Microstructure and Mechanical properties of fine grain seamless Nb tube by an innovative shear deformation process.

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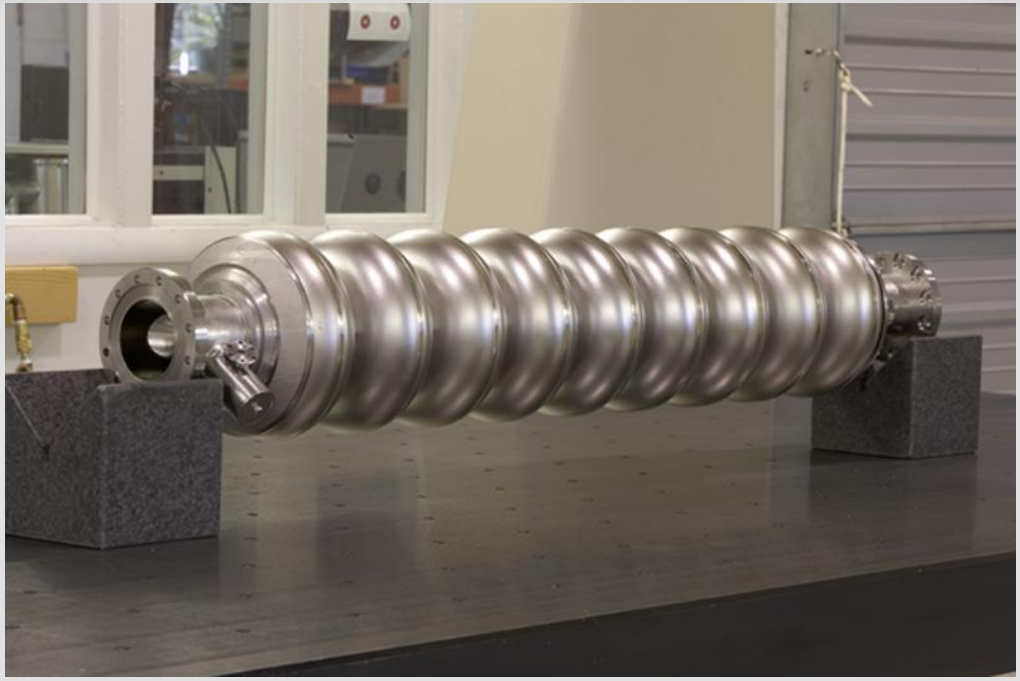
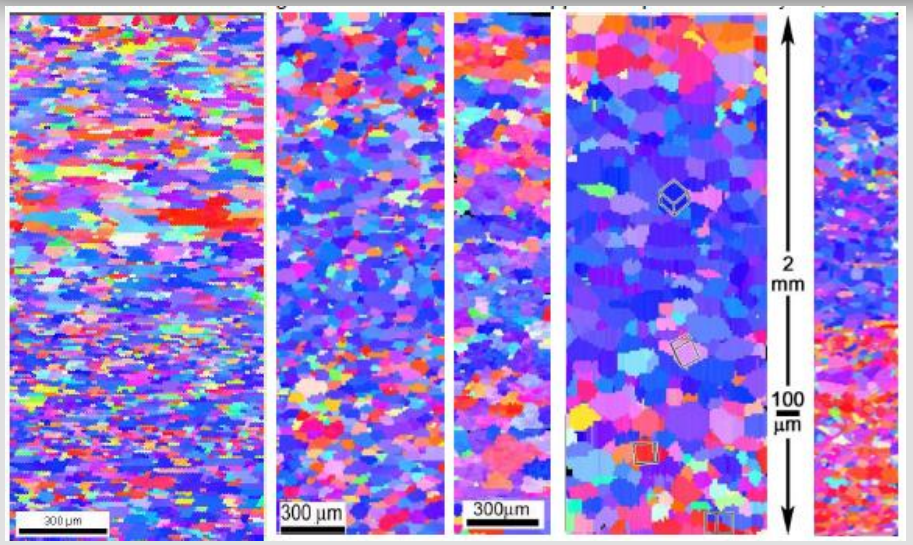
Motivation and Objective



Courtesy: FNAL

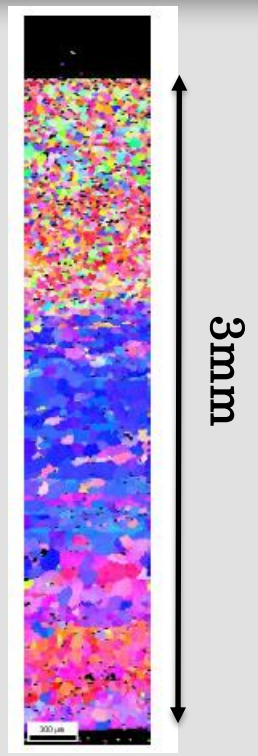
The main objective of this work is to develop processing strategies for seamless Nb tube that give uniform through thickness microstructure and desired mechanical properties that are suitable for hydroforming.

