

# Cost-effective production of HTS wires by chemical solution deposition

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# CSD processing

- Chemical solution deposition for complete layer architecture
  - Best price performance ratio for large volume production
  - Unique and protected technology

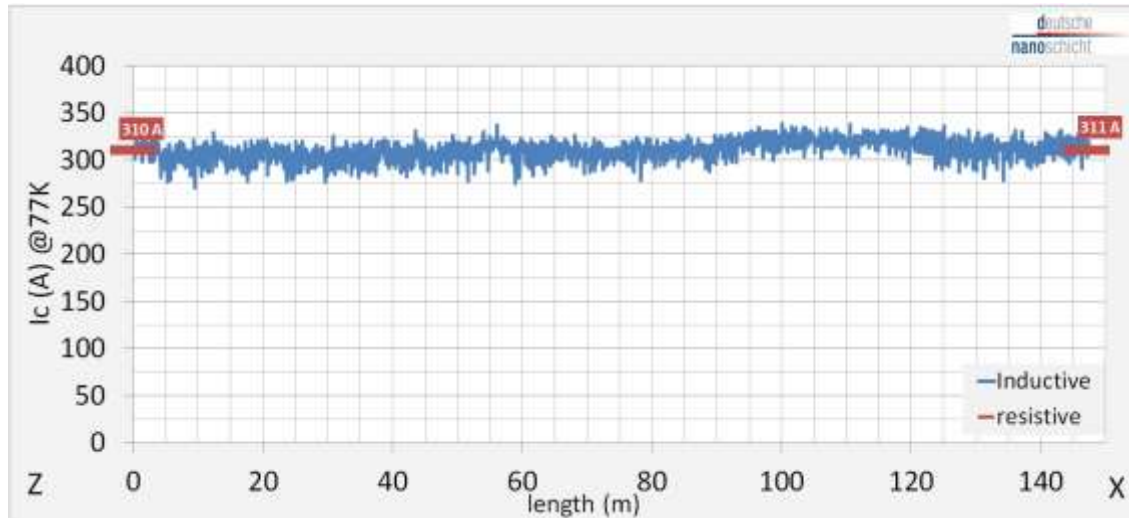


- Industrial applications
  - DC bus bars
    - Long length laminates
    - Performance at low fields and high temperatures
    - Production upscaling
  - Magnets
    - Performance at medium fields and low temperatures
    - Joint technology
    - Mechanical performance: bending
- Distribution grids
  - AC cables
    - Non-magnetic substrates
    - Mechanical requirements: strain and twist

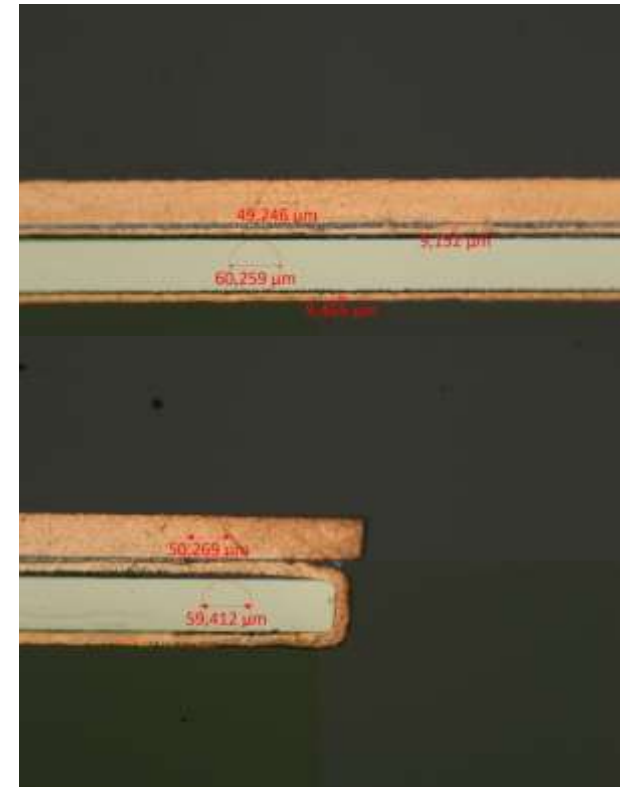
# Industrial applications

## DC bus bars

- single copper laminate - HTS neutral fiber
  - Long length with high homogeneity
  - Mechanical and electrical stability with high  $J_e$



