Update on SRF Materials Effort for the ILC R&D at Fermilab – ILC meeting 05/18/06

P. Bauer

other participants (at Fnal):

C. Antoine, M. Battistoni, C. Boffo, D. Burk, C. Cooper, L. Elementi, K. Ewald, M. Foley, D. Hicks, O. Lira, F. McConologue

and

A. Aizaz, T. Bieler, T.Grimm, H. Jiang

NSCL/Michigan State University

Outline:

1) ILC-AES Batch 1 Material Issue

ILC-AES Batch 1 Material Issue

- Non-uniform mechanical properties in batch 1 ILC niobium caused non-uniform spring-back and non symmetrical half-cells as produced at AES by reverse hydro-forming, min 6 passes needed during deep-drawing;
- Microstructure analysis at MSU and FNAL confirmed that material properties are not uniform;
- Heat treatment test at Fnal was successful – heat treated sheets formed better, as expected from micro-structural analysis;
- Wah Chang agreed to take back the sheets and conduct heat treatment free of cost;
- Heat treatment campaign in preparation! Heat treated material expected back in June.

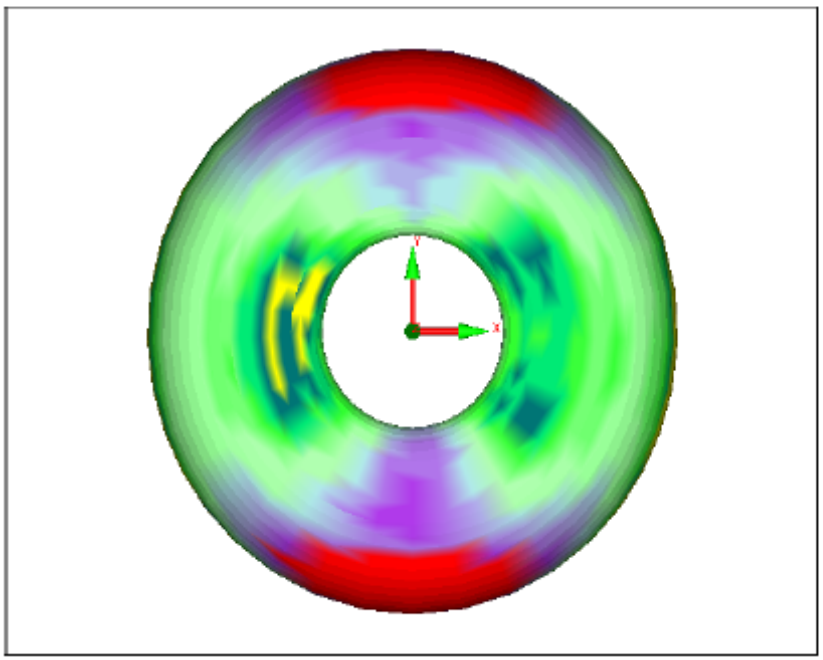
Elliptical Half-cells

PART NUMBER=PN439156-n-contour-IR-M223 DATE=3/17/2006 TIME=1:18:47 PM PAGE#=12

MM	DIM PROF12= PROFILE OF SET SCN C-1 FORMANDLOCATION					
AX	NOMINAL	MEAS	DEV	+TOL	-TOL	OUTTOL
M	0.000	0.427	0.427	0.100	0.100	0.227

MM	DIM PROF13= PROFILE OF SET SCN C-2 FORMANDLOCATION					
AX	NOMINAL	MEAS	DEV	+TOL	-TOL	OUTTOL
M	0.000	0.204	0.204	0.100	0.100	0.005

MM	DIM PROF14= PROFILE OF SET SCN C-3 FORMANDLOCATION					
AX	NOMINAL	MEAS	DEV	+TOL	-TOL	OUTTOL
M	0.000	0.203	0.203	0.100	0.100	0.015



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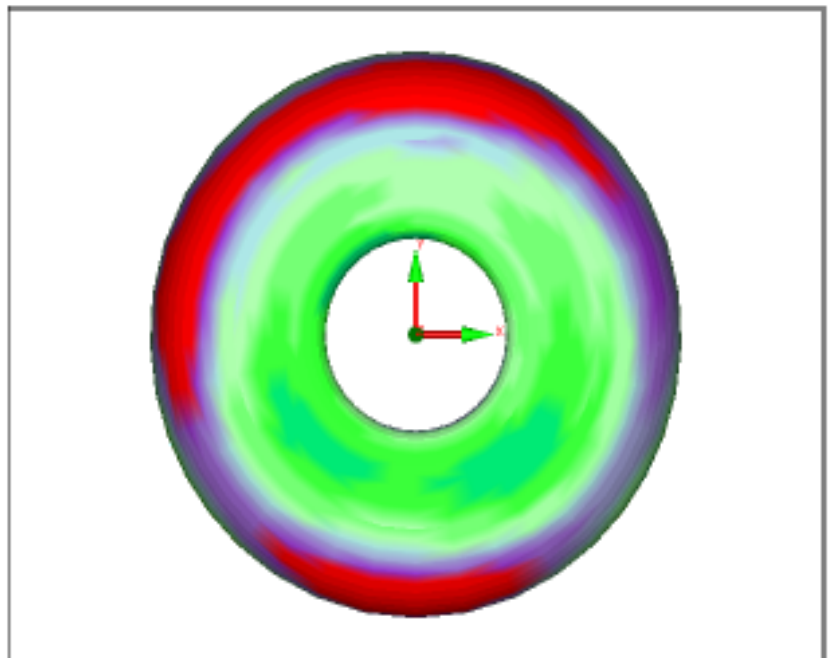
MM	DIM PROF12= PROFILE OF SET SCN C-1 FORMANDLOCATION					
AX	NOMINAL	MEAS	DEV	+TOL	-TOL	OUTTOL
M	0.000	0.280	0.280	0.100	0.100	0.050

MM	DIM PROF13= PROFILE OF SET SCN C-2 FORMANDLOCATION					
AX	NOMINAL	MEAS	DEV	+TOL	-TOL	OUTTOL
M	0.000	0.129	0.129	0.100	0.100	0.000

MM	DIM PROF14= PROFILE OF SET SCN C-3 FORMANDLOCATION					
AX	NOMINAL	MEAS	DEV	+TOL	-TOL	OUTTOL
M	0.000	0.145	0.145	0.100	0.100	0.000

