Fabrication of ILC Cavities from Axisymmetric RRR Nb Tubes

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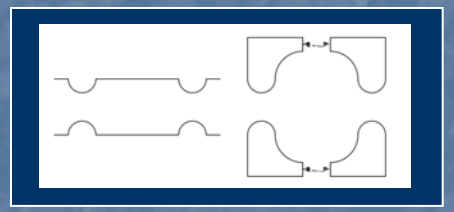
Processing History – Design for Seamless Tube SRF Cavities

- DESY Tube Spun from Plate
  - Large (>400 μm) grain, non-uniform structure and properties
- Our Approach:
  - Open die, high-strain, processing
  - Recrystallization T for billet lower than subsequent processing, so grain size could be stable
    - To be stable, grains must be recrystallized with mostly high angle grain boundary misorientations
    - Fine grain and weak texture for enhanced formability, axisymmetric properties
  - 50 mm billet, subscale evaluation; 165mm diameter production scale billet to make 150 mm I.D. tubes for DESY set-up
  - Extrusion for steady-state tube forming
    - Back-extruded, extruded, flow-formed, Rx
  - Spun and Hydroformed at DESY



spinning of irises

hydroforming equator expansion

Collaborations with ATI Wah Chang, Albany, Oregon; Dynamic Flow Forming, Billerica, MA; Dept. of Mech. Engineering and NHMFL, FSU, Tallahassee, FL; MPL DESY, Hamburg, Germany.

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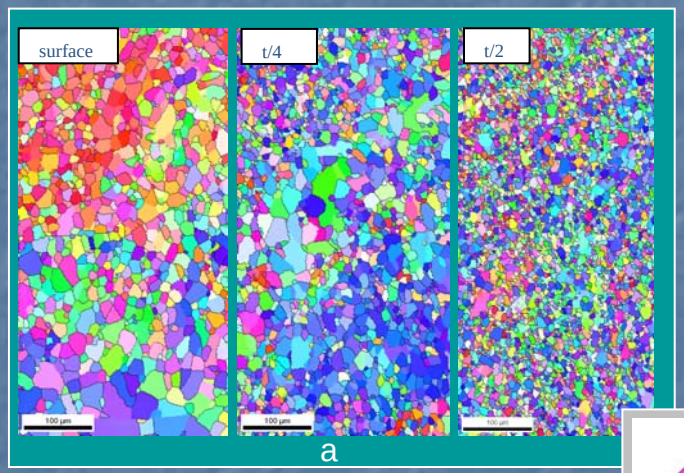
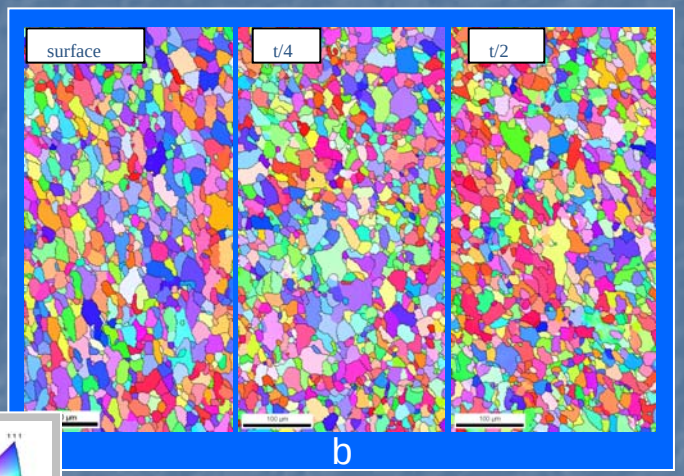
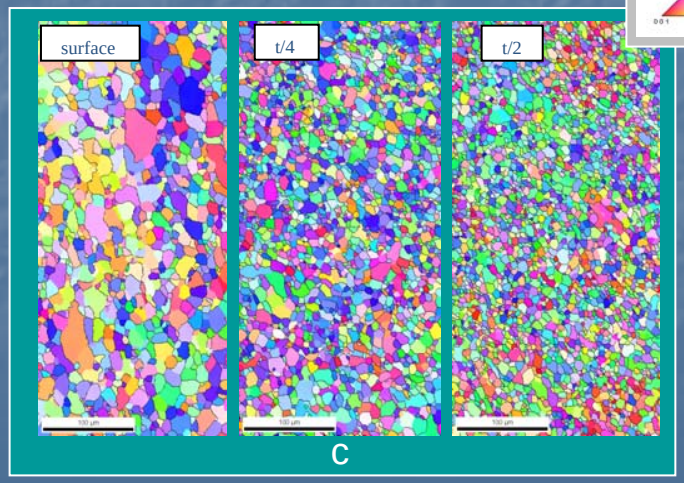
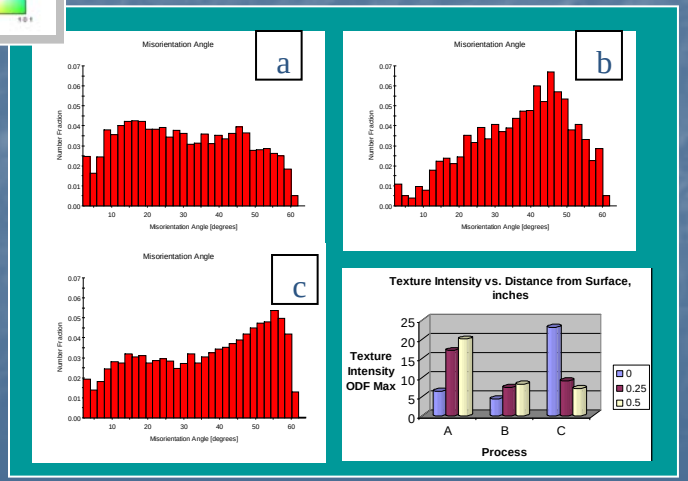
Billet Results (3 processes)