150m x 10mm,  $310 \pm 10$ A (@77K,sf), homogeneity <5%

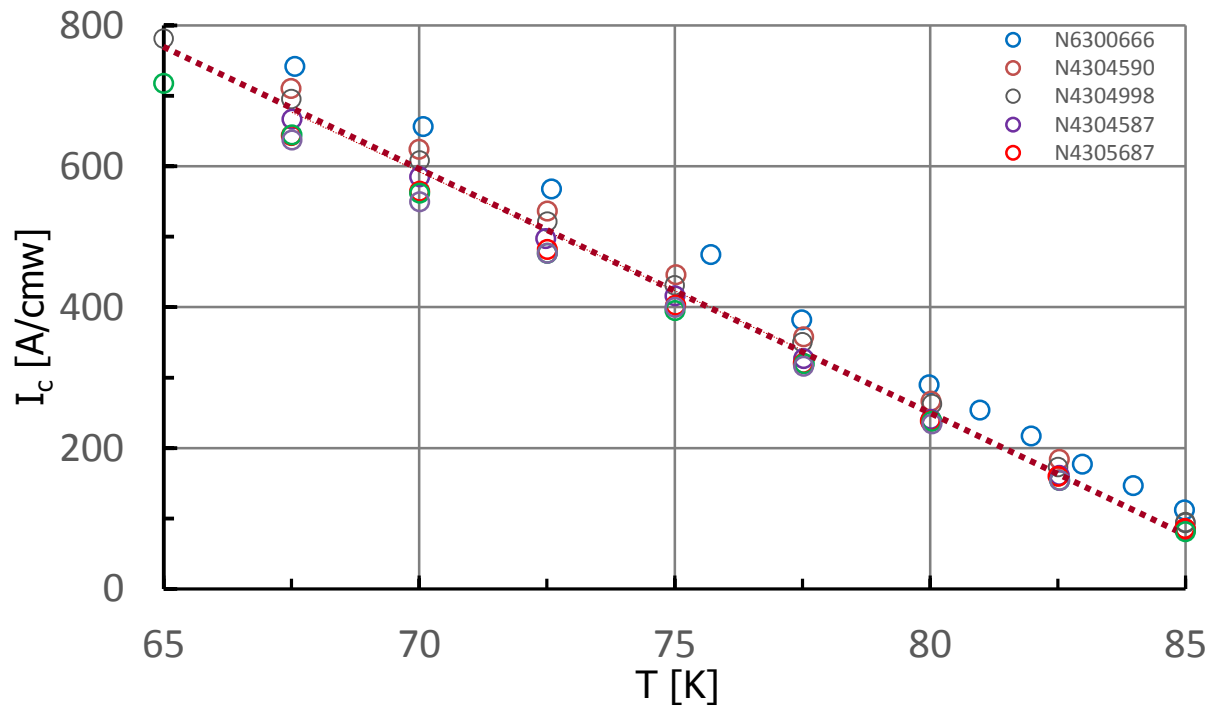


50 $\mu$ m single copper laminate

# Industrial applications

## DC bus bars

- single copper laminate - HTS neutral fiber
  - Performance at low fields and high temperatures



**Best HTS tapes > 800A @65K,sf**



$I_c(B, \theta, T)$  system  
(0-5T, 0-180°,  
0-800A, 20-100K)

# Industrial applications

## DC bus bars

- single copper laminate - HTS neutral fiber
  - Upscaling: wide tapes and production devices