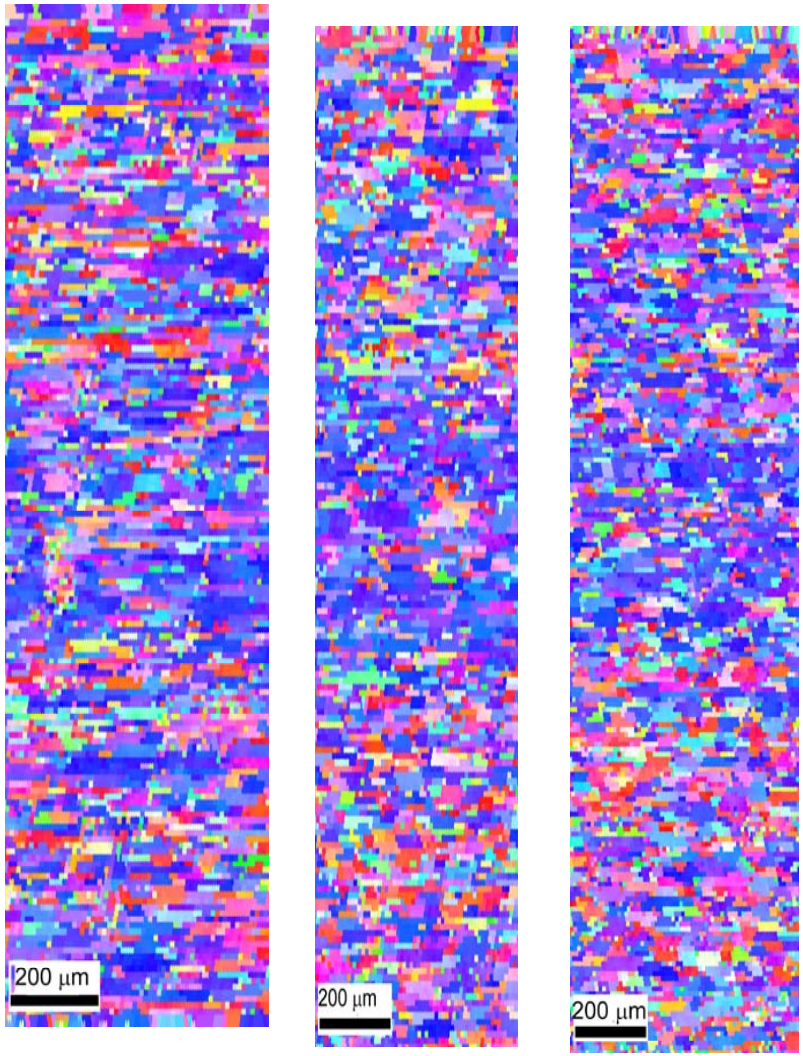


before (6 passes)

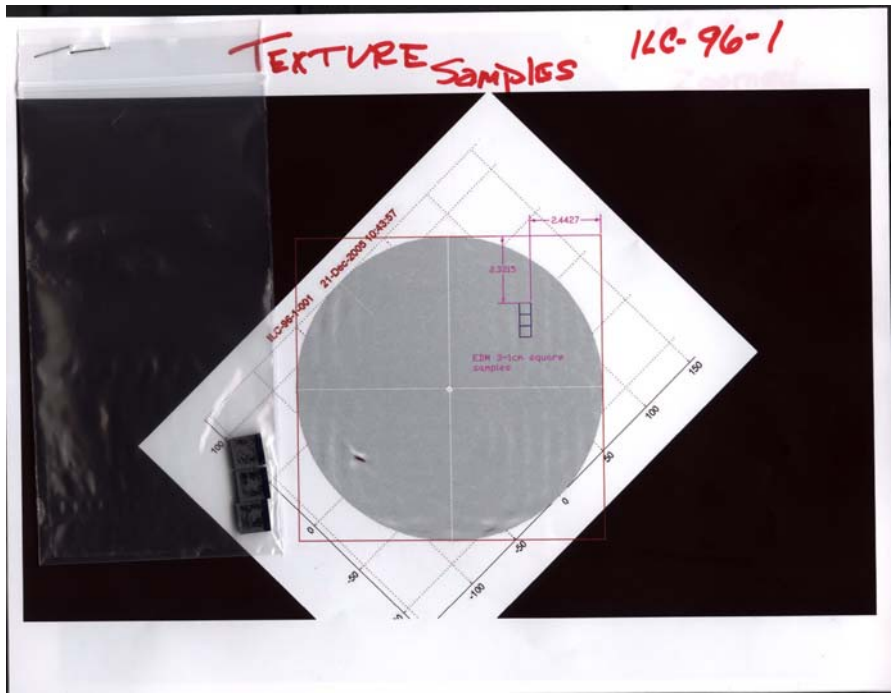
after (2 passes)

Courtesy R. Riley

MSU texture measurements

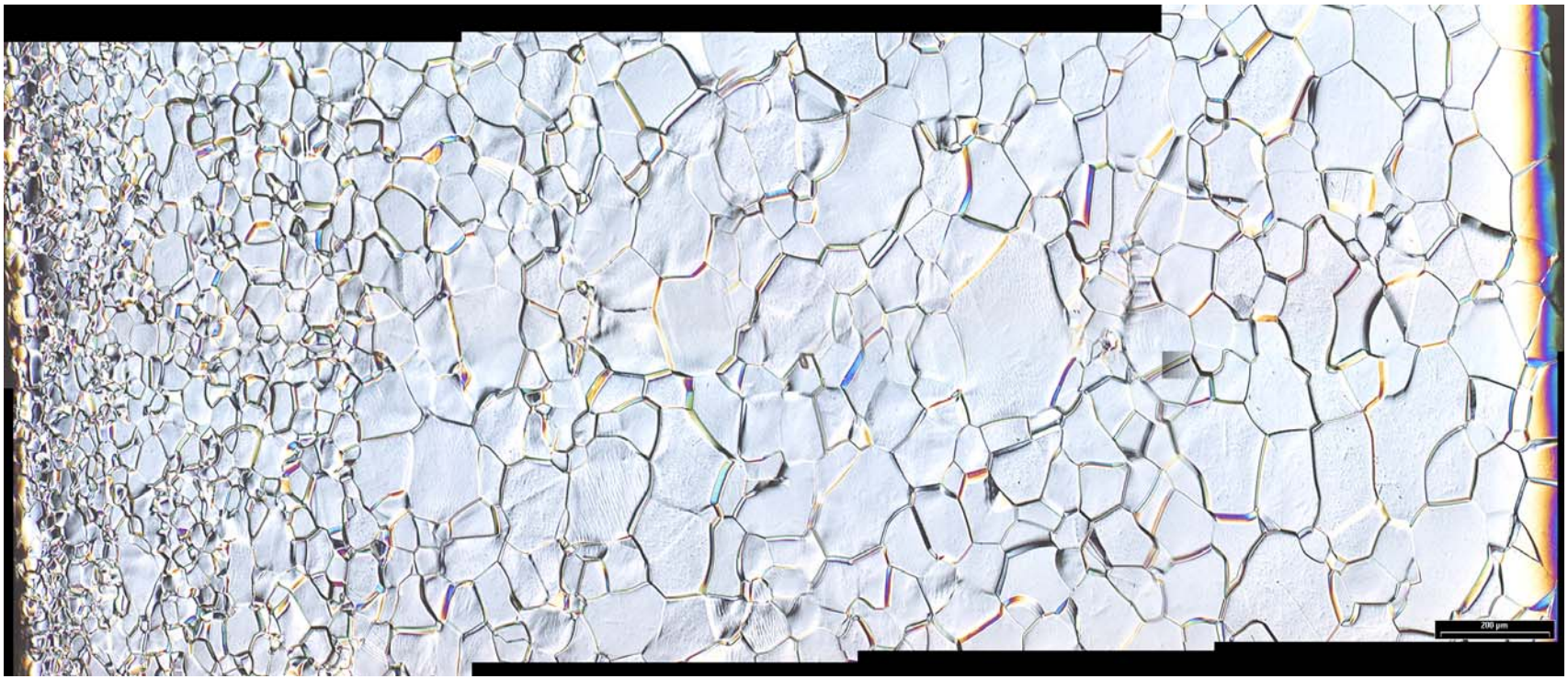


(a) (b) (c)



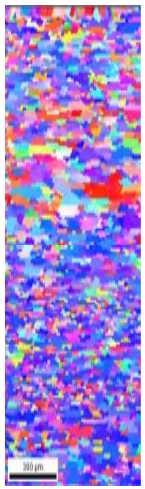
texture samples cut from areas giving a "stripe" in the Eddy current scan. Samples (a) inside the stripe (b) outside the stripe (c) perpendicular (across) to stripe

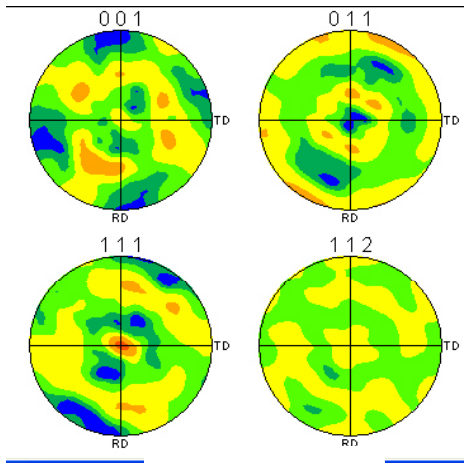
Once Upon a Time at DESY



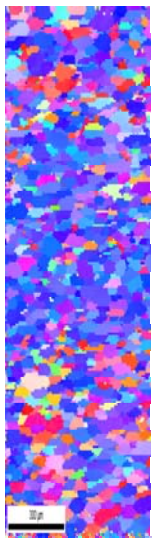
2002 case of insufficiently re-crystallized material delivered to DESY
Polycrystalline, high purity Nb is a high tech product – things can go wrong!

