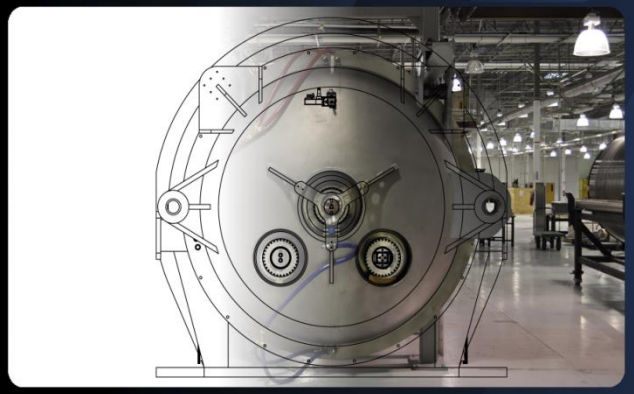
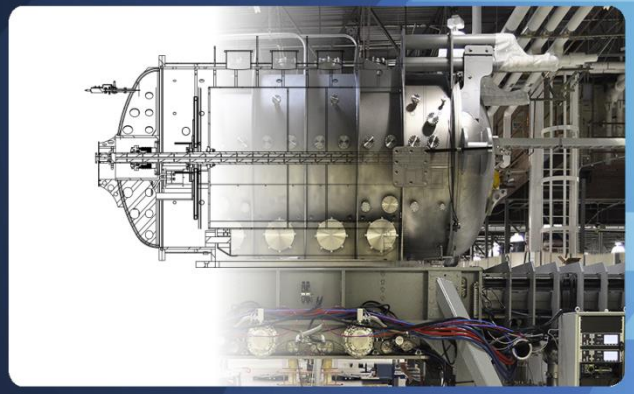
2G HTS Coated Conductors 1 km Scale-Up at STI

CERN Presentation
Feb 16, 2016





STI®
SUPERCONDUCTOR TECHNOLOGIES INC.

Safe Harbor Provisions

Statements in this press release regarding our business that are not historical facts are "forward-looking statements" that involve risks and uncertainties. Forward-looking statements are not guarantees of future performance and are inherently subject to uncertainties and other factors, which could cause actual results to differ materially from the forward-looking statements. These factors and uncertainties include, but are not limited to: our limited cash and a history of losses; our need to materially grow our revenues from commercial operations and/or to raise additional capital (which financing may not be available on acceptable terms or at all) in the very near future, before cash reserves are depleted (which reserves are expected to be sufficient well into the first second quarter of 2016), to implement our current business plan and maintain our viability; and the performance and use of our equipment to produce wire in accordance with our timetable; overcoming technical challenges in attaining milestones to develop and manufacture commercial lengths of our HTS wire; the possibility of delays in customer evaluation and acceptance of our HTS wire; the limited number of potential customers; the limited number of suppliers for some of our components and our HTS wire; there being no significant backlog from quarter to quarter; our market being characterized by rapidly advancing technology; the impact of competitive products, technologies and pricing; manufacturing capacity constraints and difficulties; our ability to raise sufficient capital to fund our operations (whether through registered direct offerings or otherwise), and the impact on our strategic wire initiative of any inability to raise such funds; the impact of any financing activity on the level of our stock price, which may decline in connection with the sales under registered direct offerings or otherwise; the dilutive impact of any issuances of securities to raise capital; and local, regional, and national and international economic conditions and events and the impact they may have on us and our customers.

Forward-looking statements can be affected by many other factors, including, those described in the "Business" and "Management's Discussion and Analysis of Financial Condition and Results of Operations" sections of STI's Annual Report on Form 10-K for the year ended December 31, 2015 and in STI's other public filings. These documents are available online at STI's website, www.suptech.com, or through the SEC's website, www.sec.gov. Forward-looking statements are based on information presently available to senior management, and STI has not assumed any duty to update any forward-looking statements.