50 mm diameter sub-scale billet
Inverse Pole Figures of radial sections,
grain boundary number fraction vs. misorientation









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Scaled up to 165 mm

from t/4

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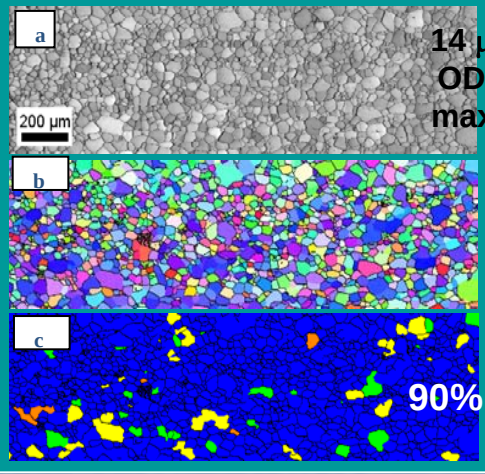
Tube Processing & Testing

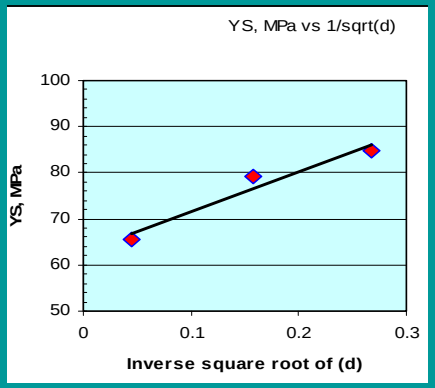
Flow Forming

Thickness

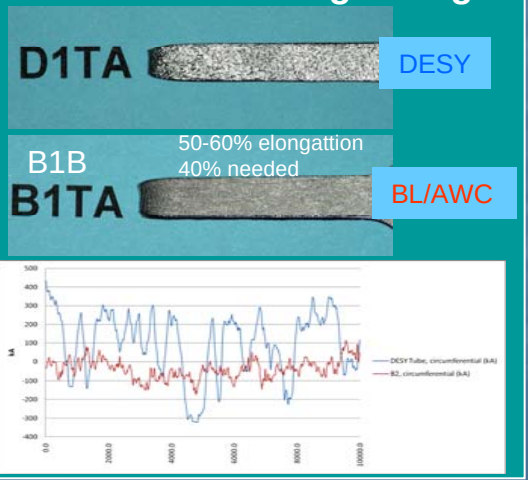
Recrystallization B1B

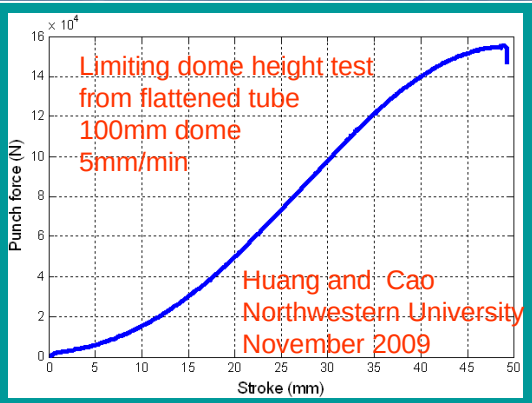


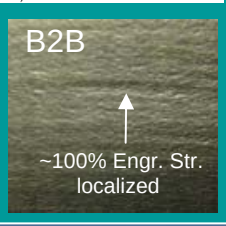
Hall-Petch



Tensile Tests/ Roughening







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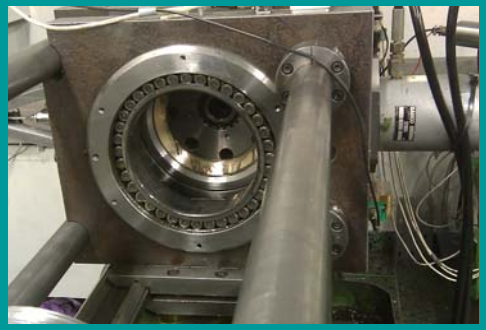
Tube Forming at DESY
December 2009

Spinning



B2B

Hydroforming

B2B

Final Hydroforming

B2B

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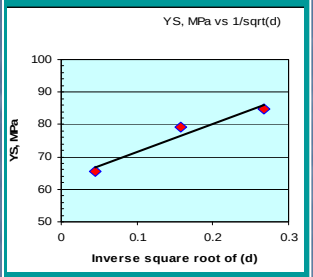
Processing improvement studies underway

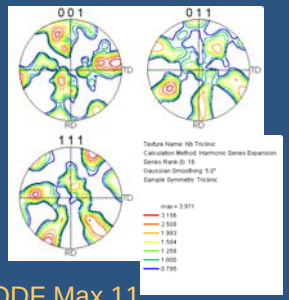
Grain Size & Texture



Low T final anneal