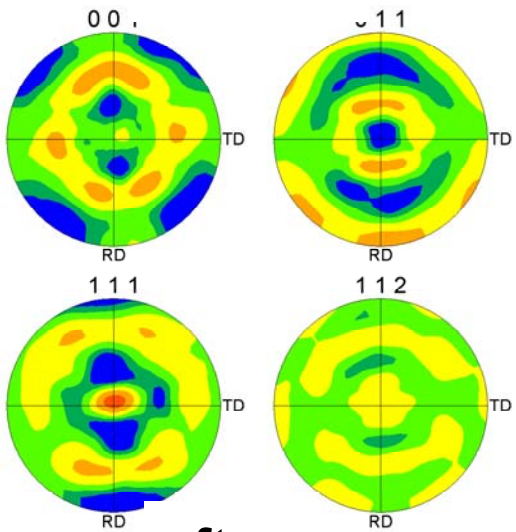
Texture Before and After Heat Treatment





before





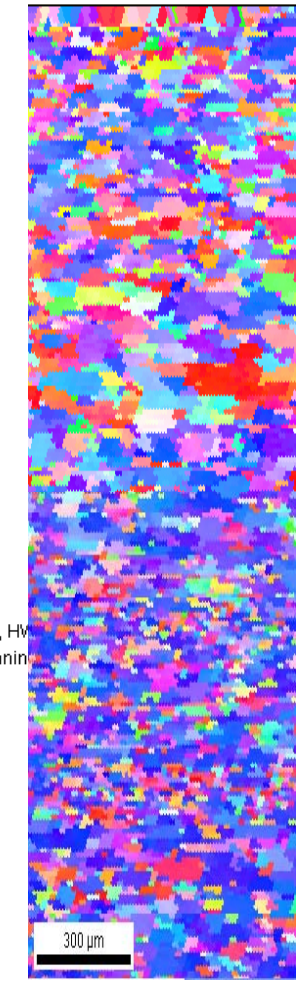
after

ILC square
#217

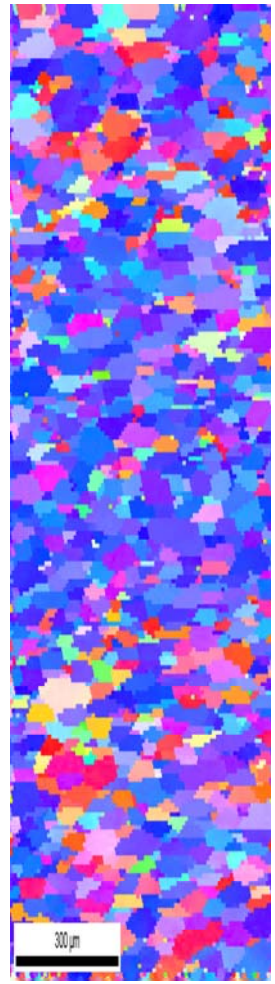
max = 4.987
8.000
4.000
2.000
1.000
0.500
0.250
min = 0.022

Texture Name: Binned: Size=5.0, HW
Calculation Method: Discrete Binnin
Bin Size: 5.0°
Gaussian Smoothing: 5.0°

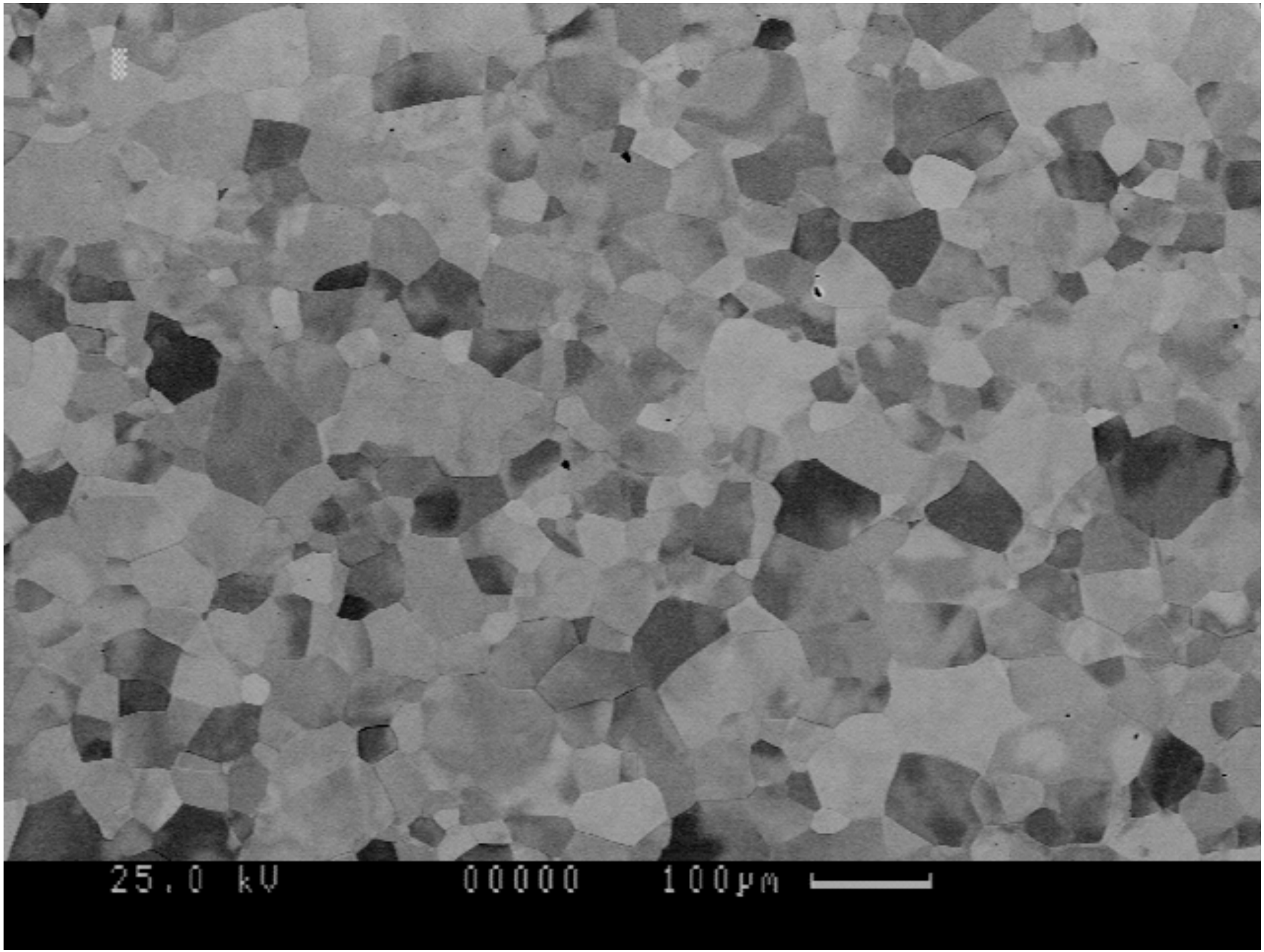
max = 6.050
8.000
4.000
2.000
1.000
0.500
0.250
min = 0.017