Superconducting Wire Innovation

Superconducting wire is to power, as fiber optics was to telecom

- Focused on ***Smart Grid*** market opportunity:
  - **Grid Reliability** - Outages are increasing, costing billions of dollars
  - **NEW Renewable energy sources** - Distributed power requires interconnection
  - **Growing demand for more power** - Aging grid must be transformed to support growth
- **Sustainable production advantages -** Technological superiority and patent portfolio
- **Commercial scale production now operational**
  - **Installed capacity of 750km/annually in late 2014 -** $15M in CAPEX invested
  - State of the art factory, ***expandable by 5X***
- **Growing customer demand for product qualification and approval**
  - Shipped wire to 37 customers globally as of Q3/2016
  - Focused on Fault Current Limiters, Magnets and Cables
- **Completed Public Funding Q4/2016 – Gross proceeds of $10 M in working capital to ramp volume**

DOE focused on Enabling Technology for NG Machines

Award	$4.5M November 2016
Provider	U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) on behalf of the Advanced Manufacturing Office (AMO)
Prime Recipient	Superconductor Technologies Inc.
Focus	Next Generation Electric Machines (NGEM) program: To improve the superconductive wires manufacturing process at high enough temperatures where nitrogen can be used as the cryogenic fluid to improve performance and yield while reducing cost. Objective: 1440A/cm @ 65K in 1.5T Field, and improved cost performance

"Advancing these enabling technologies has the potential to boost the competitiveness of American manufacturers and take the development of more efficient electric machines a giant step further. These technology R&D projects aim to significantly improve industrial motors for manufacturing, helping companies who use these motors in manufacturing save energy and money over the long run."

Mark Johnson, director of the EERE Advanced Manufacturing Office

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Our best-in-class partners for DOE project

"TWMC recognized the immense value of superconductor technology for high-power electric machines early, and we are committed to their commercialization. We look forward to collaborating to develop the transformational technology needed to achieve commercial viability of high power superconducting next-generation electric machines."

Pat Rogers, President, TWMC

"STI's goal of high performance at low cost can be a game changer for a wide range of applications, not only at temperatures near liquid nitrogen, but also at lower temperatures."

Joseph V. Minervini, Plasma Science and Fusion Center Assistant Director, MIT

"By bringing together university knowledge and capabilities from MIT and UNT with STI, a world class manufacturer of superconducting materials, and TWMC, the end user and device maker with over 100 years of experience in motor design and application, the full range of research and development to product manufacturing and wide scale commercialization of superconducting materials will be achieved."

Dr. Marcus L. Young, Assistant Professor Materials & Science Engineering, UNT

(4)-Step Superconducting Wire Manufacturing

SDP

1km x

100 mm

Ceramic Coating

SST / C-276

1

IBAD

1km x 12mm

MgO

Template

2

RCE

1km x 12mm

2G HTS + Ag Cap

3

METALS

(Optional)

Ag / Cu / Other

Varying Thick (µm)