Problem

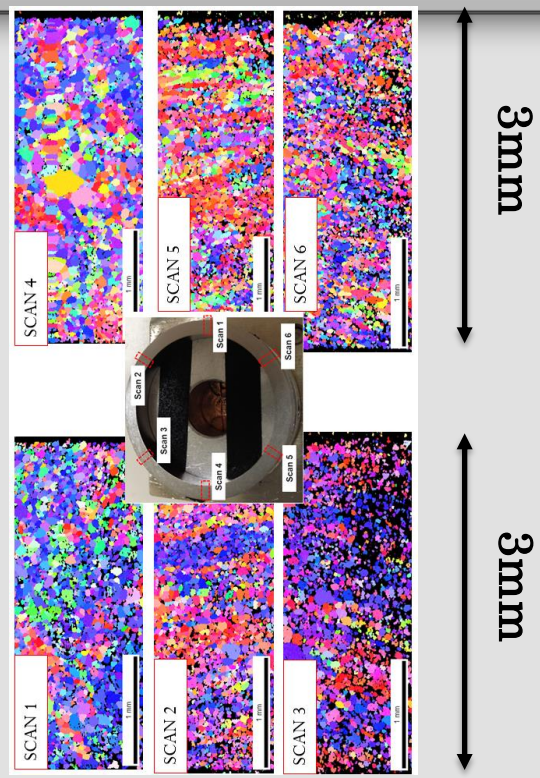


Rolled Nb sheet

Courtesy: Dr. Bieler, MSU



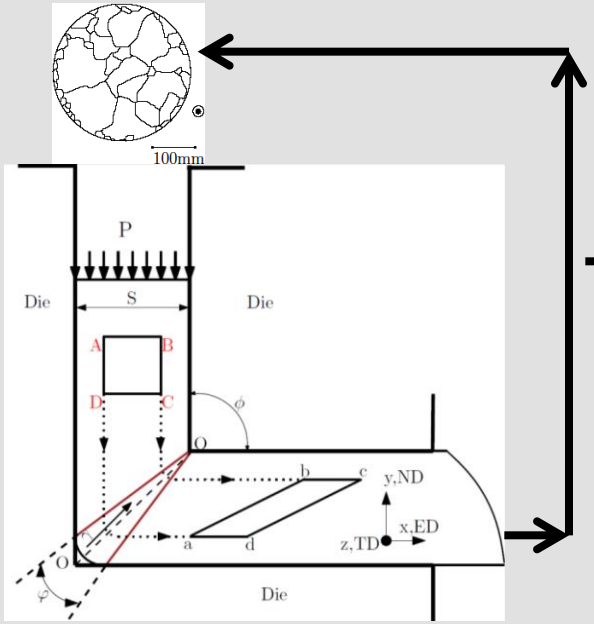
Back extrusion and flow forming



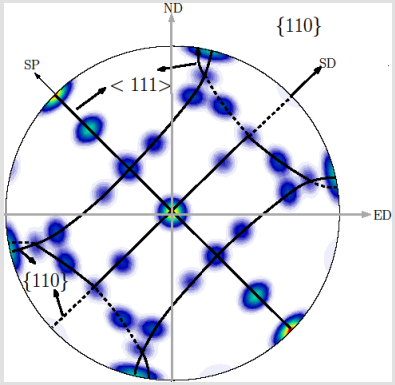
Forward extrusion/ SFI, TAMU

Obtaining polycrystalline Nb with a fine grain sizes and uniformity is a challenge

Approach: Multi pass ECAE of Nb with intermediate heat treatments for microstructure engineering.

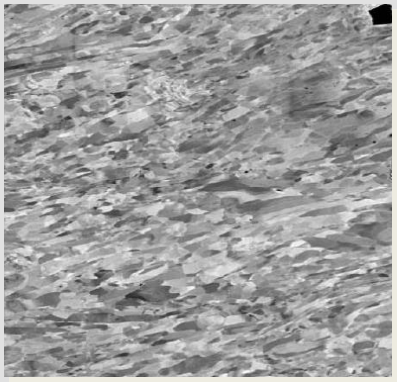


Texture



Typical texture components in Nb that occur after ECAE. Depends on route and intermediate heat treatment.