4x25m high temperature annealing furnace

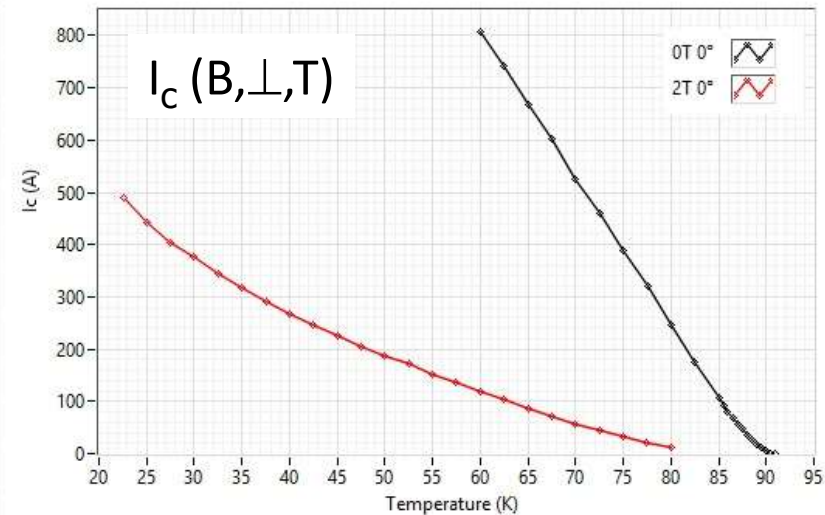
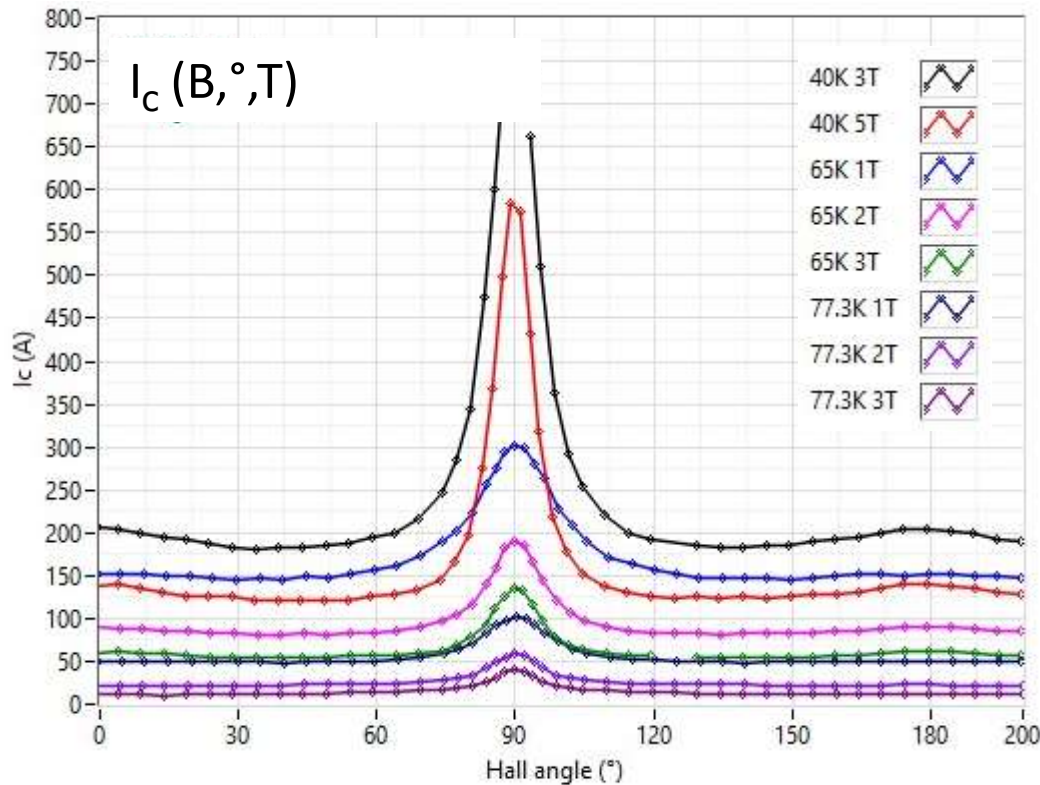