4

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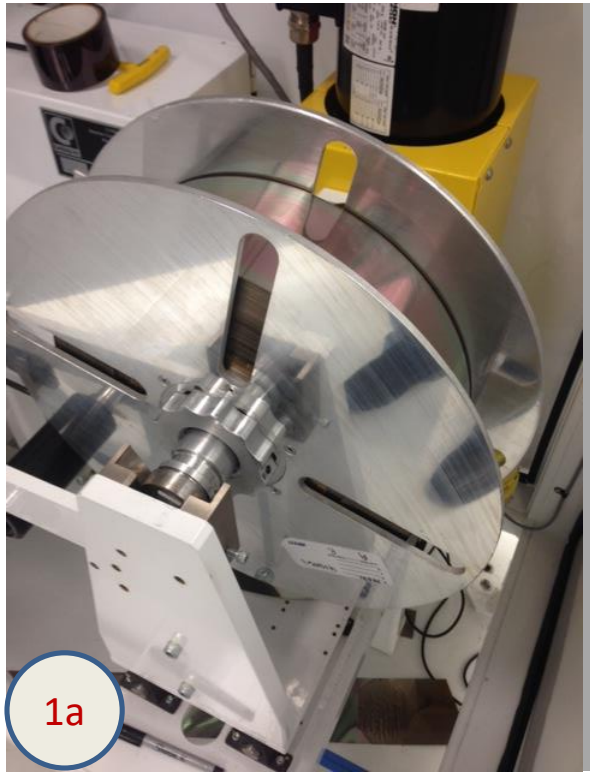
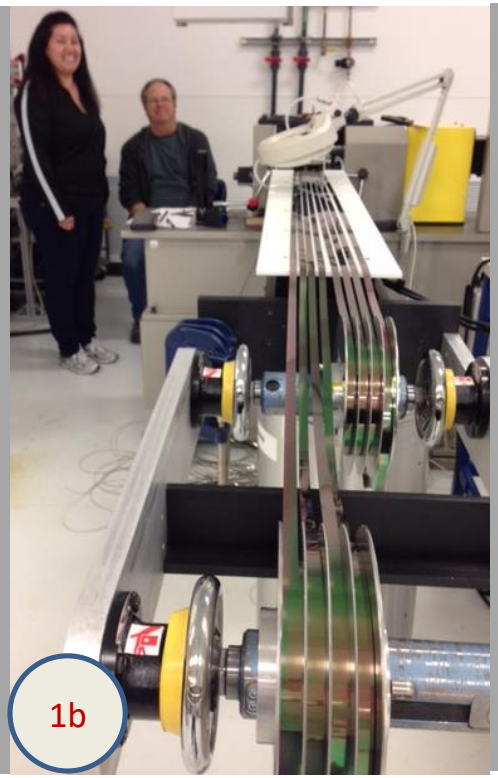
STEP 1 - 1km SDP Planarized Tape

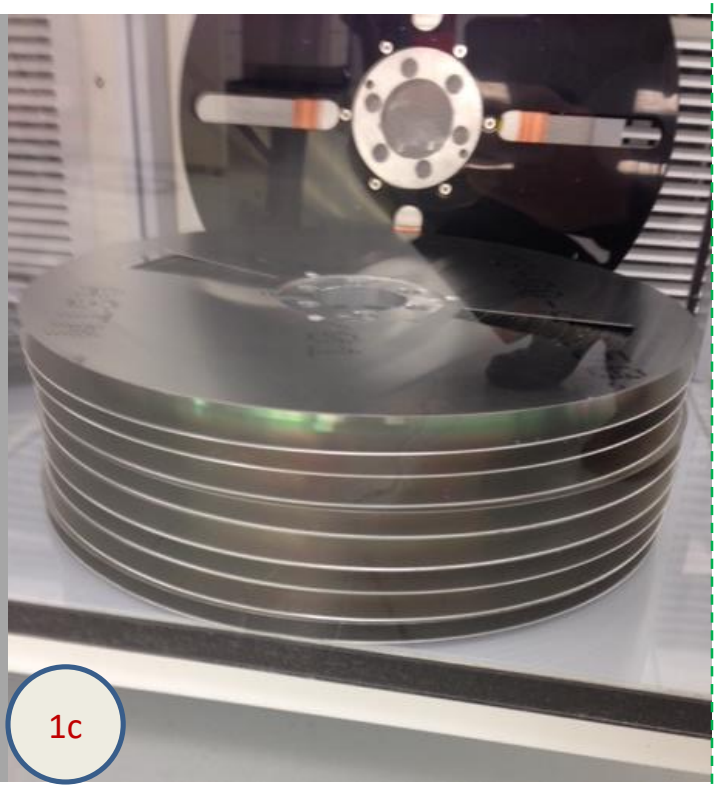
1km x 100mm Wide
Ceramic/SDP
Coated Substrate

EXAMPLE:
Slitting to (8X) 12mm Wide
(Typical Product Dimension)

