

WP2.1- R&D on accelerator grade HTS REBCO conductors

Bernhard Holzapel, Institute for Technical Physics, Karlsruhe Institute of Technology,
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Institute for Technical Physics



WP2.1- R&D on accelerator grade HTS REBCO conductors

- KC⁴ Concept
- Technical background
- Timeline and R&D topics
- Current Status

KC⁴: KIT-CERN Collaboration on Coated Conductor



KIT and CERN will establish a **joint, open HTS CC synthesis Lab**, which will bridge the gap between small scale materials research on CC and larger scale component requirement of **tailored, high quality full Coated Conductor architectures** in sufficiently long length



- Both **power applications** as well as **magnet applications** will be targeted
- Focus on R&D CC issues, **not on low cost CC production**
- KC⁴ is part of the Helmholtz R&D Programm „Materials and Technologies for the Energy Transition“ at KIT
- KC⁴ is part of the High Field Accelerator Magnets R&D Programm at CERN
- Third party R&D projects towards tailored CC synthesis for specific applications will be become possible based on an HTS CC open foundry concept
- KC⁴ is based on established Bruker CC-technology for long CC and wide tapes, but Bruker is not involved in KC⁴- contract/operation
- Long length filamentization and ROEBEL cable fabrication will be feasible

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BHTS's process chain

➤ The standard processing route for the BHTS coated conductors consists of ...

... stainless steel substrate polishing and cleaning

... YSZ buffer layer coating by vacuum deposition (ABAD)

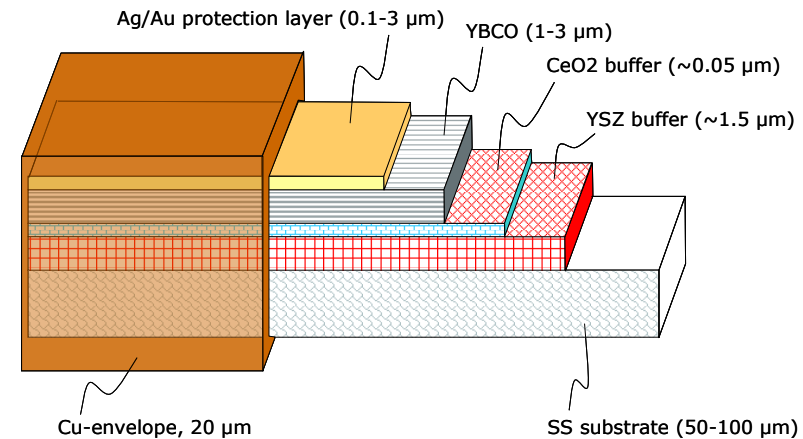
... Ceria and YBCO layer coating by vacuum deposition (PLD)

... Ag shunt layer coating by vacuum deposition (evaporation) and Ag layer annealing in O₂ atmosphere

