

1MOr2A-07

Production and characterization of YBCO superconductor tapes produced by chemical solution deposition processes

Michael Baecker; Ron Feenstra; Brygida Wojtyniak; Martina Falter; Jan Bennewitz; Jan Kunert; Mark O. Rikel

Deutsche Nanoschicht GmbH
Heisenbergstr. 16
53359 Rheinbach
www.d-nano.com



Federal Ministry
of Economics
and Technology

Outline

- Deutsche Nanoschicht GmbH
- Process technology
- Expanded pilot line
- Performance
- Technical HTS conductor
- Summary



Deutsche Nanoschicht GmbH

- Since June 2013 part of BASF group
- 63 employees , located in Rheinbach and Heidelberg, Germany
 - High Temperature Superconducting (HTS) wires,
 - chemical solution deposition, ceramic functional layers, ink-jet-printing, epitaxial growth
 - magnetocaloric materials / energy efficient cooling
 - Additive manufacturing / 3D-printing



High Temperature Superconductors

- Challenges for development and production
 - Best price performance ratio (€/kAm)
 - Scalable large volume production
 - Reliable and in-time supply
 - Flexible but mechanically and electrically stable



Process Technology

- Chemical solution deposition
 - Chemical solution deposition (CSD) for all layers is considered to be the „most promising and most challenging process“
 - Unique and protected CSD-multi-layer technology



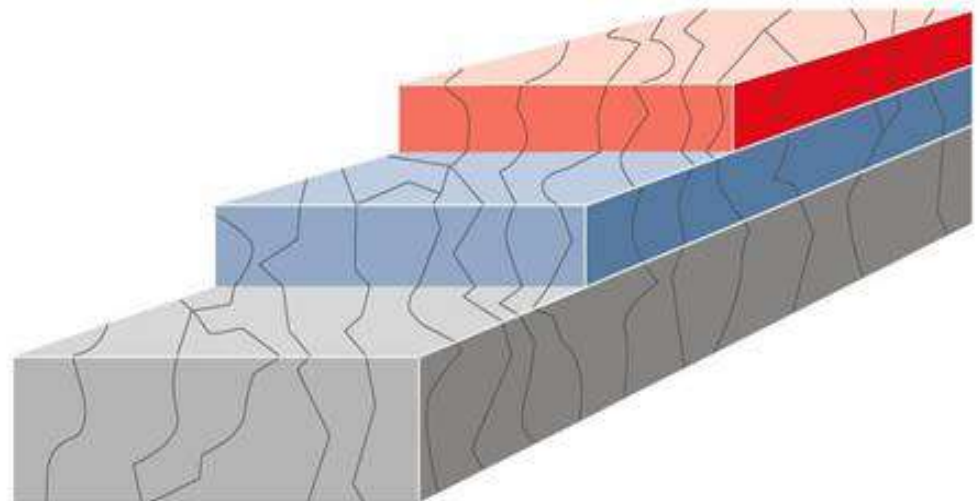
Process Technology

- HTS wire architecture – thin flexible ceramic coatings

Superconductor layer
 $\text{YBa}_2\text{Cu}_3\text{O}_x$ (YBCO)