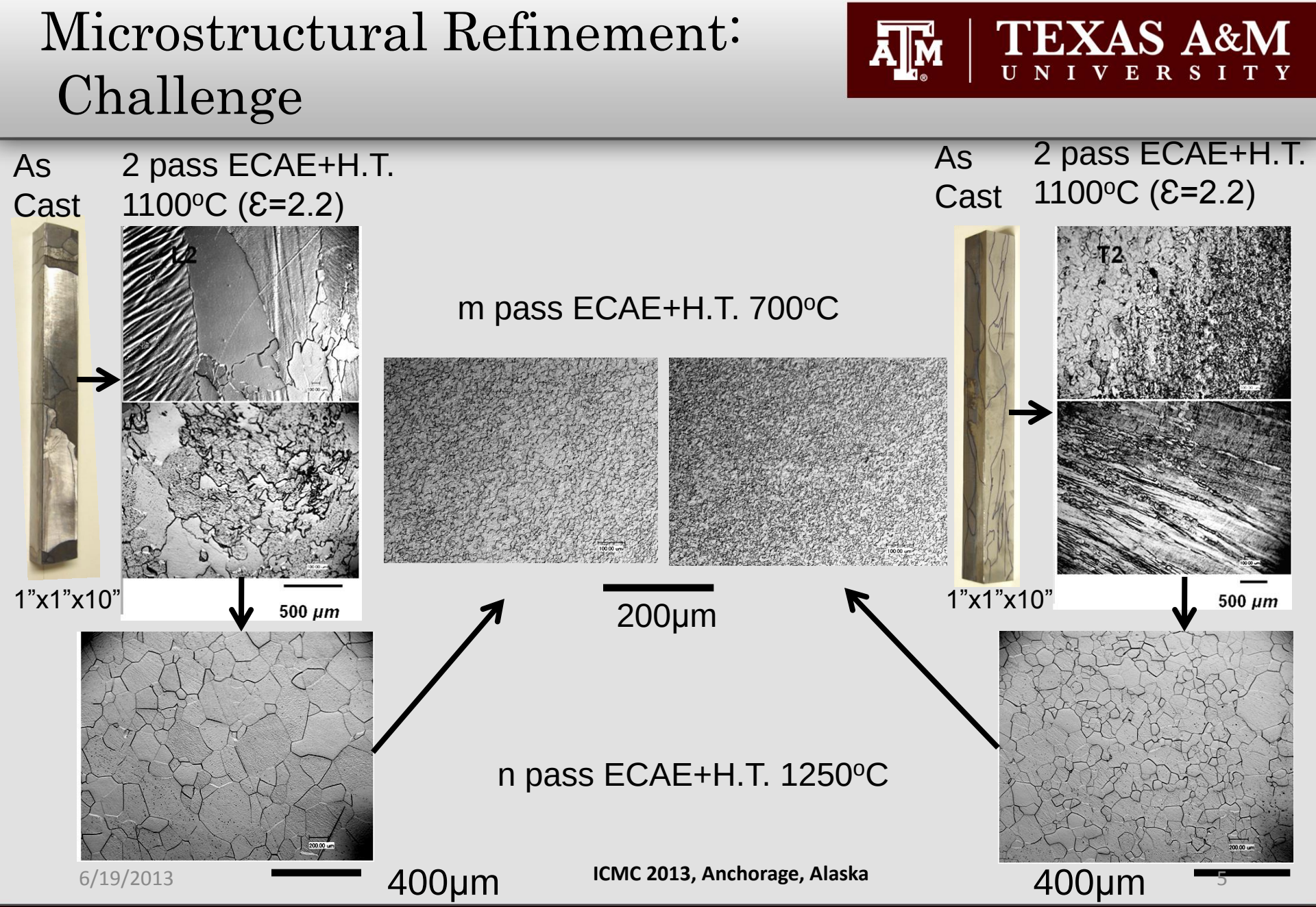
Ultra fine grain (UFG)- 100-300nm



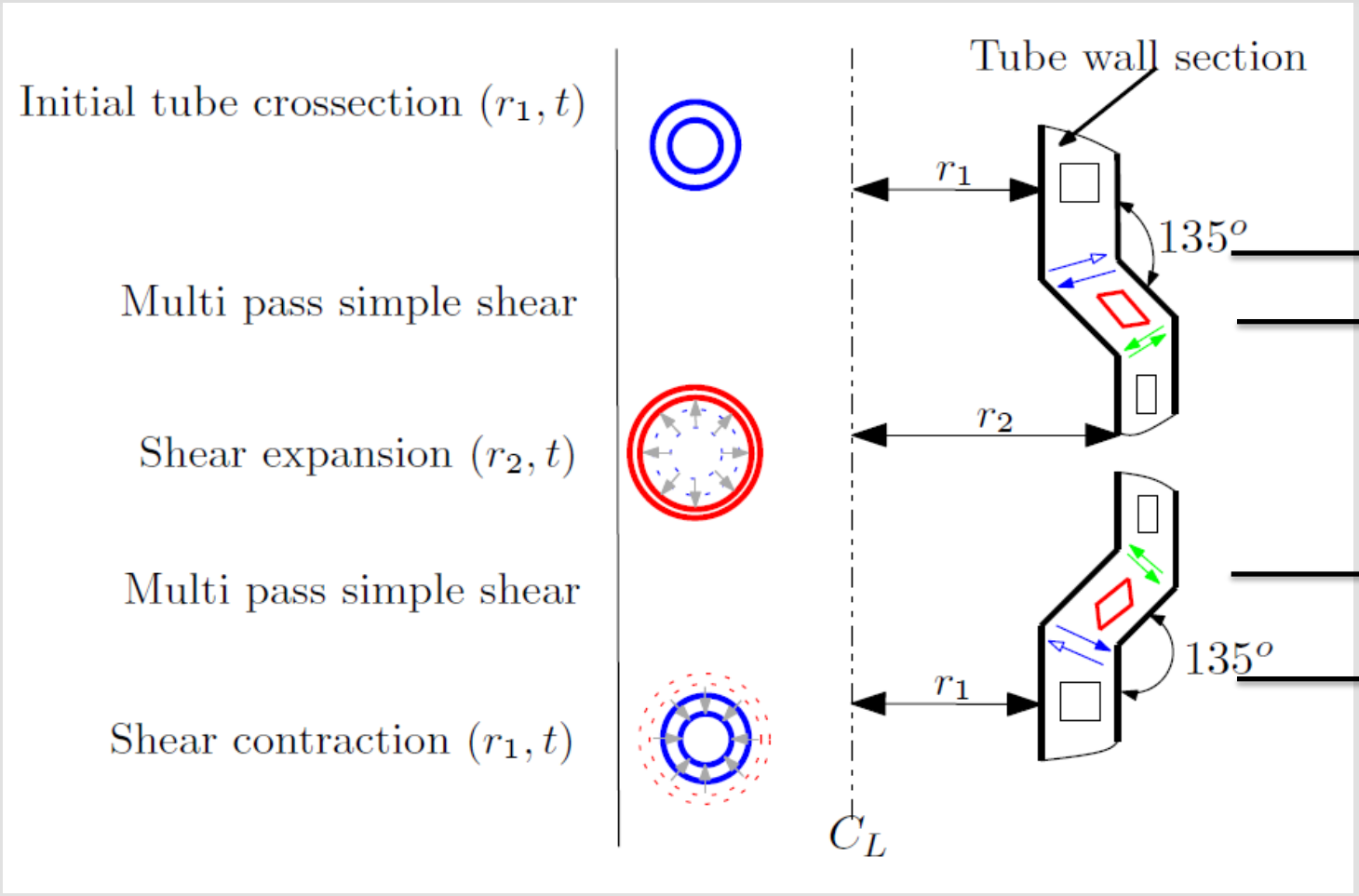
5 μm

Back scatter image of a Nb bar processed through four ECAE passes(90^{o} between passes)

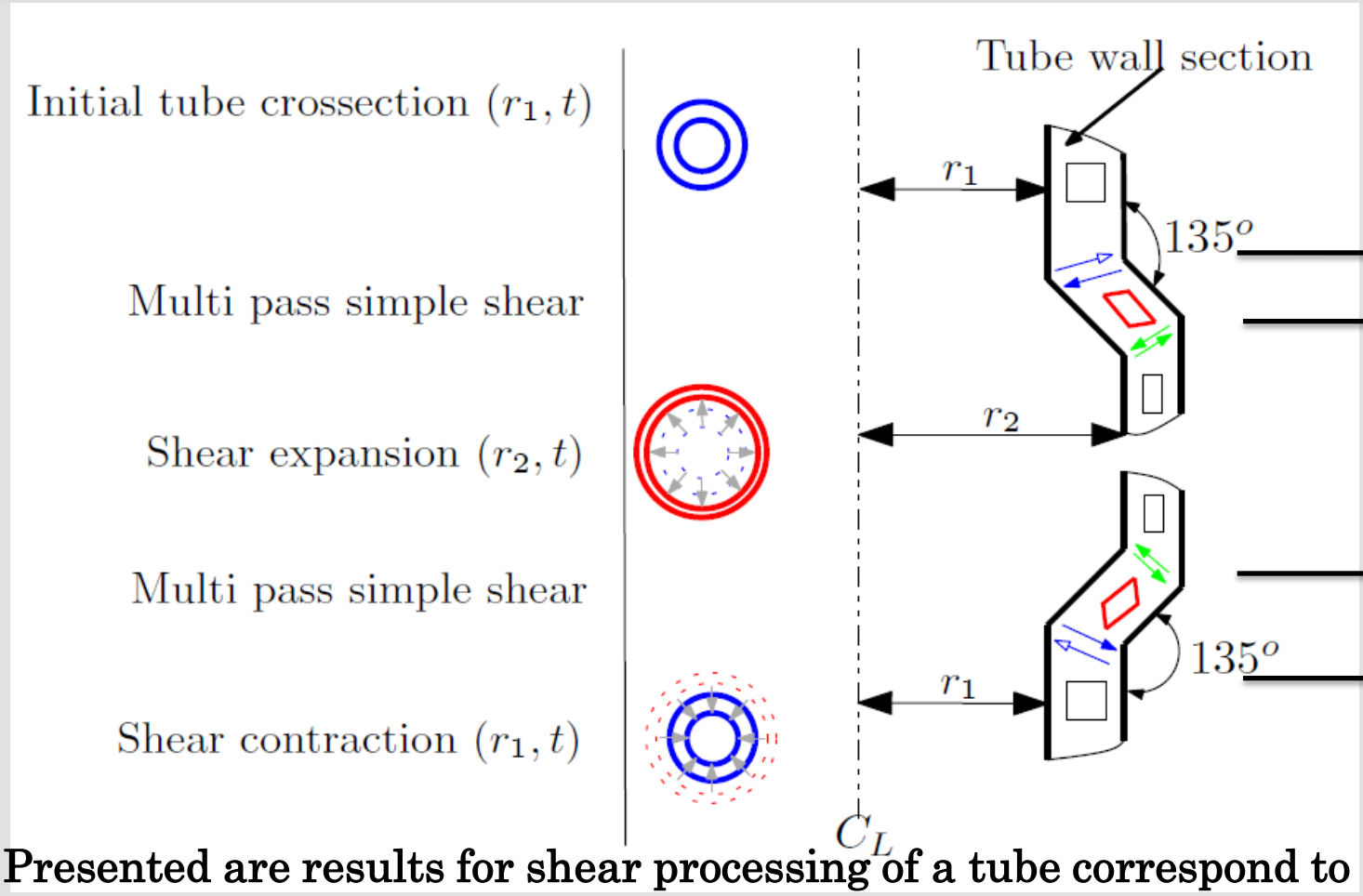
Microstructural Refinement: Challenge



Tube processing by simple shear



Tube processing by simple shear



Presented are results for shear processing of a tube correspond to the shear expansion step.

