

4 mm wide SuNAM- ReBCO Tape Critical Current Measurements at field and 4.2 K

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Nov-19-2014

4 mm wide ReBCO tapes from SuNAM

Conductor ID: SCN04200, 10m long

Min I_c : above 200 A @ 77 K SF

Width x Thickness : 4 mm x 0.15 mm

Copper plating on all sides (~25 um thick)

Substrate : non-magnetic Stainless steel (~110 um thick)

AVERAGE	STDEV	MAX	MIN
211	2.7	216	207

Conductor ID: HCN04200, 10m long

Min I_c : above 200 A @ 77 K SF

Width x Thickness : 4 mm x 0.10 mm

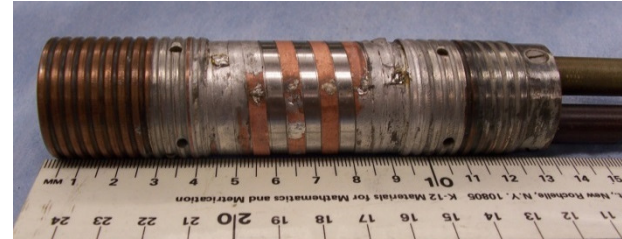
Copper plating on all sides(~25 um thick)

Substrate : Hastelloy (~60 um thick)

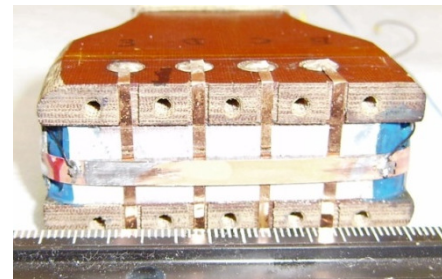
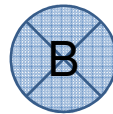
AVERAGE	STDEV	MAX	MIN
229	1.8	233	224

Test Set-up for I_c Measurements

B-Field 

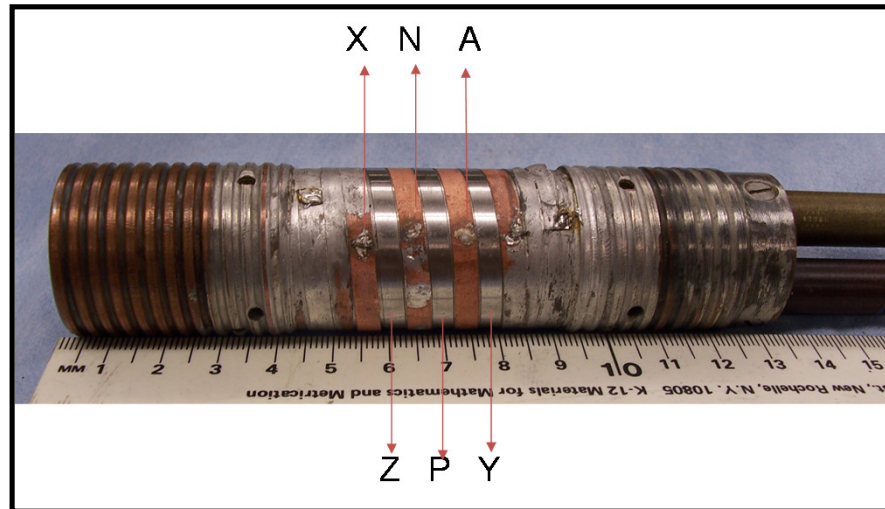


- Samples are mounted on ITER-type barrels for I_c measurements in // field. Typical length used 0.5 m
- Measurements in //-field at 4.2 K using either a 12 T or 16 T solenoid magnet to provide background field
- For H-parallel to ab-plane: using SS barrel holder V-tap separation of 47 mm total length 235 mm.
- H-perpendicular to ab-plane: using U shaped sample V-tap separation 10 mm; total length 30 mm



Typical Measurement Sequence

- 77 K SF
- 4.2 K, // Field, 11.0T
 - 15 T, 14 T, 13T, 12 T, 11 T, 10T, 8T, 6T, 4T, 2T
- 77 K, SF



SCN04200 SS-substrate

Tested on a SS barrel

T= 77K SF

77K	XZ	ZN	NP	PA	AY	XY
Ic, A	201.8	199.3	196.3	198.9	203.3	199.1
n	39.7	36.3	39.7	33.7	41.4	35.7

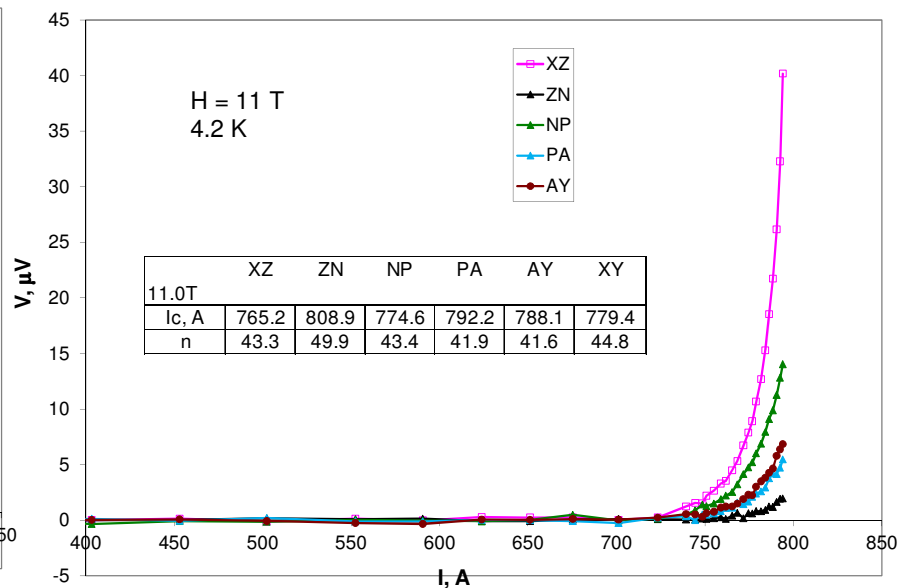
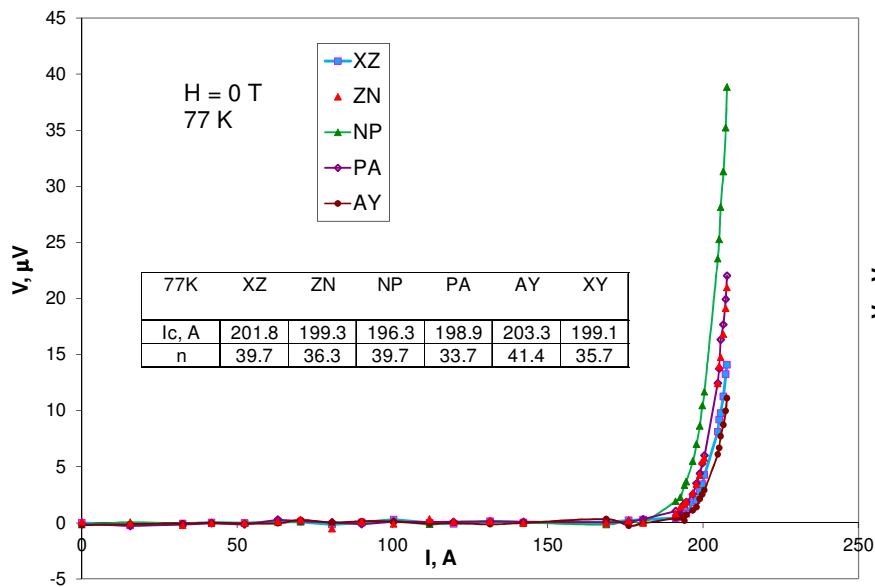
AVG, A	199.9
σ, A	2.7
Variance	1.37%