40mm fully buffered tape

# Industrial applications

## Magnets

- Performance at low temperatures and medium magnetic fields
  - Typical operation conditions: 30-50K, 1-3T

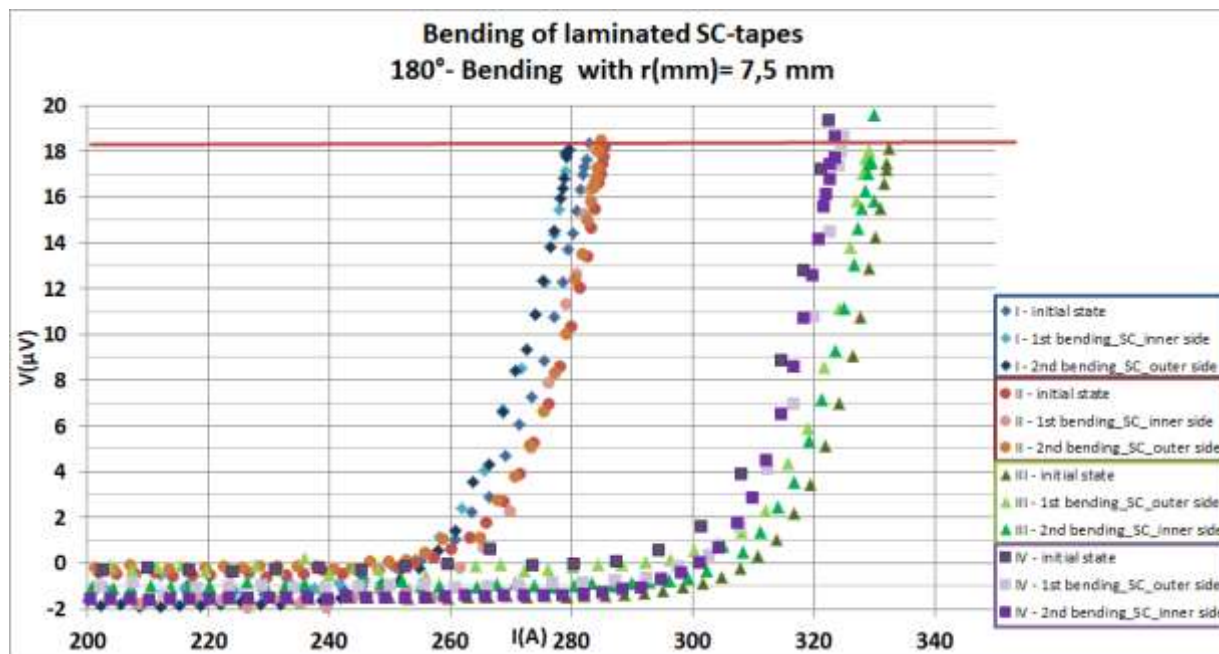


Typical  $I_c(B, T)$  behaviour

# Industrial applications

## Magnets

- Customized laminates
  - Small bending diameter possible



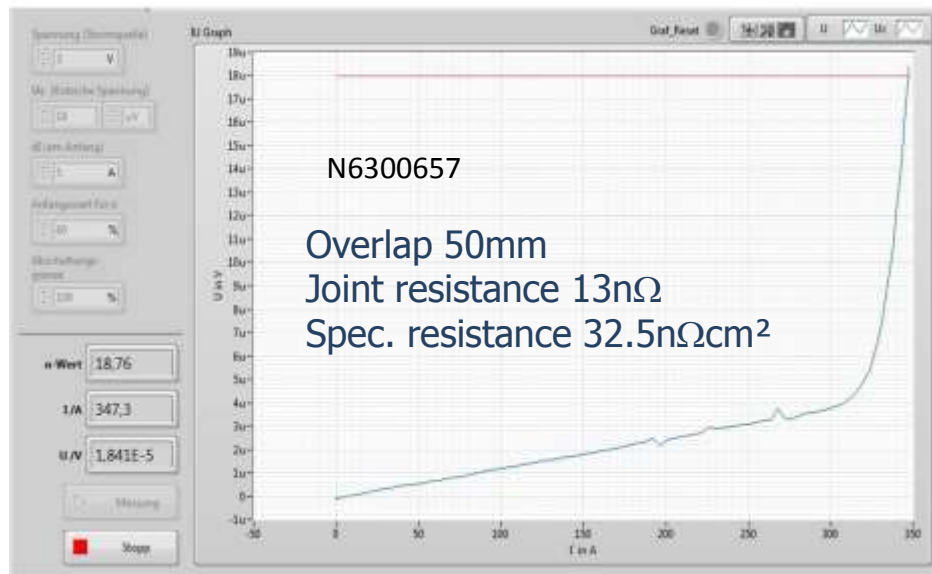
**$I_c$  degradation <2%  
for double bending  
on 15mm diameter**



# Industrial applications

## Magnets

- Joints and splices
  - Bridge-type joints
  - Lead free solder paste (mp >200°C)