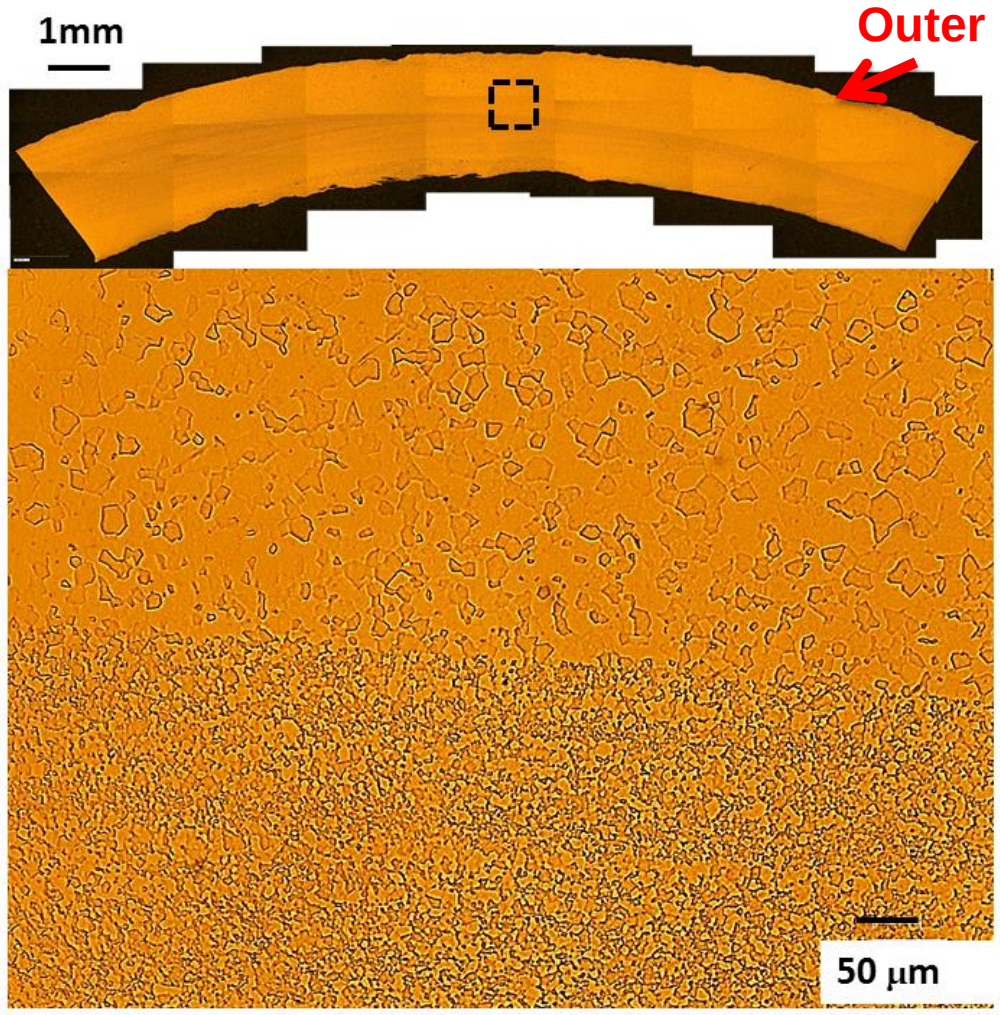
Materials and Methods

- RRR 185 Nb from Niowave
- ECAE processing to refine the initial microstructure.
- Area reduction Extrusion
- Shear processing of a tube.

Three different thermo-mechanical processing histories:
Area Reduction + Rx at 900 C
Area Reduction + Rx + Shear Processing + Rx at 900 C
Area Reduction + Shear Processing + Rx at 900 C

- Mechanical testing and macro texture characterization.

Results: Optical Microscopy Area Reduction + Rx



- Strain of ~1.18.
- Banding in microstructure observed. No specific directionality was observed

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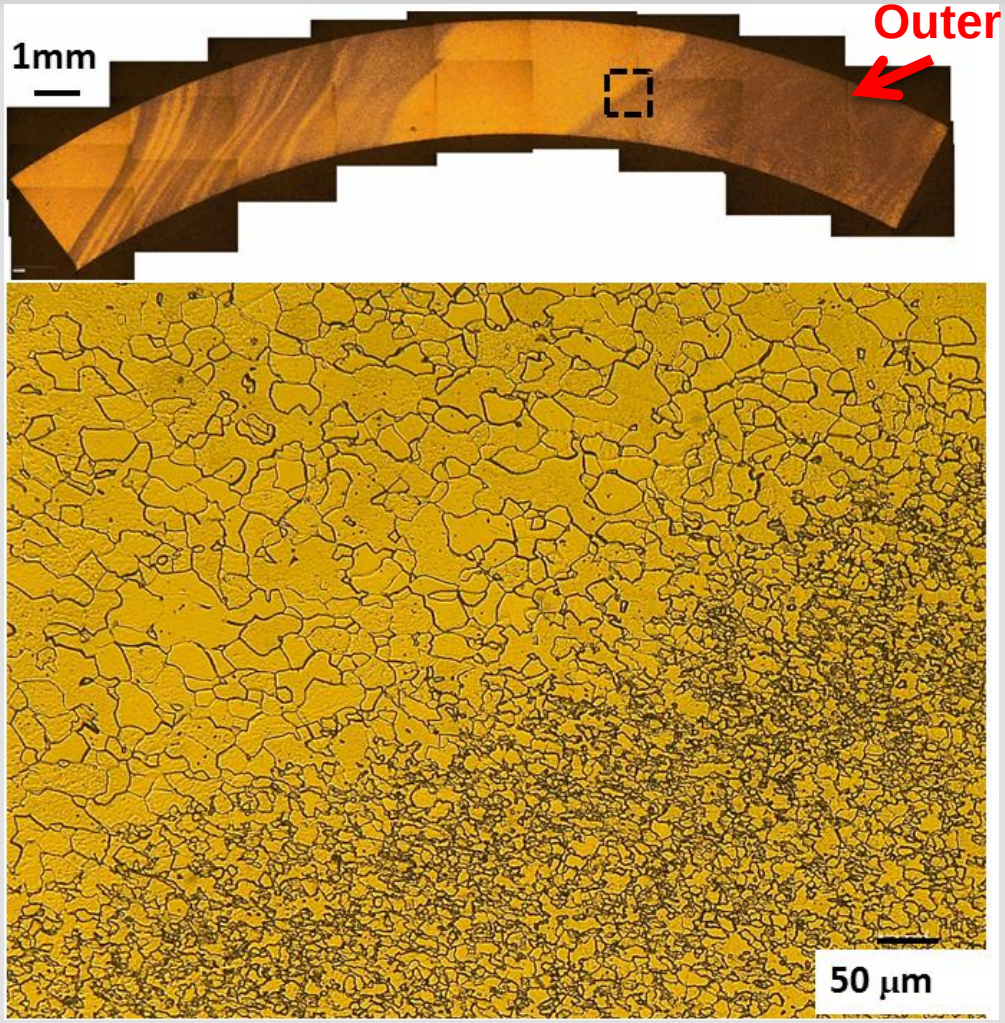
- Average grain size 53±34μm
- Grain size in banded regions 13 ±4 μm

Results: Optical Microscopy Area Reduction + Rx + SPt+ Rx



- Strain of ~1.18 + Rx + 0.48
- Bands propagate through the thickness.