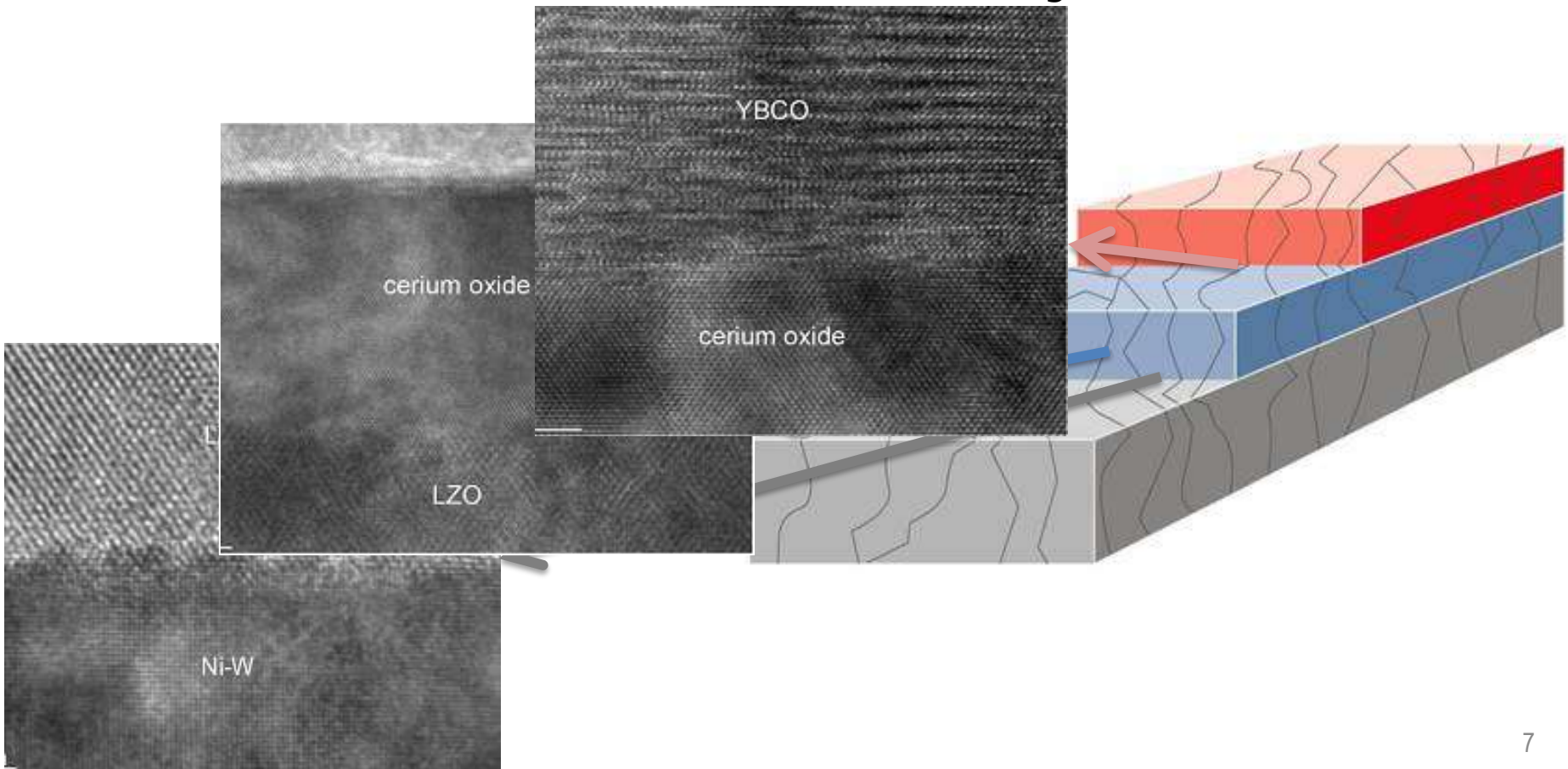
Buffer layer
 $\text{La}_2\text{Zr}_2\text{O}_7$ (LZO), CeO_2