(8X) 1km length Reels
12mm width Planarized
Coated Substrate







Atmospheric
Reel-to-Reel Process

OPTIONAL Slitting Width – Product Configuration Flexibility

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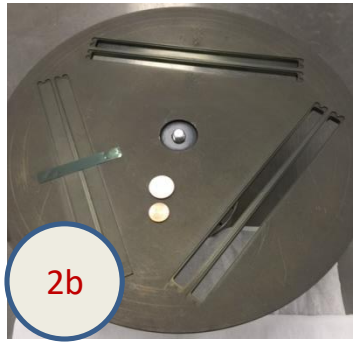
STEP 2 - 1km IBAD Template & Qualification

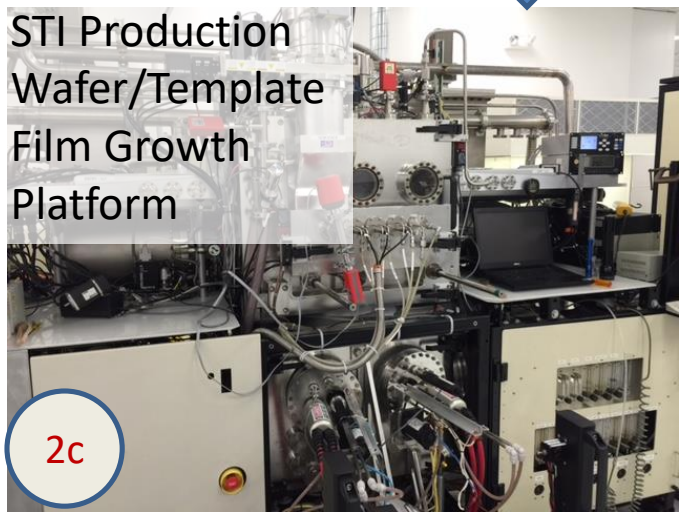
Vacuum

Reel-to-Reel

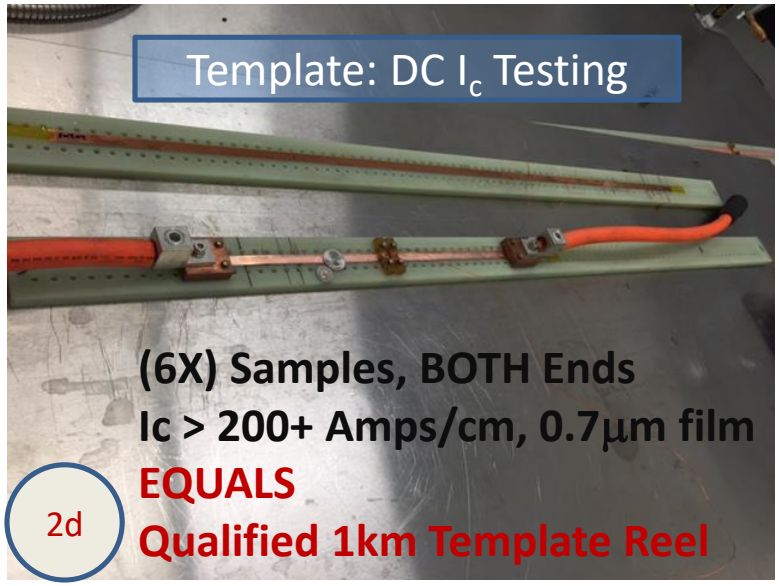
Template Quality Control



Load (6x) 20 cm Samples from 1km Reel START & END



Grow Standard 0.7µm Recipe REBCO on (6X) 20 cm tapes



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STEP 3 – 1km Superconducting Tape Coating

Preparing Drum for Template Loading

Atmospheric Plasma Clean drum surface after previous cycle.
Dry clean, no chemicals.