T= 4.2K, 11T H // ab

11.0T	XZ	ZN	NP	PA	AY	XY
Ic, A	765.2	808.9	774.6	792.2	788.1	779.4
n	43.3	49.9	43.4	41.9	41.6	44.8

AVG	786
STDEV	17
Variance	2.13%

V-I curves for the sections at 77 K and at 11 T, 4.2 K

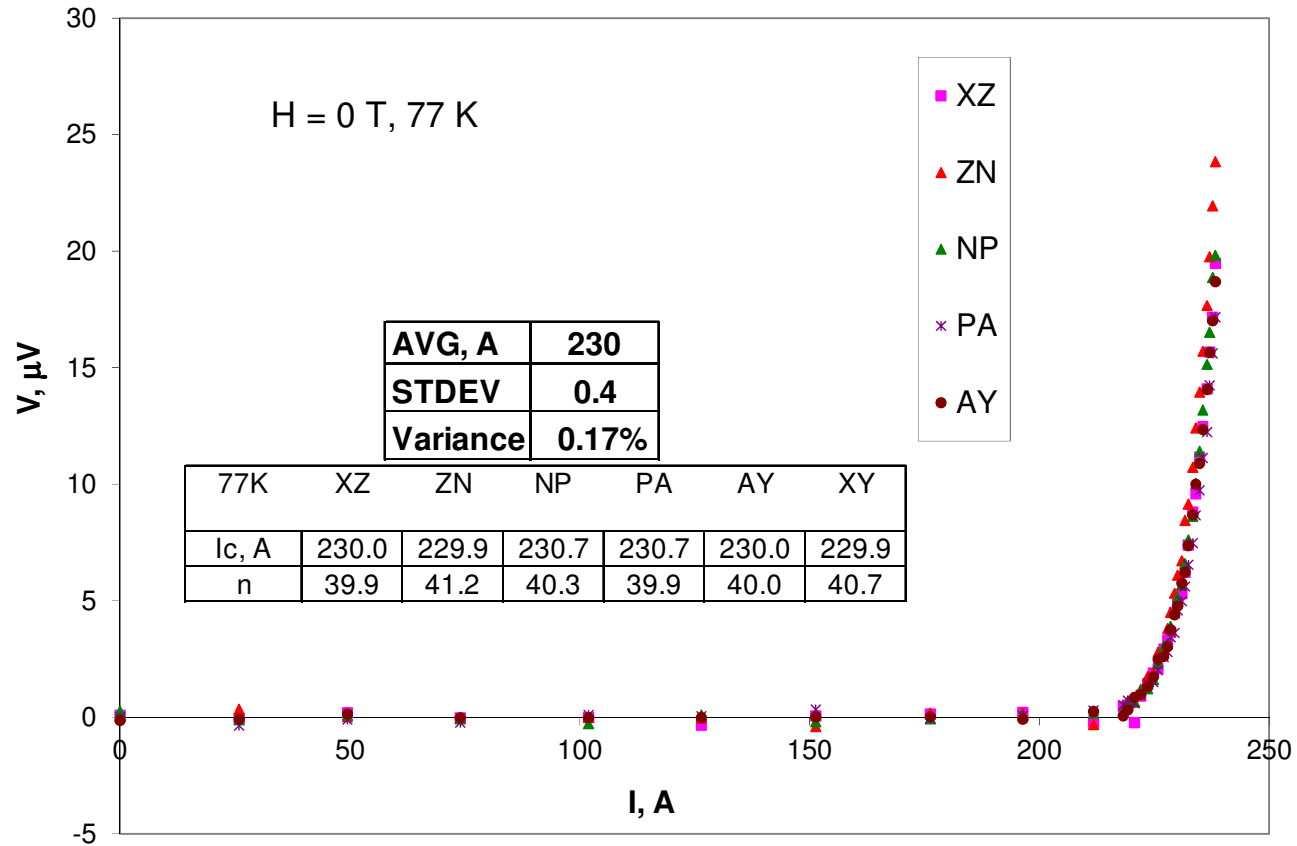


Ratio of I_c(11T, 4.2K) and I_c(77K, SF) for all the sections

I _c (11T, 4.2 K) / I _c (77K, SF)	XZ	ZN	NP	PA	AY	XY
	3.79	4.06	3.95	3.98	3.88	3.91

The different sections look fairly uniform

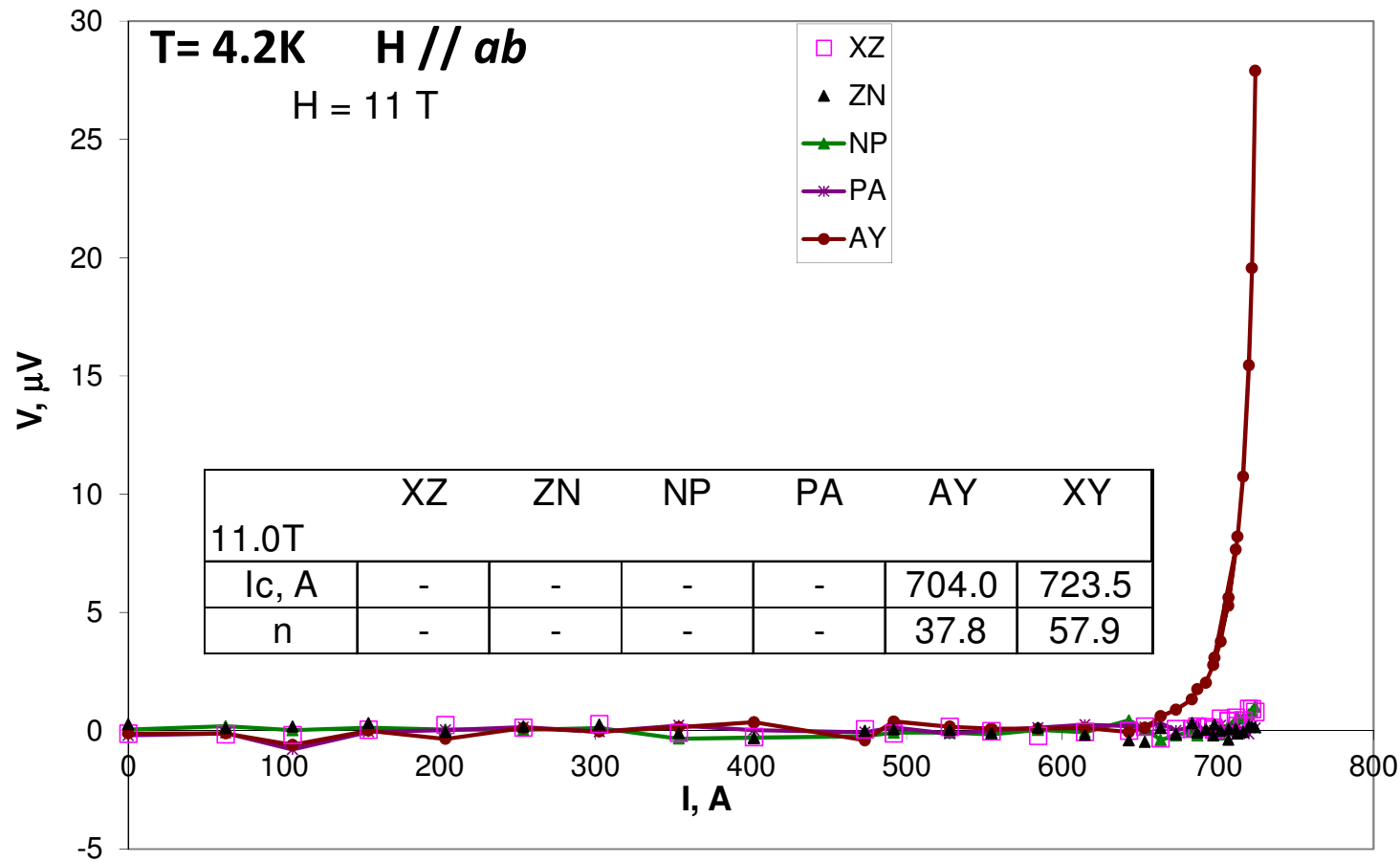
HCN04200 Hastelloy Substrate I_c at 77K, SF



