SuperOx

Production and integration
of 2G HTS wire into HTS devices

Outline

- The SuperOx group of companies
- The material: 2G HTS wire
- Further integration

Outline

- **The SuperOx group of companies**
On the market, quick and efficient

- The material: 2G HTS wire

- Further integration

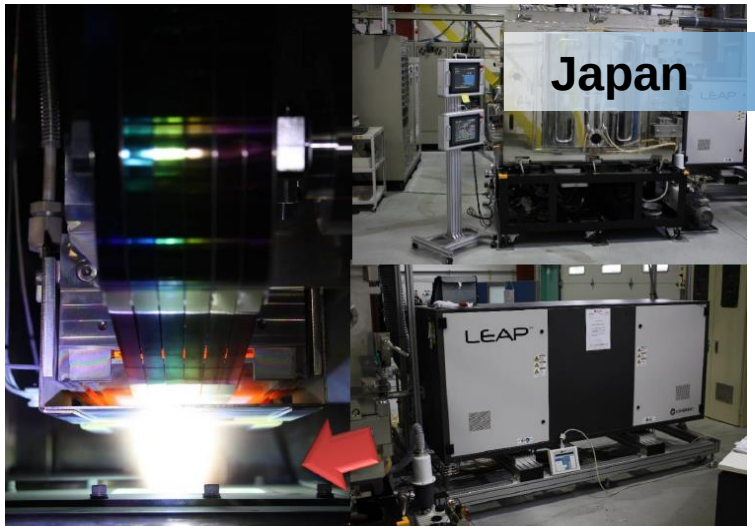
SuperOx

+ 2006: SuperOx founded in Moscow

+ 2011: SuperOx Japan LLC founded in Tokyo

+ 2012: starts joint production of 2G HTS wire in Russia and Japan

+ 2014 : delivers 2G HTS wire to customers worldwide

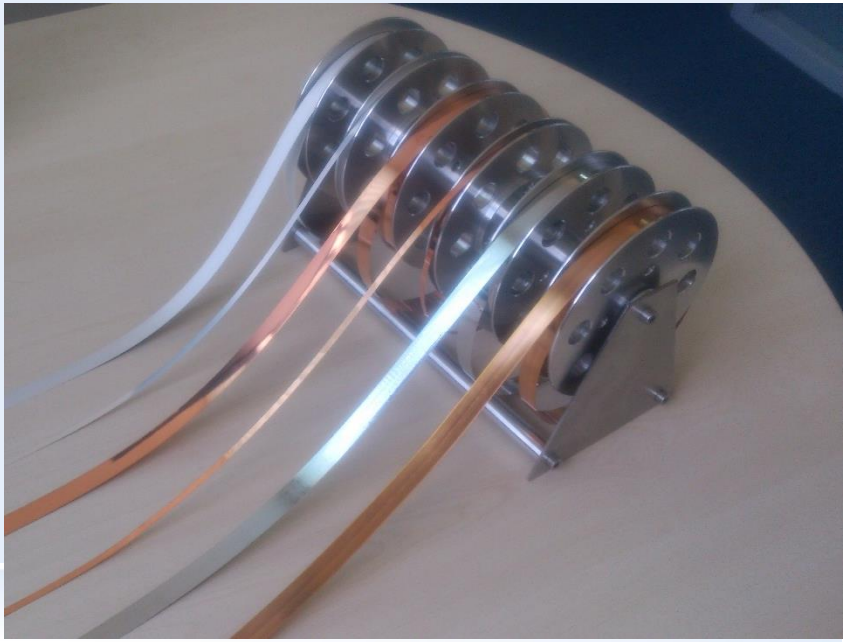


SuperOx (Moscow)

- Electropolishing
- Silver DC sputtering
- Copper electroplating
- Solution deposition (MOD & SDP)
- MOCVD (R&D)
- Polyimide insulation
- Solder plating & lamination
- Quality testing, etc.

850 sqm / 20 employees

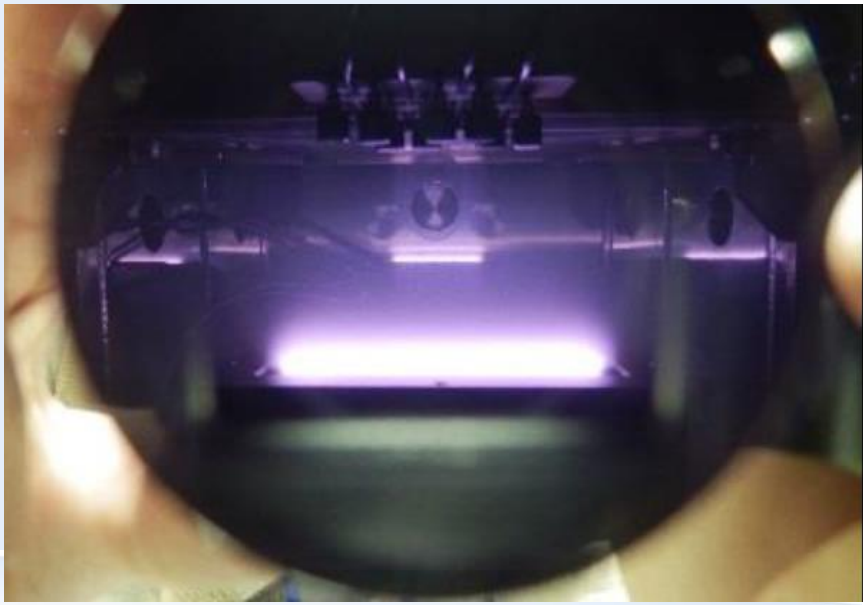
Focus on customisation and applications



SuperOx Japan LLC (Tokyo)

- RF sputtering: buffer layers
- IBAD-MgO
- PLD: CeO_2 & HTS
- DC sputtering: silver
- I_c measurements

220 sqm / 5 employees



Focus on PVD technology

Outline

- The SuperOx group of companies

- **The material: 2G HTS wire**
Good for all applications

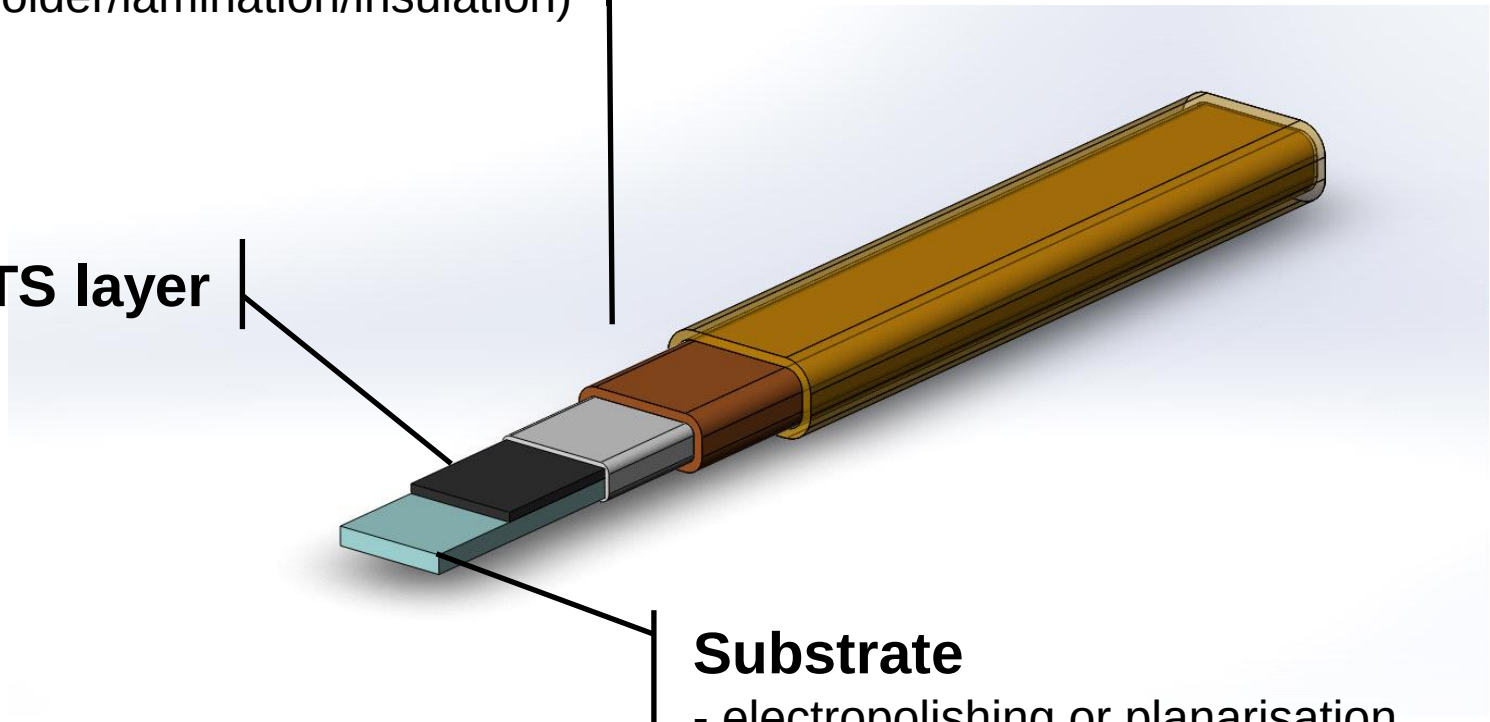
- Further integration

2G HTS wire: basic structure

SuperOx

Customisation
(silver/copper/solder/lamination/insulation)