Template Loading

700+ meters loaded onto drum cartridge.
Ready for 2G HTS film deposition

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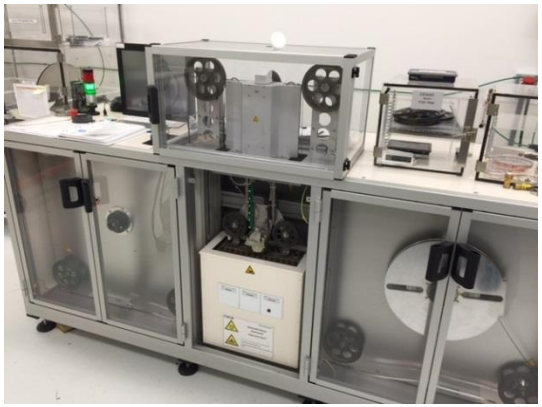
STEP 3 - 1km Superconducting Tape Production

PHOTO:

Loading Drum w/ Template into 1km Deposition System

STEP 3 - 2G HTS Tape Completed // Measure

UNLOADING:
12mm x 400 meter length (RE)BCO HTS with Silver cap layer



METROLOGY: TapeStar XL Atmospheric, Reel-to-Reel

Tape Product Width:	3mm	4mm	10mm	12mm	100mm (tbd)
Batch Size: (meters)	3000	2150	1000	850	100
Capacity: Kilometers/Year/Machine	950	750	300	250	25

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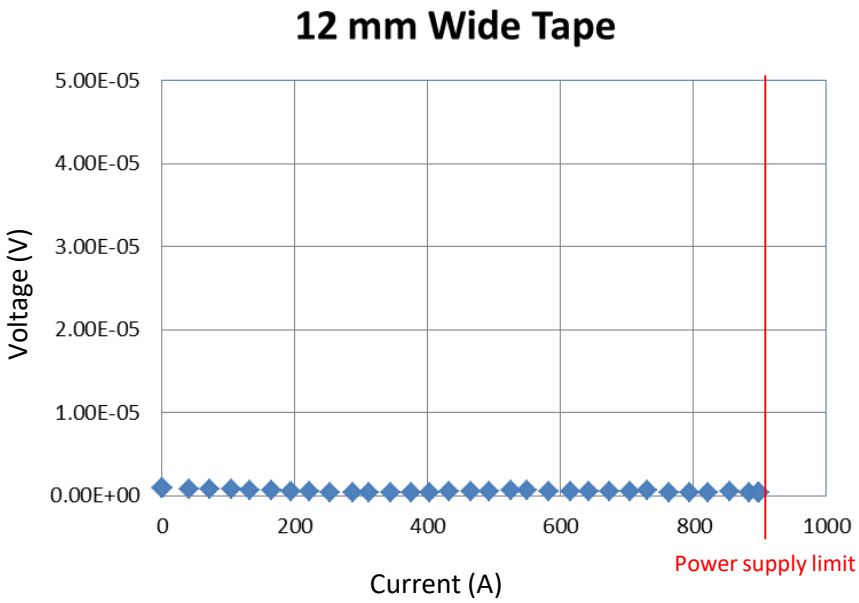
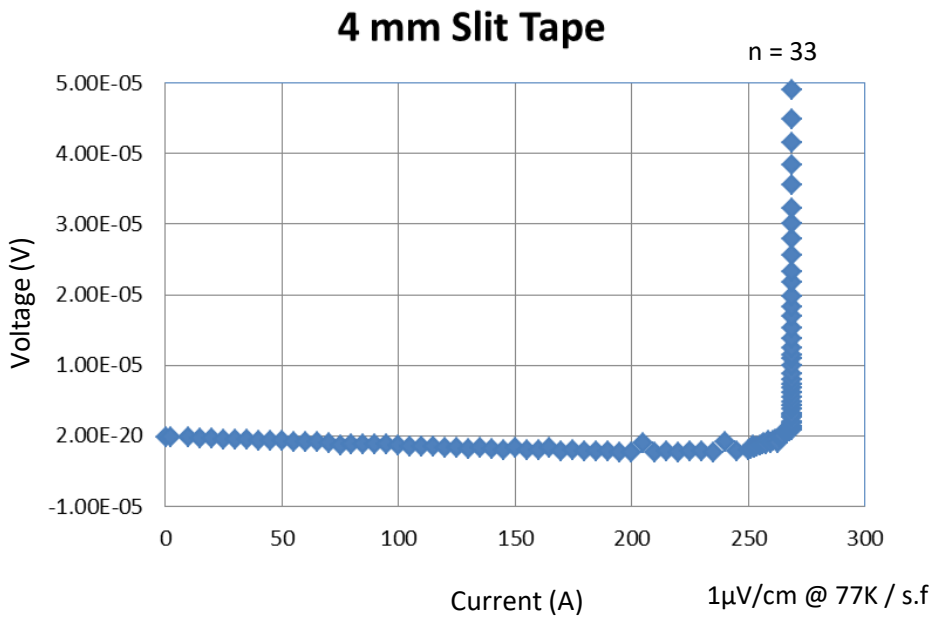
Conductus® Ic Measurement

