRF Cavity

• MG Nb mechanical properties are closer to FG Nb at room temperature.
• KEK results => elongation is lower than FG Nb.
• ATI results => elongation is higher than FG Nb.
• MG Nb can be considered as a clear and cost-effective alternative and has the necessary mechanical strength to be accepted as a viable alternative to the FG Nb for 1.3 GHz cavity manufacturing.
• Further studies are necessary to characterize the MG Nb mechanical properties at various annealing temperatures and to study the effect of direct slicing and other processes on its properties.

Conclusion

• MG Nb’s mechanical properties are closer to FG Nb at room temperature and depends on the orientation of the tensile specimen.
• MG Nb can be considered as a clear and cost-effective alternative and has the necessary mechanical strength to be accepted as a viable alternative to the FG Nb for 1.3 GHz cavity manufacturing.

Methodology

• Tensile tests are conducted to obtain mechanical properties of a material.
• Material is subjected to tension until failure to obtain Young’s Modulus (E), 0.2% Yield Strength (YS), Tensile Strength (TS) and Elongation.
• Shimadzu Autograph AG-5000C with Kyowa strain gages and Kyowa strain amplifier were used to conduct tests.
• Cross-head speed kept constant at 2 mm/min with strain rate of 4.4E-4 s⁻¹.

Fig. Room temperature tensile testing

Fig. Tensile testing in liquid helium

Fig. Stress-strain curves at room temperature for some specimens