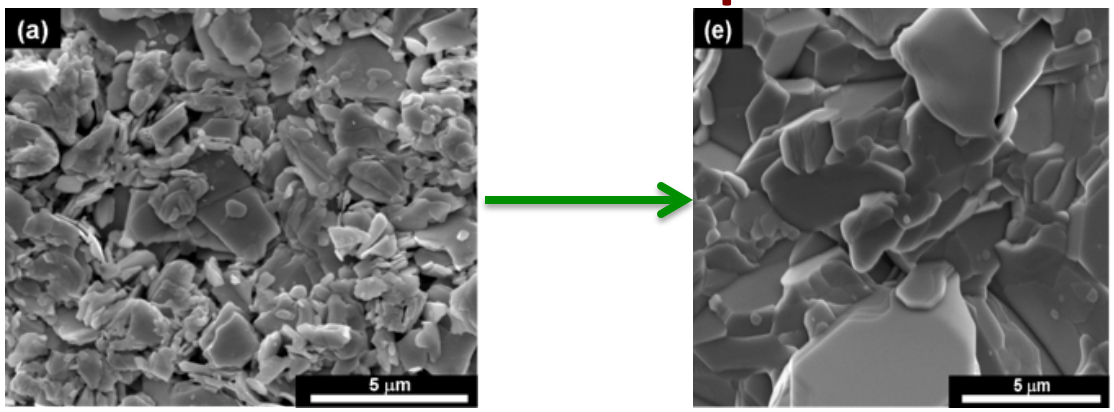
Bi-2212 Textured Powder Conductor Recent Developments



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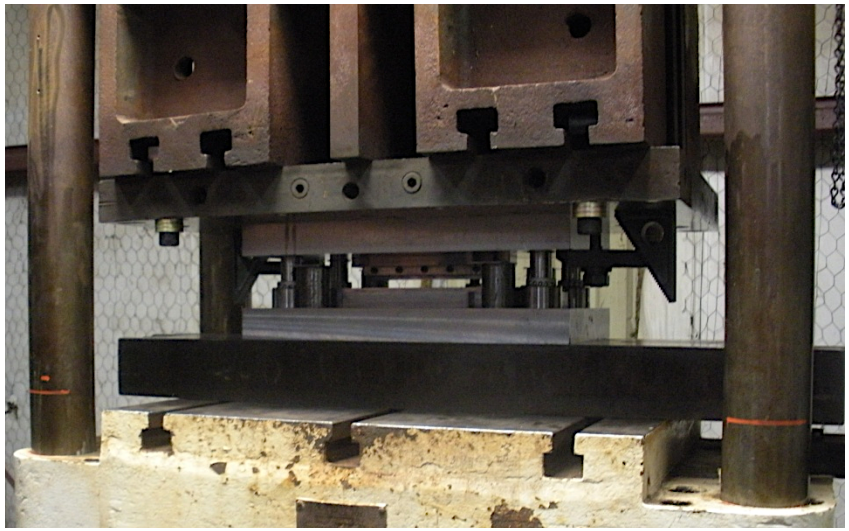
Purpose of Pre-Texturing

- Enhance J_e by aligning High-J_c ab planes
  - 70% texture in green billet
- Open possibility for *non-melt heat treatment*
  - inter-grain connectivity without melt
  - nearly phase-pure Bi-2212 after non-melt HT
  - widen processing windows: 870 ± 10 C
  - 90% texture after non-melt heat treatment
  - ~85% dense after non-melt heat treatment

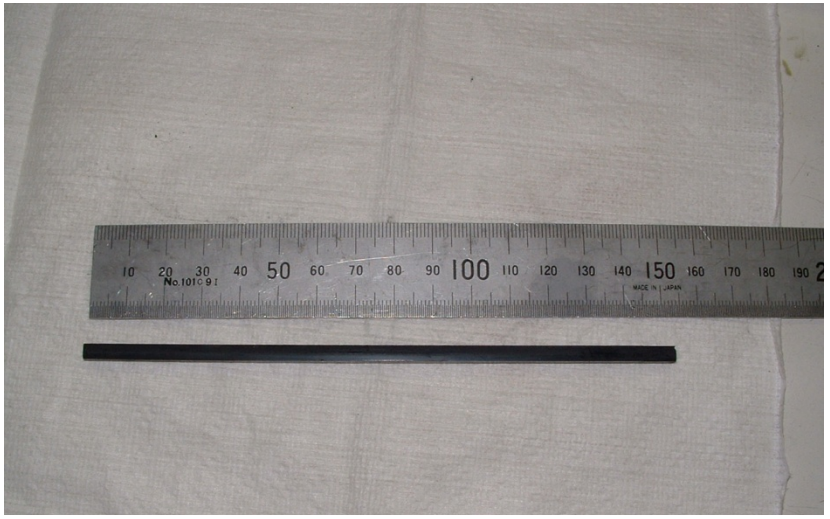
Outline

- Summary of Phase 1 results:
  - Demonstration of ability to texture in bulk
  - Developed (not optimized) non-partial melt HT
  - Initial transport measurements
- Recent developments
  - Evidence of preferential shear
  - Low current, high temp measurements
  - Advanced microstructure and AEC growth quantization (ongoing)
  - Emergence of probable amorphous phase
- Upcoming work
  - Monocore extrusion and drawing
  - Heat treatment optimization
  - SS measurement capability