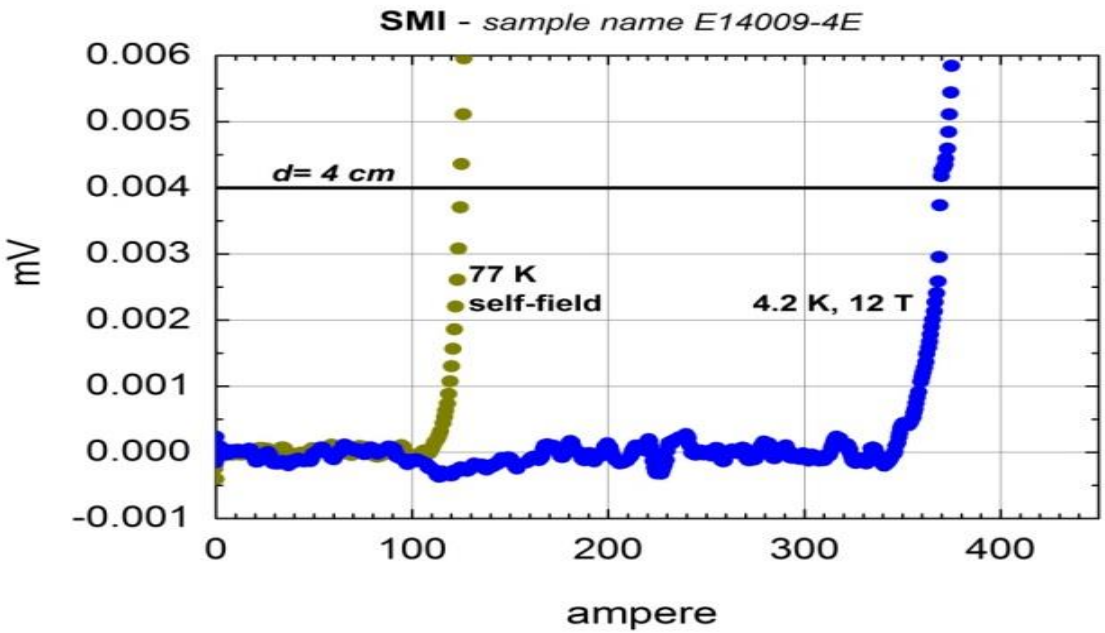




Direct Ic measurement maxed out at 900A for 12 mm tape (power supply limit)

- Slit same tape to 4mm and measured 269A
- This corresponds to 807A – lower than 12 mm due to slitting loss (~ 10%)
- 4mm tape cut on both edges