I_c matches data provided by SuNAM

HCN04200

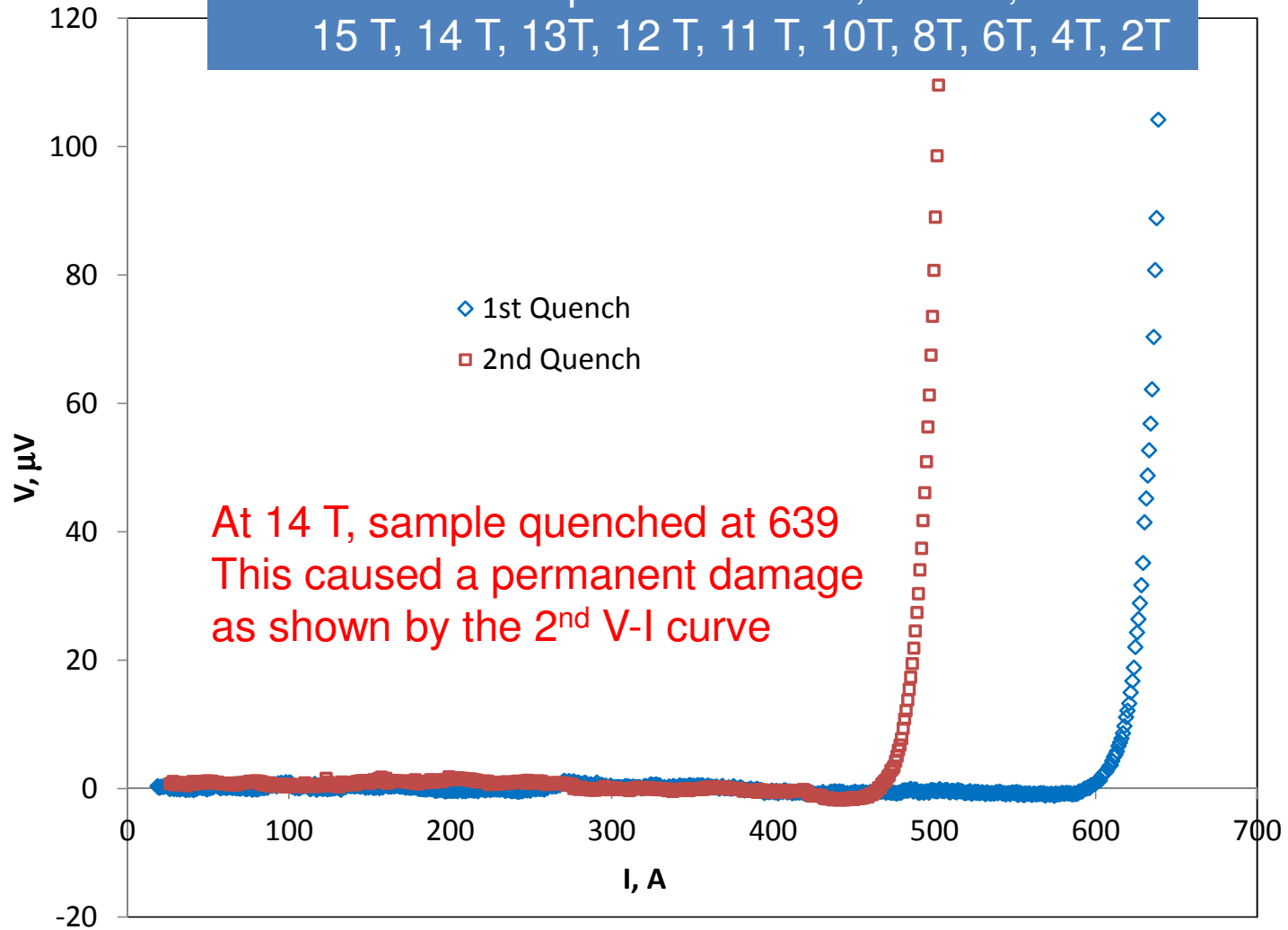
Sample #1



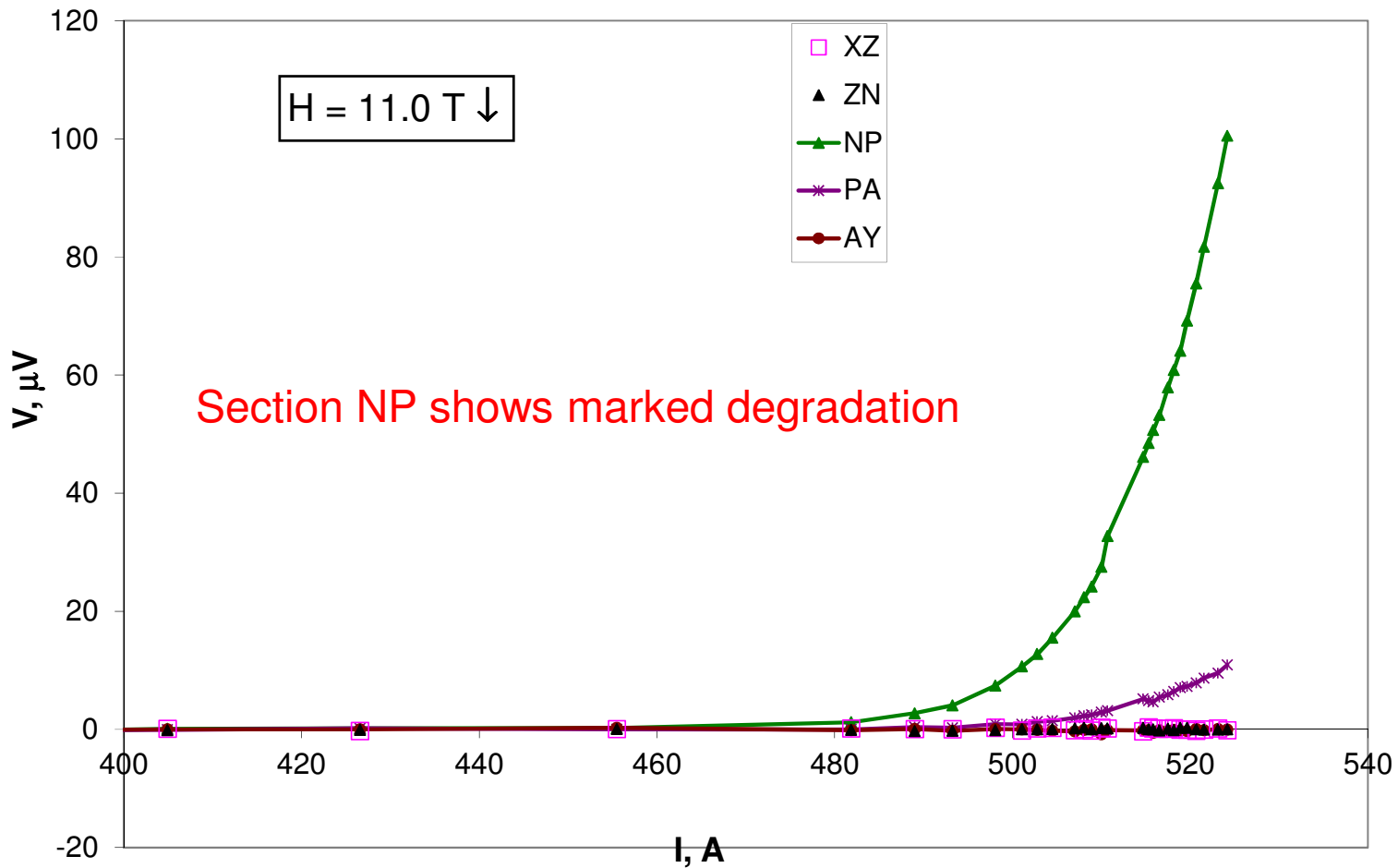
Voltage mostly in section AY; Voltage development not uniform along the length

