2G HTS for Current Leads

SuperPower’s 2G high temperature superconducting (HTS) wire enables current leads to carry high power between liquid nitrogen and lower temperatures with minimal heat leak.

2G HTS leads offer system stability, safety, security and compactness with greater design optimization from liquid nitrogen to lower cryogenic temperatures.

Conventional current leads (copper, brass, stainless-based) have a limited optimization point and suffer from heat leak due to conduction and Joule heating. Superconducting current leads offer freedom from the effects of the Wiedemann-Franz Law (optimization point = electrical conduction + high thermal conductivity for minimum heat load) by eliminating resistance and no Joule heating.

<table>
<thead>
<tr>
<th>Length (mm)</th>
<th>Heat Load (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0001</td>
</tr>
<tr>
<td>200</td>
<td>0.0010</td>
</tr>
<tr>
<td>400</td>
<td>0.0100</td>
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<tr>
<td>600</td>
<td>0.1000</td>
</tr>
<tr>
<td>800</td>
<td>1.0000</td>
</tr>
<tr>
<td>1000</td>
<td>10.0000</td>
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Comparison of Heat Leak for Current Lead Options (100A, 77 K - 4.2 K)

SuperPower'd™ for superior performance.

2G HTS Current Leads offer important benefits when compared to other options:
- Better in field properties
- Greater current density
- Superior mechanical properties (strain, stress tolerance [up to 700 MPa], and superior fatigue properties)
- Potentially lower thermal conduction than 1G over the same cross-section

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Best practices for soldering current leads

The overriding issue with soldering the SF material is the thin Ag layer and its possible dissolution in the solder layer. Two possible solutions:

1. Use solder compositions that do not readily dissolve Ag. These include 97%In3%Ag eutectic (mp ~144°C) or 96.5%Sn3.5%Ag eutectic (mp ~221°C). By using the eutectic, you are at the region where the Ag on the 2G HTS does not readily dissolve further into the solder. Temperature control is critical and should be limited to ~5 degrees above the eutectic point.

2. Locally electroplate copper on the ends of the lead elements to protect the Ag from dissolving into the solder. Our experience shows that 5 microns of copper is sufficient. With this technique more varieties of solders can be successfully used.

A rosin-based flux that is readily cleaned after the soldering operation is recommended.

Stable 2G HTS leads can be fabricated without soldering multiple tapes together. We do not recommend soldering tapes together over their full length for current lead applications. Depending on the lead design, parallel structural support (typically glass/epoxy) may be desirable.

- Tapes of 4 mm, 6 mm and 12 mm widths are available in the SF configuration. The 12 mm widths are available ranging from 240 to 360 A at 77K self field.

Example of 4000 Amp, high current prototype leads under development by NHMFL with SuperPower 2G HTS Wire

A partly assembled pair of binary leads with resistive sections of specially designed Cu heat exchangers operating in N2 self-demand mode, fed via the internal reservoirs. The HTS sections are thermally anchored to the N2 reservoir at the top and connected to helium cooled feeders/bus-bars at the bottom (not present in this image).