Conductus® Hi-Field Performance



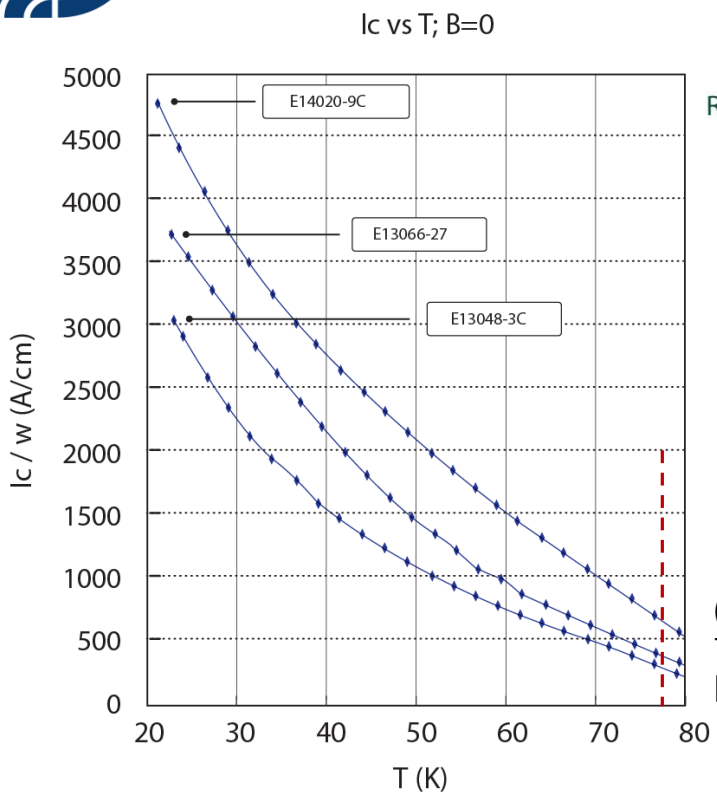
PAUL SCHERRER INSTITUT

4mm wide wire

Low temperature measurements show high performance potential of STI 2G Tape

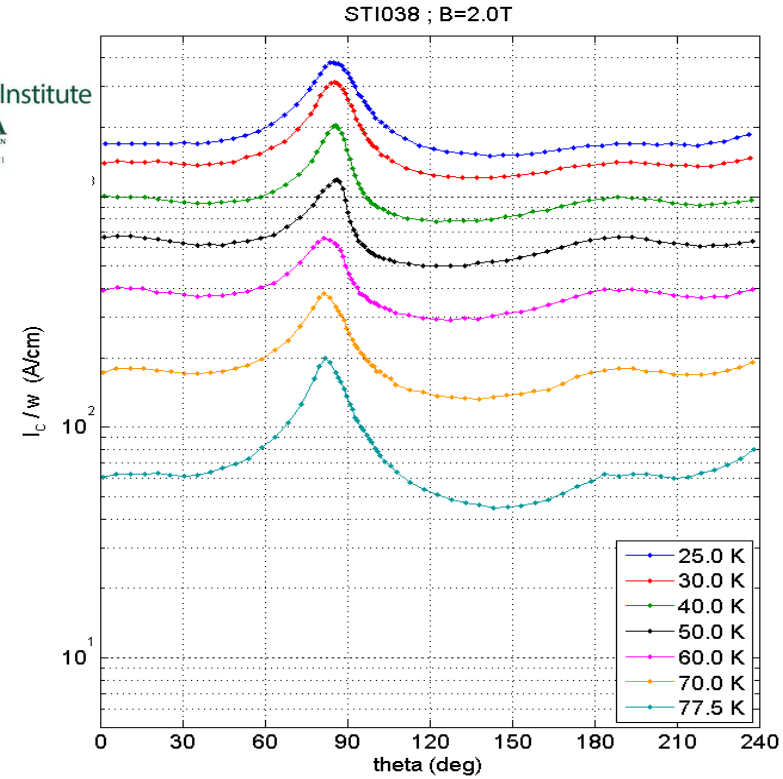
- 930A/cm@ 4.2K, 12T perpendicular to wire
- **New test data** - improves Ic performance by over 32%
- Retains high N-value

Conductus® Low Temperature Performance



Robinson Research Institute
VICTORIA UNIVERSITY OF WELLINGTON
TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