Texture radial sections

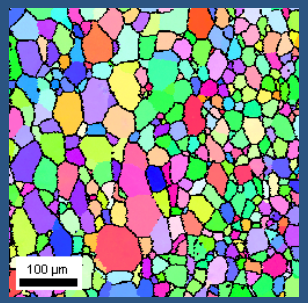
850°C



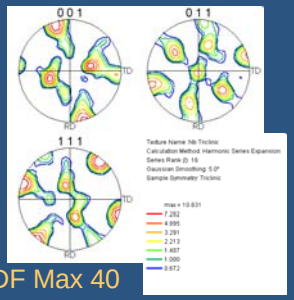
Radial

ODF Max 11

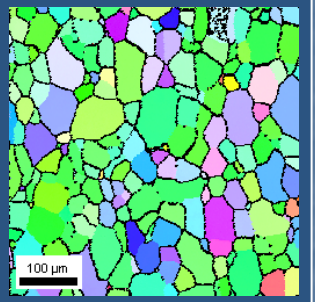
Axial (TD)



B1B



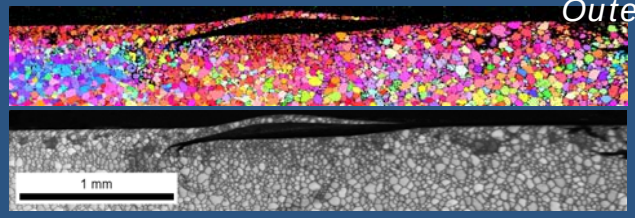
ODF Max 40



B1A

Tube Surfaces

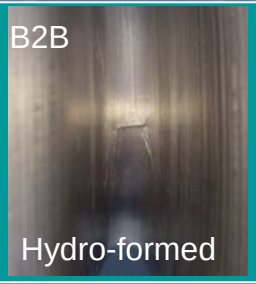
Surface lapping cracks

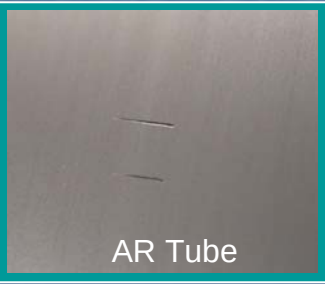


Outer surface

B1B

Surface cracks of unknown origin





B1C

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Conclusions

- High-strain billet processing, extrusion, flow-forming and recrystallization were used to produce fine-grained, weakly textured, recrystallized RRR niobium tube
- Surfaces of the fine-grained metal showed less roughening after forming
- Properties of the tube were adequate for the spinning/hydroforming with the DESY facility
- Two, 3-cell ILC cavities have been produced
- 3, 3-cell sections will be joined by EBW for final testing at Fermilab
- Processing improvement studies are underway