V-I for section XY (235 mm) at 14 T, 4.2 K

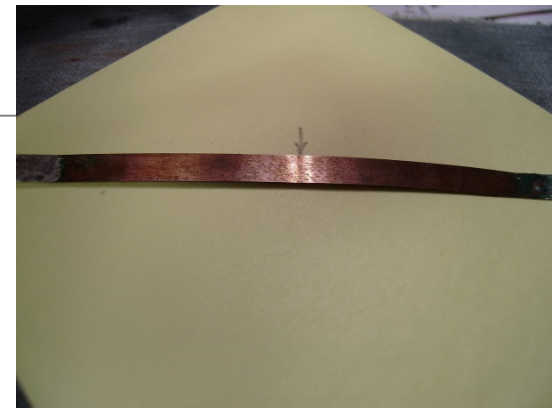
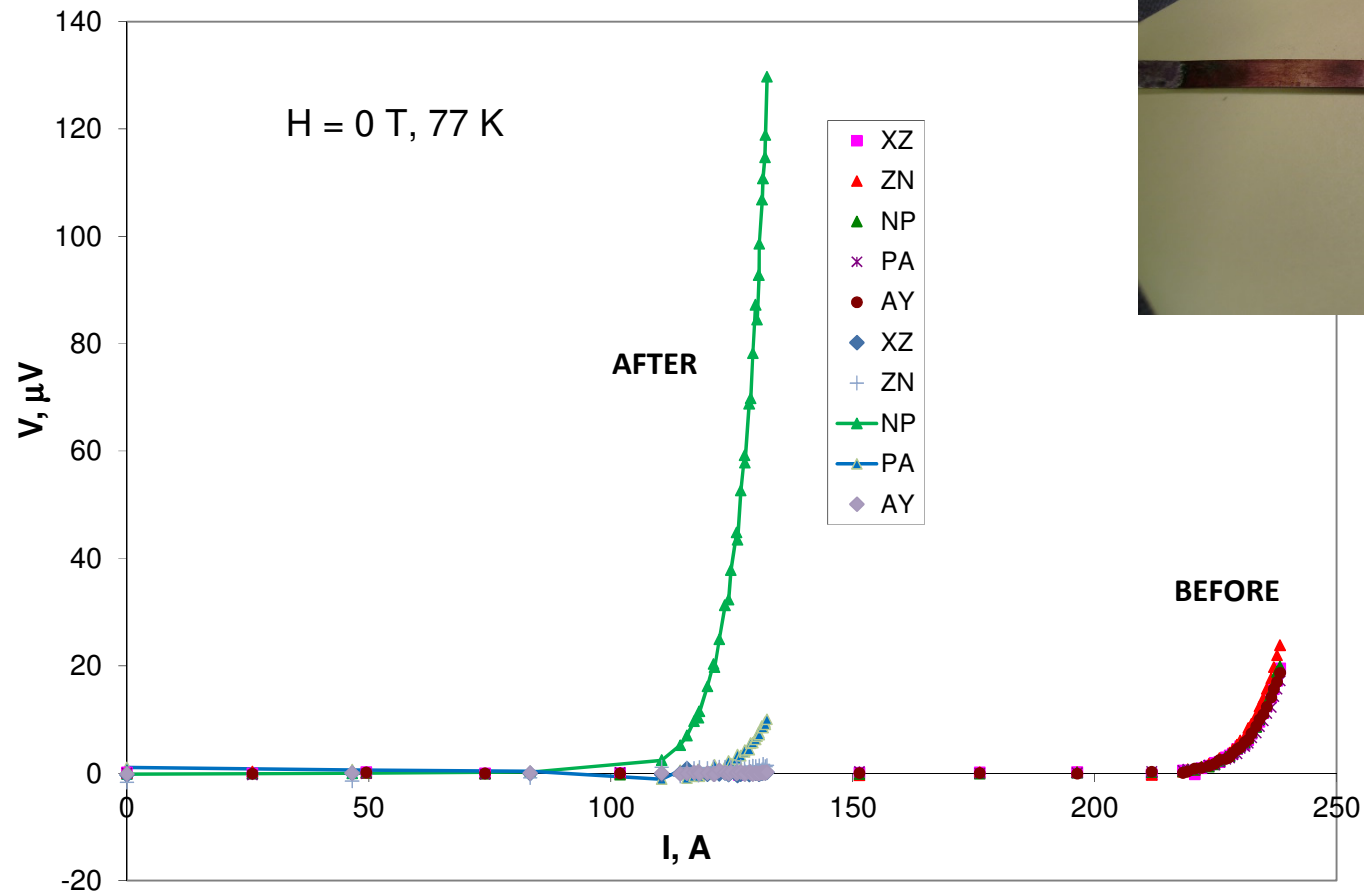
Measurement Sequence at 4.2 K, // Field, 11.0T
15 T, 14 T, 13T, 12 T, 11 T, 10T, 8T, 6T, 4T, 2T