(3) Samples
77K I_c
[300-600] A/cm



Low temperature measurements show high performance potential of STI 2G Tape

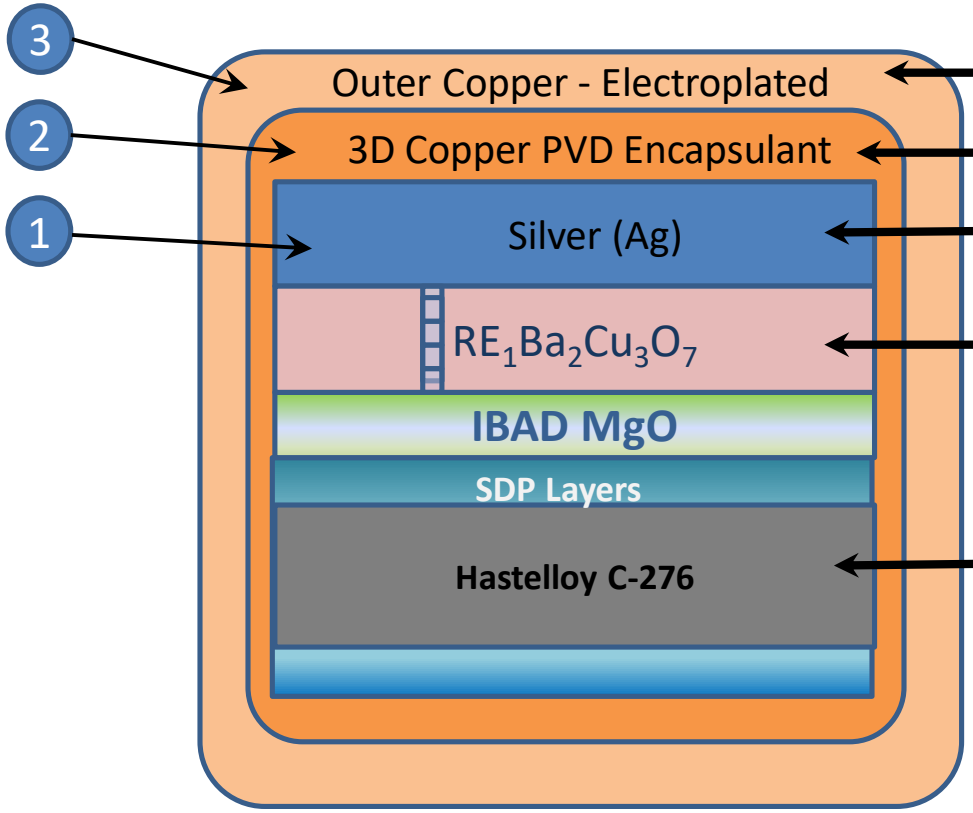
- I_c Correlation between 77K →30K values *using STI Process for 2G Film Growth*
- 600A @77K SF improves by a factor of 8 = 4800A @20K
- Angular Scan In-Field performance, 2 Tesla 77K→25K
- No artificial pinning center

STEP 4 – Added Metal Layers (Optional)

Optimized per Application;
SFCL // CABLE // MAGNET // Low Temp (4K) // ETC..

Metals:

Thickness: (microns)



[3-75] 99.9% Cu Electroplating

[0.5-1.5] 99.9% Cu PVD

[1-2] 99.9% Silver In-Situ Evap.

[2-4] (RE)BCO HTS Film

[100] Substrate

2G HTS Tape Cross-Section View
[3 / 4 / 8 / 10 / 12 /…100 mm Tape Widths]

Summary

- STI has 750km/year 4mm 2G HTS wire capacity.
- A variety of metal coating options available for;
  - Cables, SFCL's, Magnets, & Other Applications
- I_c Range [400-800] Amps/cm @ 77 Kelvin, Self Field
  - Ongoing R&D to further improve performance
- Flexible batch system enables unique process optimizations
  - Substrate Width Flexibility [3-12mm (now) → 3-100mm (future)]
  - High-Field Intrinsic Pinning
  - Multi-Layers without breaking vacuum
- Production capacity can be expanded by adding (3)-Step equipment set.
- Accepting multi kilometer orders now!