**Typical joint resistance <20nΩ**

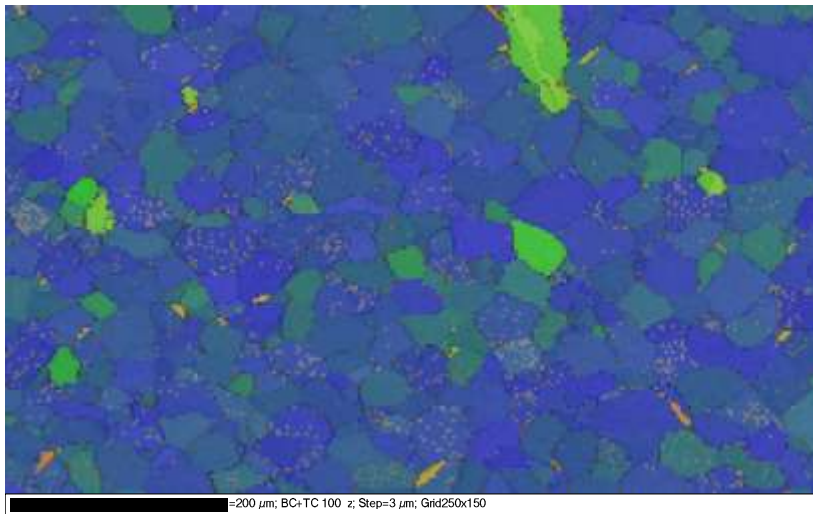


Device for joints and splices

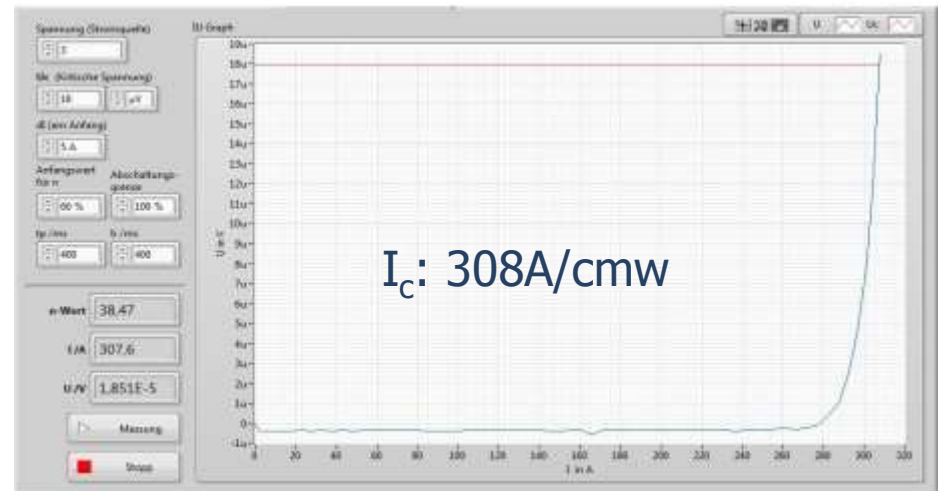
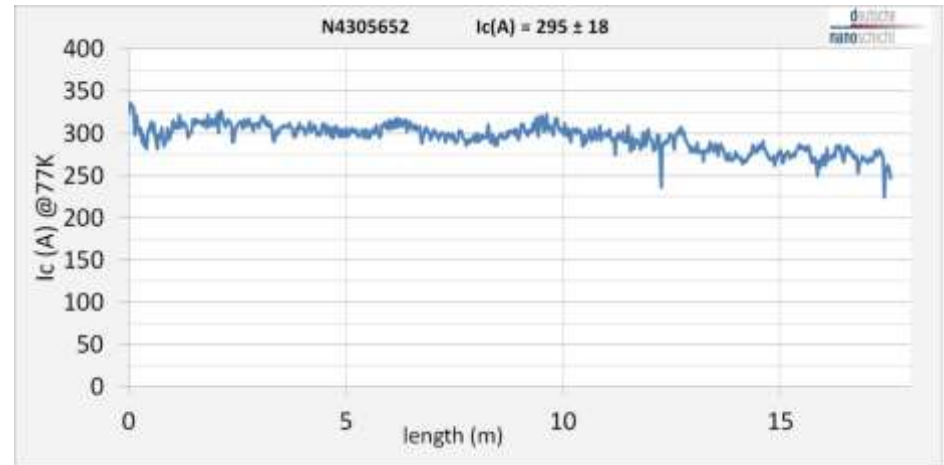
# Grid applications

## AC cables

- Non-magnetic substrates
  - <100m processing in R&D
  - $I_c$  (@Ni9W)  $\approx$   $I_c$  (@Ni5W)