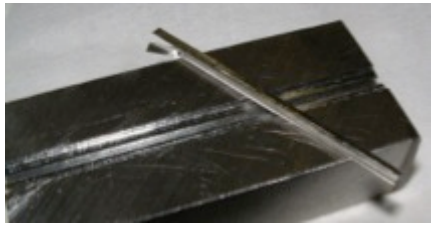
Fabrication of short-length textured bulks



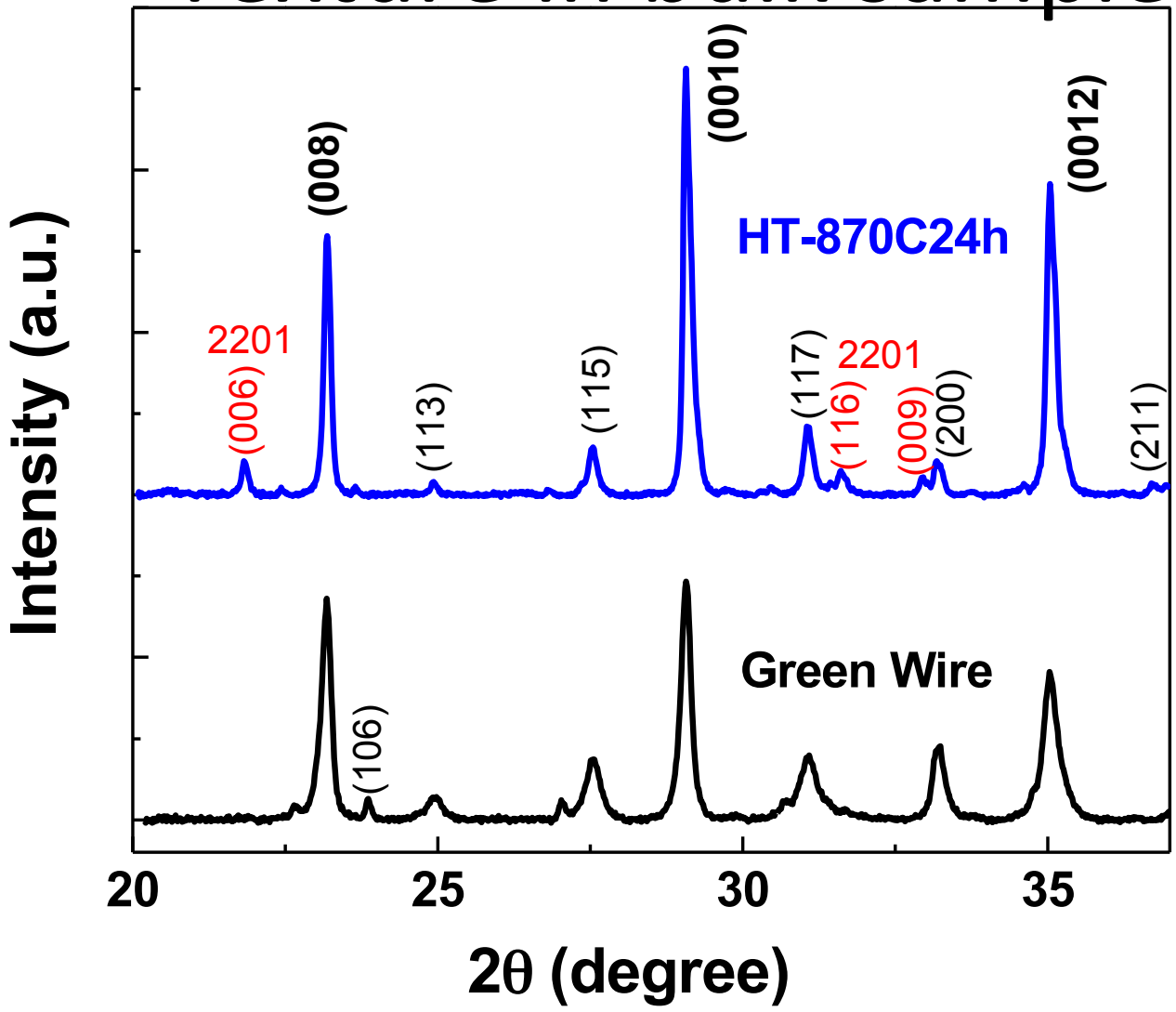
Die set mounted in press



140 MPa, 4 mm x 4 mm x 150 mm sample.



Texture in bulk samples



Texture parameter

τ= 0.896

τ = 0.787

Texture in bulk samples

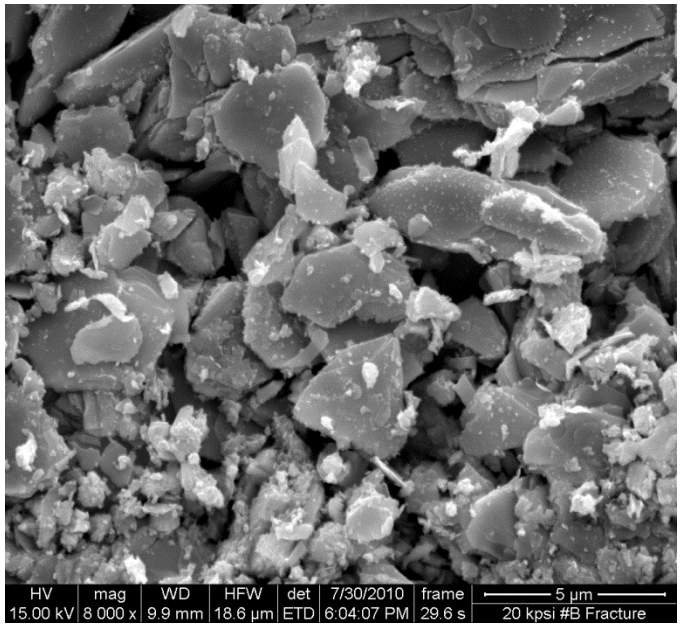
Round Pellet

Heat treatment		Density (g/cm^3)	Grain size in ab plane (μm)	Texture parameter**
Temperature (°C)	Time (hour)			
Loose Powder		1.30	1.20	0.13
OPIT Green Wire*		-	-	0.32
Green Pellet		3.98	1.20	0.68
800	2	-	1.39	0.69
835	2	4.24	1.55	0.74
835	24	4.37	1.79	0.75
865	24	5.13	3.55	0.80
875	2	5.24	2.69	0.84
875	24	6.32	4.31	0.89