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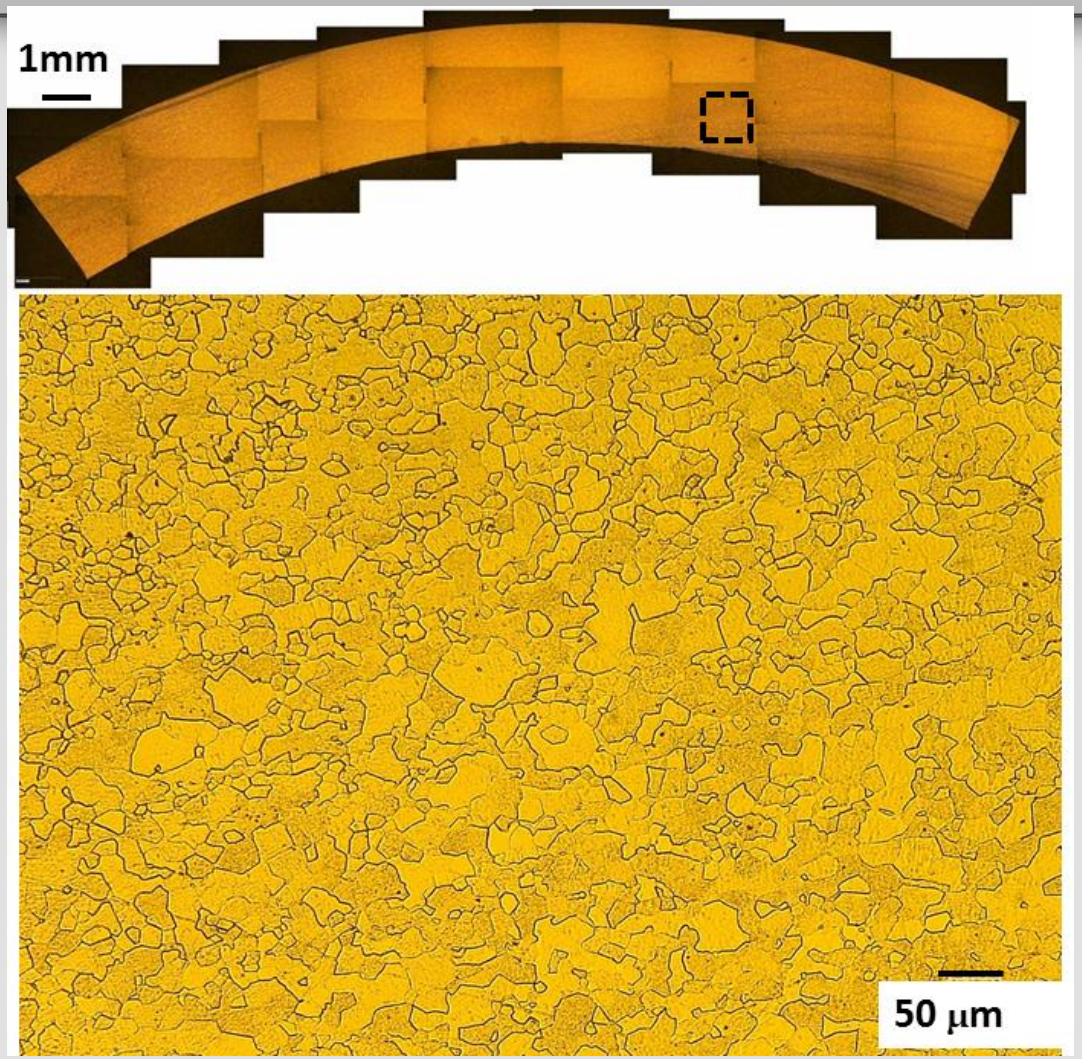
- Average grain size 40±30μm
- Grain size in banded regions 7±2 μm.

Results: Optical Microscopy Area Reduction + SPt + Rx



- Strain of ~1.18 + 0.96 +Rx
- Very diffuse banding.
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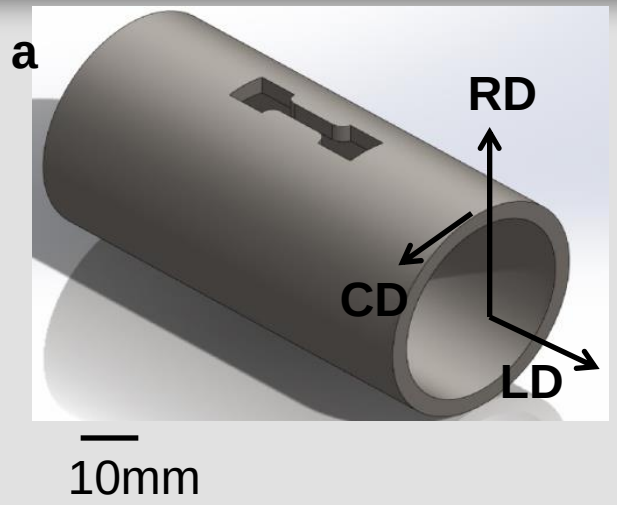
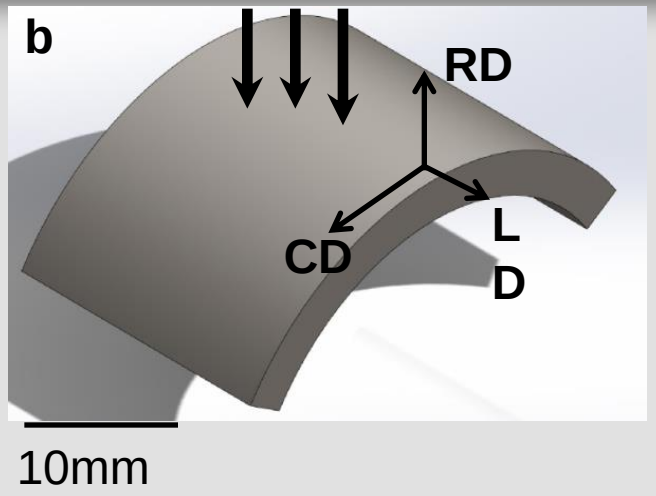
- Average grain size : 20±17 μm
- Grain size in banded region: 12 ±4 μm