Metal alloy substrate
NiW-alloy



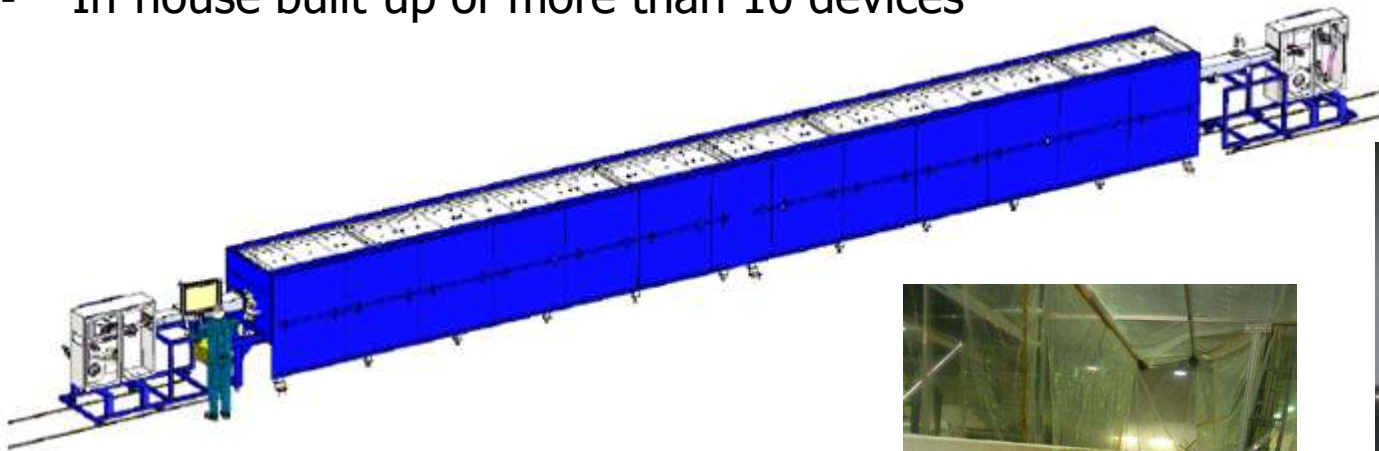
Process Technology

- HTS wire architecture – thin flexible ceramic coatings



Expanded pilot line

- Construction of key process devices in house
- In-house built-up of more than 10 devices



Expanded pilot line

- Opening of expanded pilot line in Rheinbach at 10th May 2016



Expanded pilot line

- EPL construction until mid 2016
- EPL capacity ramp-up until end 2016
- Planned capacity > 200km technical HTS wire
- Start sampling for projects in 2016