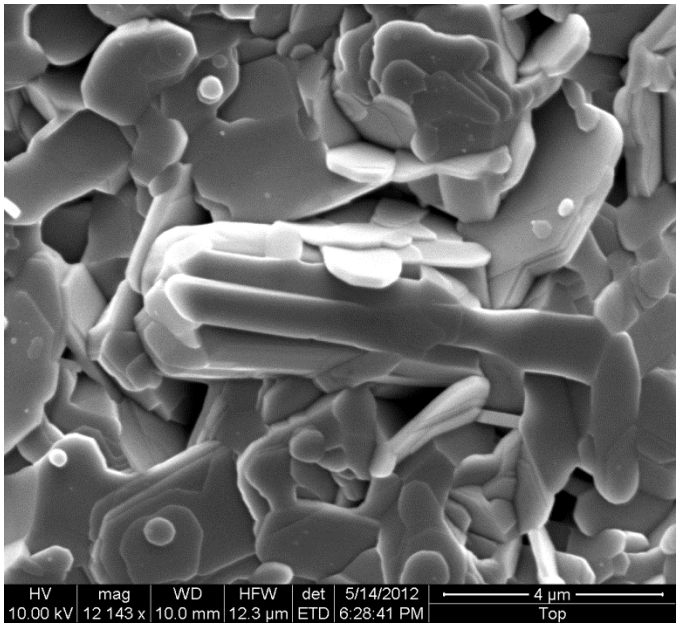
Square Wire

Pressed Green Wire		-	-	0.79
870	**24**	5.86	2.5-5	0.90

Phase growth of 2212



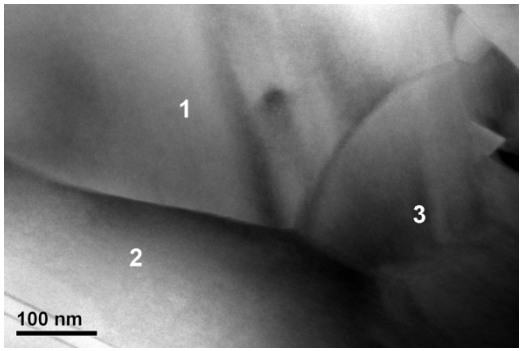
Green Pellet



870 C, 24 h sample.
Typical particle size ~4 um

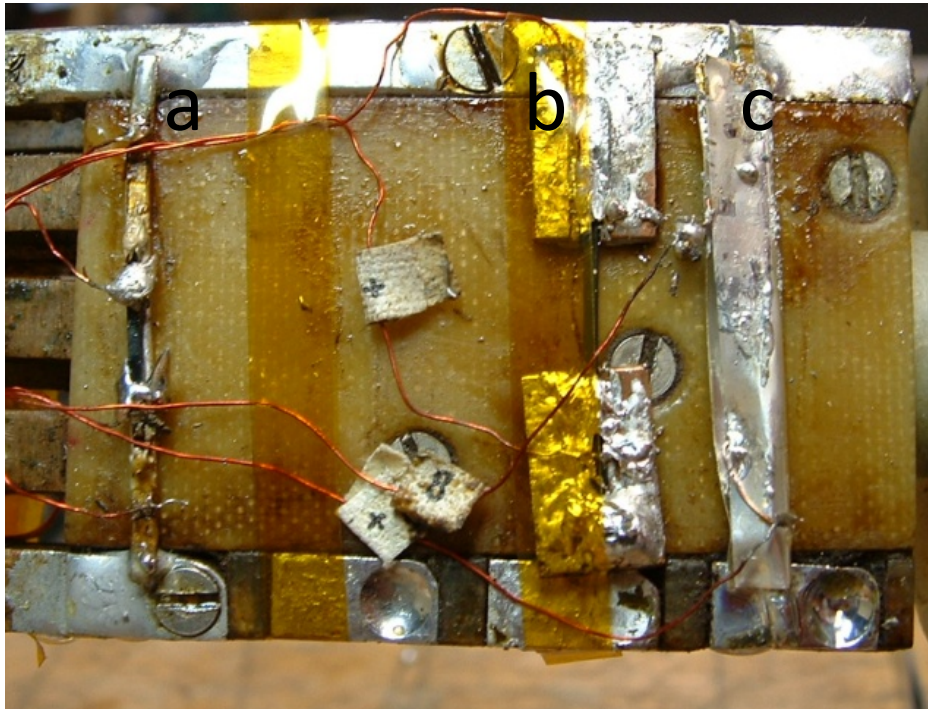
TEM images of 870 C, 24 H sample:

Right: Planar view showing three adjacent 2212 grains