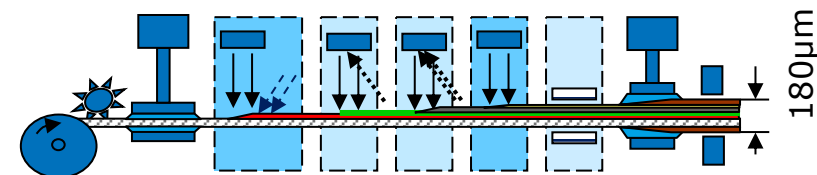
... Cu encapsulation by plating

... final inspection and quality check of the HTS tapes

Typical HTS layer stack



Idealized sketch of the BHTS process chain

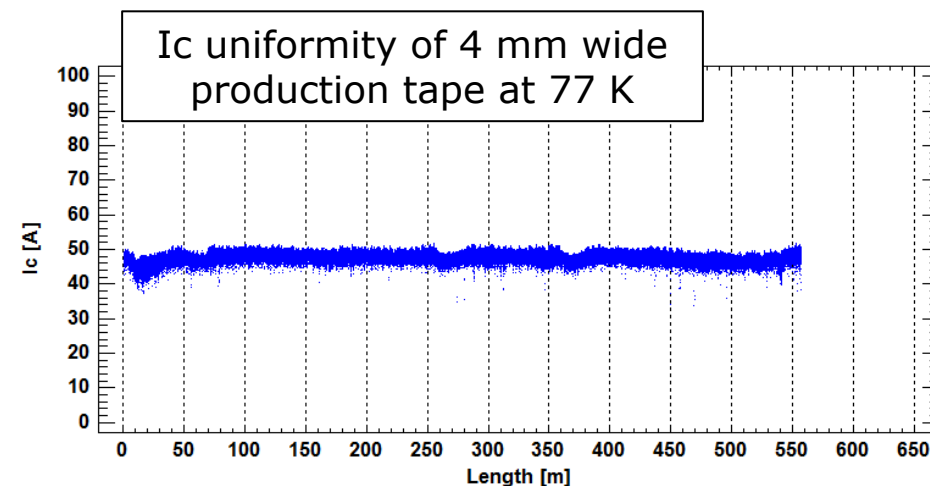
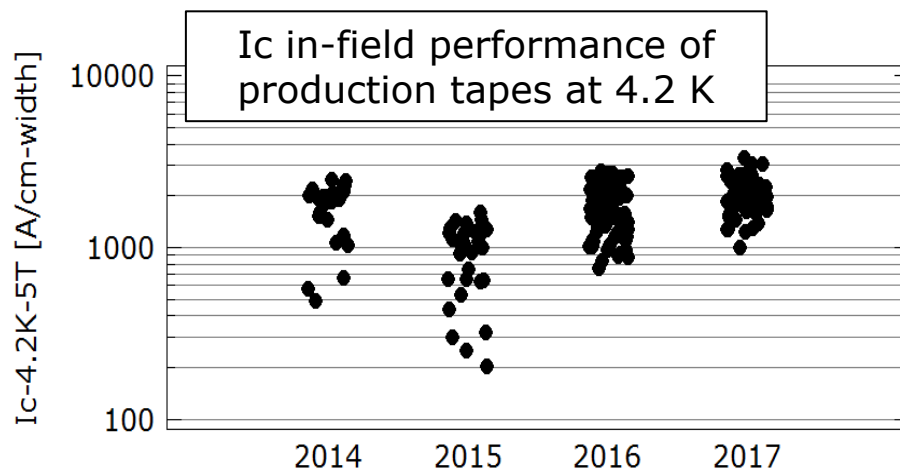


Bruker Energy & Supercon Technologies (BEST)



BRUKER HTS at a glance

- BHTS pilot-line plant (about 2000 sqm operation area), max. capacity 25 km p.a. (further ramp-up to 100 km p.a. possible within the plant)
- HTS tapes for ultra-high magnetic field application at intermediate and low temperatures, I_c at 4.2 K, 30 T, $B//c$ exceeding 750 A/cm-width
- Tape width 4 mm and 12 mm (optionally 40 mm), the max. actual batch size for 4 mm is 600 m (max. tape length in 2014 was 200 m, production capability ramp-up to 600m started in 2015)



BRUKER HTS R&D-line equipment

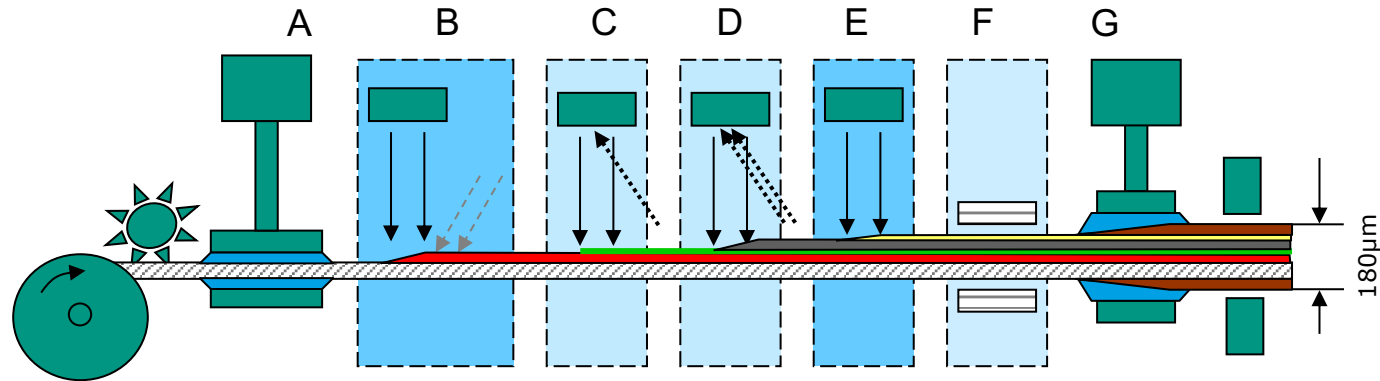
To be transferred to KIT....