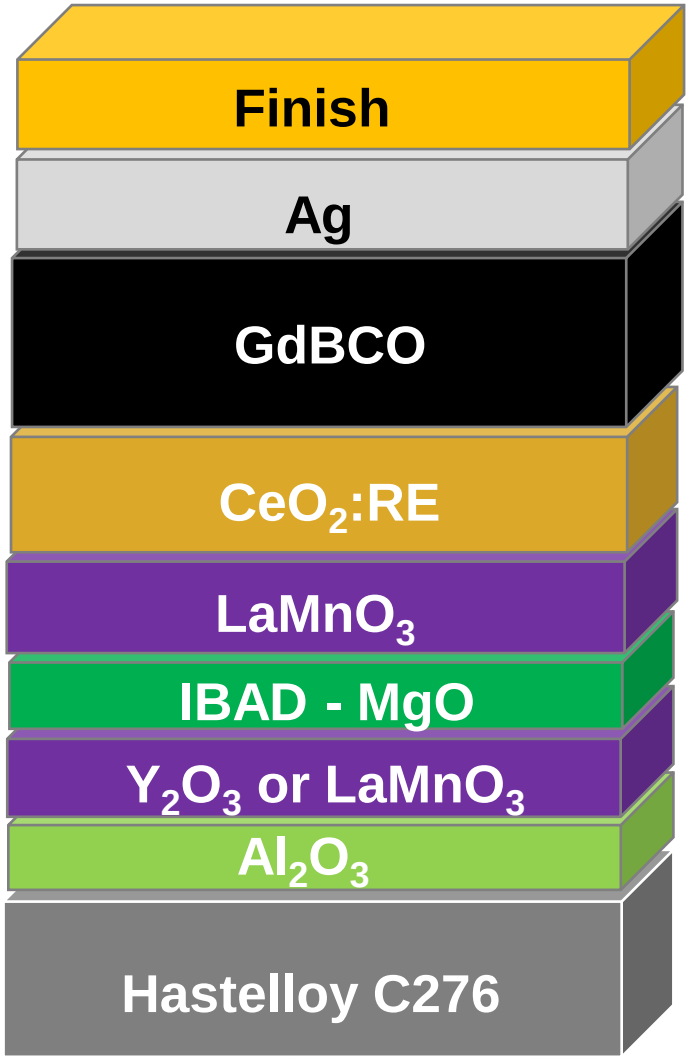
HTS layer



Substrate
- electropolishing or planarisation
- buffer layers

2G HTS wire: layer architecture

SuperOx



Customised finish tailored to application

DC sputtering (custom thickness)

PLD-2 (1-3 microns)

PLD-1 (100-200 nm)

Dual-Chamber: PLD system

RF sputtering (30-50 nm)

IBAD with RF sputtering (5-7 nm)

RF sputtering (30-50 nm)

RF sputtering (50 nm)

Single Chamber: RF sputter + IBAD

Cold rolled & electro polished (60-100 microns)

Production development

SuperOx

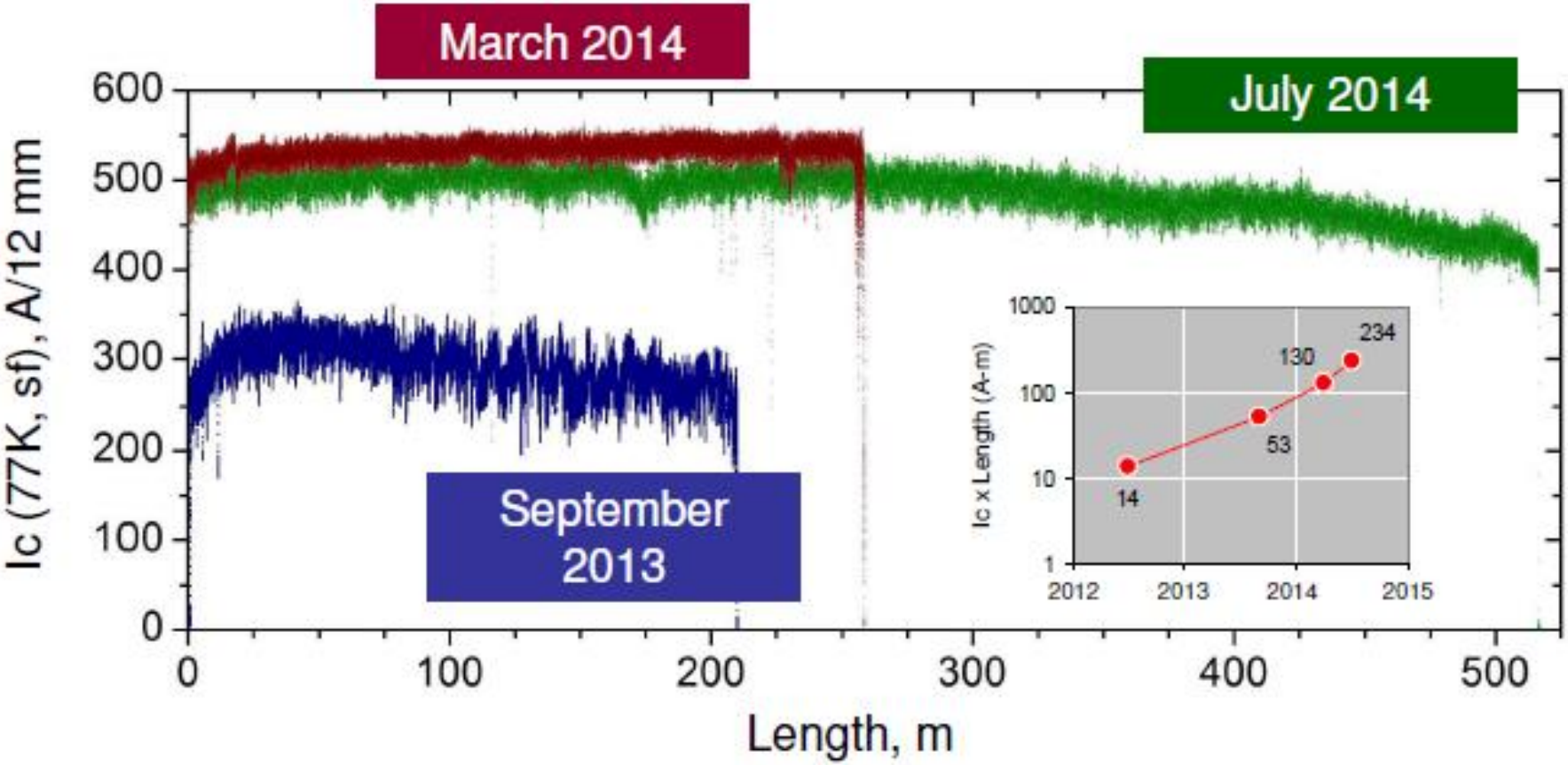
Present status: 2011-2015						
Moscow	**Substrate**	Buffer	HTS	**Ag**	**Cu**	**Finish**
Tokyo	Substrate	**Buffer**	**HTS**	**Ag**	Cu	Finish

Coming: 2015						
Moscow	**Substrate**	**Buffer**	HTS	**Ag**	**Cu**	**Finish**
Tokyo	Substrate	**Buffer**	**HTS**	**Ag**	Cu	Finish

Next step: 2016-…						
Moscow	**Substrate**	**Buffer**	**HTS**	**Ag**	**Cu**	**Finish**
Tokyo	**Substrate**	**Buffer**	**HTS**	**Ag**	**Cu**	**Finish**