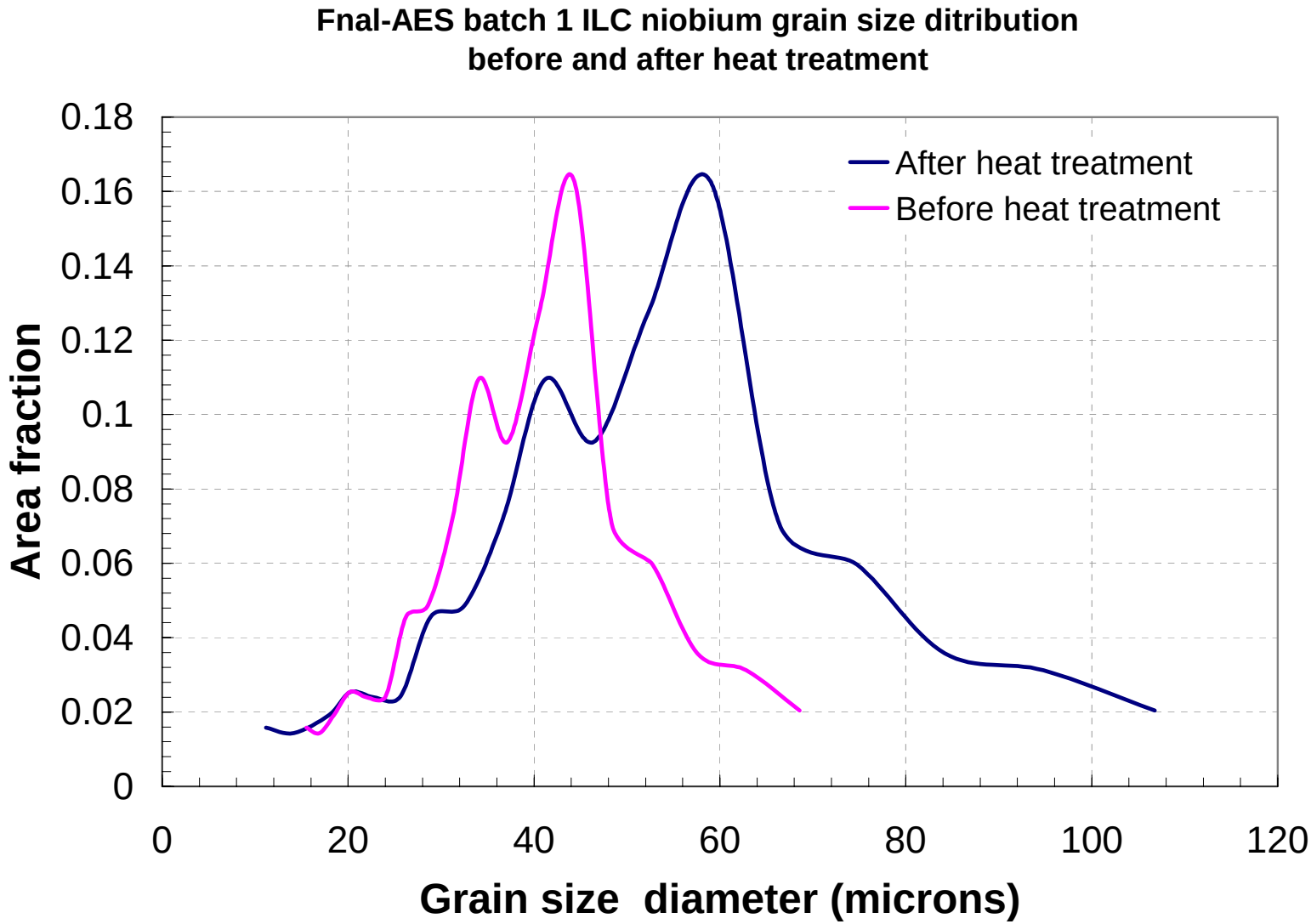
before



after


25.0 kV
00000
100µm

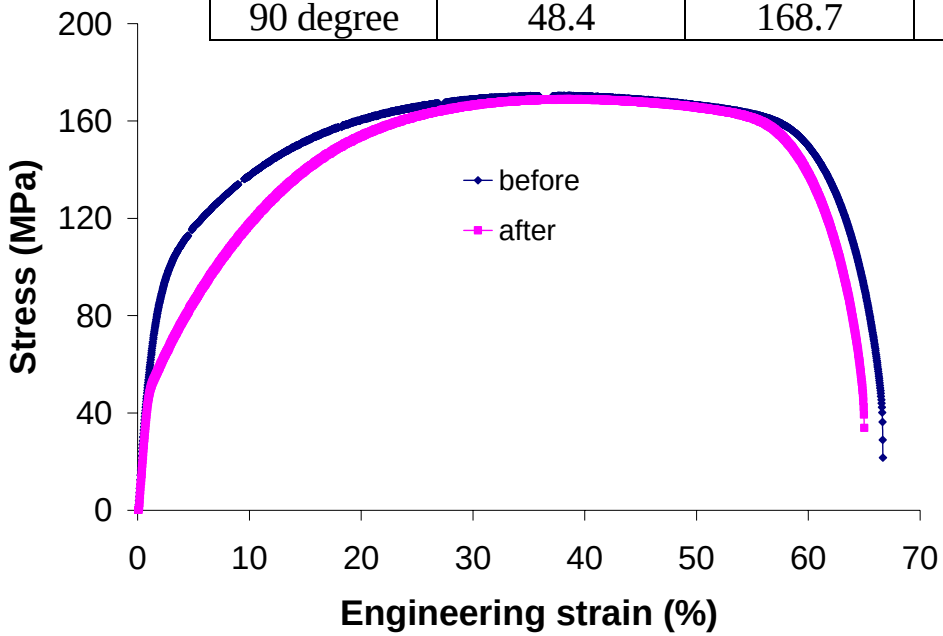
Grain Size Before and After Heat Treatment

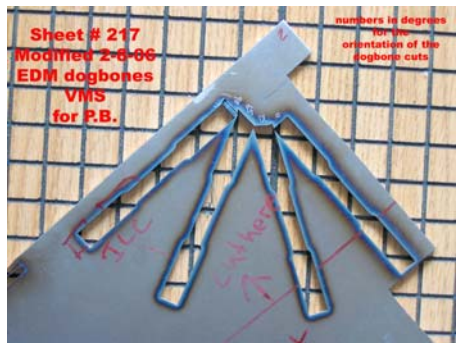


Mechanical Properties Before and After HT

BEFORE	Yield strength (MPa)	UTS (MPa)	Elongation (%)	Strain Hardening Coeff.
0 degree	67	173.2	66.7	0.32
25 degree	63	185.8	60.67	0.35
65 degree	62	185.6	60.04	0.33
90 degree	86	170.1	66.68	0.21
AFTER				
0 degree	46.2	168.5	65	0.38
25 degree	58.1	180.8	59.3	0.36
65 degree	43.2	178.4	60.7	0.41
90 degree	48.4	168.7	65	0.37