- Tape processing equipment with different substrate handling concepts (batch and reel-to-reel R2R processes) including stabilization



PLD

KC⁴ Coated Conductor Synthesis Steps



b > 12mm
(foils)

b < 12mm
(tapes)



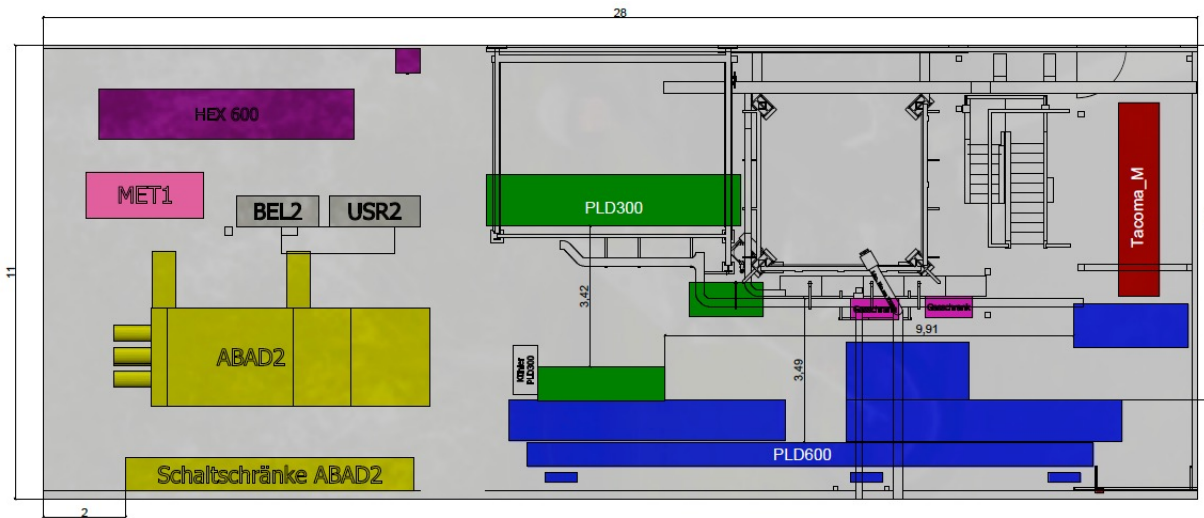
(A : substrate cleaning/polishing)
 B : IBAD Puffer deposition
 C : PLD Puffer deposition
 D : PLD SC deposition
 E : Ag- coating
 F : O₂- loading
 G : Cu-plating

+ characterization
 (structural, electrical, mechanical)

USP/USR-F/USR-B/POL
 ABAD
 HEX600+PLD300/600
 HEX600+PLD300/600
 Tacoma-M/MET-F
 Tacoma-O/BEL-F
 PLA

e.g. TapeStar

Core KC⁴ Lab space



Transferred Bruker equipment list

USR-F*	substrate cleaning
USP*	tape spooling
USR-B*	reel-to-reel
	substrate cleaning
POL*	substrate polishing
ABAD	IBAD deposition
HEX 600	tape handling
PLD300	PLD
PLD600	long length PLD
Takoma-M	Ag-coating
Takoma-O	O-loading
MET-F	Ag-coating
BEL-F	O-loading
PLA*	Cu-plating
TapeStar*	J _c -characterization

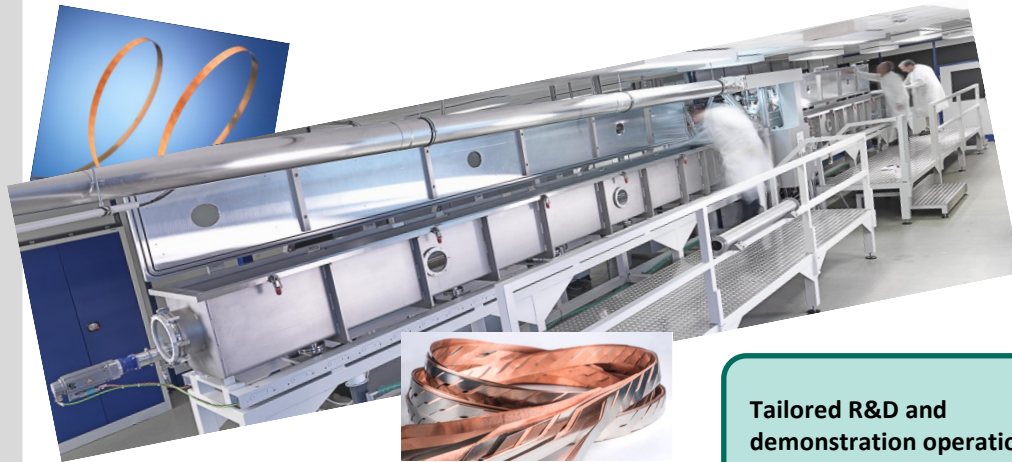
*: equipment located in other ITEP labs

ITEP wide > 500 m² lab space dedicated to KC⁴

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Timeline of KIT-CERN Collaboration