Lab processing

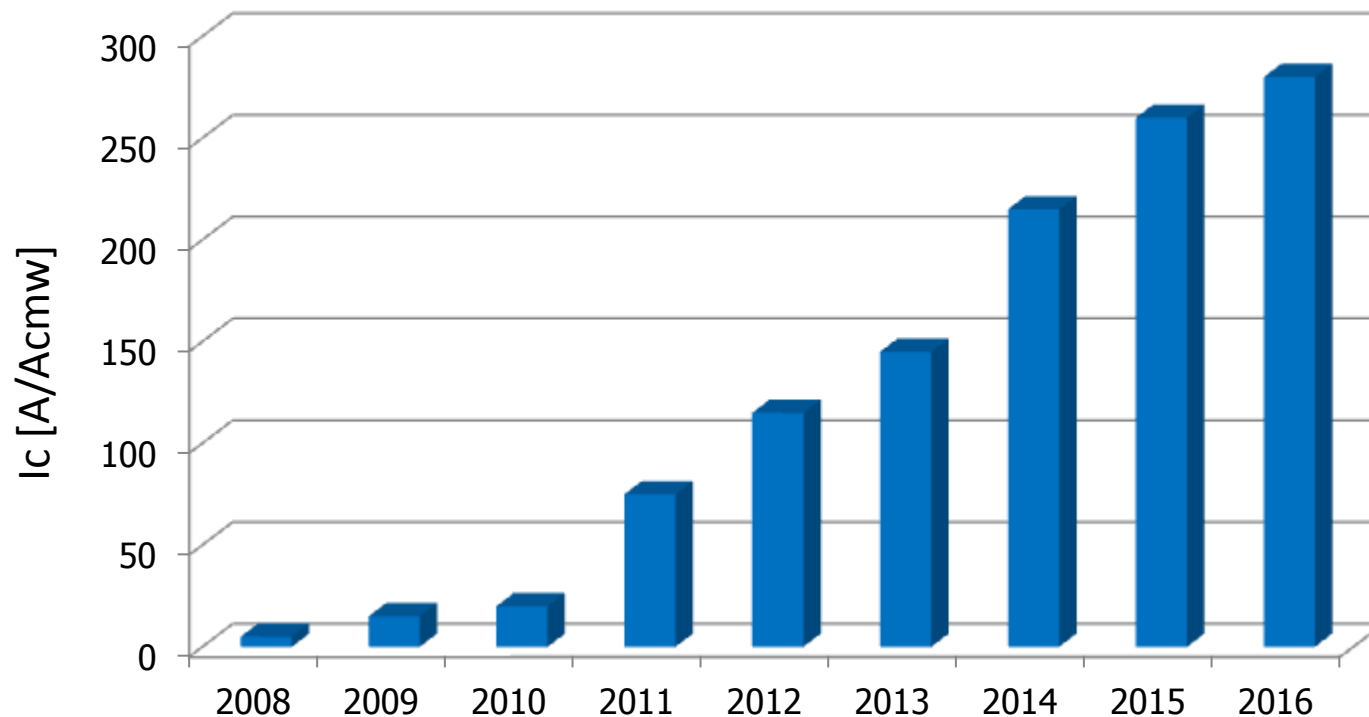


Expanded Pilot Line

Performance

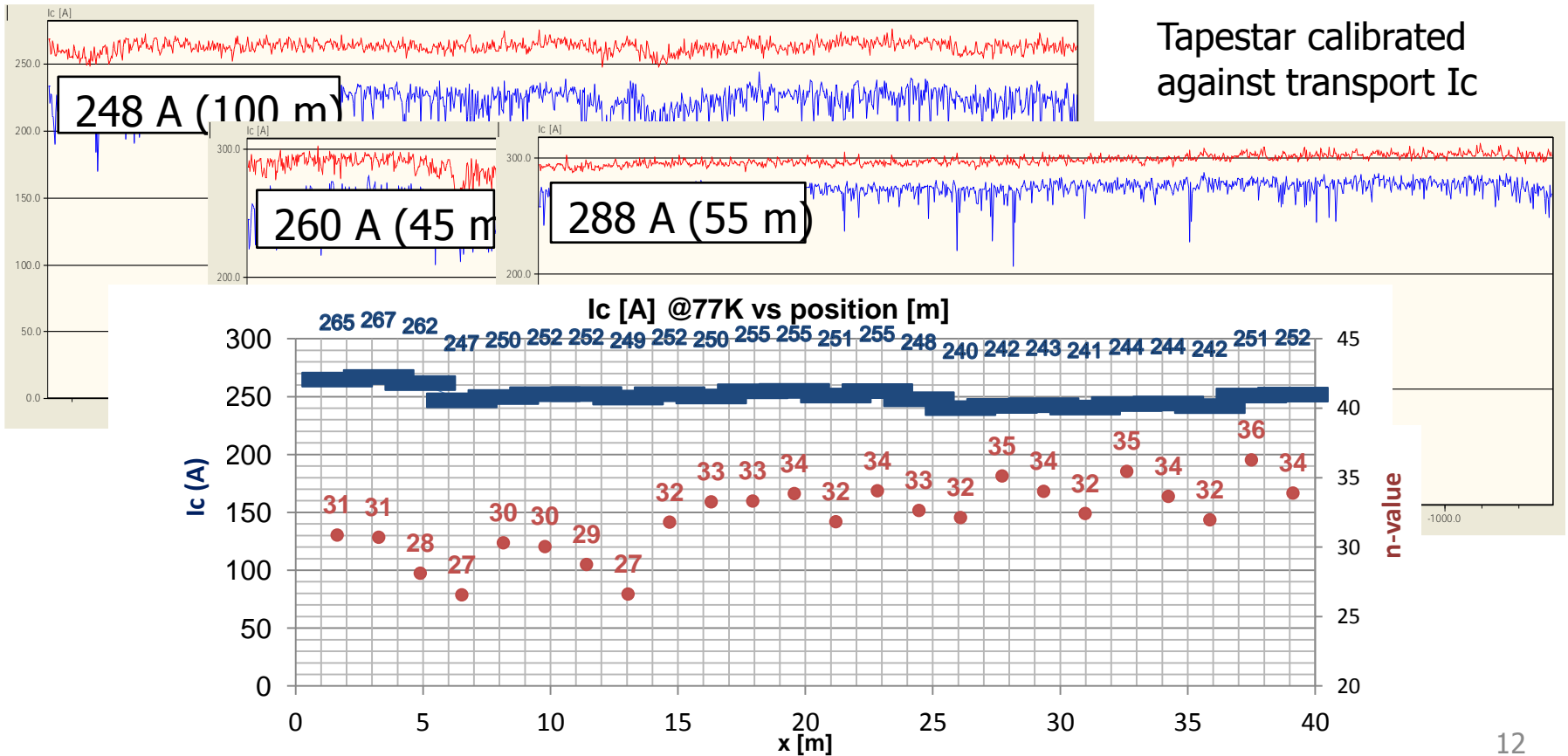
- Development with industrial partners over nearly 10 years
 - Long lengths samples >20m

