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Coated conductor HTS tape for energy and magnet applications

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Abstract

Recently, THEVA started to produce HTS coated conductors at its facilities in Germany. The performance and length of the tapes was steadily increased over the last one and a half years reaching 400 m as a standard production length with critical current up to 500 A/cm (77 K, s.f.) in the production tapes. An overview is given on the current status of the tape manufacturing. Electrical performance data at various temperatures and magnetic field levels will be given and discussed. Different types of stabilization like lamination with Cu foil and surround copper plating were developed. For applications in cables as well as magnets the mechanical properties like dimensions, bending properties or delamination strength of the final stabilized tapes are important aspects of qualification. Results gained with the various types of tapes are given.

Acknowledgements

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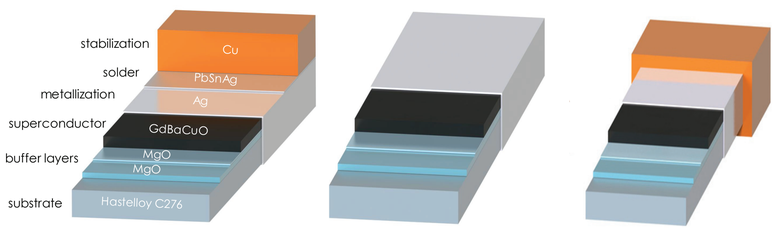
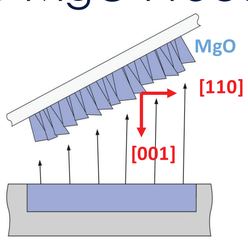
Pro-Line HTS wire



Cu laminated TPL2100 | Ag coated TPL1100 | Cu plated TPL4100

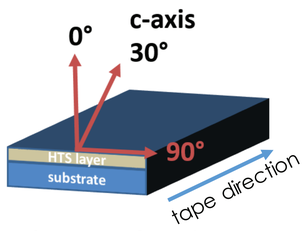
- Cu stabilization according to application
- Standard width 12 mm
- Smaller width samples available

ISD MgO Process



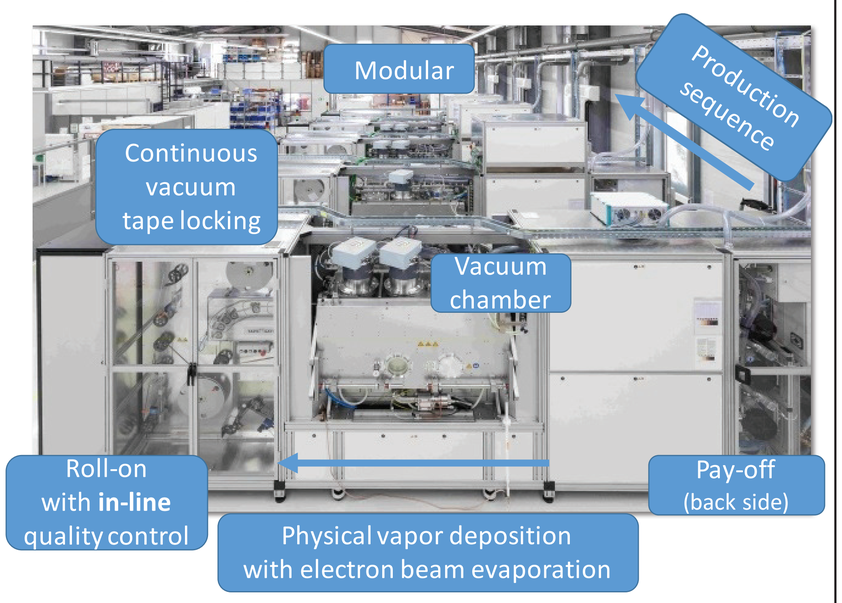
- E-gun evaporation on a tilted substrate (30°)
- Simple process and fast (> 6 nm/s)
- Tilt angle of MgO<100>: $\beta_{MgO} \approx 30°$
- In-plane texture: $\Delta\Phi_{MgO} \approx 10°$

HTS Process



- Tilt angle is transferred
- Texture improves
- Tilt angle of HTS c-Axis $\beta_{GdBaCuO} \approx 30°$
- In-plane HTS $\Delta\Phi_{MgO} \approx 6°$

HTS tape production à la THEVA

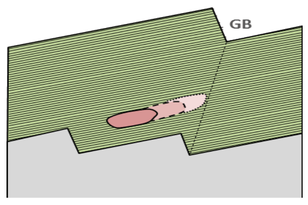


Pilot line features
- Built 2012-2014, commissioned end of 2015
- Maximum production capacity: 150 km/yr (@ 12 mm-width)
- Production tape length: 300 m, up to 600 m demonstrated!