V-I curves for the sections at 11 T, 4.2 K after degradation observed at 14 T

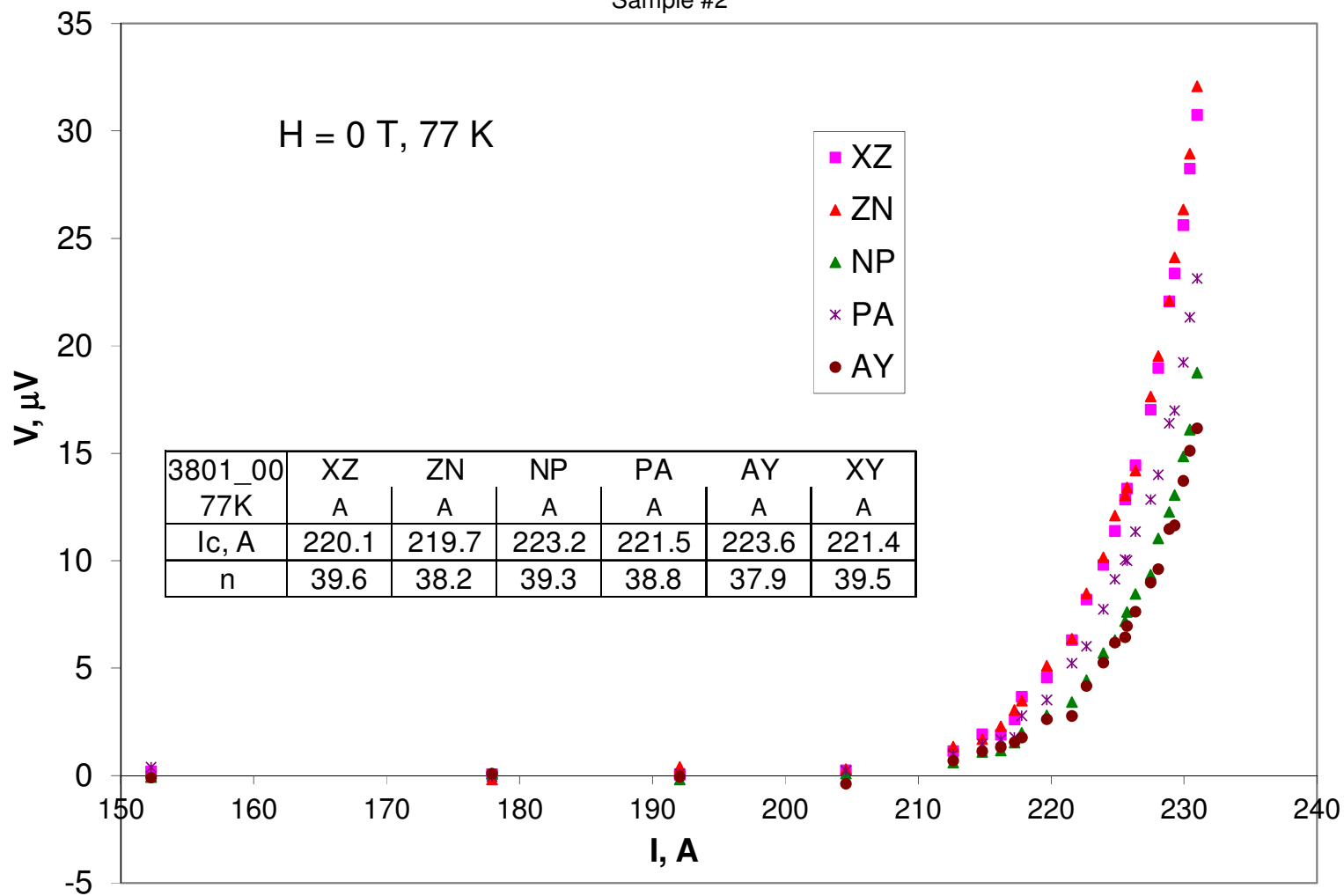


Re-Test at 77 K, shows that sample is locally degraded near voltage tap P – tape kinked