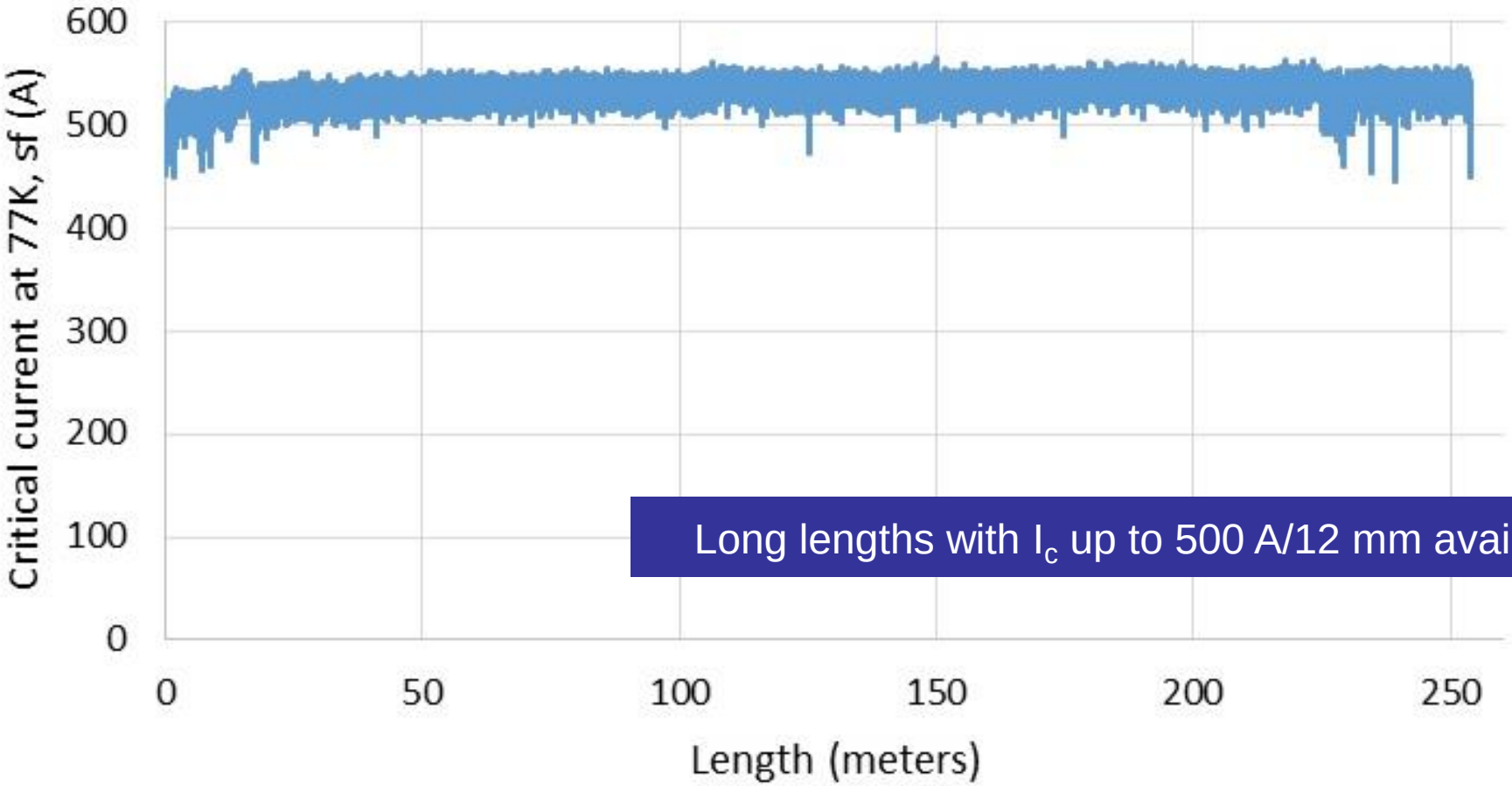
2G HTS wire: progress in production

SuperOx



2G HTS wire: 12 mm width

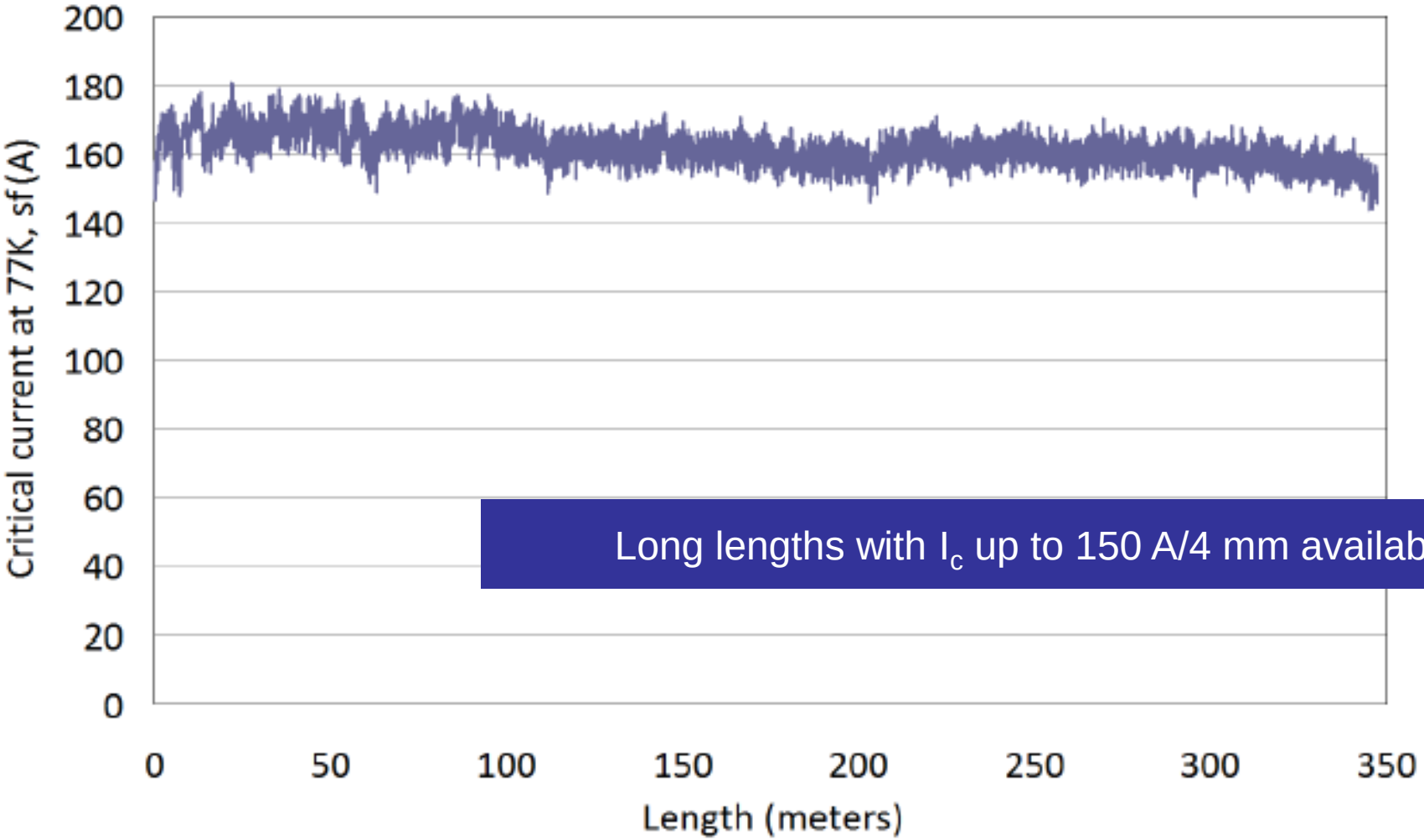
SuperOx



Long lengths with I_c up to 500 A/12 mm available

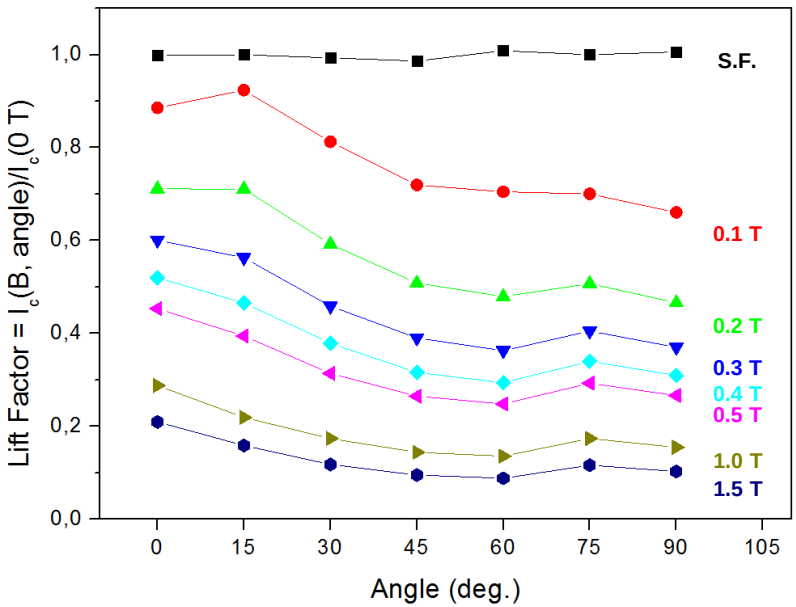
2G HTS wire: 4 mm width

SuperOx

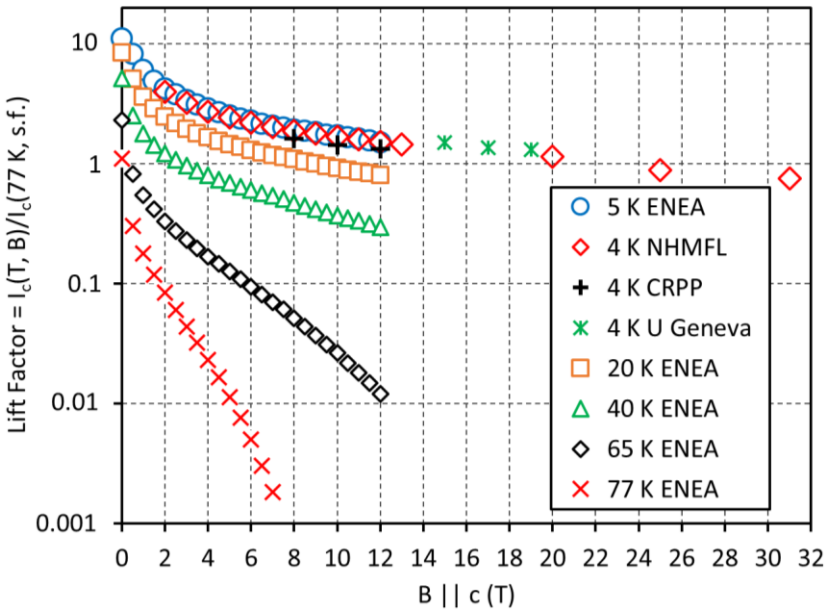


Long lengths with I_c up to 150 A/4 mm available

2G HTS wire: performance in magnetic field

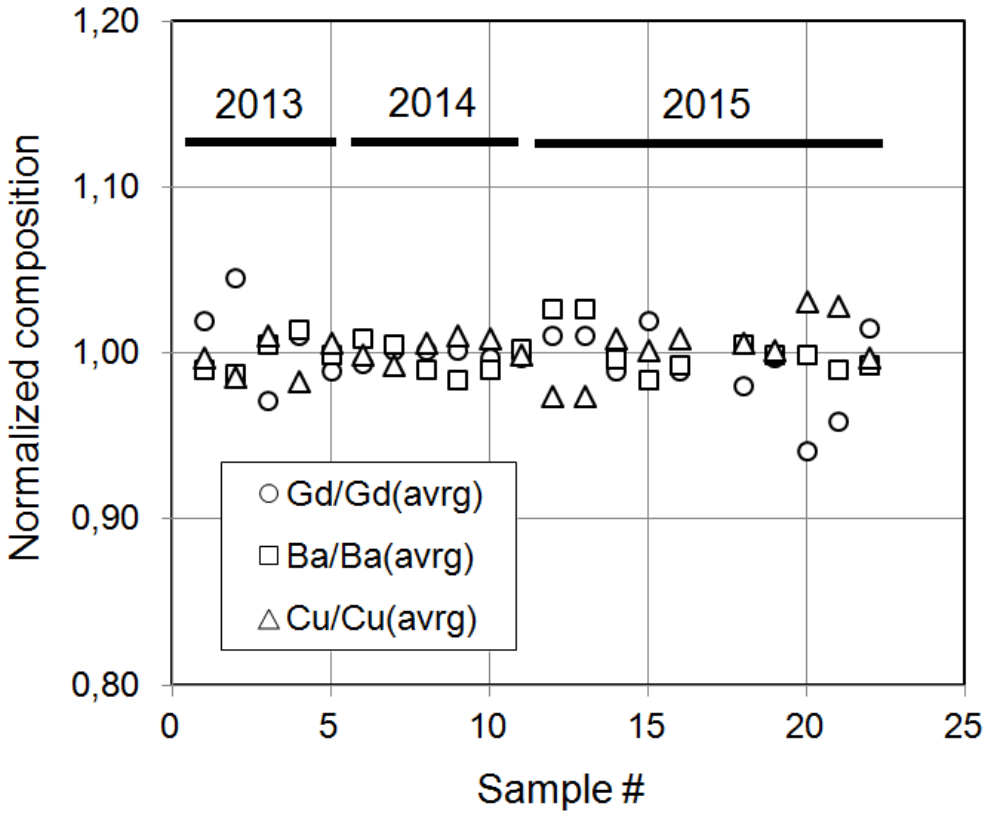


Low angular anisotropy



Reproducible lift factors

2G HTS wire: consistent HTS composition

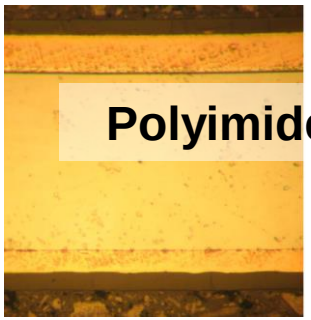


Consistent composition of the PLD-GdBCO layer
over years of production results in consistent wire performance

2G HTS wire: customisation

SuperOx

Manufacturer	Customisation options						