VDM Metals
Honeywell
Heraeus



Performance

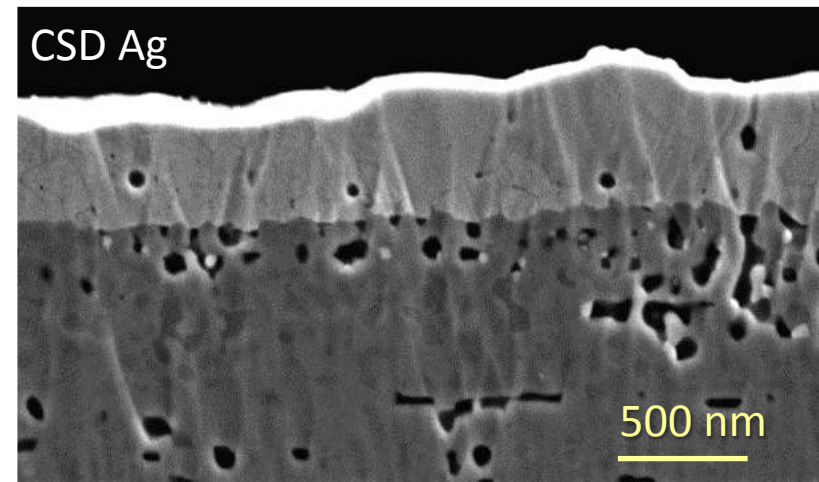
- D-nano has produced 50-100m tapes with $I_c \cong 250$ A/cm



Technical HTS conductor

- Silver coating
 - Unique chemical solution deposition process
 - Fast and vacuum-free processing
 - Thin and dense coating

Sample	T_c (K)	ρ_{contact} ($\mu\Omega/\text{cm}$)
N433460	90.1	< 0.45
N432135	88.2	< 0.68
N432161	88.2	< 0.38
N432162	86.4	< 0.45
N433507	89.9	< 0.60
N433508	89.4	< 0.35
N433509	89.3	< 0.30



Technical HTS conductor

- Copper electro-plating
 - Homogeneous coating
 - Variable copper layer thickness
 - Low contact resistance