Far Right: transverse view showing stacked 2212 grains



Transport Measurements

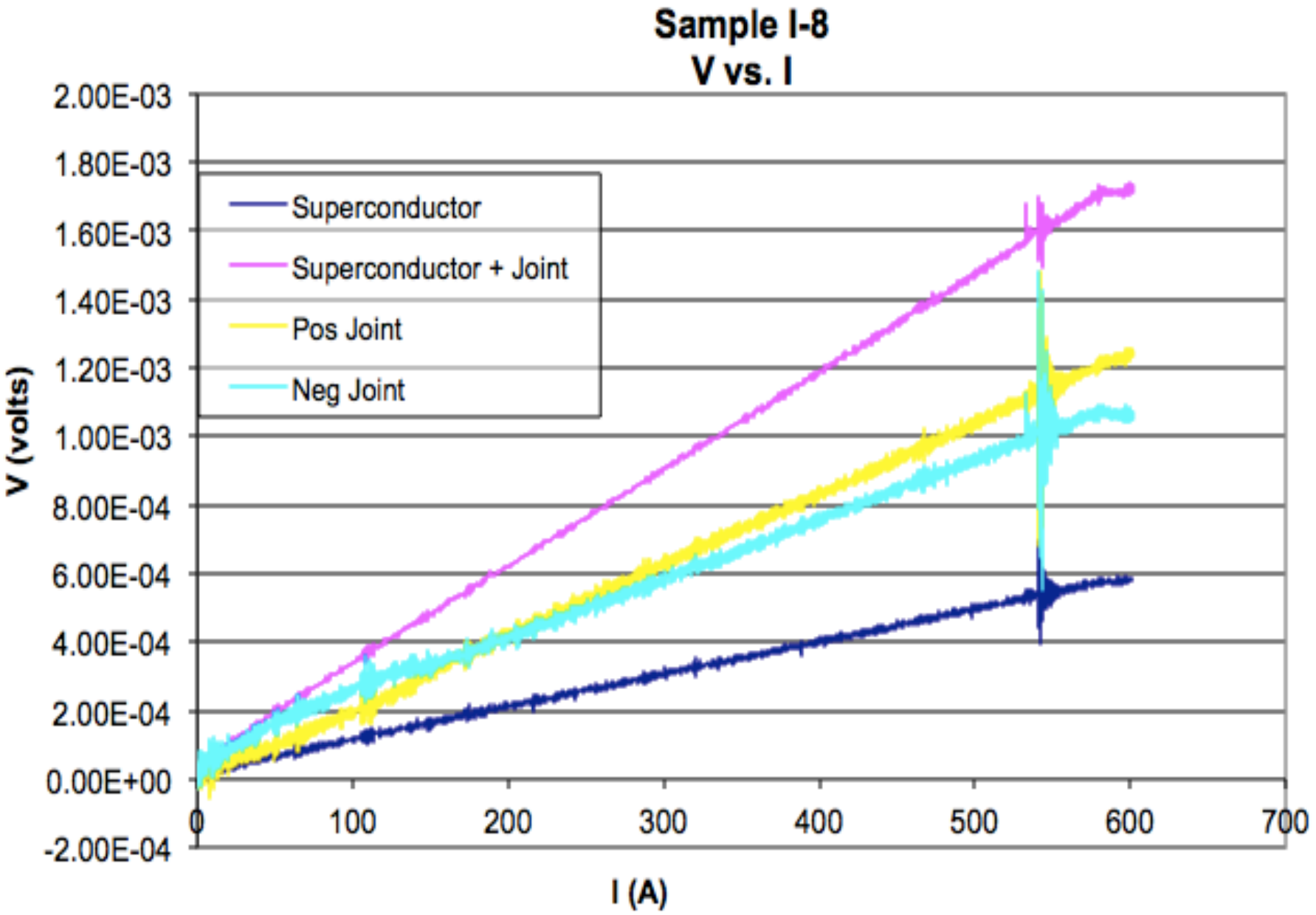
- 4.2 K
  - Self field
  - 5 T
  - Thanks to ASC/NHMFL
- Open bridge (B)
- Silver wrapped (before HT)
- Open faced: only one BSCCO surface in contact with Ag (A)
- Indium used as solder (released in several samples)