	Silver	Copper plating	Lamination	Surround polyimide	Polyimide wrapping	Solder plating	Tape stacks
AMSC	●		●		●		
Fujikura	●		●		●		
SuNAM	●	●	●		●		
SuperOx	●	●	●	●	●	●	●
SuperPower	●	●			●		

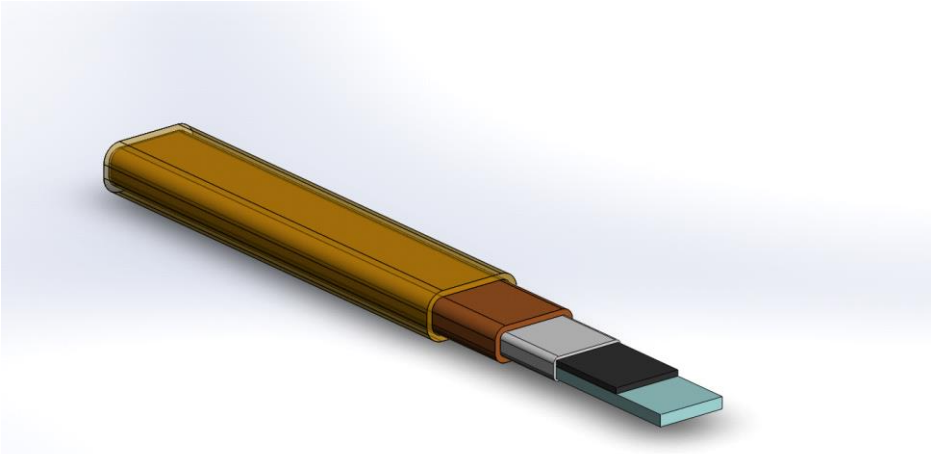


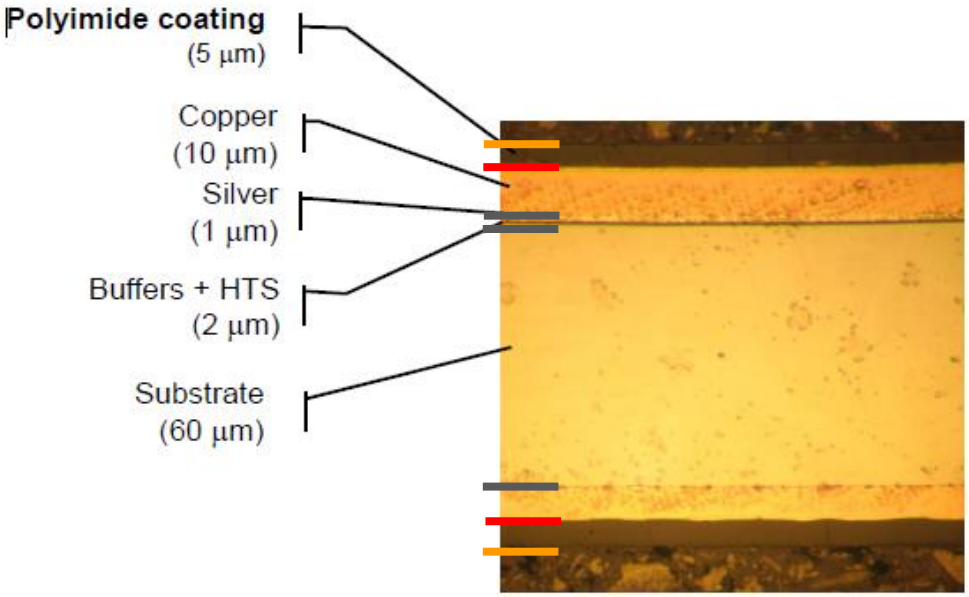
Polyimide deposition

Custom solder plating

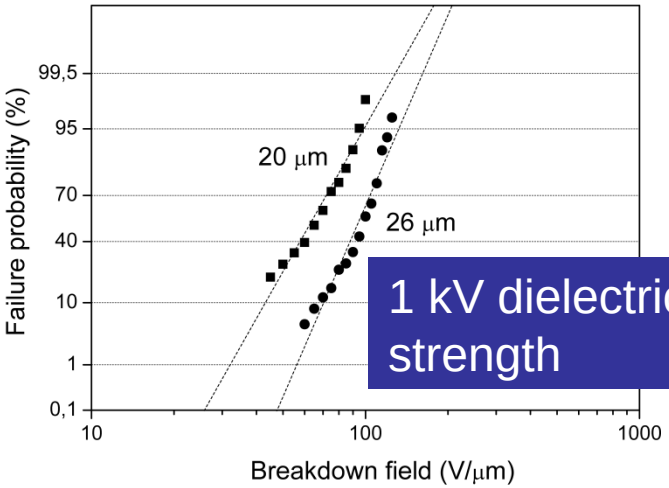
Custom copper plating

Customisation: surround polyimide coating

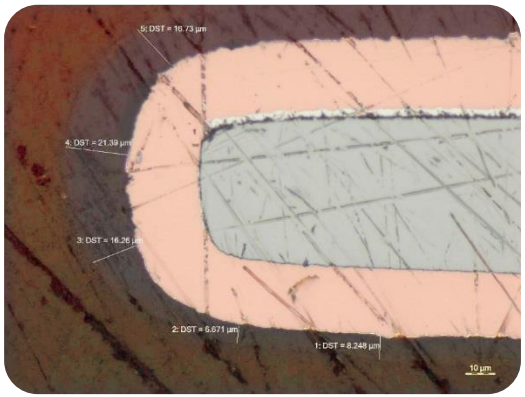




Thin PI layer: keeps J_e high



1 kV dielectric strength



Complete edge coverage

2G HTS wire: specifications

SuperOx

Parameter	Value	
Production Length	up to 500 meters	
Substrate Thickness	60–100 µm	
Tape width	4 mm	12 mm
Critical Current @ 77K, s.f.	100-150 A	300-500 A
J_e at 4.2 K, 20 T	> 400 A/mm^2	> 400 A/mm^2
Current Uniformity	±10%	±10%

Customisation:

+ Variable silver thickness
+ Variable copper thickness
+ Lamination
+ Insulation
+ Artificial pinning centres
+ Solder plating
+ Low resistance splices
+ … just ask

Outline

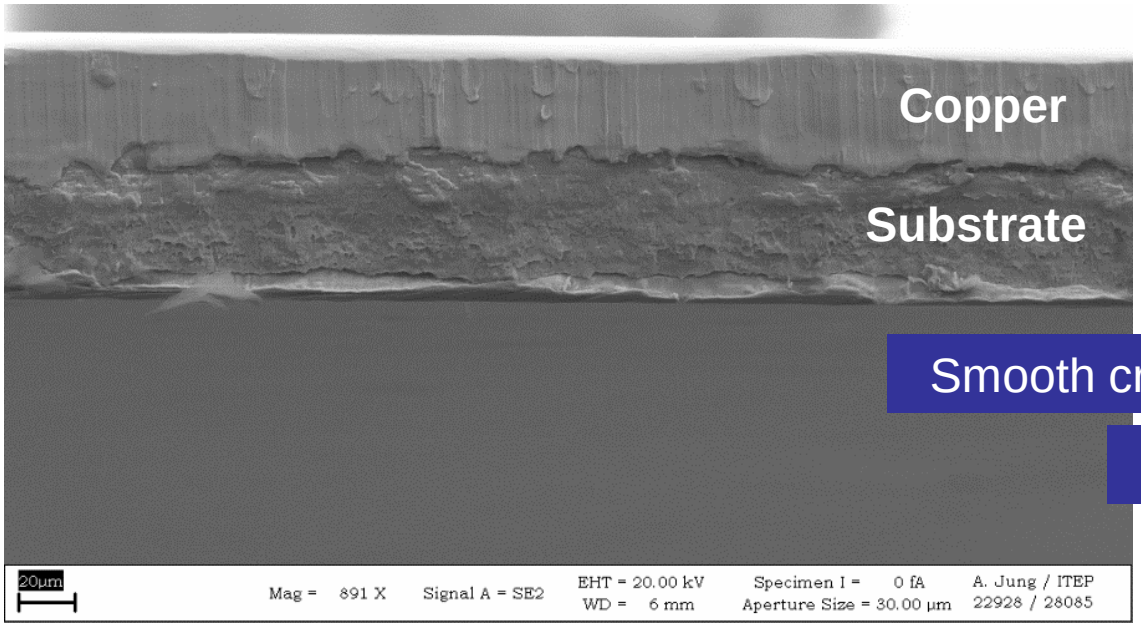
- The SuperOx group of companies
- The material: 2G HTS wire
- **Further integration**

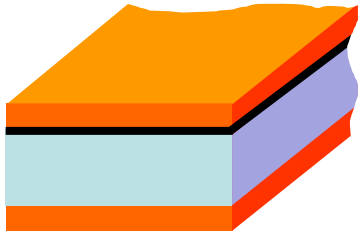
We want to deliver HTS solutions, not just the material

Integration: Roebel cables

Collaboration with Karlsruhe Institute of Technology, Dr. Anna Kario et al.

Standard way: coat-and-punch





Smooth cross-section of the punched edge

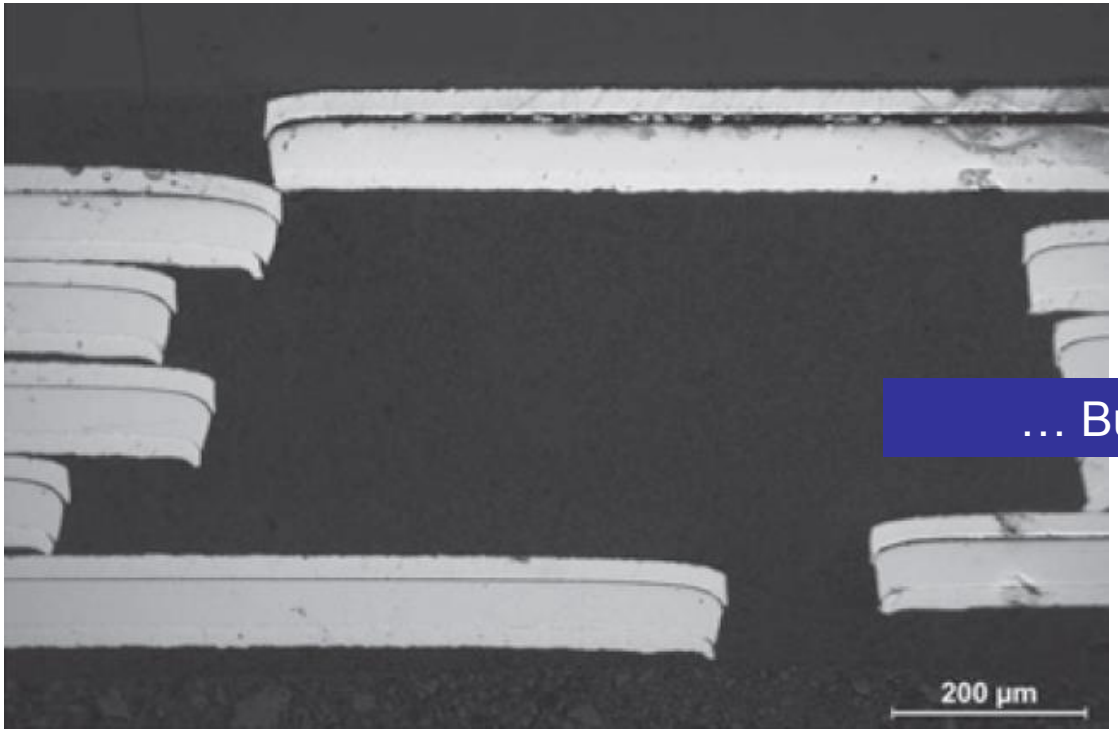
Cu gets smeared over HTS layer

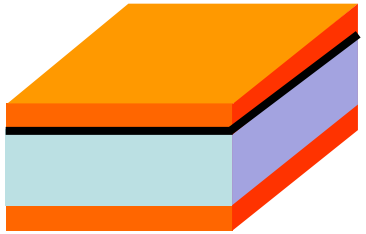
Well, most times …

Integration: Roebel cables

Collaboration with Karlsruhe Institute of Technology, Dr. Anna Kario et al.

Standard way: coat-and-punch





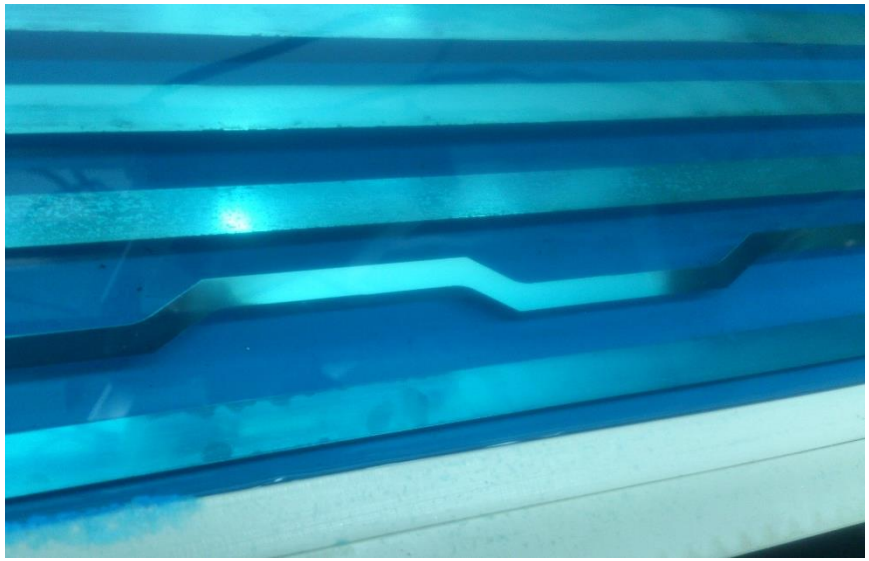
… But sometimes delamination occurs

S. Otten et al., SUST 28 (2015) 065014

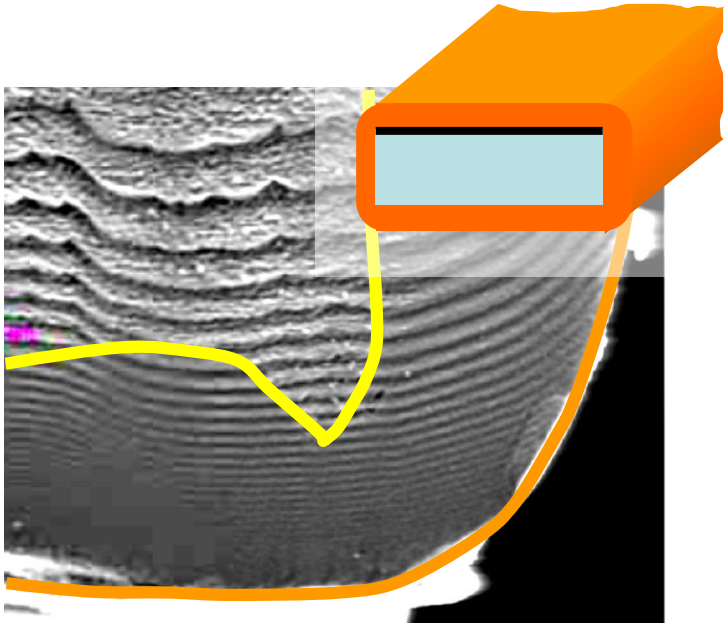
Integration: Roebel cables

Collaboration with Karlsruhe Institute of Technology, Dr. Anna Kario et al.

