Cost-effective production of HTS wires by chemical solution deposition

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CSD processing

- Chemical solution deposition for complete layer architecture
  - Best price performance ratio for large volume production
  - Unique and protected technology
Content

- **Industrial applications**
  - DC bus bars
    - Long length laminates
    - Performance at low fields and high temperatures
    - Production upscaling
  - Magnets
    - Performance at medium fields and low temperatures
    - Joint technology
    - Mechanical performance: bending

- **Distribution grids**
  - AC cables
    - Non-magnetic substrates
    - Mechanical requirements: strain and twist
Industrial applications

DC bus bars

-single copper laminate - HTS neutral fiber
  - Long length with high homogeneity
  - Mechanical and electrical stability with high $J_e$

150m x 10mm, 310±10A (@77K, sf), homogeneity <5%

50µm single copper laminate
Industrial applications

DC bus bars

- single copper laminate - HTS neutral fiber
  - Performance at low fields and high temperatures

Best HTS tapes > 800A @65K, sf

$I_c$ ($B, \theta, T$) system
(0-5T, 0-180°, 0-800A, 20-100K)
Industrial applications
DC bus bars

- single copper laminate - HTS neutral fiber
  - Upscaling: wide tapes and production devices

4x25m high temperature annealing furnace

40mm fully buffered tape
Industrial applications
Magnets

- Performance at low temperatures and medium magnetic fields
  - Typical operation conditions: 30-50K, 1-3T

**Typical** $I_c(B,\theta,T)$ behaviour

**Typical** $I_c(B,\perp,T)$ behaviour
Industrial applications

Magnets

- Customized laminates
  - Small bending diameter possible

$I_c$ degradation <2% for double bending on 15mm diameter
Industrial applications
Magnets

- Joints and splices
  - Bridge-type joints
  - Lead free solder paste (mp >200°C)

Typical joint resistance <20nΩ
Grid applications

AC cables

- Non-magnetic substrates
  - <100m processing in R&D
  - $I_c (@\text{Ni9W}) \approx I_c (@\text{Ni5W})$

EBSD: 93.4% index rate, 94% in 10° tilt

$I_c: 308 \text{A/cmw}$
Grid applications
AC cables

- Non-magnetic substrates
  - Improvements in large scale processing

~10 t ingot processed to 60 µ tape

Preference in cube growth >90%

Out-of-Plane distributions from EBSD

<table>
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<tr>
<th>Tape</th>
<th>% Cube</th>
<th>Error</th>
<th>% Cb-G</th>
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<td>Ni5W (MAY 2017)</td>
<td>99.9</td>
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Grid applications
AC cables

- Mechanical requirements
  - Tensile stress: 250mPa
  - Twist: 200mm, 360°
  - Bending: Ø 30mm

_3 batches of 10mm wide HTS tape_

HTS tapes fullfill typical requirements for AC cable applications
Summary

- Up-scaling of production ongoing
  - 40mm technology partially implemented
- HTS tapes customized for applications available
  - Laminates, joints
- Mechanical and electrical specifications reached
  - Bending, twist, strain, resistance, \( I_c (B,\theta,T) \)
- In-house test facilities qualified
  - 5T-\( I_c \)-tester, mechanical testing
Thanks for your attention