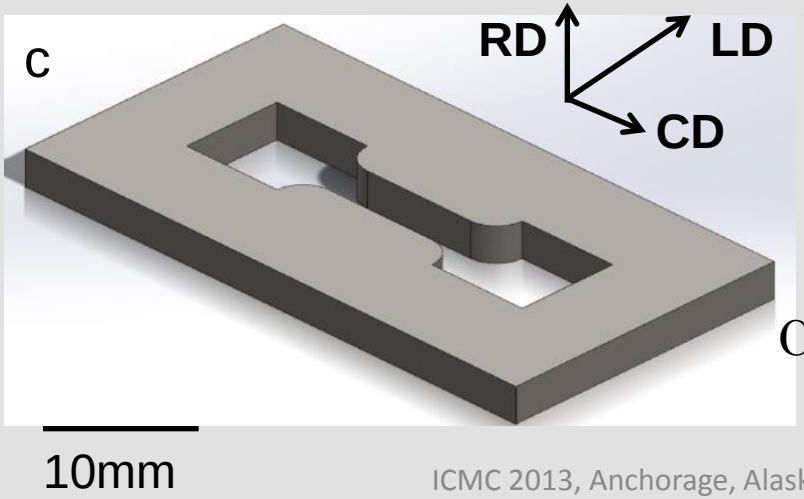
Tensile testing along major axes



Longitudinal tensile samples

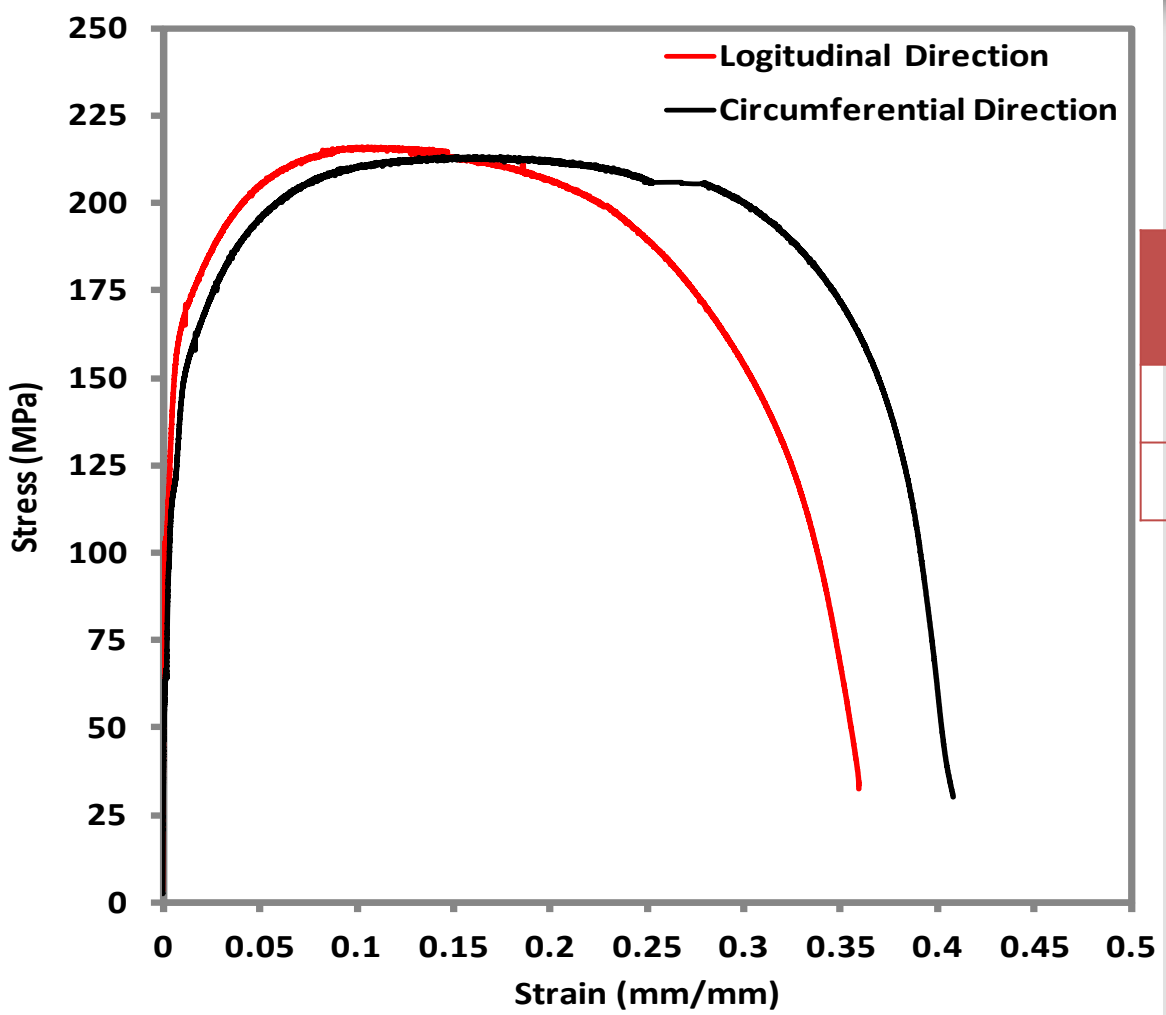


The tube section was flattened before Rx in all cases



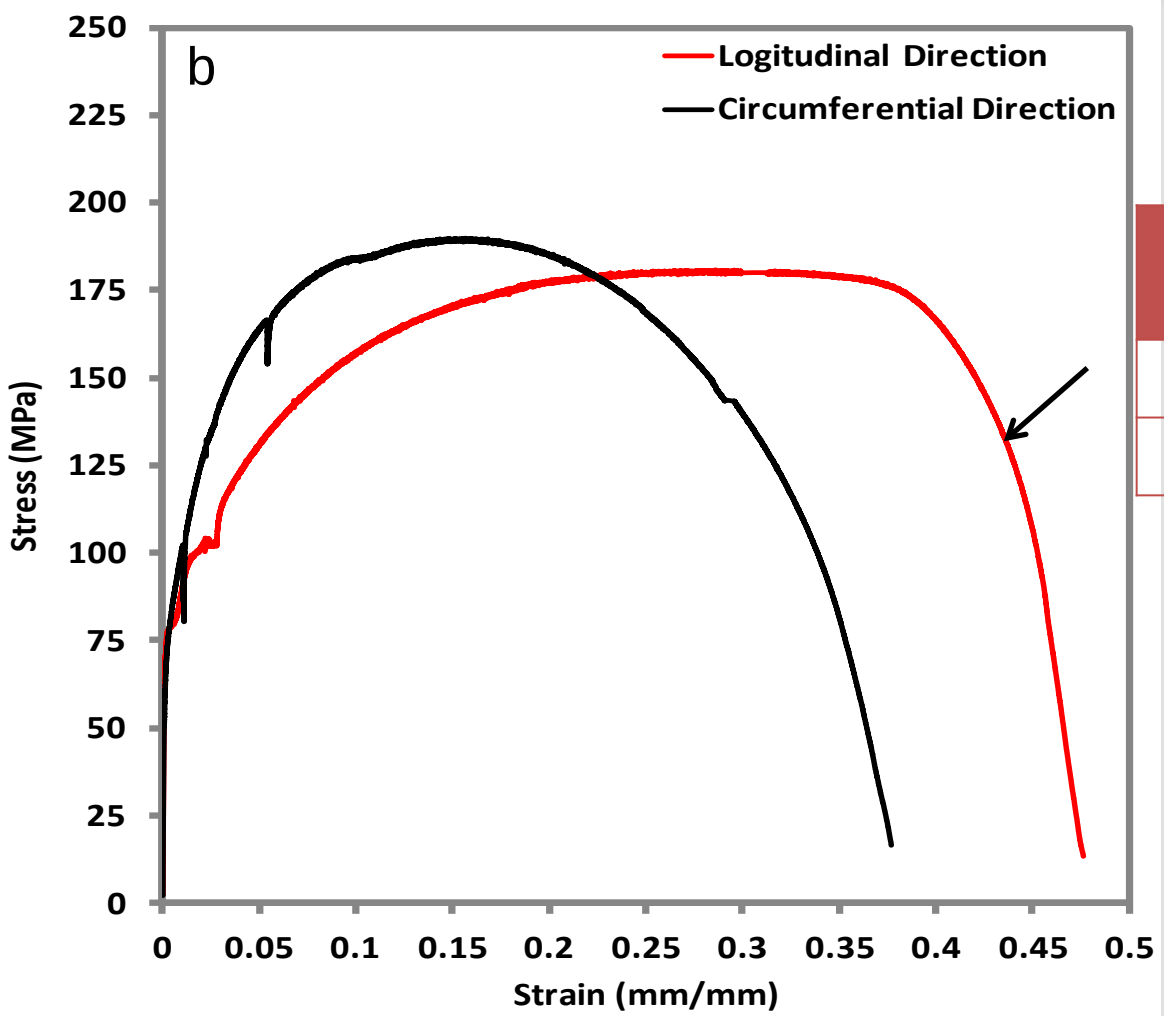
Circumferential tensile specimens

