Bruker Energy & Supercon Technologies (BEST)

AREAS: BRUKER HTS: Task 14.5 AT A GLANCE

Video conference: June 26th 2017

BRUKER HTS: AREAS TASK 14.5

- **Task 14.5. HTS innovative process for accelerator magnet conductor** (CERN, CEA, BHTS, UNIGE , UT)

- Define the characteristics of the new generation higher performance/lower cost HTS tape
- Define the new process for halving the production cost and doubling the Jc eng.
- Demonstrate pilot production (5 to 15 m long) and verification of higher performance (Jc eng > 600 A/mm^2 - vs. 400 for Eucard2 - at 4.2 K and 20 T).
- Fabricate at least two long length cables (80-100 m) and verify their electrical, mechanical and magnetic properties (see above).
- Test two long lengths cables in a dipole magnet capable of 5-8 T

BRUKER HTS: TASK 14.5 Content 1/4

Task 14.5. HTS innovative process for accelerator magnet conductor (CERN, CEA, BHTS, UNIGE , UT)

This task, under the leadership of CERN, will be devoted to a breakthrough in the cost reduction of industrial High Temperature Superconductors (HTS) for high magnetic fields. It is based on the technical success of EuCARD-2 (WP10), where HTS conductor parameters suitable for accelerator magnet have been reached and qualified. The specificity of this task in the Innovation WP, is to foster an industrial development of HTS YBCO/REBCO (Rare earth - Barium - Copper Oxide) tapes intended to bridge the gap between technical performance and readiness for application.

BRUKER HTS: TASK 14.5 Content 2/4

Task 14.5. HTS innovative process for accelerator magnet conductor (CERN, CEA, BHTS, UNIGE , UT)

Today the BHTS company, also thanks to EuCARD-2 has reached world record Jc and Jc eng at 20 T (field perpendicular to broad face of tape) and 4.2 K. The scope of the task is to decrease by a factor four the present cost of the HTS tapes, expressed in kA-m. In order to achieve this goal, two main steps are envisaged:

1) **increase of Jc eng by a factor two, aiming at a minimum of 600 A/mm2 and targeting 800 A/mm^2, at 4.2 K, 20 T**;

2) decrease by a factor of two the total cost of production. Critical in this step of **doubling the process output** are new faster and more precise methods for Alternating Beam Assisted Deposition (buffer layers) and electroplating, however all production stations will be reviewed, from the substrate preparation to copper sheathing via electroplating, passing though deposition of buffer layers and YBCO (or REBCO) deposition via laser pulsed laser and silver coating)

BRUKER HTS: TASK 14.5 Content 3/4

Task 14.5. HTS innovative process for accelerator magnet conductor (CERN, CEA, BHTS, UNIGE , UT)

The above described objective must be reached without degrading the good electric, mechanical and magnetic properties reached in EuCARD2 HTS tapes. Therefore, to accomplish the task, a tight collaboration between Industry and Laboratories is needed, to define the tape parameters, to measure the results and to qualify the tapes on short samples and after cabling. Eventually, the tapes will be completely qualified by winding to a coil, either with single tape or with cable (like Roebel or other type of cables).

CERN and CEA in mutual agreement with BHTS will define the general parameters of the tapes; **BHTS will develop the new technology and set up as well the testing and operate the innovative HTS line for obtaining short lengths (5-15 m) of tape. Then, as final stage, the production of tapes will be expanded to long lengths (80-100 m).**