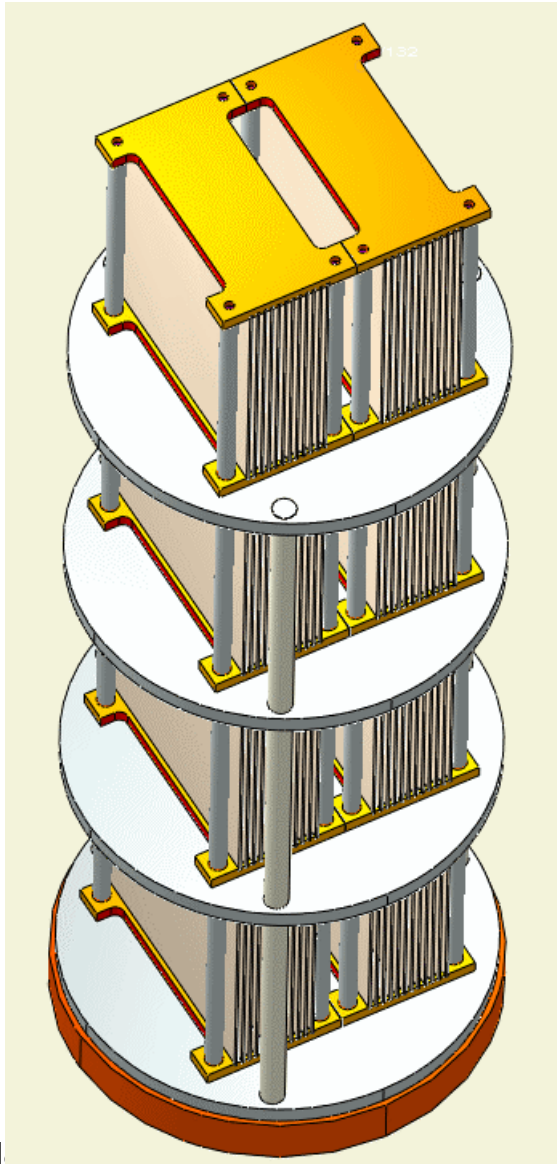
doubled n!





Heat Treatment Fixture

M



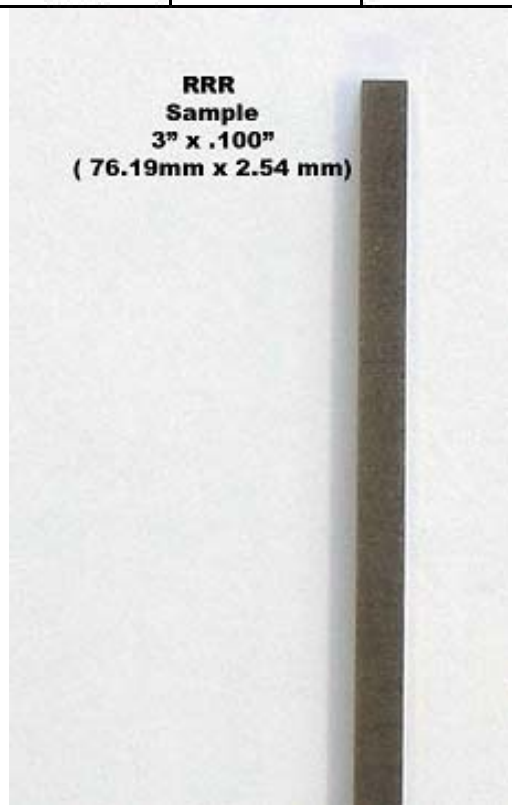
P.

3R Measurements

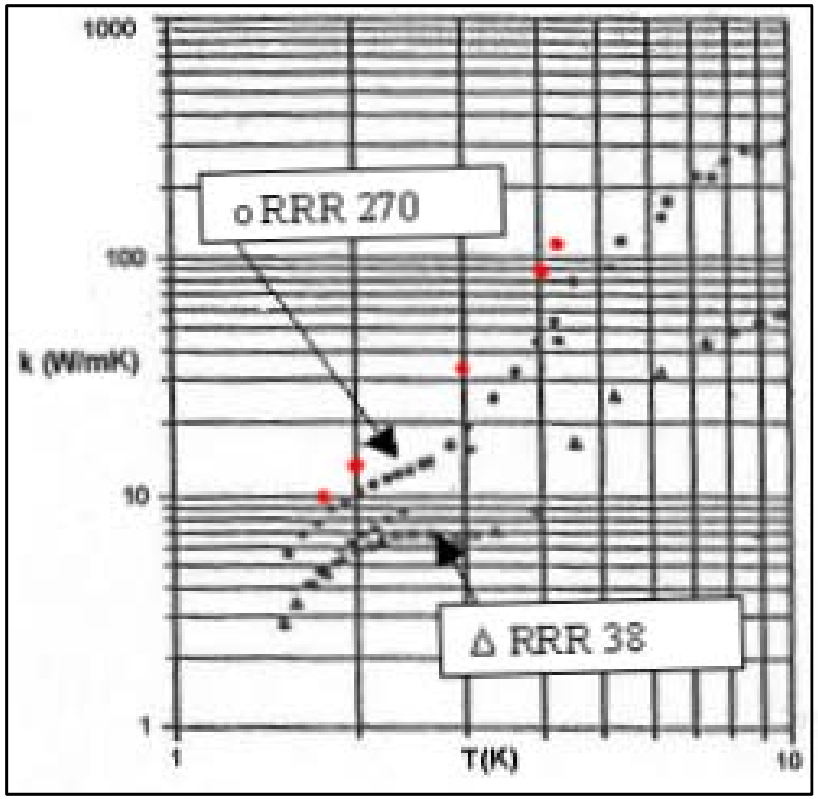
Etch before HT* (microns)	0	10	40	100
Sample A	373	391	365	388
Sample B	381	388	385	380
* HT=750C,3hrs,10^-5Torr				

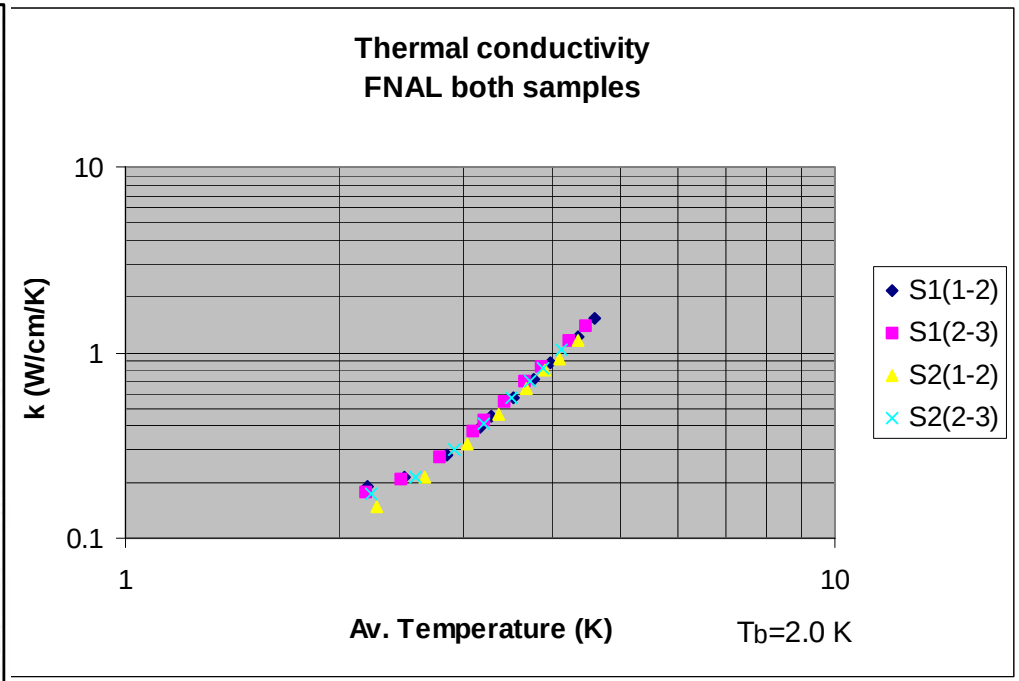
3R - ILC-AES b1	sample 1	sample 2	sample 3	sample 4
as received, from sheet 217	417	403		