Novel alternative: punch-and-coat



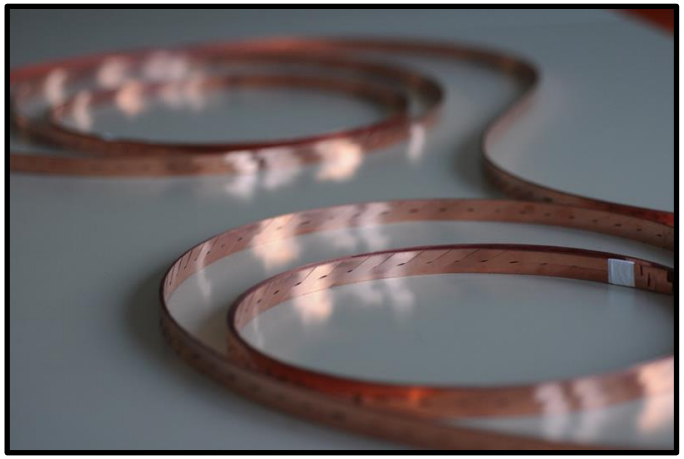
Cu-plating of a punched strand

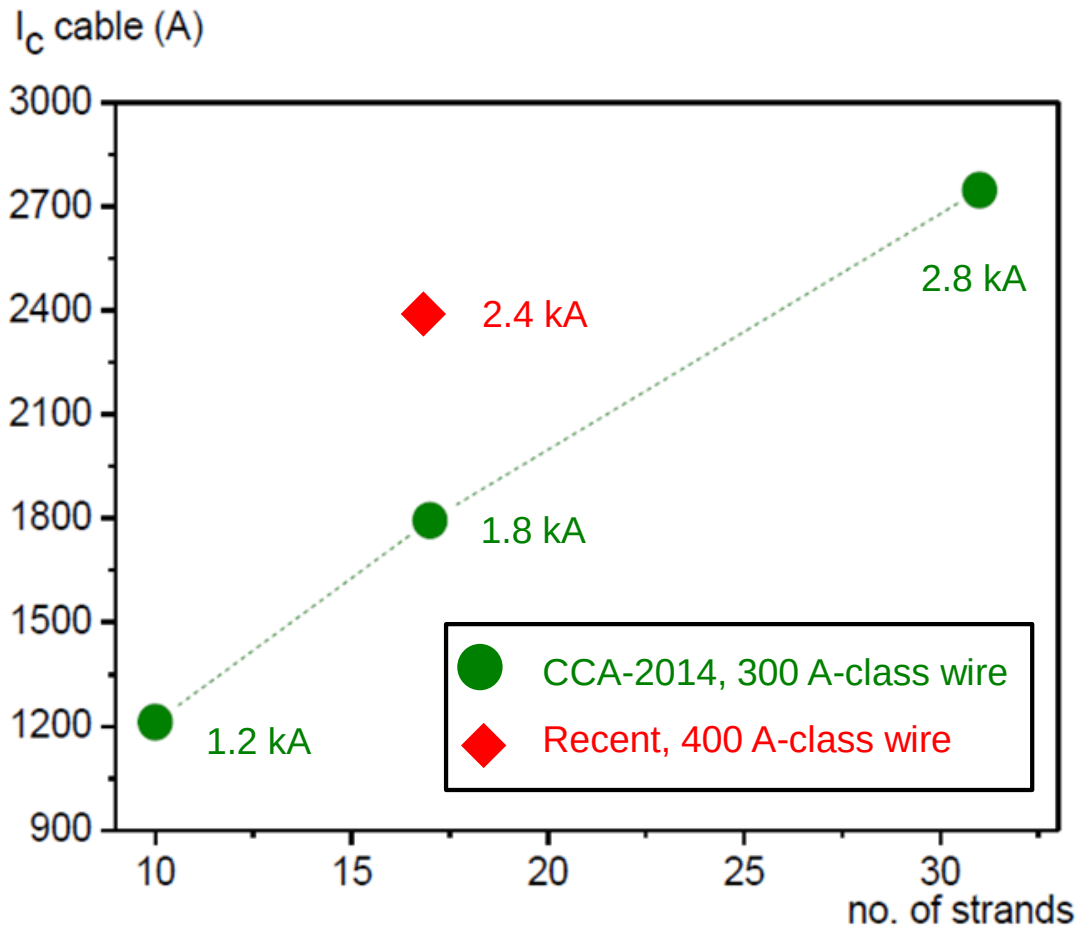


HTS layer fully enclosed
Sharp punch burr smoothed

Integration: Roebel cables

Collaboration with Karlsruhe Institute of Technology, Dr. Anna Kario et al.





Coat-and-punch results

Integration: Roebel cables

SuperOx is acquiring own machinery for Roebel cable fabrication

Will provide advanced punch-and-coat cable

Filamentisation for AC loss reduction

Collaboration with KIT

Finish-and-striate:

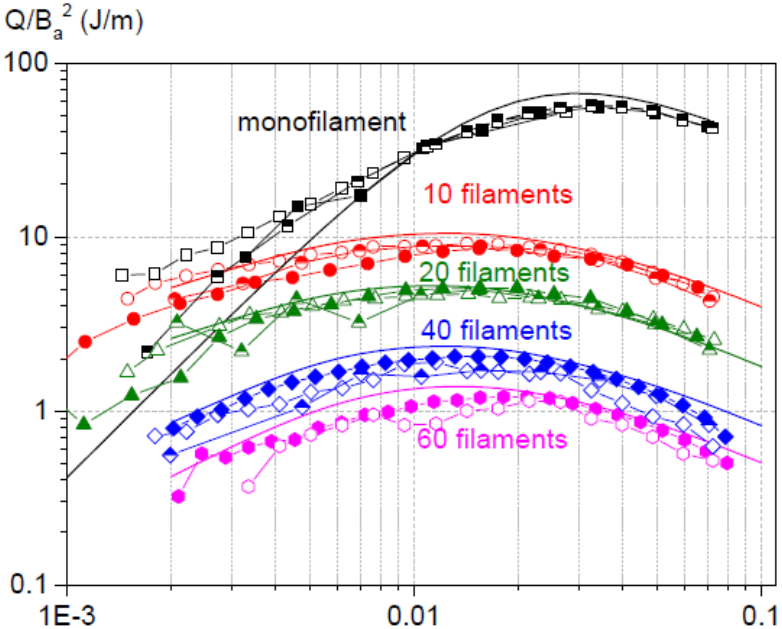
- SuperOx provides wire with different finish: 0-5-10-20 μm Cu
- KIT makes up to 120 laser striations and AC measurements

Striate and finish:

- KIT striates Ag-coated wire
- SuperOx electroplates 5-7-10 μm Cu

At SuperOx (new):

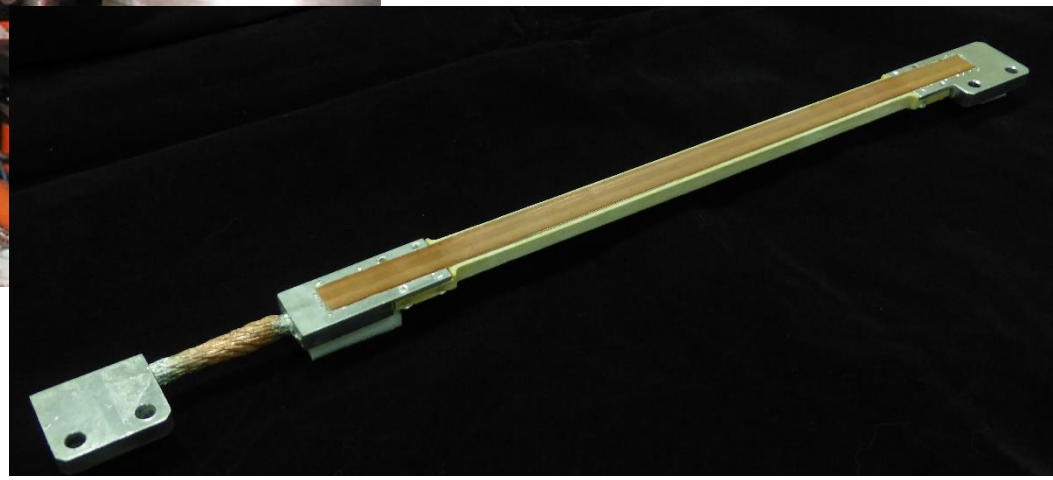
- Develop reel-to-reel chemical etching 100 μm grooves, 1 mm filaments