HTS CC Open Lab/Foundry

KIT ITEP	CERN	Third Parties
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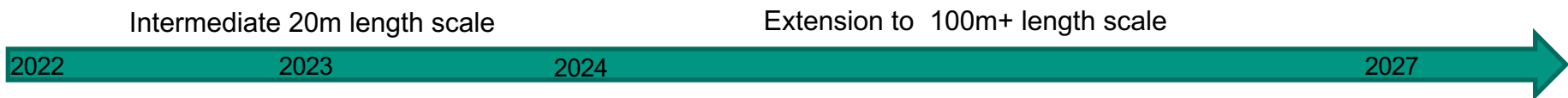
Tailored R&D and demonstration operation

CERN	KIT/ITEP
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Baseline R&D Operation (< 25% capacity use)

KIT/ITEP			CERN
I-A Installation	I-B Commissioning	I-C Performance demonstration	I-D Baseline R&D operation

t.b.c





KC⁴: Baseline R&D Topics

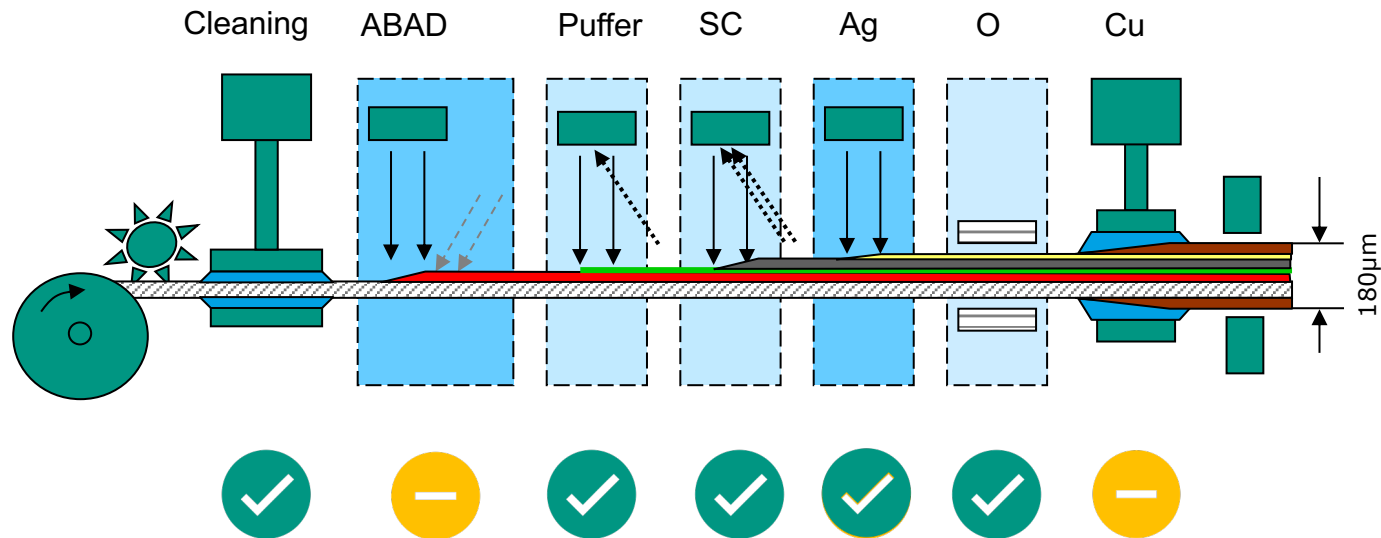
- Investigate scaling laws to transfer small scale PLD materials development results towards larger scale Coated Conductor production systems
- Address specific Coated Conductor architectures needed for the R&D program at CERN and KIT
- Investigate and improve electromechanical properties of full coated conductor architectures (mechanical stability, interface resistance, thermal properties,....)
- Evaluate in-line quality control systems
- Establish accelerated materials development concepts
-

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Current Project Status I

(intermediate 20m length scale)



1st full deposition run
on march 1st, 2023



Current Project Status II

- Short length (0,5m) experiments to optimize deposition conditions for regular Y123 coatings
- IBAD tapes from Faraday Inc., SUNAM and Shanghai SC under investigation
- J_c (self field, 77K) $> 1\text{MA}/\text{cm}^2$ for 0.5 μm samples reached
- 10m, $> 1\mu\text{m}$ samples until June
- More detailed (low T, magnetic field) characterization under way