Transport Measurements

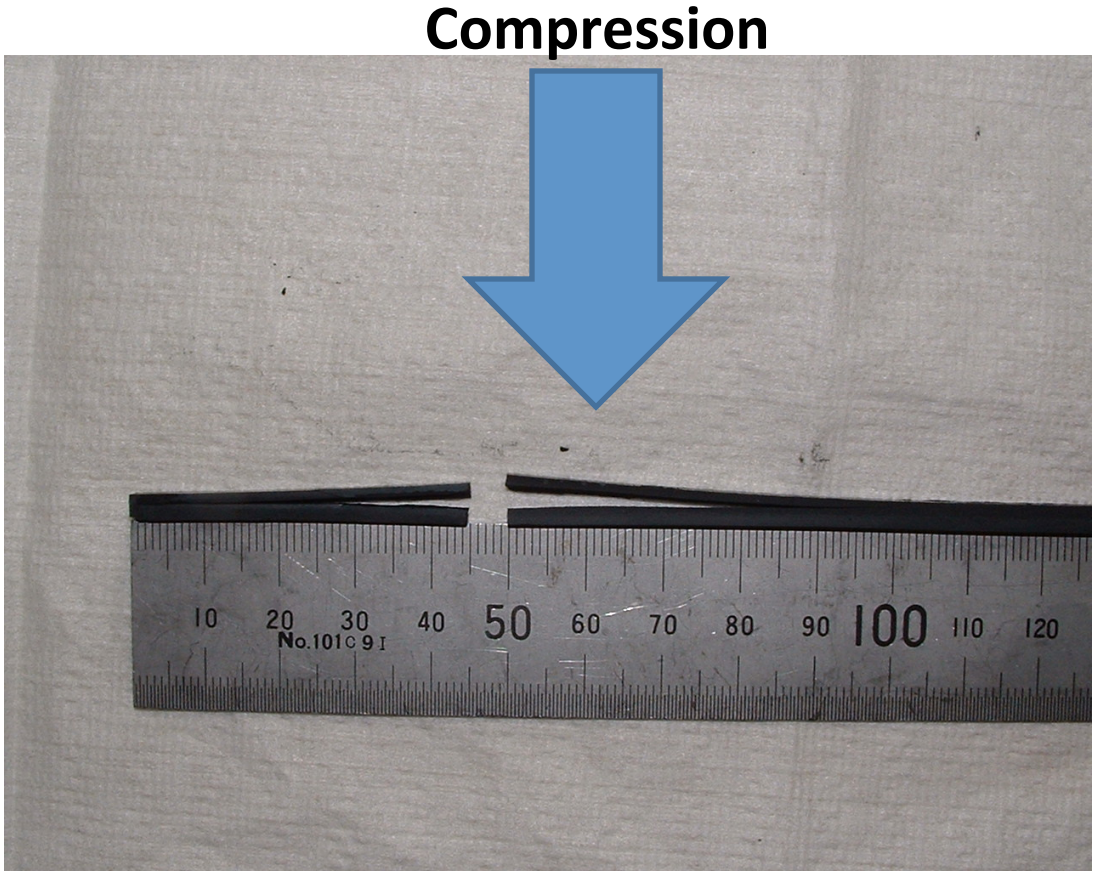
Sample	T_{max}, time	B (T)	Calculated normal resistance of sample @ 4.2 K (μΩ)[*]	Measured V/I (mW)	$\frac{V/I}{R_p}$
I-8	870 C, 24 h	5	16.2	0.96	.06
II-5	870 C, 24 h	0	2.8	1.66	.37
II-5	870 C, 24 h	5	12.0	4.42	.59
I-4	870 C, 24 h	0	0.9	0.36	.64
I-4	870 C, 24 h	5	1.1	0.68	.40