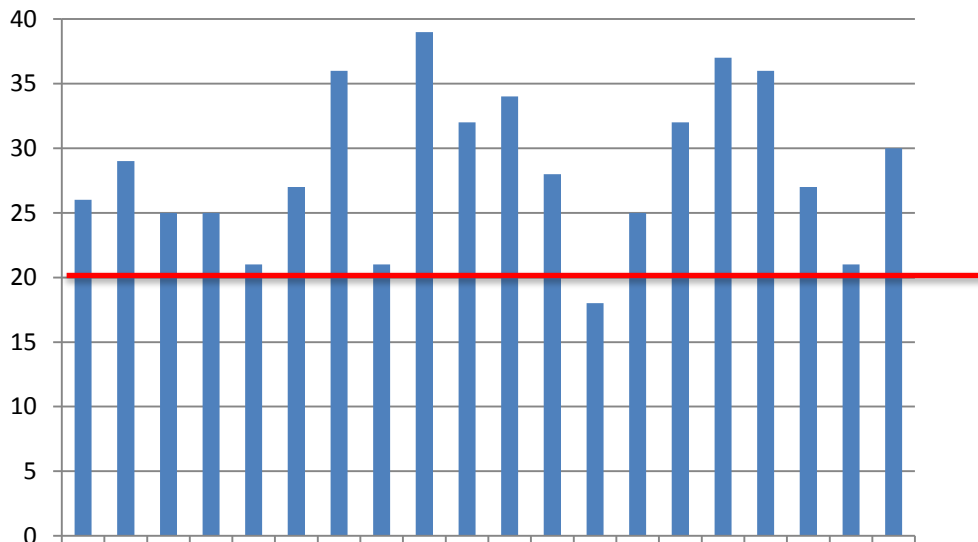


Cu-plated HTS conductor,
45 μ m single Cu-layer

Sample	Cu layer thickness	T _c (K)	ρ_{contact} ($\mu\Omega/\text{cm}$)
N630078	9 μ m	89.8	7.5
N630095	40 μ m	89.8	3.7
N630102	9 μ m	89.8	2.3
N630106Z	45 μ m	88.7	4.2

Technical HTS conductor

- Delamination strength
 - c-axis tensile av. 28(6) MPa (bare insert, non-laminated)
 - Architecture suitable for most energy applications



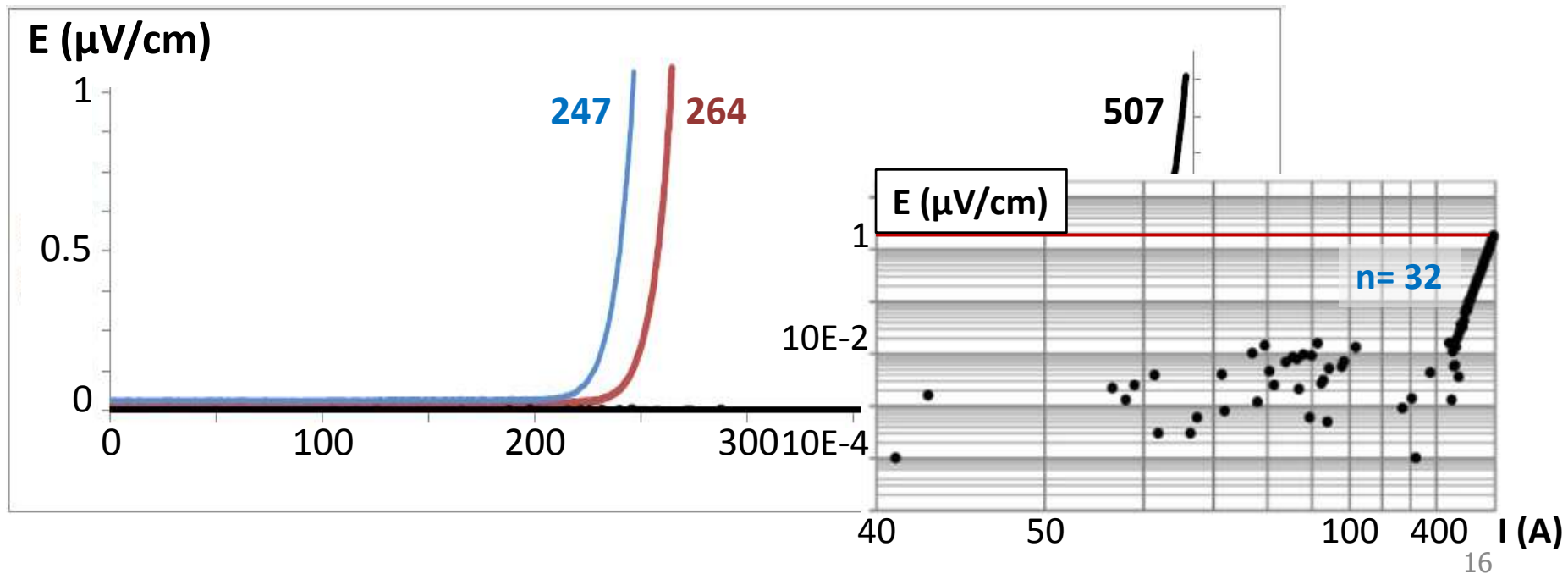
Threshold for
cable applications

Specimen geometry: 12.8 x 6.4 mm²
(soldered on 10 x 20 mm² sample)