EBSD: 93,4% index rate, 94% in 10° tilt

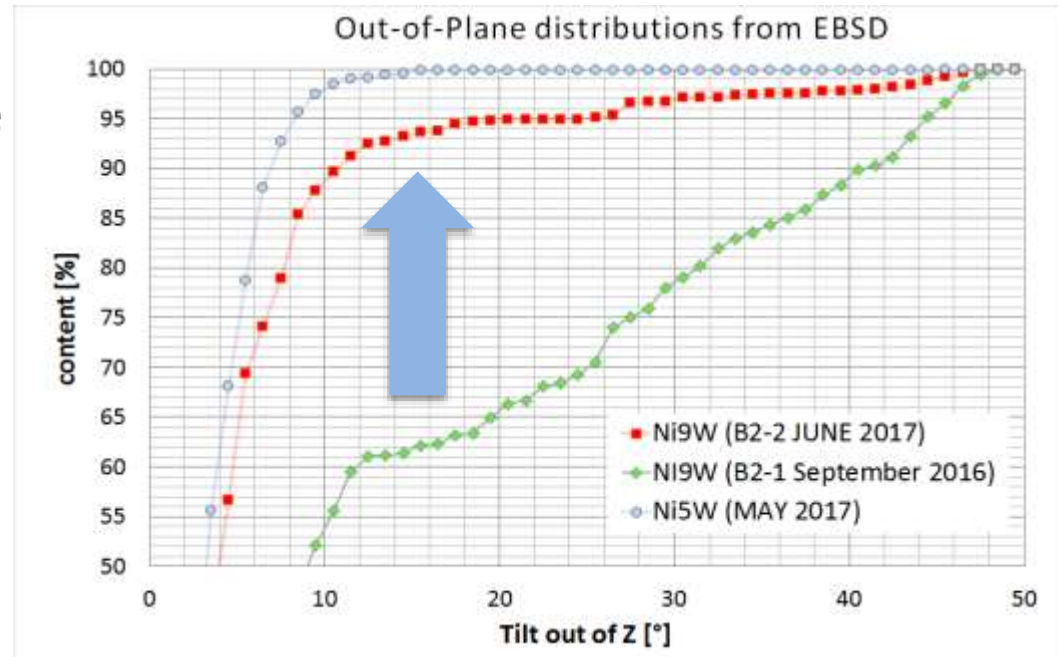


# Grid applications AC cables

- Non-magnetic substrates
  - Improvements in large scale processing



~10 t ingot processed to 60 μ tape



Tape	% Cube	Error	% Cb-G	Error
Ni5W (MAY 2017)	99.9	0.1	0.0	0.0