*Resistivities of Ag from:
A.J. Barber and A.D. Caplin,"The low temperature electrical resistivity of high purity Ag and Ag-based alloys," J. Phys. **F5**, 679-96 (1975). (104-29).


Sample I-8
V vs. I
2.00E-03
1.80E-03
1.60E-03
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
-2.00E-04
V (volts)
Superconductor
Superconductor + Joint
Pos Joint
Neg Joint
0
100
200
300
400
500
600
700
I (A)

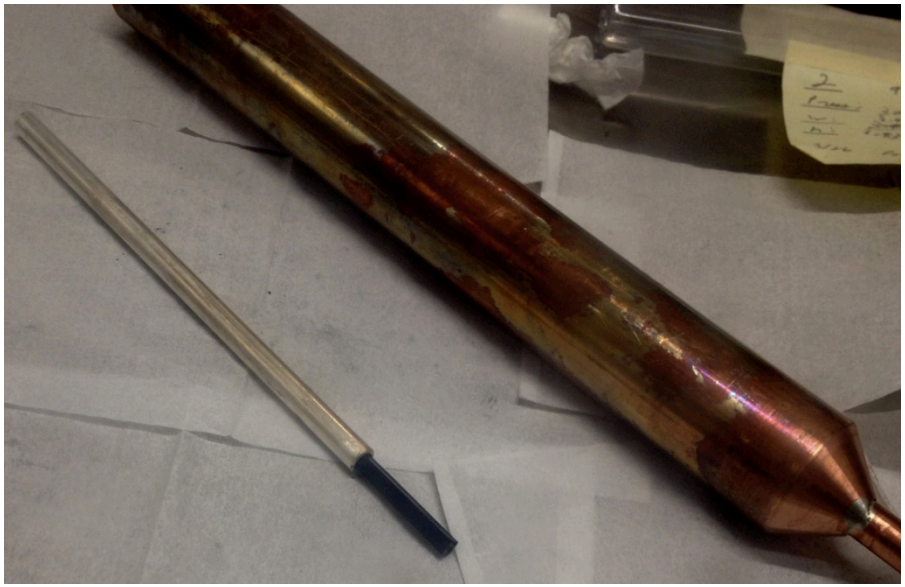
Preferential shear in 4 mm x 4 mm

- Fortuitous accident during 4 mm x 4 mm stamping
- Demonstrates that textured powder exhibits ultra-low shear modulus (micaceous)



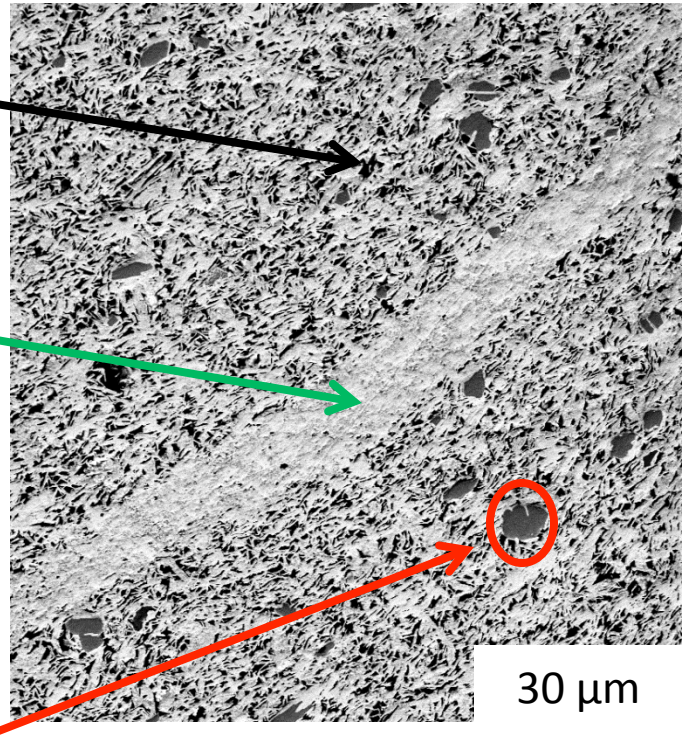
Billet Fabrication

- 3 billets ready for extrusion
- Cu/Ag/2212 composites
- Goal: 1 mm OD monocore wire (~3.5 m)
- Square inside/round outside Ag billet from Supramagnetics
- Extrude at NHMFL