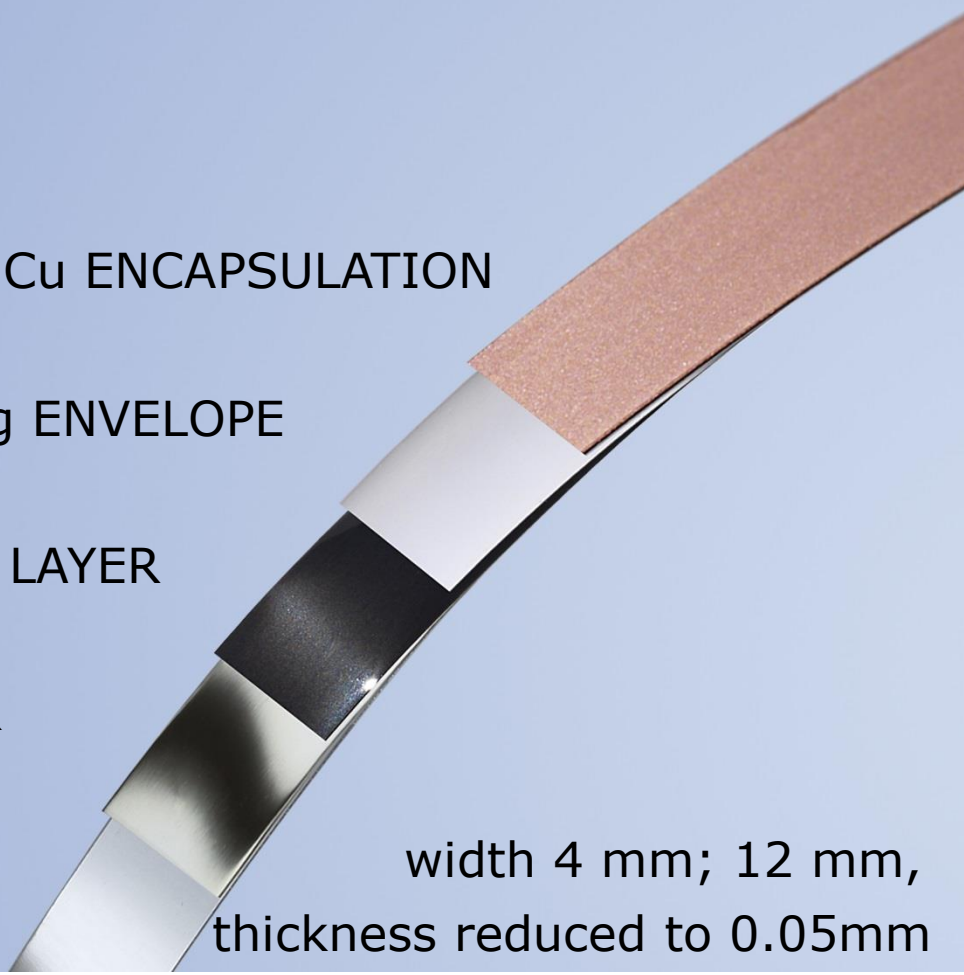
BRUKER HTS: TASK 14.5 Content 4/4

Task 14.5. HTS innovative process for accelerator magnet conductor (CERN, CEA, BHTS, UNIGE , UT)

UNIGE and UT will measure critical current of short samples under various conditions: temperature at 4.2 K and high field, in various field angle and vs. stress (longitudinal and compressive, with and without impregnation) as well as magnetization and power losses vs. frequency. CERN and CEA, in addition to coordinating the effort, will take care of cabling, through the partner of EuCARD-2 WP10 collaboration, and the testing of the long lengths in a HTS coil, to verify that the new process has equal or even better technical characteristics with respect to present world record tapes of BHTS. The goal of the magnet, a dipole of accelerator type, is to reach 5 to 8 T (8 T being the field level of the LHC dipole). This prototype magnet will have a bore and a reasonable field quality that makes it suitable, in perspective, for collider magnet.