Ni9W (B2-2 JUNE 2017)	93.7	0.8	3.0	0.6
Ni9W (B2-1 September 2016)	62.2	1.6	15.8	1.2

Preference in cube growth >90%

# Grid applications

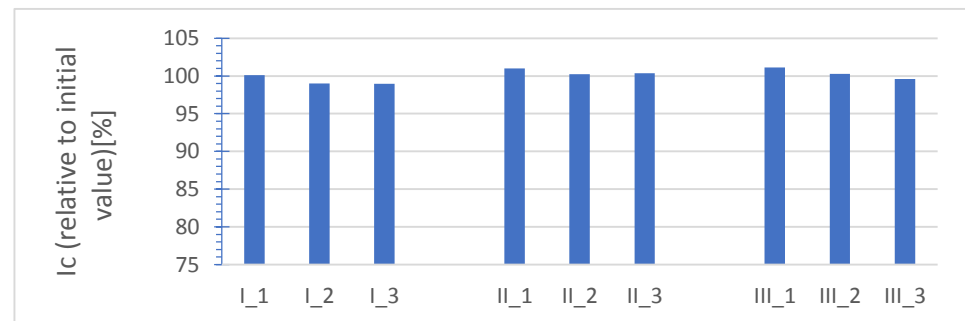
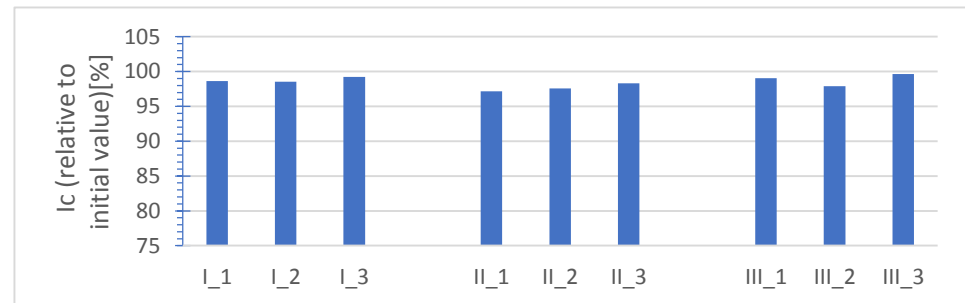
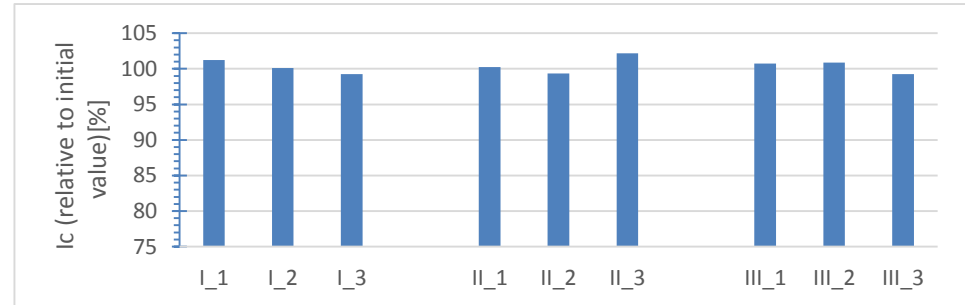
## AC cables