Phase Growth (ongoing)

- Vacuum impregnated cross sections of 1 mm x 1 mm samples
- Polished to 0.3 µm
- Back scatter images

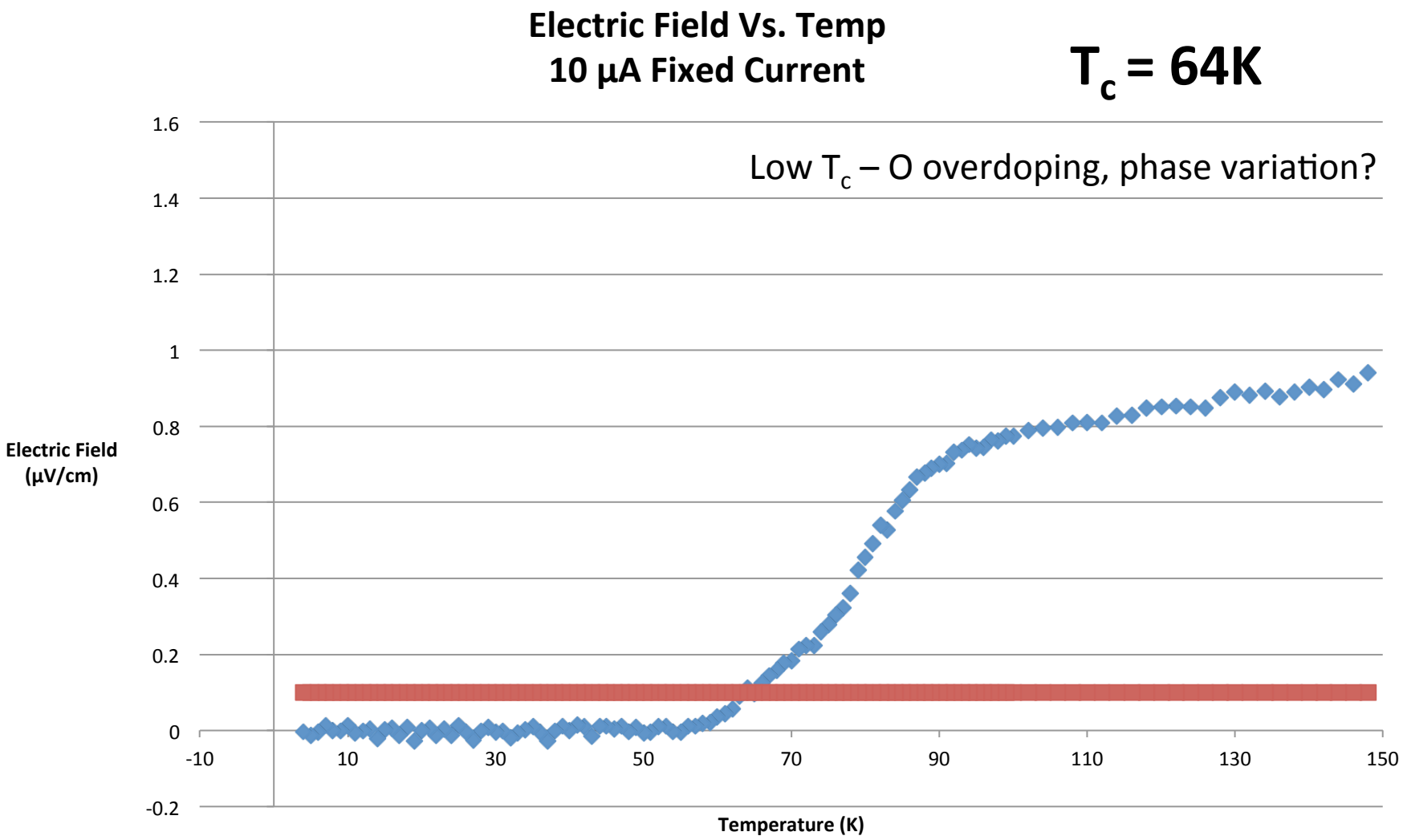


Area Calculations			
	2212	AEC	Void
Area Fraction	83%	2%	15%
Max. Particle Size μm^2	---	50	23