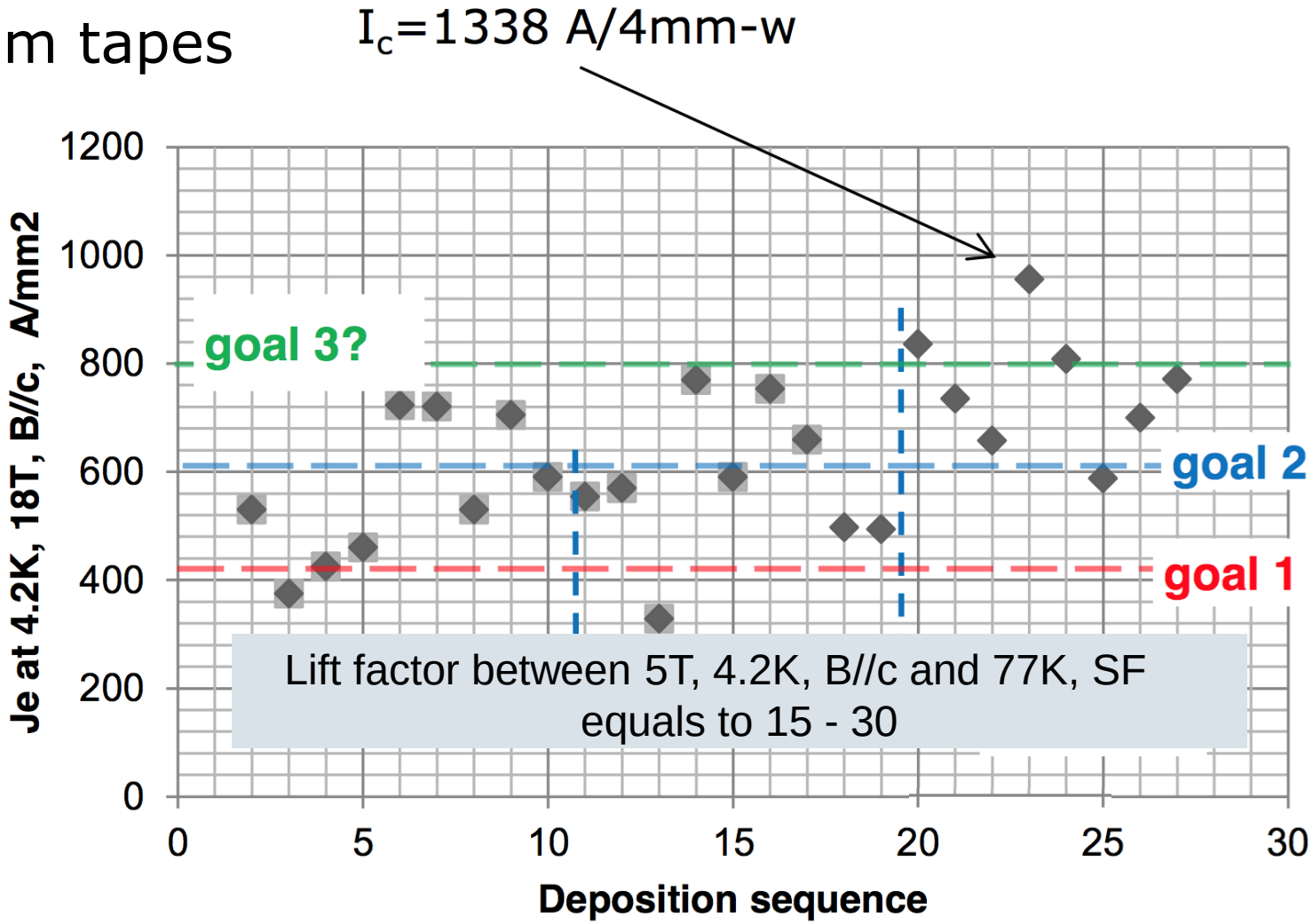
BRUKER HTS: TASK 14.5: Draft Workplan 1/3

- **"ARIES" configuration of high Je HTS coated conductor for in-field application**



Motivation
based on earlier results

30 m tapes



BRUKER HTS: TASK 14.5: Draft Workplan 1/3

1. Ic assurance: Analysis of 50 µm-thick tape processing along the entire processing chain

   1.1. Development of advanced art for tape handling (including tape winding/re-winding, rinsing, new degree for tape “hygiene”, implementation of interleaf tape, …)

   1.2. Polishing (tension, tool pressure, …)

   1.3. ABAD (tape tension, regimes, thickness, …)

   1.4. PLD (tape tension, temperature, deposition speed, …)

   1.5. Ag deposition (budget for length extension,)

   1.6. Cu-electroplating (reduced dog boning, …)

   1.7. Adjust quality assurance QA and process control PC for processing the thin HTS tapes

BRUKER HTS: TASK 14.5: Draft Workplan 2/3

2. Reduction of production costs

2.1. Increasing yield
- All processing steps

2.2. Increasing processing speed
- Applying E-polishing process to 12mm tapes

2.3. Reduction of materials and consumables
- Reduction of Xe consumption
- Reduction of He(l) consumption
- Alternative solution to Cu plating

2.4. Increasing production performance
- Increasing PLD batch size
- Alternative way for tape translation

result will be a combination of process improvements and theoretical evaluations for prospective