Goals
- Cost efficient production
- Robust process allowing high yield
- Implementation of industrial standards
- Proof of production: high quality tape

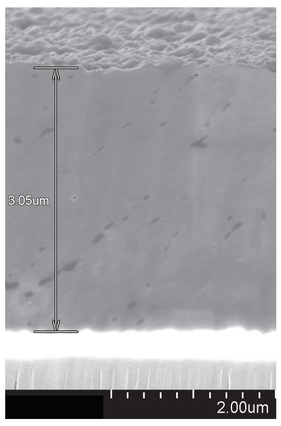
First step towards industrial HTS wire production

Tunable critical current

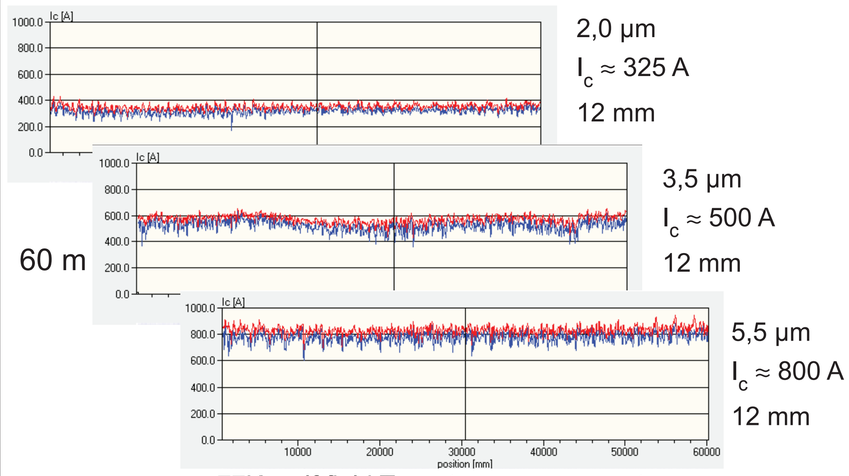


Tilt leads to **textured** overgrowth of precipitates and misoriented regions

- J_c is thickness independent
- **Very high I_c possible**



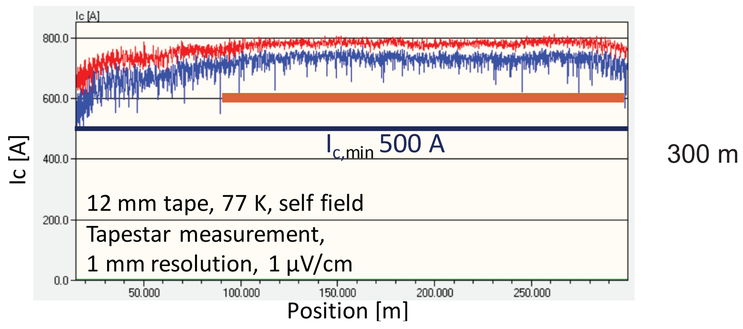
Homogeneous cross section



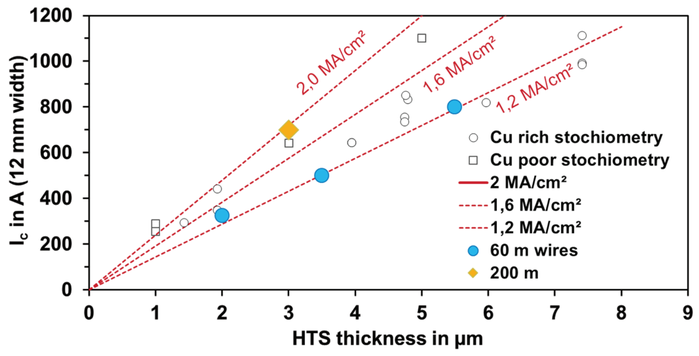
77K, self field Tapestar measurements
Increase of thickness → Increase of I_c

Improved performance was successfully transferred to production

- High performance over long length

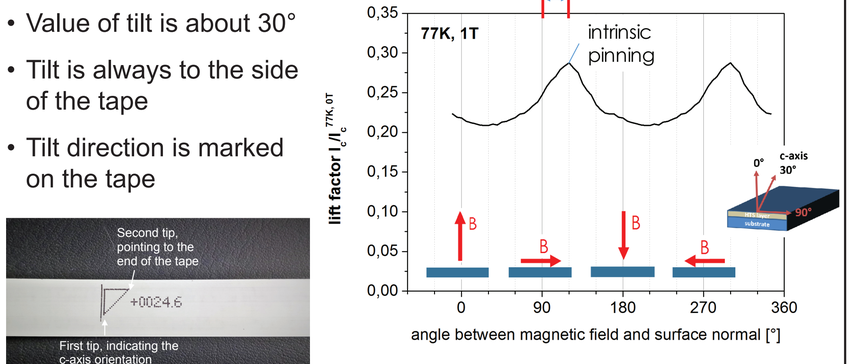


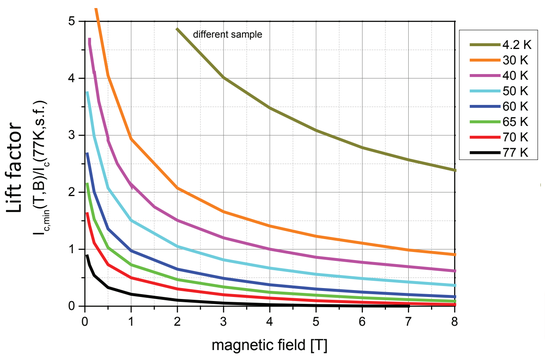
Over 200 m: $I_c \approx 700$ A, $I_{c,min} = 600$ A



Magnetic field performance

- B || c is not B || *n*
- Value of tilt is about 30°
- Tilt is always to the side of the tape
- Tilt direction is marked on the tape





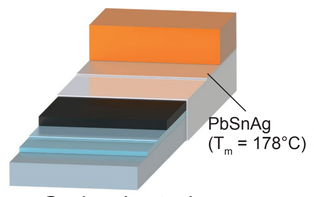
- No artificial pinning centers
- Lift factor of 15 samples taken out of production over about 1a: LF(1.5 T, 30K) = **2.2 ± 0.4 (± 18%)**

Reliable magnetic field performance!