3R of this material generally high: ~450 (spec 300)
Etching before Heat Treatment is common safety precaution – does not seem to affect 3R however



Thermal Conductivity Measurements at MSU

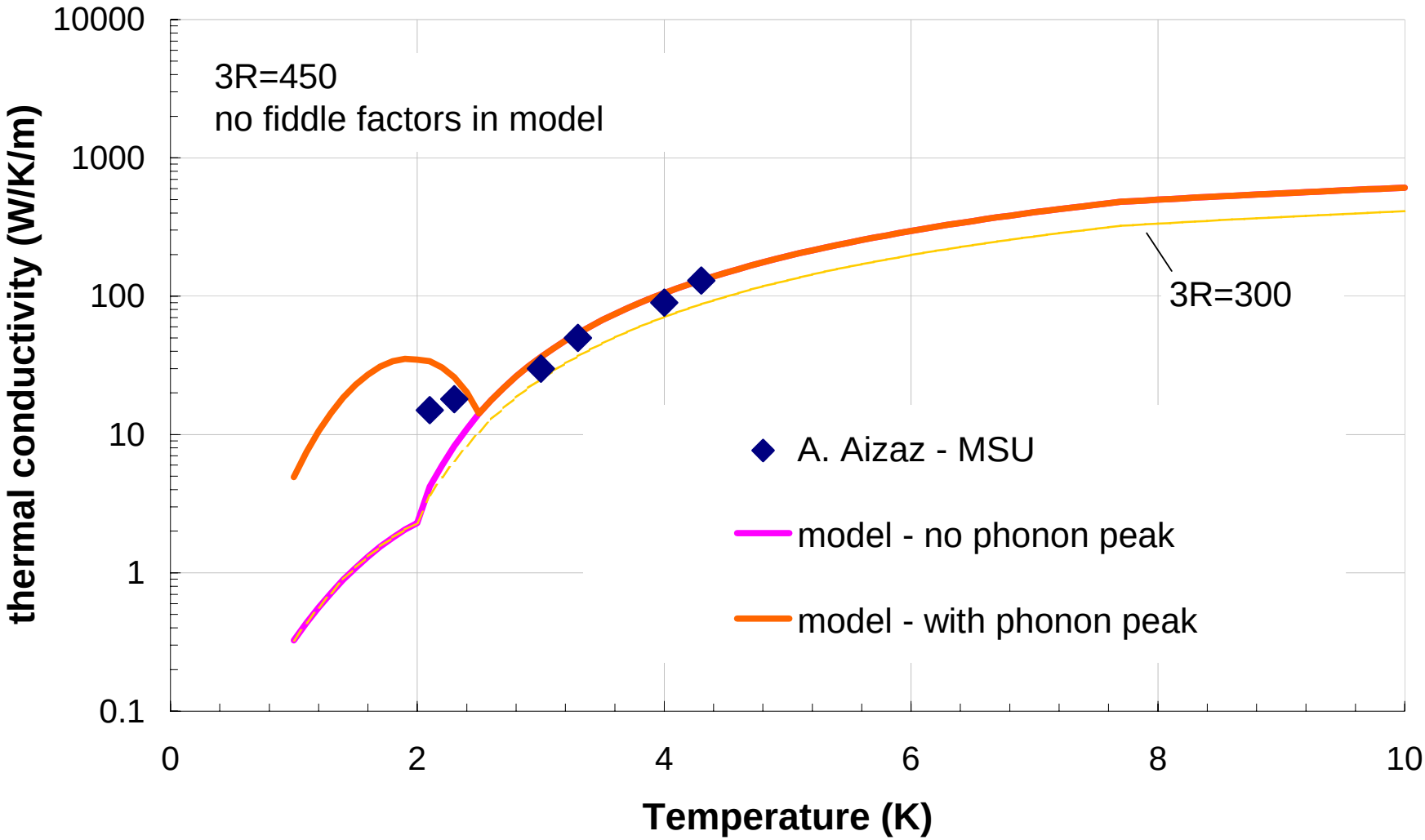




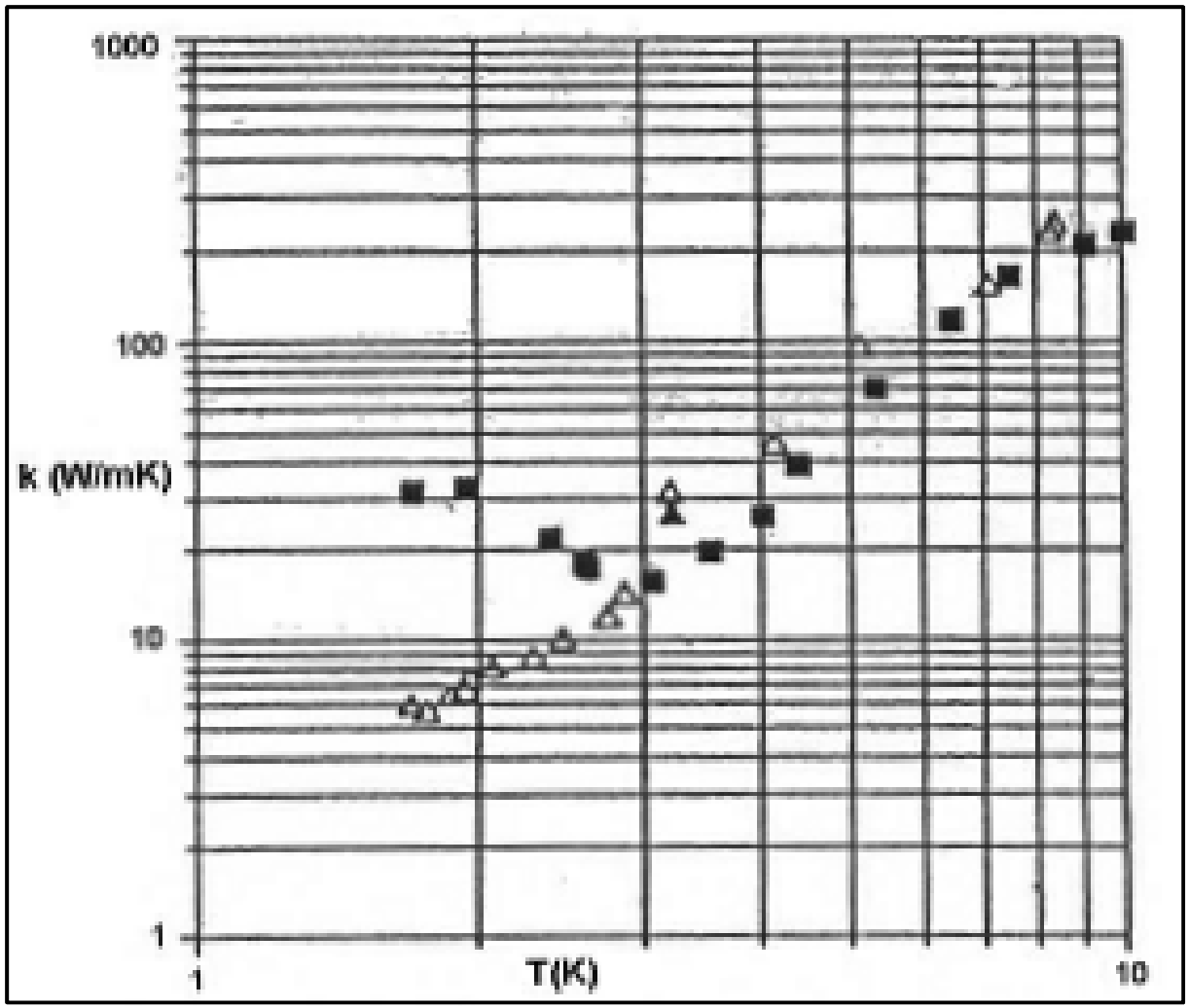
* A. Boucheffa, M.X. Francois and, F. Koechlin, Kaptiza Resistance and Thermal Conductivity for Niobium, Cryogenics Vol 34 ICEC supplement, pp 297-300 (1994).