BRUKER HTS: TASK 14.5: Draft Workplan 3/3

3. Samples foreseen

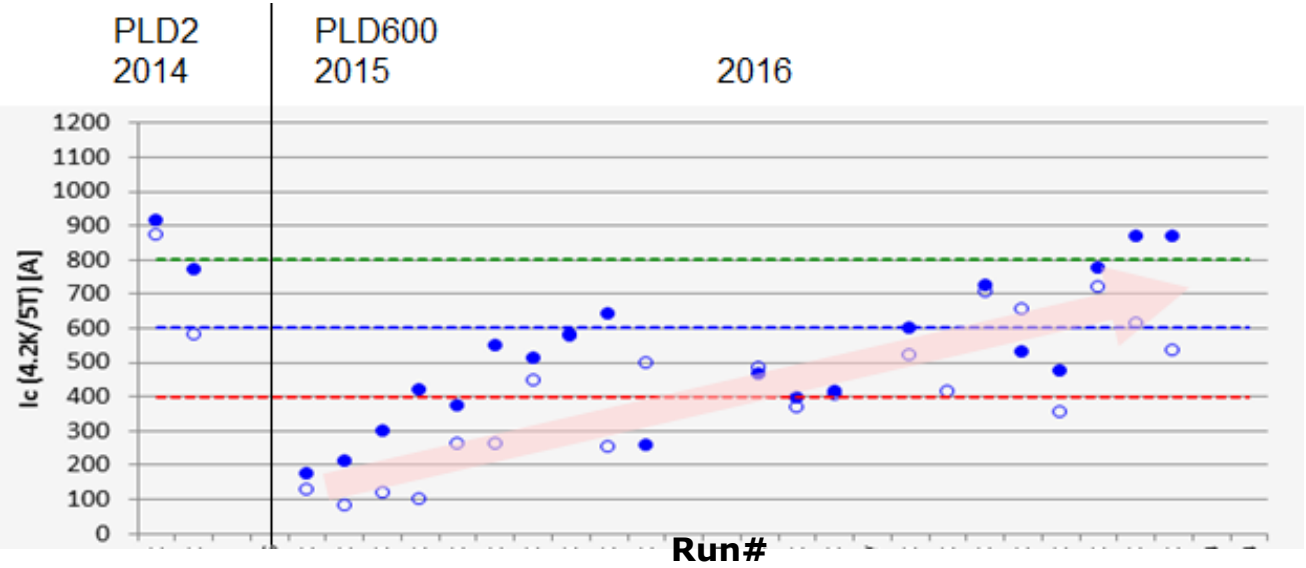
3.1. from steps 1.1-1.5:
during 2017 and 2018: set of samples of 5-15 m long pieces with 12 mm wide tape, based on 50µm thick substrate

3.2. from steps 2.1-2.3:
in 2018: 2 sample of 80-100 m long pieces with 12mm wide tape, based on 50µm thick substrate

Technology status

- **BHTS milestones in HTS wire length (4mm wide)**
  - 2013 – 100m length
  - 2014 – 200m length
  - 2015 – 600m length