HCN04200 Sample #2

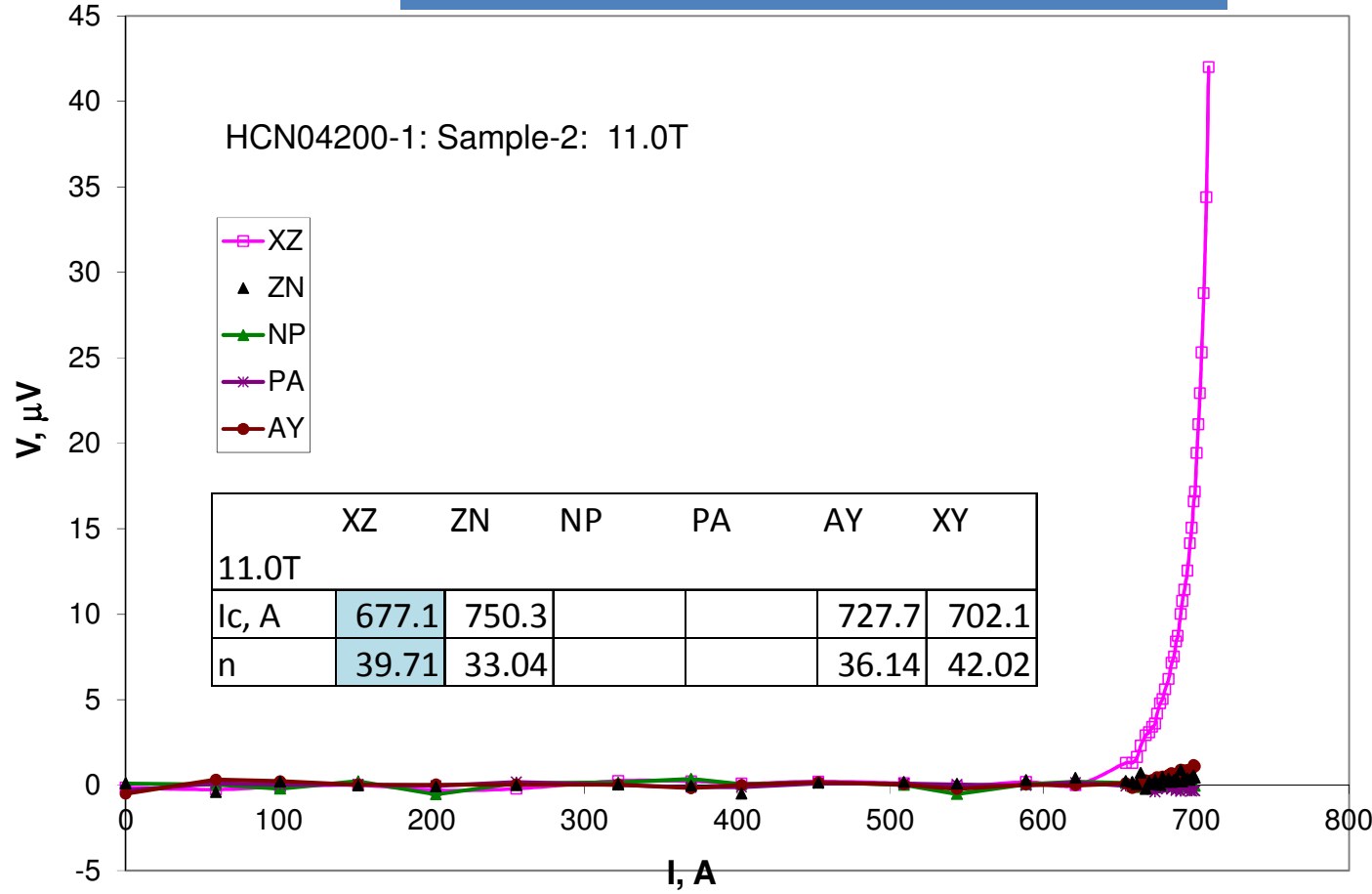
Sample #2



HCN04200

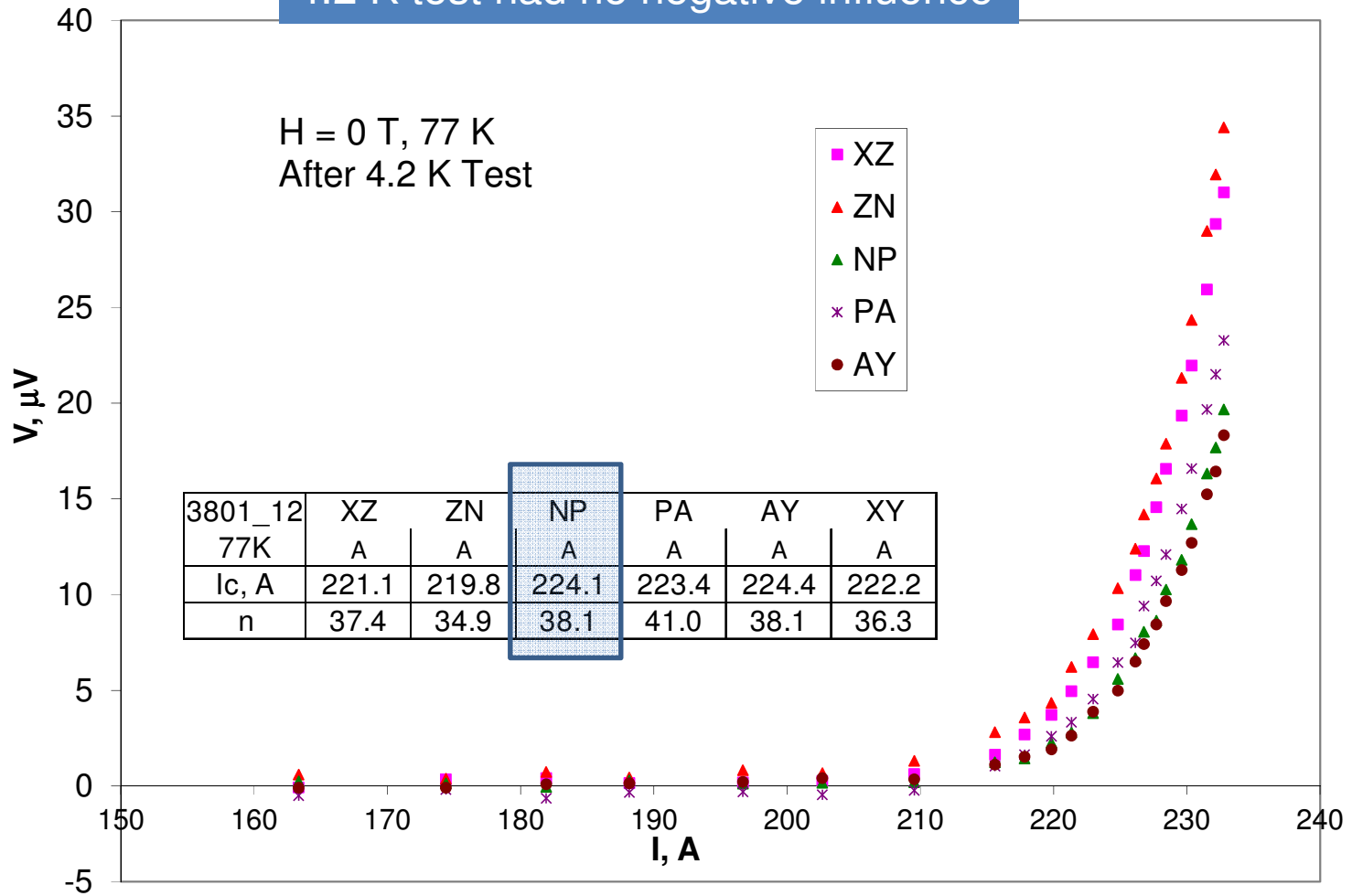
T= 4.2K H // ab

Voltage mostly in section XZ



Sample has no change after 4.2 K test.

