Customization of coated conductors for different applications

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About SuperOx

- 2006: SuperOx company is founded in Moscow
- 2011: SuperOx Japan LLC is founded in Tokyo
- 2012: Starts production of 2G HTS wire in Russia and Japan
- 2016: Delivers 2G HTS wire and products to customers in 14 countries
SuperOx Japan LLC

- Multiprocess one-chamber sputtering/IBAD system
- Dual-chamber PLD-HTS system for CeO$_2$ and GdBCO
07-2011 registration of a company
09-2011 orders for equipment placed
12-2011 rent a place in Sagamihara
04-2012 installation of equipment complete
06-2012 first 50 m / 300A wire produced

Ramping up production in less than 1 year
New equipment in Moscow

- Buffer layer deposition line installed in Moscow in 12-2015
- PLD-HTS system to be commissioned in 2016
Moscow buffer layer line commissioned in 2016

IBAD-MgO RHEED patterns

$\Delta \phi \ (110) \ LMO \ < \ 7^\circ$

High $I_c$ demonstrated with PLD-HTS on Moscow buffer

Production of high quality IBAD-buffered tape in 5 months


CCA-2016, Aspen
### Production status and development

**Originally: 2011-2015**

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<thead>
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<th>Finish</th>
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<tbody>
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**At present: 2016**

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Decisions to increase throughput are driven by demand.
SuperOx 2G HTS wire architecture

Customised finish tailored to application

- DC sputtering (custom thickness)
- PLD-2 (1-3 microns)
- PLD-1 (100-200 nm)
- Sputtering (30-50 nm)
- IBAD (5-7 nm) + homo-epi (10-50 nm)
- Sputtering (10-50 nm)
- Sputtering (50 nm)
- Cold rolled & electro polished (60-100 microns)
Important properties of 2G HTS wire

- **Electrical**
  - critical current
  - pinning force
  - resistance in normal state
  - dielectric strength of insulation

- **Physical**
  - width
  - thickness
  - tensile strength
  - delamination strength
  - specific heat
  - thermal conductivity
  - thermal expansion

- **Chemical**
  - thermal stability
  - chemical stability

A lot of critical properties are influenced by customization!
2G HTS wire for resistive SFCL

- **Electrical**
  - critical current: uniform
  - pinning force
  - resistance in normal state: 100 mO/m
  - dielectric strength of insulation: high

- **Physical**
  - width
  - thickness: high
  - tensile strength: high
  - delamination strength: high
  - specific heat: high
  - thermal conductivity: high
  - thermal expansion

- **Chemical**
  - thermal stability: high
  - chemical stability
2G HTS wire for SFCL – some tasks to solve

• add a heat capacity without compromising the electrical resistance
• add a dielectric insulation without compromising the heat transfer
• add stabilizing metal layers without compromising the thermal stability
Lamination wit SS – a traditional way

Quench test 55 V/m

Stainless steel

Stainless steel

I(t)  U-LEM (t)

I, A / U, V

t, ms

0 20 40 60 80 100 120 140 160 180 200 220 240

0 1000 2000

-1000

-2000

13.09.2016  CCA-2016, Aspen
Lamination with steel – a traditional way

Reference module: 40 ms. Module from laminated wire: 60 ms. 50% improvement compromising resistance and thermal stability.
Impregnation – an alternative way

Thermally conductive impregnation material helps to increase both heat capacity and thermal transfer to LN2.
Impregnation – an alternative way

Reference: **150 ms.** Alumina: **350 ms.** Epoxy: **440 ms.**

**Improvement 100-200%.**

Without compromising resistance and thermal stability.
Impregnation – an alternative way

Will future resistive SFCL technology use impregnation?
Surround polyimide coating

- Thin PI-layer keeps $J_e$ high
- Complete edge coverage (electrophoresis technique)

Surround polyimide coating

![Graph showing breakdown field vs. failure probability for 20 μm and 25 μm coatings. The graph indicates a high strength of > 1kV.](image)

- Strength > 1kV
- Breakdown field (V/μm)
- Failure probability (%)
Surround polyimide coating

NO degradation upon thermal cycling

Voltage at 63% failure probability (kV)

Number of cycles

Cycle: RT - 77 K
Surround polyimide coating

Can it be improved?

CIGRE Technical brochure, WG D1,38, 2015
Thick PI+BN composite layer

Polyimide (PI) film + boron nitride (BN), thickness 200 um
Dip-coating reel-to-reel method

Reference sample : 1 um Cu stabilizer

Test sample : 1 um Cu stabilizer + PI BN 200 um
Thick PI+BN composite layer: tests

Quench test results are promising!
Reduction of tape temperature by 20%

Reference (no coating)
Thick Polyimide + BN coating
New customization opportunities for 2G HTS wire are being developed in SuperOx.

New approached and materials should help to improve performance of HTS wire in practical devices.
Thank you for your attention!

www.superox.ru/en