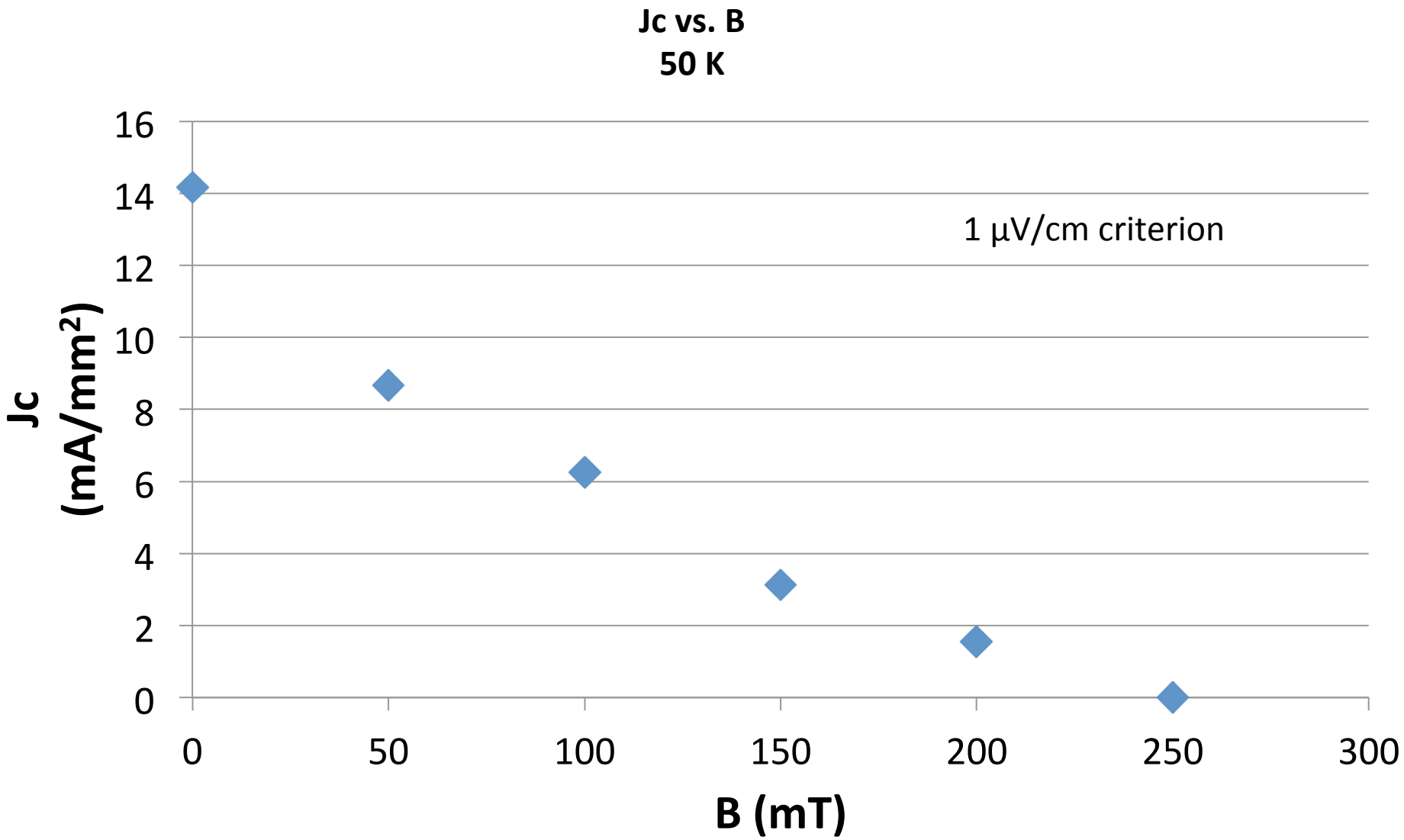
Theoretical Density: 6.6 g/cm^3

Image Calc. Density: 5.6 g/cm^3

T_c Measurement



50 K I_c Measurements



Works in progress

- Optimizing heat treatment
  - Time
  - Temperature
  - Atmosphere
- Short sample facility
  - 4.2 K, 0 – 5 T at Texas A&M
- Monocore extrusions, drawing
- Re-stacked billet extrusion, drawing

Summary

- Demonstrated textured microstructure and 2212 growth without melting
- Demonstrated transport current in non-melt bulks
- Just beginning to explore heat treatment
- High core density wires on the way
- Texture powder could provide a path to solve the challenges of porosity and connectivity, perhaps without melt heat treatment.
- No Phase 2 support:
  - We continue development from our hide, but without support the timeline cannot match MAP needs.