Comparison with literature data*. Thermal conductivity versus temperature for different niobium: Δ RRR 38, o RRR 270, ▪ RRR 194, ● FNAL sample 2

(MSU) Data - (Saclay) Model Comparison
Thermal Conductivity ILC-AES batch 1 Niobium



Phonon Peak after Heat treatment?

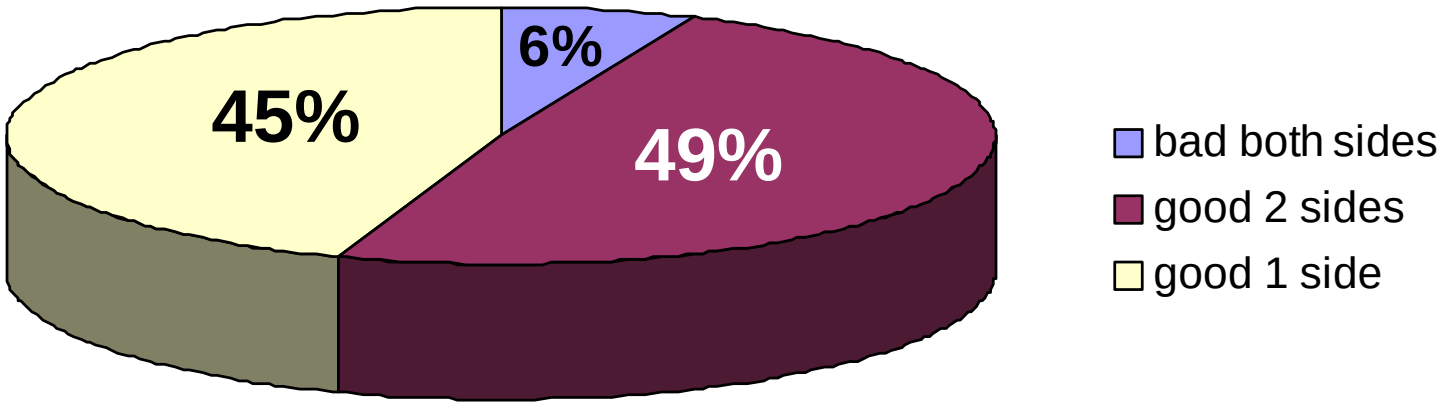


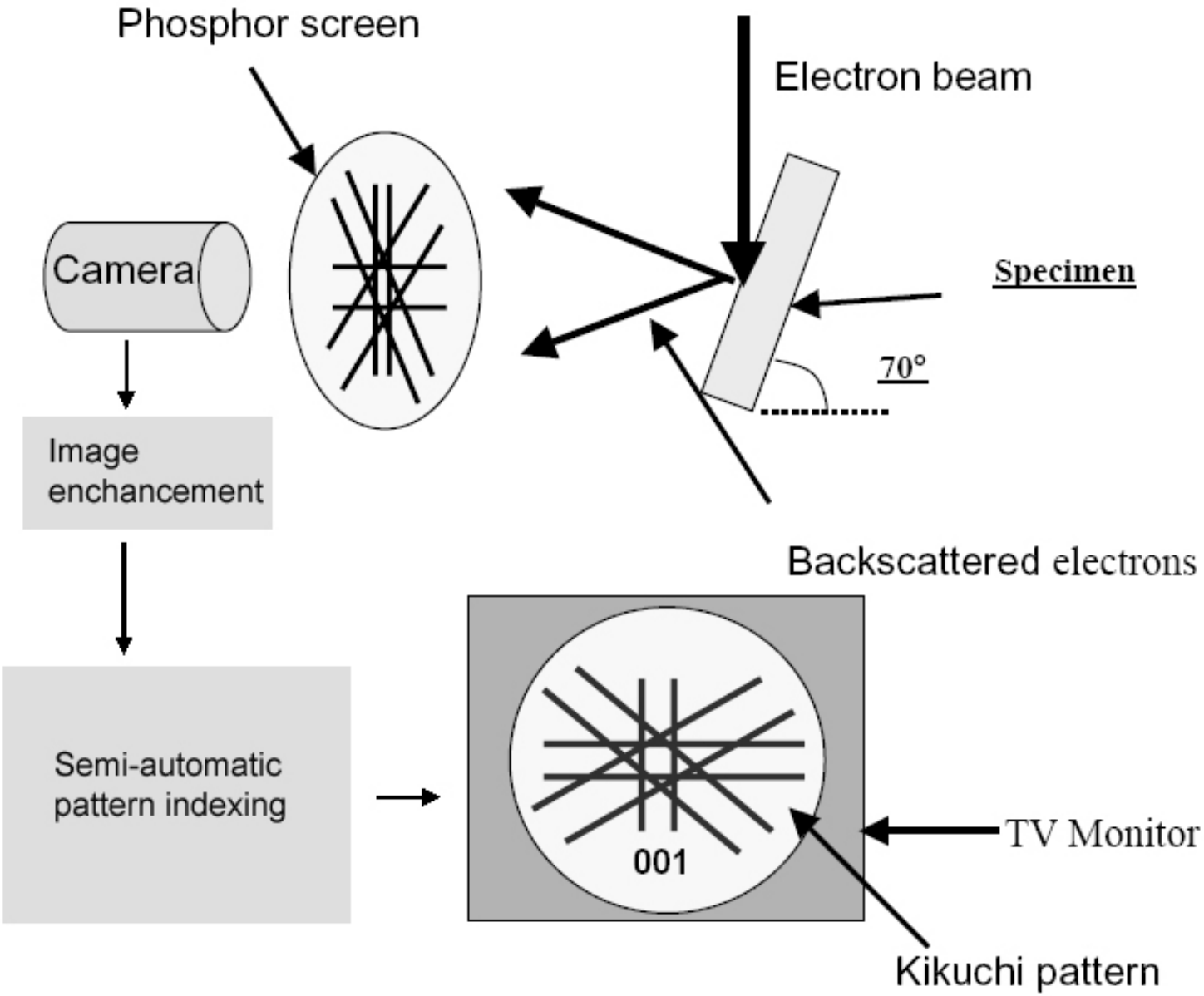
Δ As received RRR 186, ▪ Annealed RRR 100