Technical HTS conductor

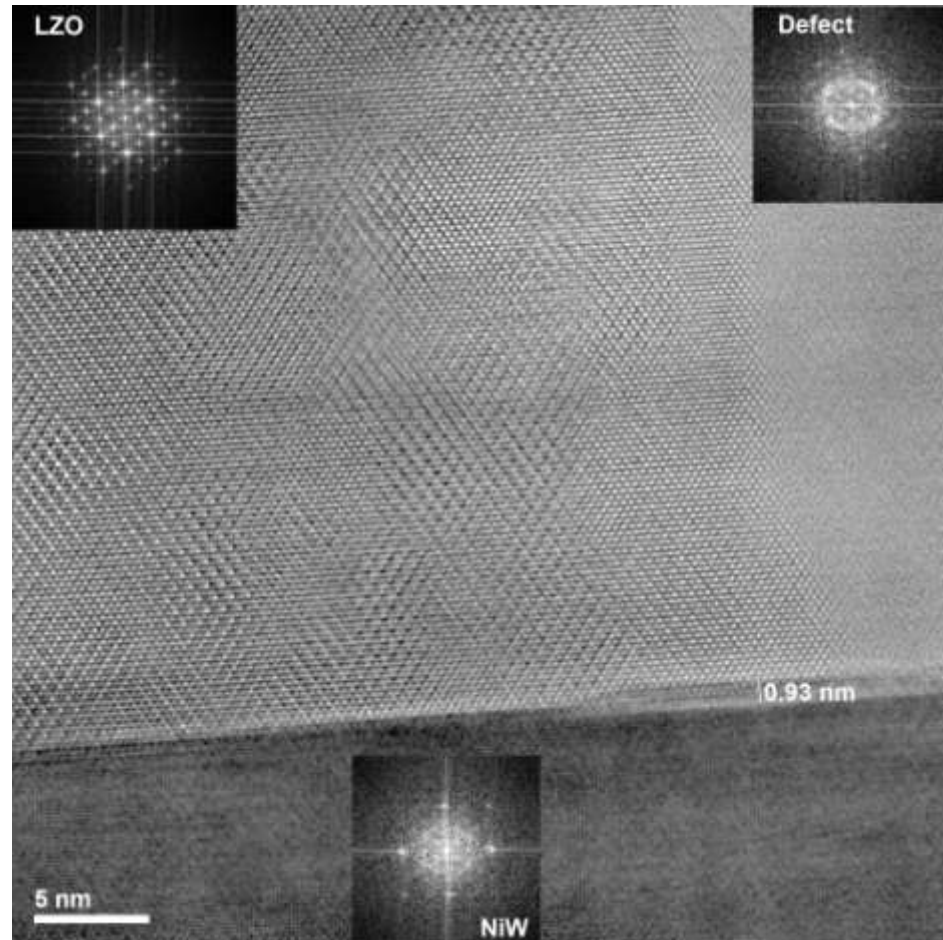


- Back-to-back lamination doubles I_c
 - Thin and dense coating temporary solution for high- I_c demand
 - suitable for busbar, FCL applications



Process challenges

- Process stabilization
- Large area processing
- High throughput
- Local dropouts
 - Interface defects
 - Handling
 - Raw materials
- customization



Interface defect: loss of orientation

Summary

- Chemical solution deposition enables economic mass production of high temperature superconducting tapes
- Deutsche Nanoschicht reached significant performance increase over last years and starts pilot production in 2016/17
- HTS conductor successfully customized for applications
- First samples provided to customers

... but challenges remain in product and process development



Thanks for your attention

Deutsche Nanoschicht GmbH
Heisenbergstr. 16
53359 Rheinbach
www.d-nano.com

Special thanks to:
Roger Würdenweber, Forschungszentrum Jülich
Werner Mader, University of Bonn



Federal Ministry
of Economics
and Technology