4.2 K test had no negative influence



Perpendicular Field Test Summary

SUPERCONDUCTOR WIRE TEST # 3829

DATE: 08/12/14

Manufacturer SuNAM

Tape Dim. Thick/width, mm 0.10 4.0
Hastelloy Substrate ~ 60 mm
Copper Coating ~ 25 mm

Description ReBCO

HCN04200

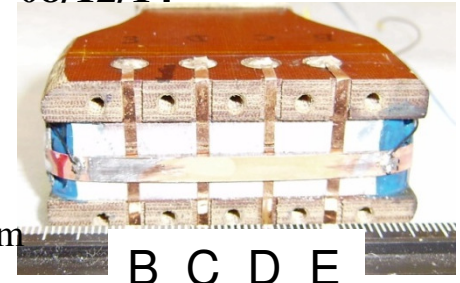
sample #2

Length: BE: 30 mm

Temp(K)= 4.204

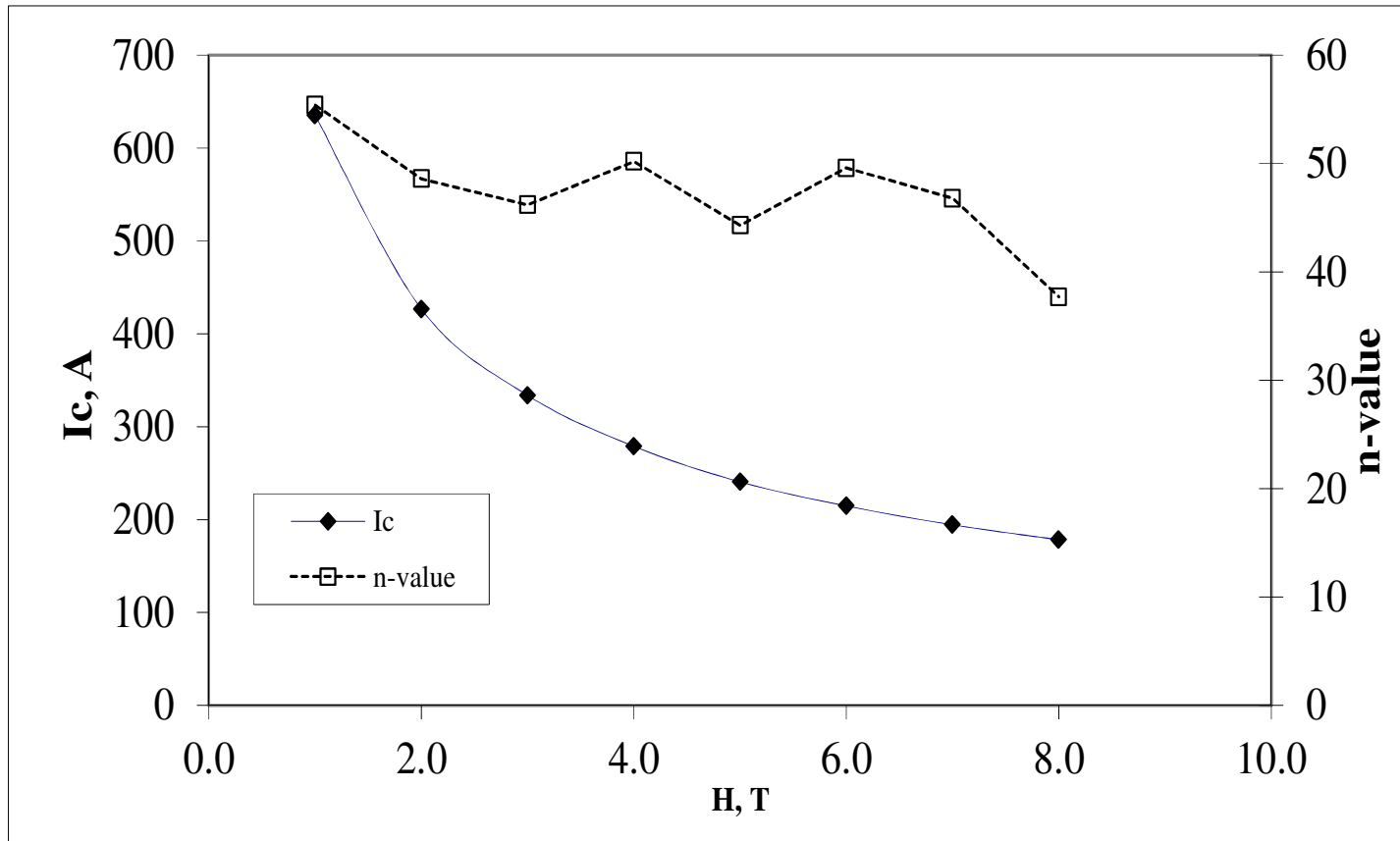
Comments

**I_c defined for $\epsilon = 100 \mu V/m$
Perp-Field (Section NP)**

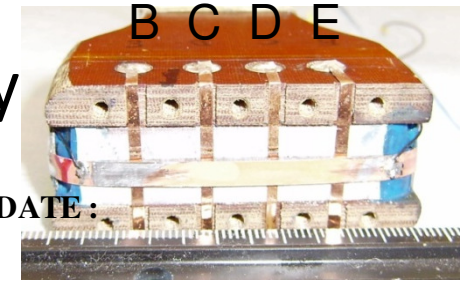


Taps	B(T)	I_c (A)	Ramp rate A/s	I_Q (A)	I_{max} (A)	n	J_E A/mm ²
BE			0				
BE	1.0	635	0	658	658	55	1588
BE	2.0	427	0	447	447	49	1067
BE	3.0	334	0	352	352	46	835
BE	4.0	279	0	293	293	50	697
BE	5.0	241	0	255	255	44	602
BE	6.0	215	0	227	227	50	537
BE	7.0	194	0	205	205	47	486
BE	8.0	178	0	189	189	38	446
77 K BE	0.0	226.6	0		236	49	567

Perpendicular Field Test Summary HCN04200 Sample #2 Section NP



Perpendicular Field Test Summary



SUPERCONDUCTOR WIRE TEST # **3830**

DATE :

Manufacturer SuNAM

Tape Dim. Thick/width, mm 0.15 4.0

Stainless steel Substrate ~ 110 mm

Copper Coating ~ 25 mm

Description ReBCO

Length: BE: 30 m

SCN04200

sample #1

Temp(K)= 4.208

Comments I_c defined for $\epsilon = 100 \mu V/m$

Perp-Field (Section NP)

Taps	B(T)	I_c (A)	Ramp rate A/s	I_Q (A)	I_{max} (A)	n	J_E A/mm ²
BE	0.5	948	0	984	984	60	1580
BE	1.0	637	0		666	54	1062
BE	2.0	426	0		449	49	709
BE	3.0	333	0		352	49	556
BE	4.0	278	0		293	49	463
BE	5.0	241	0		255	44	401
BE	6.0	214	0		227	47	357
BE	7.0	195	0		205	49	324
BE	8.0	179	0		189	47	298