Tensile tests: Area Reduction + Rx



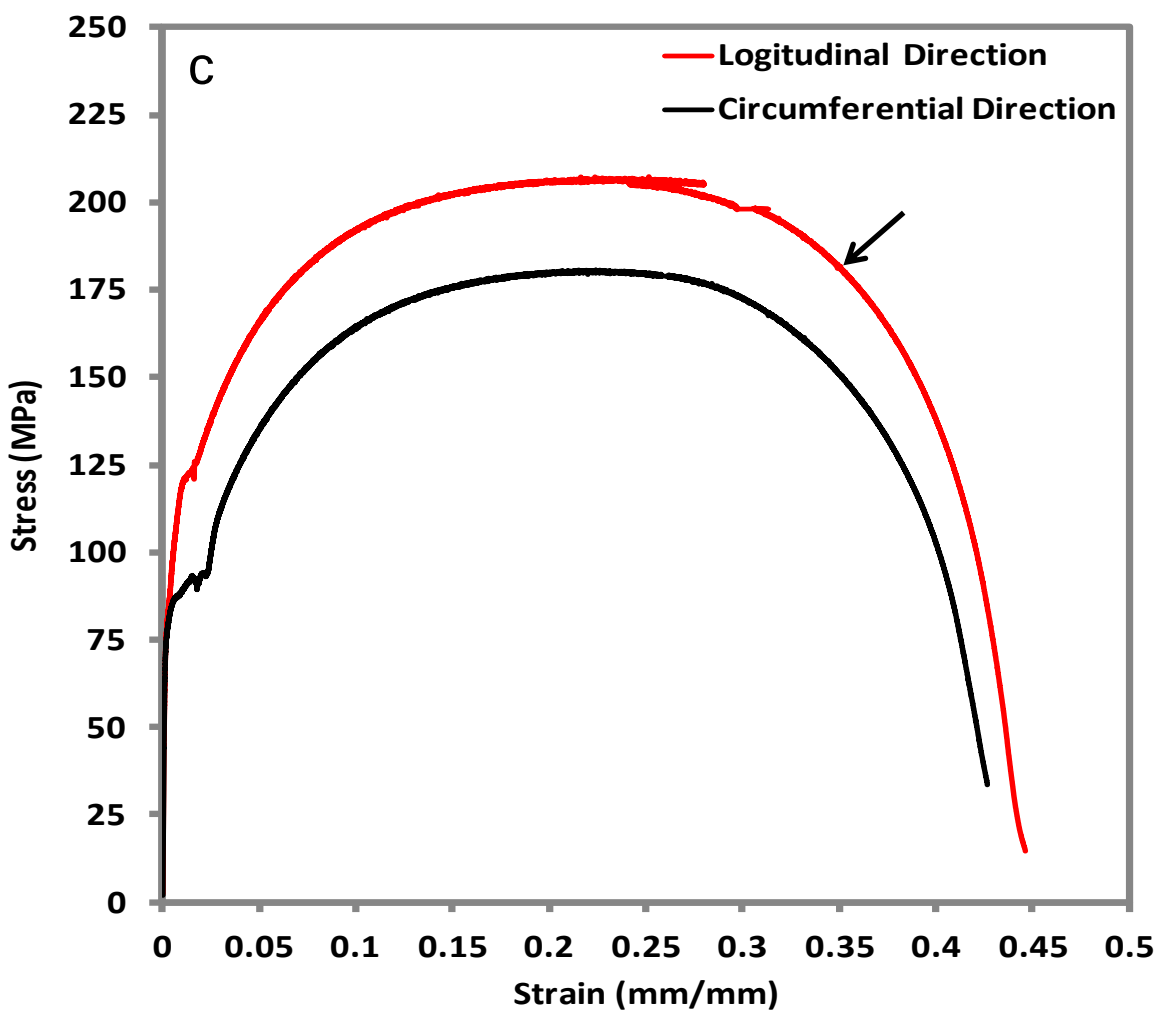
	n	UTS (Mpa)	Strain at failure (%)
LD	0.16	210	37
CD	0.16	205	42

Tensile tests: Area Reduction + Rx + SPt + Rx



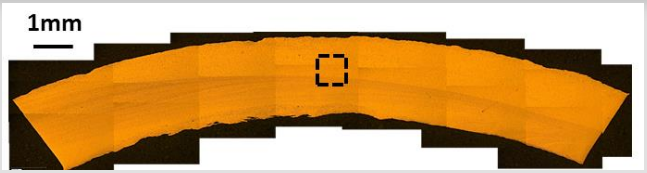
	n	UTS (MPa)	Strain at failure (%)
LD	0.25	172	37
CD	0.12	187	42