Graph from Anna Kario's talk on Monday M1OrC-01

Current leads for LTS magnets

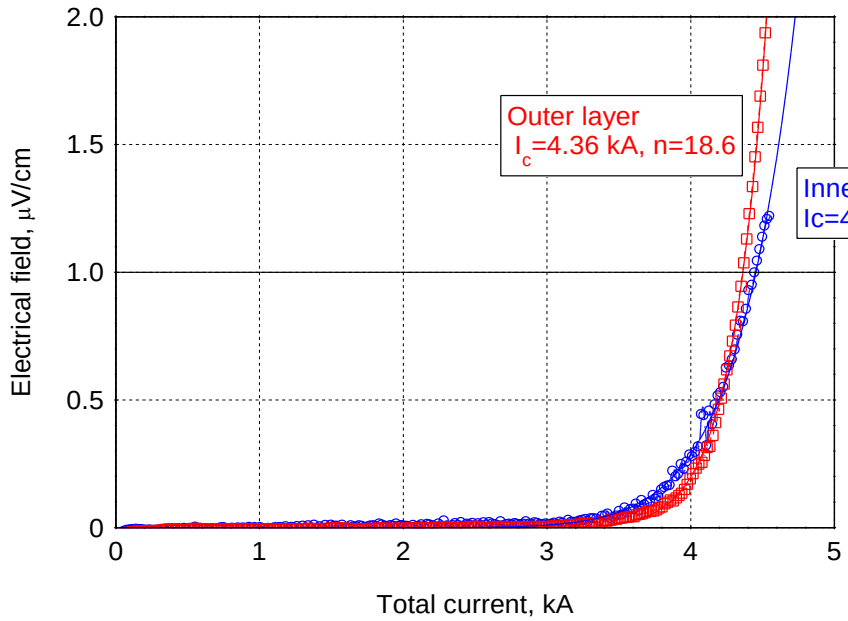
Nuclotron LTS magnets
NICA collider, Dubna JINR

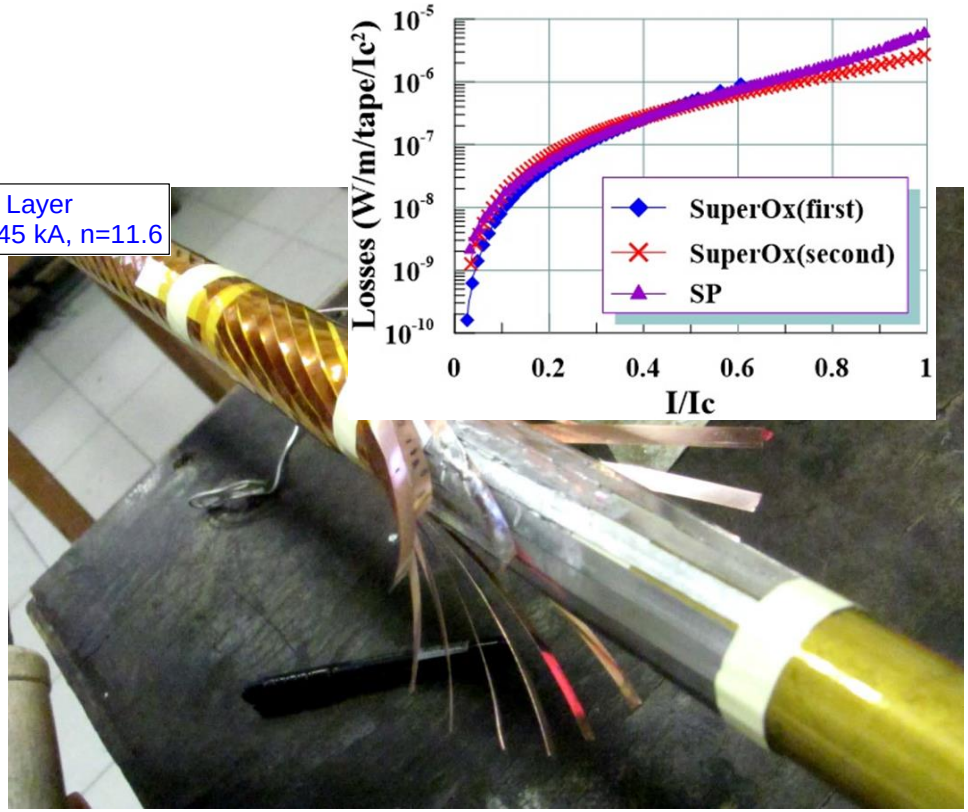


SuperOx's custom 100 A HTS current lead for a corrector coil of an LTS magnet

2G HTS coaxial cables

Cooperation with Russian cable Institute (VNIIKP), Dr. Vitaly Vysotsky





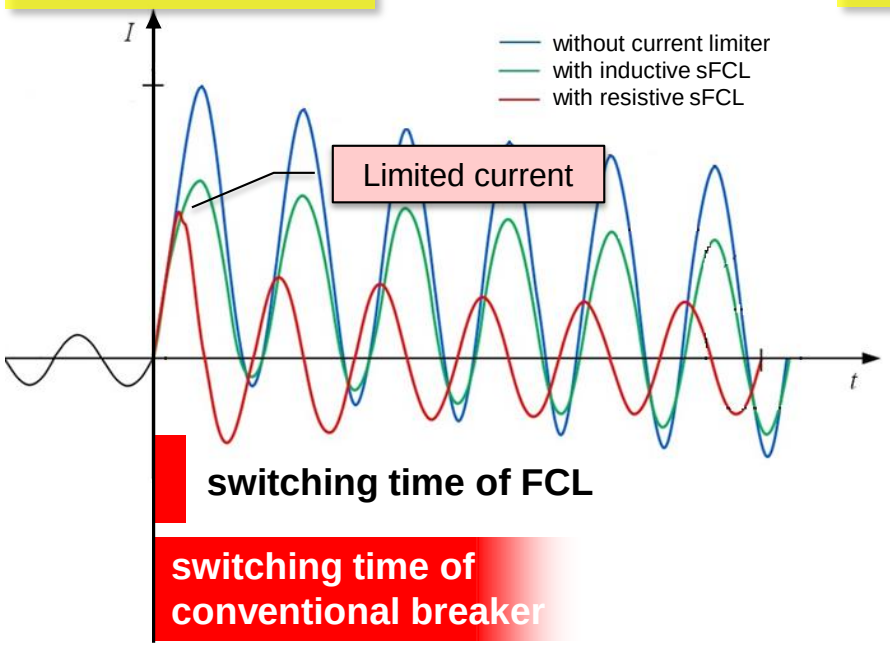
Low level of AC losses confirmed

HTS Fault Current Limiter (FCL)

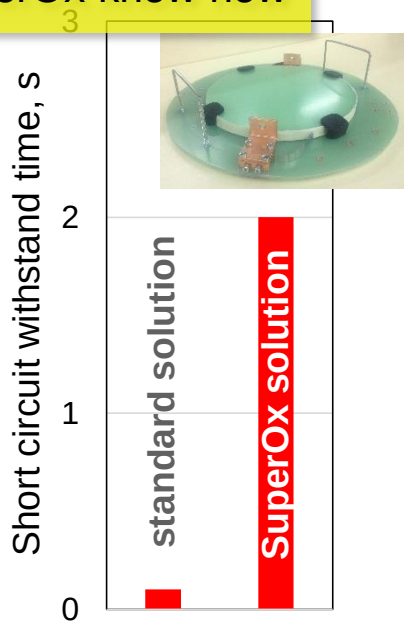
SuperOx

■ FCL is extremely needed equipment for power utilities, as well as for electric infrastructure of railways, large industry, ships, etc.

Operation of FCL



SuperOx know how



Main features

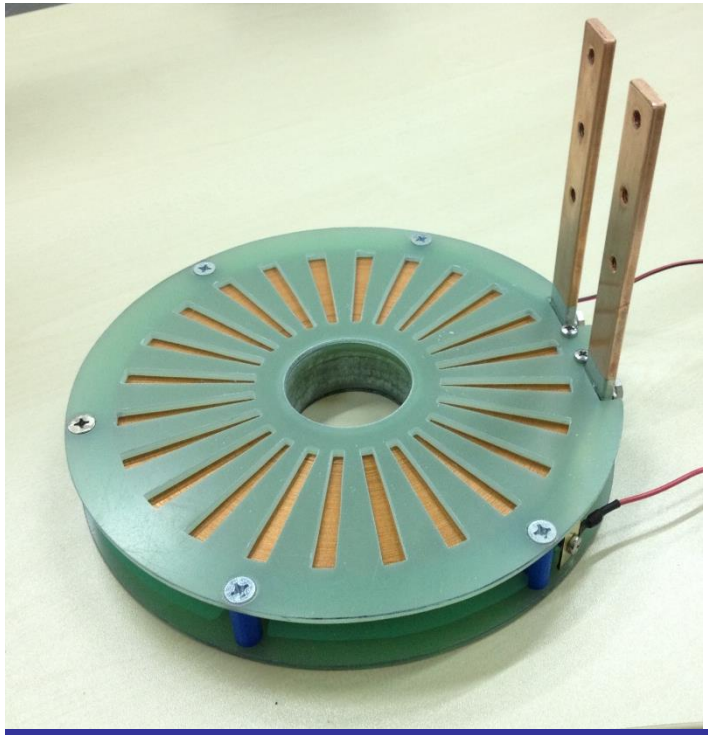
- up to 220 kV
- up to 5 kA
- no inductance
- low losses
- 3 ms switching time
- self-recovery

Three FCL machines are being built with SuperOx 2G HTS tape: two in Russia and one in France

Magnets / coils

Double pancake coil

- Made of polyimide coated Cu plated tape
- Magnetic field 1 T at 77 K without core
- Operation current up to 120 A
- 84 000 Amps*Turns.