77 K BE

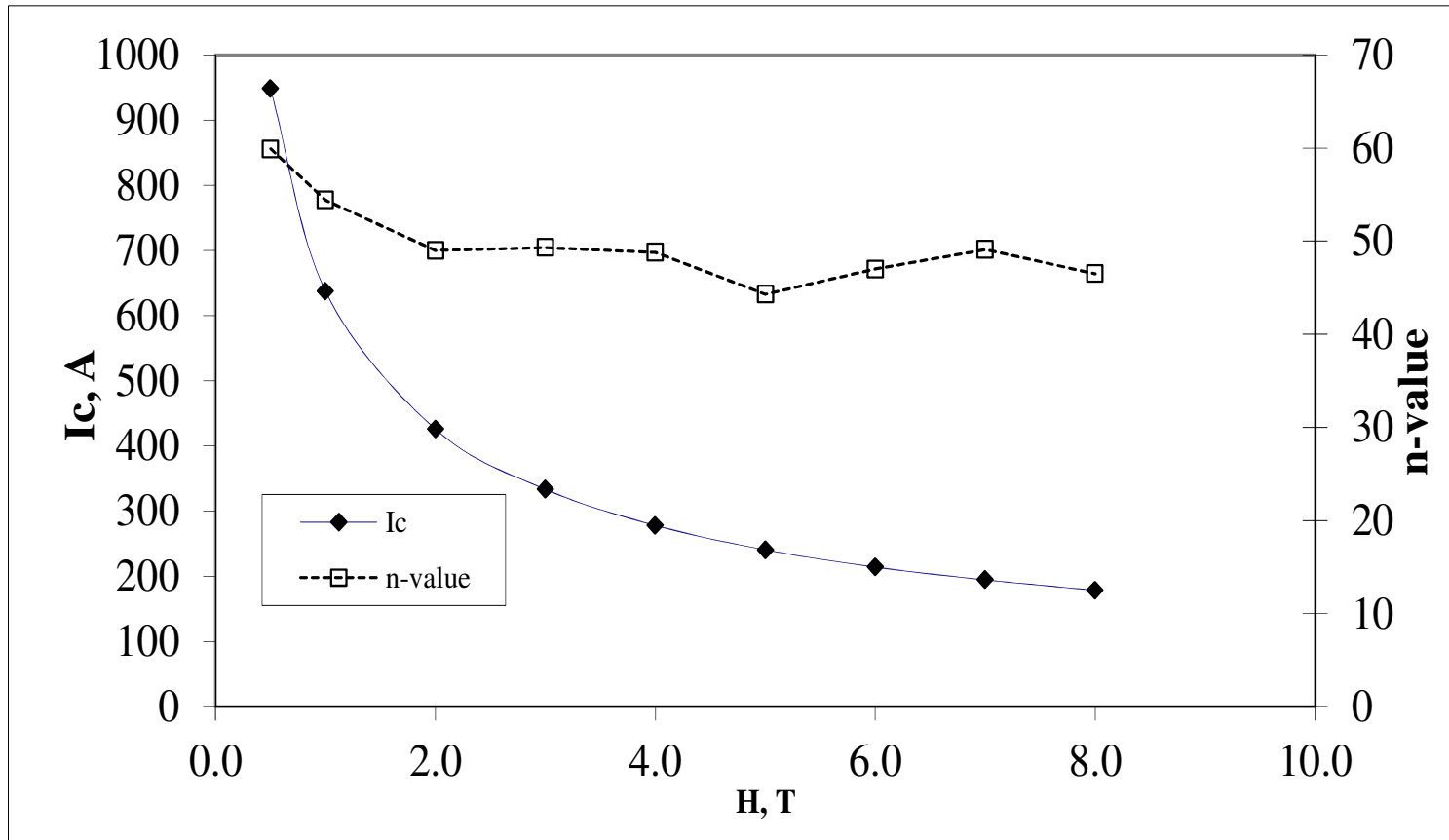
0.0 203.7

0 216

44

340

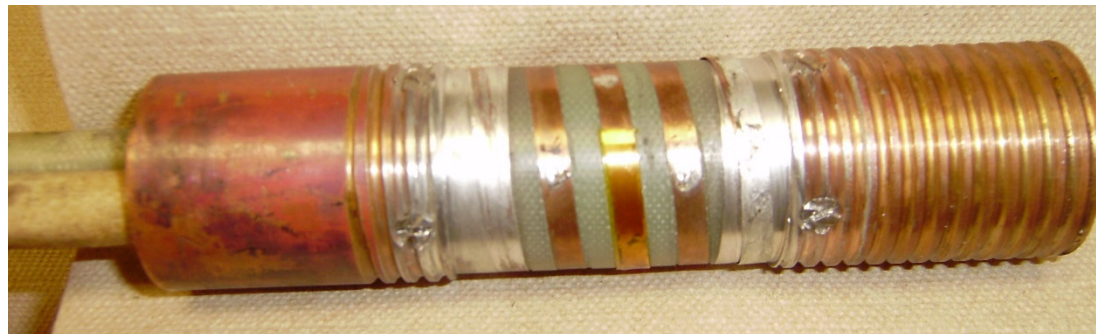
Perpendicular Field Test Summary SCN04200 Sample #1 Section NP



HCN04200 and SCN04200 have the same I_c in Perp. Field

Test on Insulating G-10 barrel for quench propagation studies

- The 1st sample measured 226 A at 77 K. All sections were reasonably uniform. However at 4.2 K, the sample damaged irreversibly at 539 A when the current was being ramped up at 11 T. No voltage was observed at the maximum current. The sample developed a kink within the section NP.
- 2nd Sample: I_c at 77 K was 226 A and the sub-sections were quite uniform. The I_c was measured at 11 T in // -field without quenching the sample. The PS was shutoff when the sample voltage reached 25 μV (1 $\mu\text{V}/\text{cm}$). $I_c = 665$ A (n=46)
 - However at 10 T, sample quenched at 692 A just as 25 μV was reached. This quenched caused a catastrophic burn-out of the sample in section AY.



Summary

- The SS-substrate conductor tested well at 4.2 K for both // and \perp applied fields.
- The Hastelloy-substrate samples seem more prone to damage during 4.2 K test. (We do not have sufficient statistics at this point).
- For all samples, // field data shows significant I_c variation along the length which is not observed at 77 K. This is not unusual for coated conductor.
- In \perp -field, sample showed almost identical I_c at all fields. Note that the ratio of $I_c(8T, \perp) / I_c(77K) < 1.0$.
- Tests done using a G-10 barrel seems to lead to irreversible damage. This may be due to the mismatch of thermal contraction of G-10 and the metal tapes.