- Mechanical requirements

- Tensile stress: 250mPa
- Twist: 200mm, 360°
- Bending:  $\varnothing$  30mm

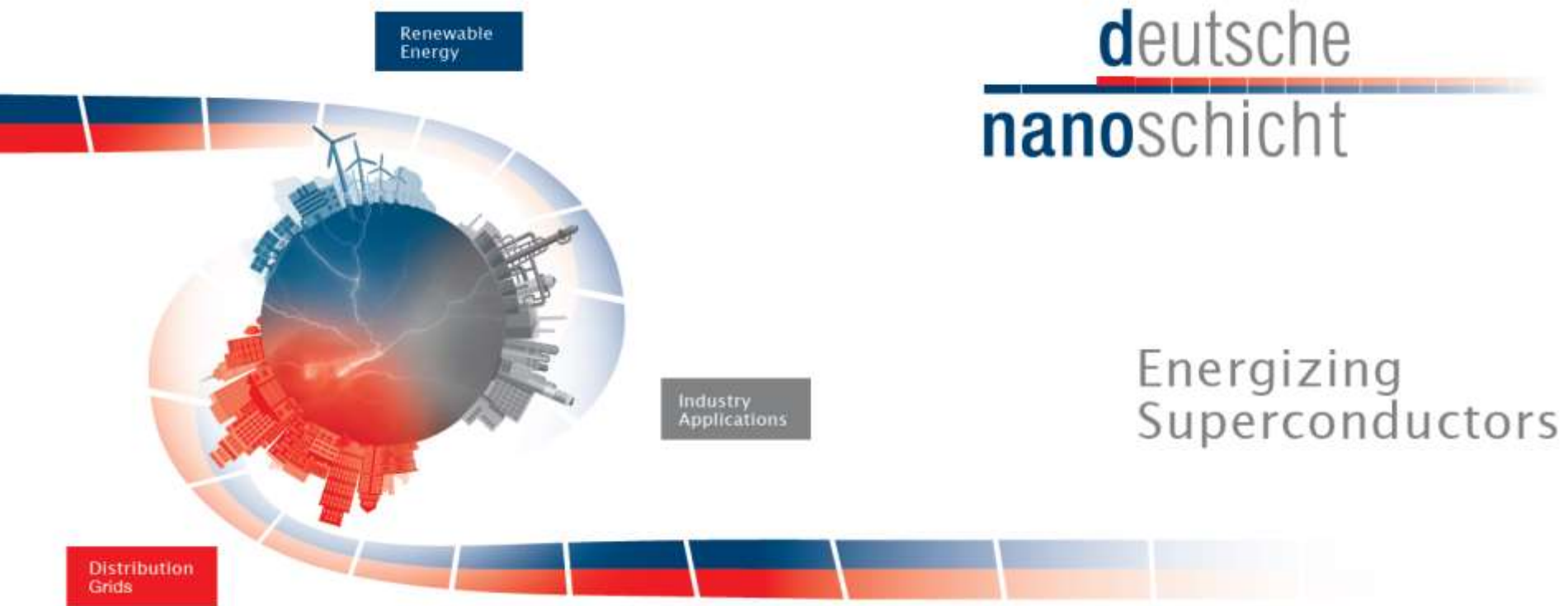
*3 batches of 10mm wide HTS tape*

**HTS tapes fullfill typical requirements for AC cable applications**



# Summary

- Up-scaling of production ongoing
  - 40mm technology partially implemented
- HTS tapes customized for applications available
  - Laminates, joints
- Mechanical and electrical specifications reached
  - Bending, twist, strain, resistance,  $I_c$  (B, °, T)
- In-house test facilities qualified
  - 5T- $I_c$ -tester, mechanical testing



**Thanks for your attention**