1 T double pancake coil

2G HTS blocks: composite bulk

SuperOx

- Blocks made from 2G HTS wires provide stable levitation over PM
- Viable alternative to HTS bulks – any shape and size possible

Superconductor Week Commercialization · Markets · Products Business Developments · R&D · Cryogenics

October 30, 2014 Vol. 28, No. 10

- EQUS REPORTS CONTACT BETWEEN DISTANT QUBITS
- NANJING ENHANCES SC IN $BISE_2$ COMPOUND
- OST/BRUKER COMPLETE ITER TF COIL WIRE
- LMU SYNTHESIZES HIGHER-T_C FERROMAGNET
- NORMAL STATE NODAL ELECTRO
- CAMBRIDGE INVESTIGATES CDW IN CUPRATES
- QUANTUM FLUCTUATIONS
- BNL OBSERVES QUANTUM FLUCTUATIONS AT 0 K
- HKU/TOHOKU REPORT SPECIFIC HEAT DATA FOR V_3SI
- *SUPERCONDUCTIVITY ROUNDUP*
- *SUPERCONDUCTIVITY STOCK INDEX*
- *U.S. SUPERCONDUCTIVITY PATENTS*

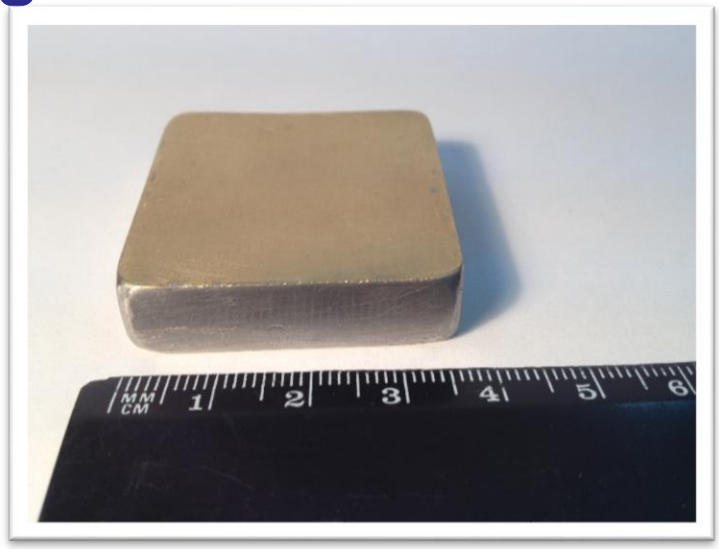
SuperOx Announces HTS Material for Maglev Applications

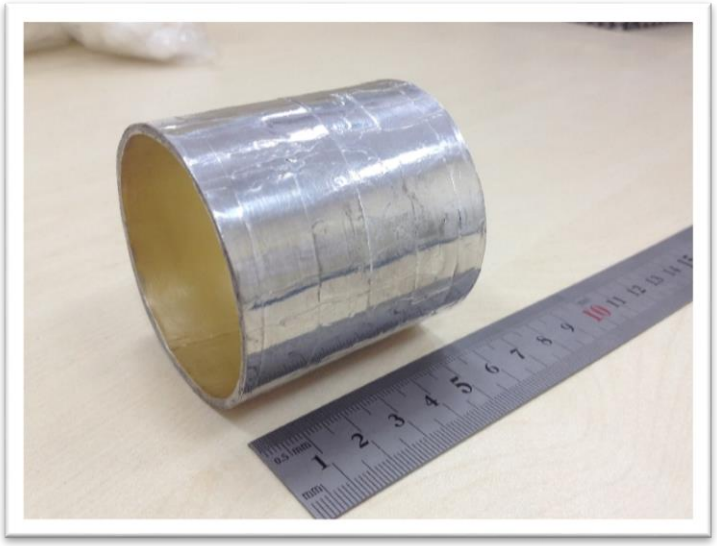
Russian HTS company SuperOx has announced the development of a new superconducting material for Maglev and other devices that can be produced more easily and cheaply than existing alternatives. The new technology, which utilizes 2G HTS tapes, is suitable for the creation of multi-layered blocks that could take the form of thin plates, cylinders, or bricks.

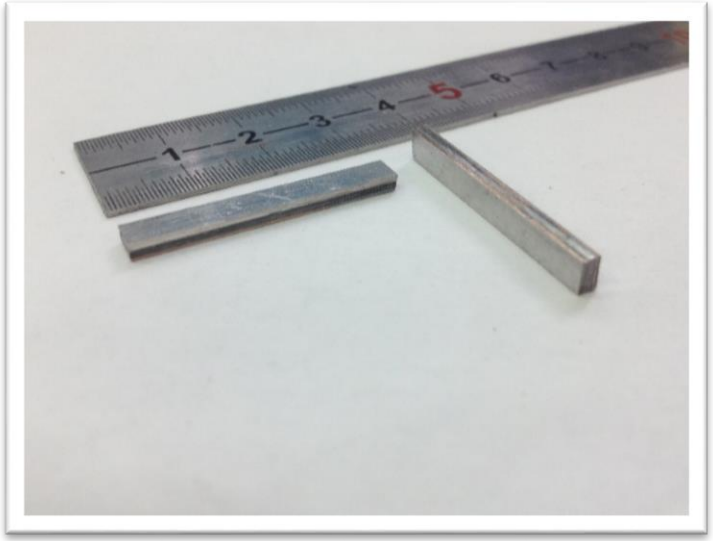
Previously, HTS ceramics intended for Maglev applications took approximately four months to create. The resulting products were brittle, could only be manufactured in small quantities, and required a high amount of rare earth materials.

By now, SuperOx has built 2G HTS blocks with levitating force of over 200 kg

Tape stacks, composite bulk blocks, magnetic field shields

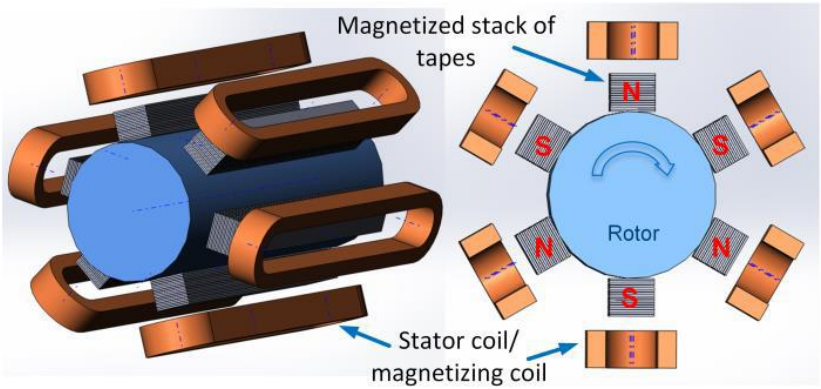


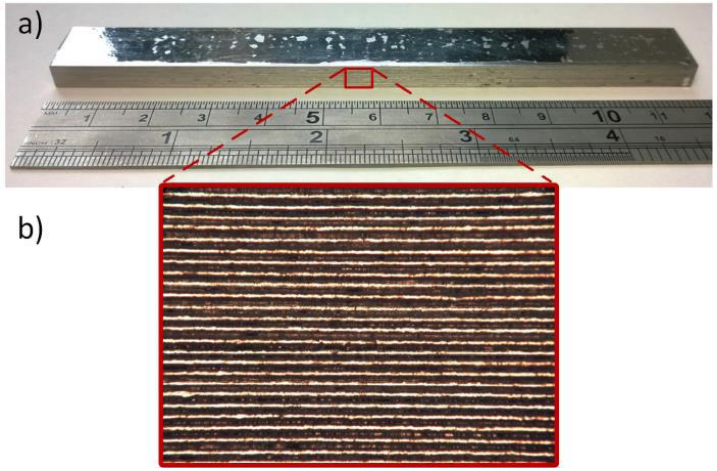




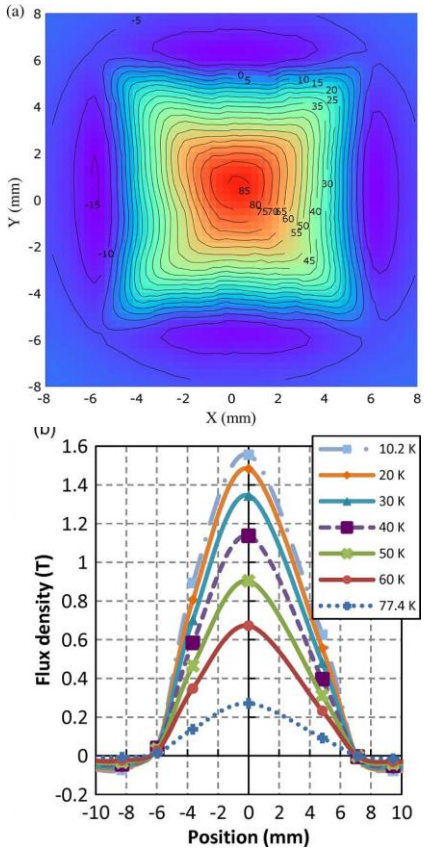
2G HTS composite bulk

Collaboration with University of Cambridge, Dr. Anup Patel et al.





A. Patel et al.
IEEE Trans. Appl. Supercond., 25(3) 2015



A. Baskis et al.
IEEE Trans. Appl. Supercond., 25(3) 2015

Summary

SuperOx

• The SuperOx group of companies
On the market, quick and efficient

• The material: 2G HTS wire
Good for all applications

• Further integration
We want to deliver HTS solutions, not just the material

THANK YOU FOR YOUR ATTENTION

www.superox.ru