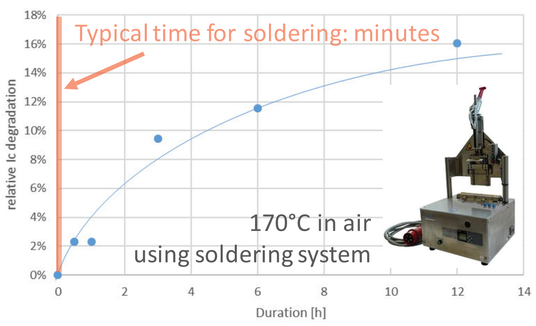
Thermal stability

HTS Tape has to withstand thermal stress during further processing:

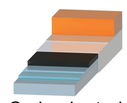
- VPI or potting: curing for hours at elevated temperature (100°C typical)
- Soldering: high temperatures for shorter time (< Tm of solder of lamination)



Cu laminated



Mechanical properties



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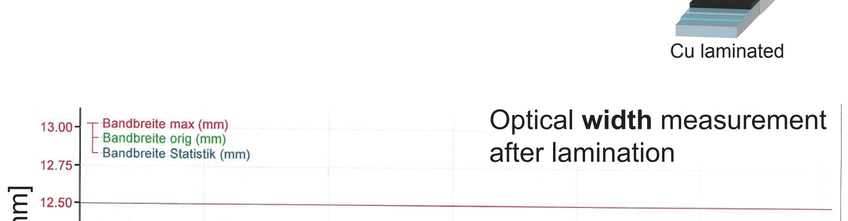
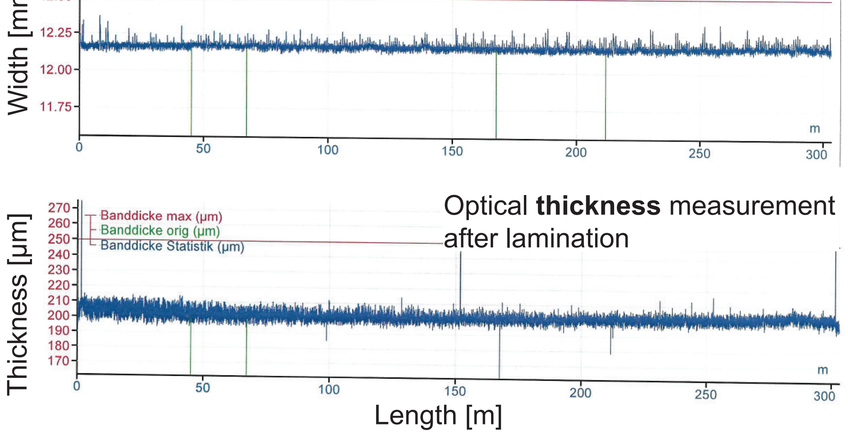
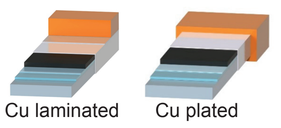




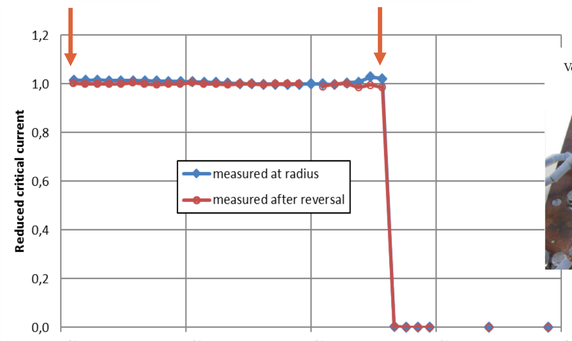
Bending test

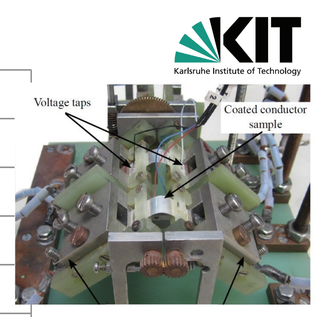


Cu laminated | Cu plated

Critical bending radius HTS inside (compression): < 5 mm

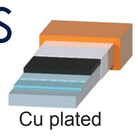
Critical bending radius HTS outside (tension): 17 mm





Similar results found for laminated tape!

Homogenous Thickness



Cu plated

- Homogenous thickness is important for high density packing of turns and reproducible coil thickness
- Development of homogeneous thickness