Tensile tests: Area Reduction + SPt+ Rx

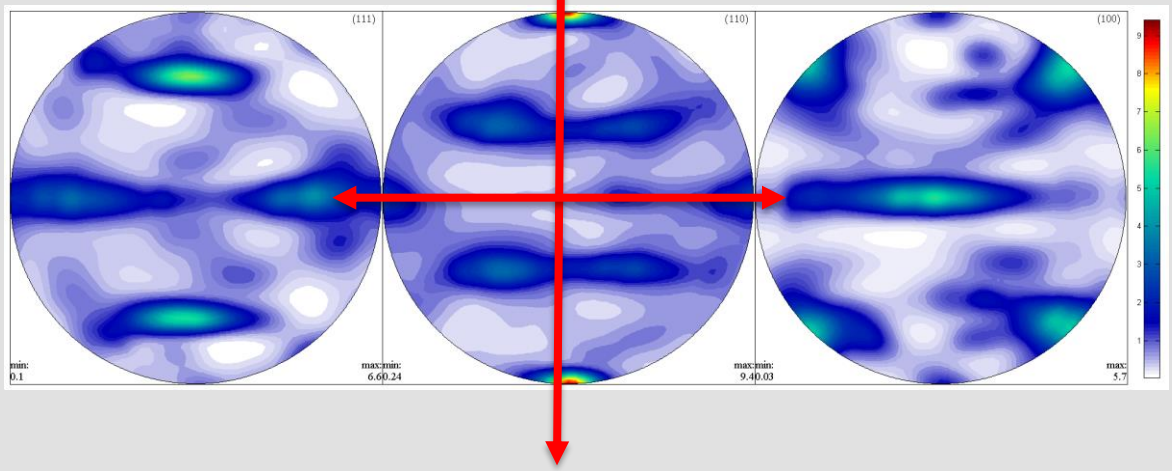


	n	UTS (MPa)	Strain at failure (%)
LD	0.2	202	45
CD	0.2	172	46

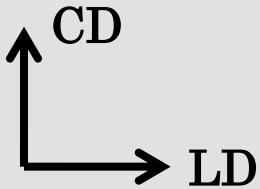
Macrotexture: XRD
As area reduced + Rx



{111} {110} {100}



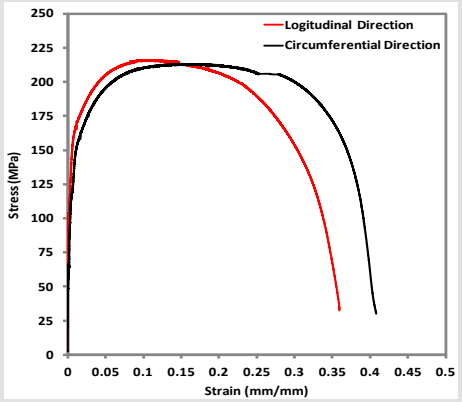
max = 9.4 m.r.d



min = 0.03 m.r.d

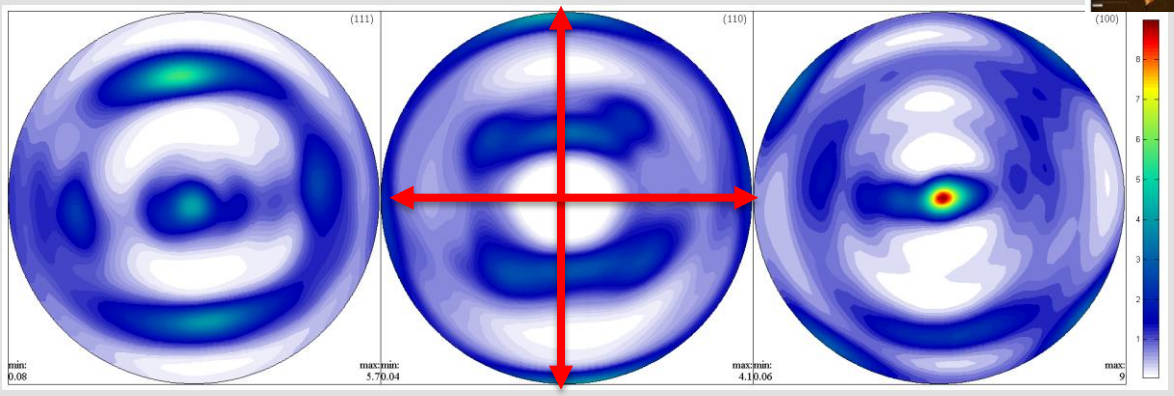
Strongest texture component:
{101}|| LD and <101>|| CD

Major texture determines the tensile property

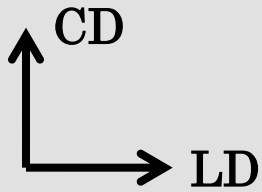


Macrotexture: XRD
As area reduced + Rx+ SPt+Rx

{111} {110} {100}



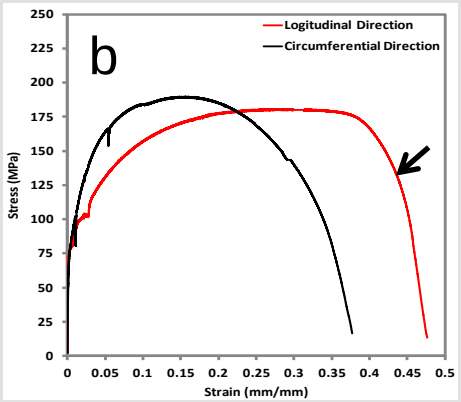
max = 9 m.r.d



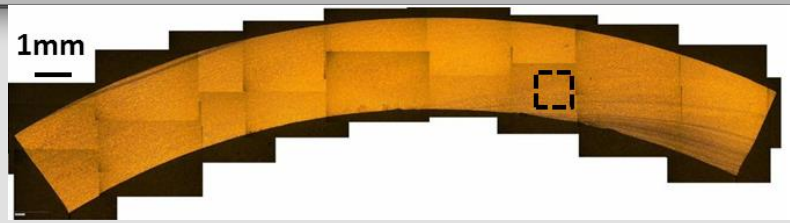
min = 0.04 m.r.d

Strongest texture component:
Rotated cube component: {100}| | RD

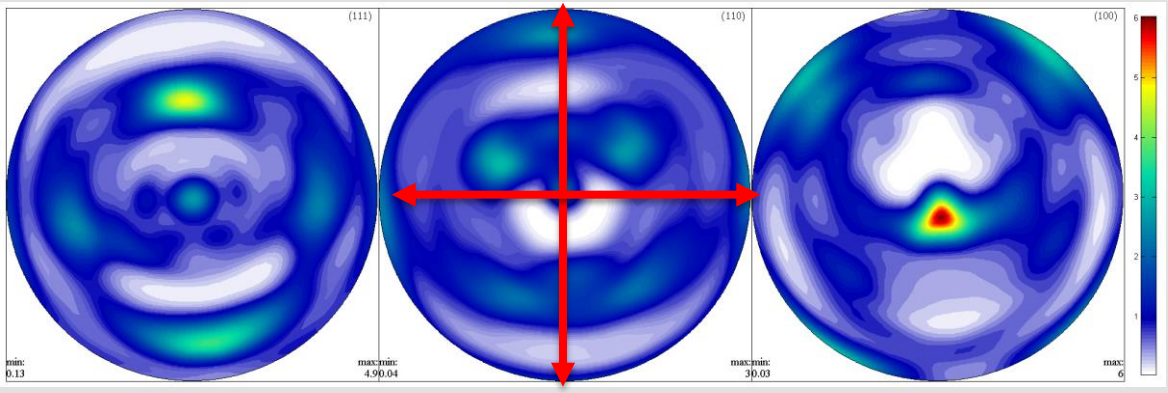
Major texture determines the tensile property



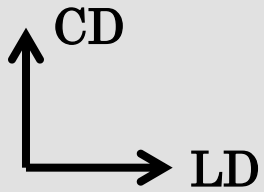
Macrotexture: XRD
As area reduced + SPt+Rx



{111} {110} {100}



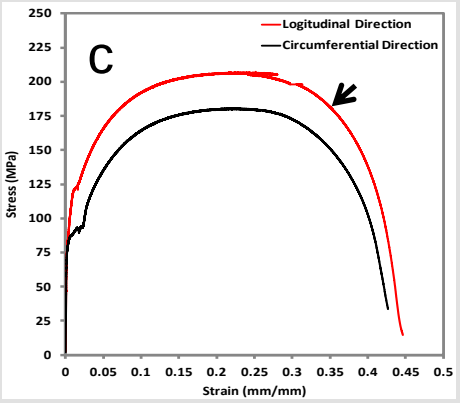
max =6m.r.d



min = 0.02 m.r.d

Strongest texture component:
20 degrees misoriented from the previous PF

Major texture determines the tensile property



Conclusions

- Ductility is mainly affected by the banded microstructure
- Tensile properties are affected by the major texture components, however there is sufficient ductility in perpendicular directions.
- Microtexture determination will provide further insight into the origin of bands.(Friction, Material depenedence?)

Thank you

Questions?

EXTRA SLIDES