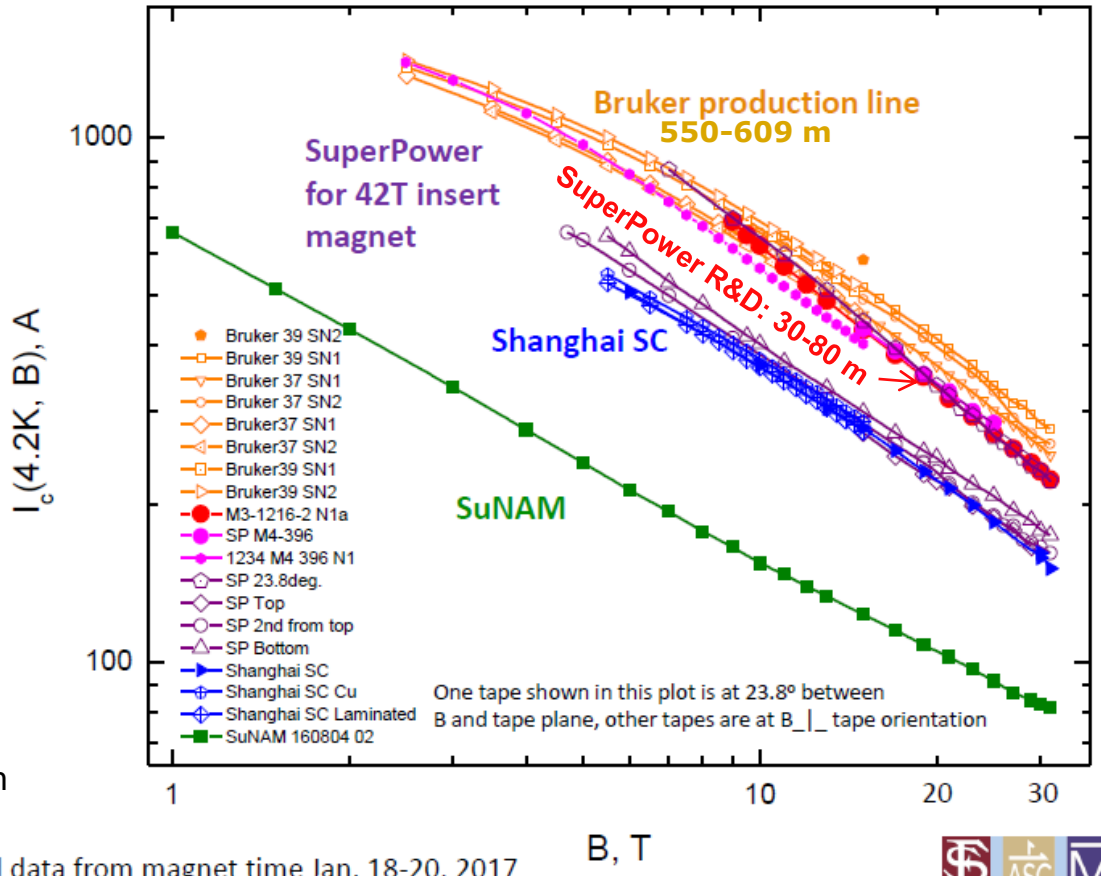
Ic in-field performance of long HTS tapes during ramp-up period



HTS wire performance

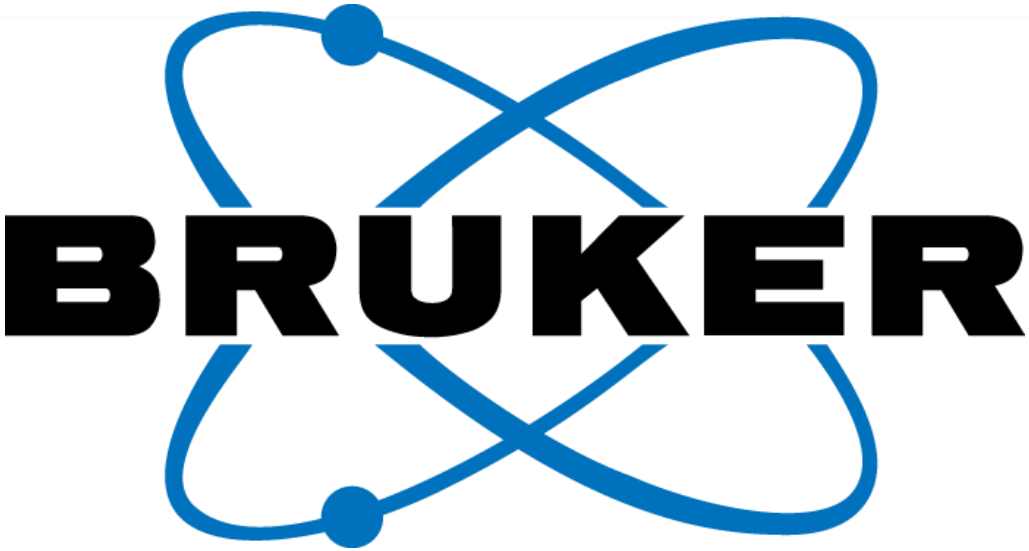
- **Ic in-field performance of A4 wires at 4.2K**

  - BHTS samples from A4/600 tapes (tape ID# 16037, 16039)
  - I_c measured up to 30T B//c at 4.2K



Based on D. Abraimov, D.C. Larbalestier et al. (NHMFL) data presented at WAMHTS-4 Barcelona in Feb. 2017

High field data from magnet time Jan. 18-20, 2017



Innovation with Integrity