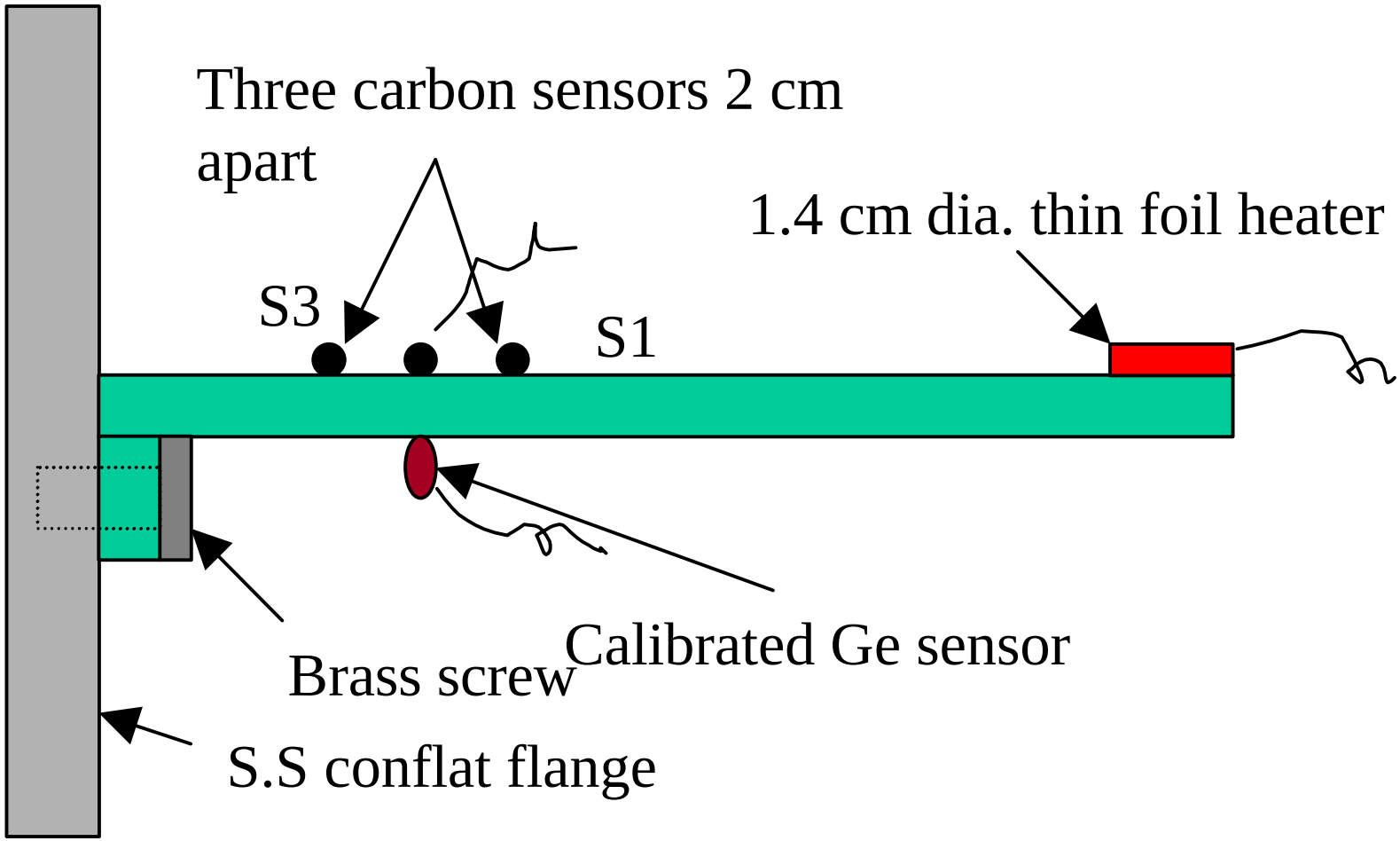
* A. Boucheffa, M.X. Francois and, F. Koechlin, Kaptiza Resistance and Thermal Conductivity for Niobium, Cryogenics Vol 34 ICEC supplement, pp 297-300 (1994).

Completed ILC Batch 1 Sheets for FNAL-AES Inspection
240 Sheets
Reports: TD-05-050, TD-06-010

ECS and Visual Inspection Results
ILC Batch 1 Sheets for FNAL-AES

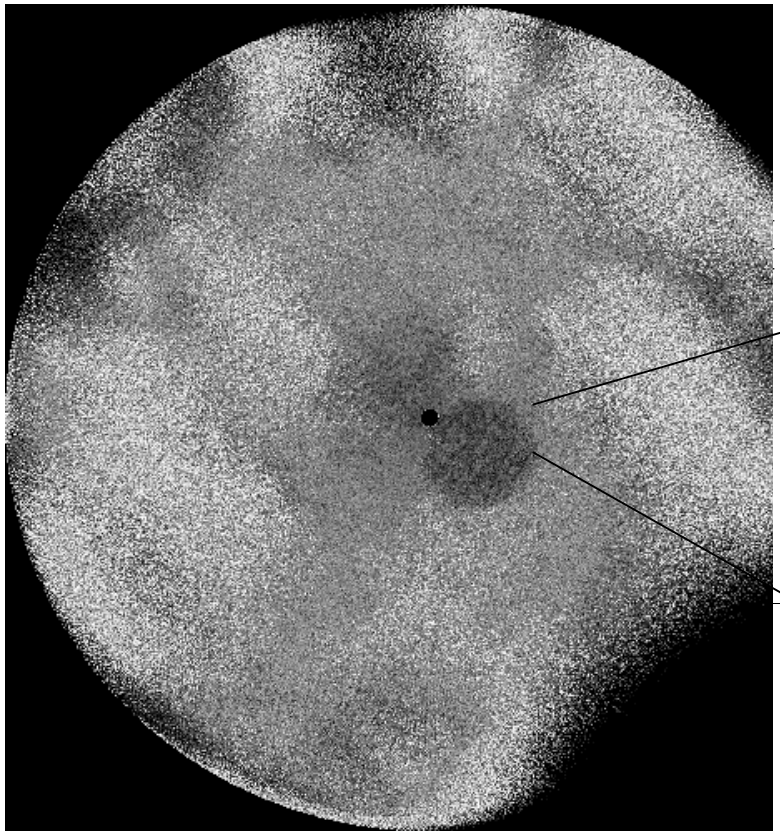


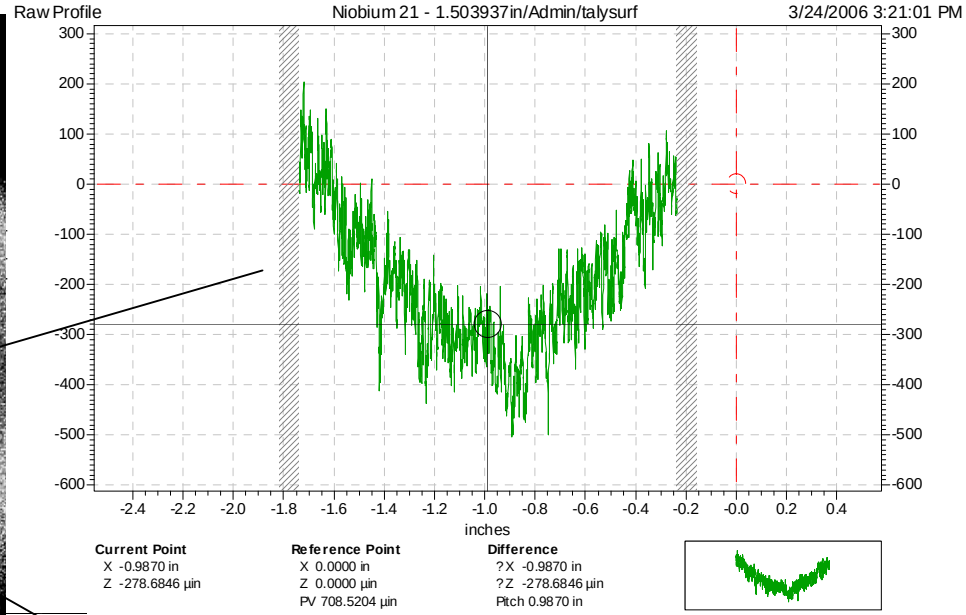

Phosphor screen
Electron beam
Camera
Specimen
70°
Image enchancement
Backscattered electrons
Semi-automatic pattern indexing
001
TV Monitor
Kikuchi pattern

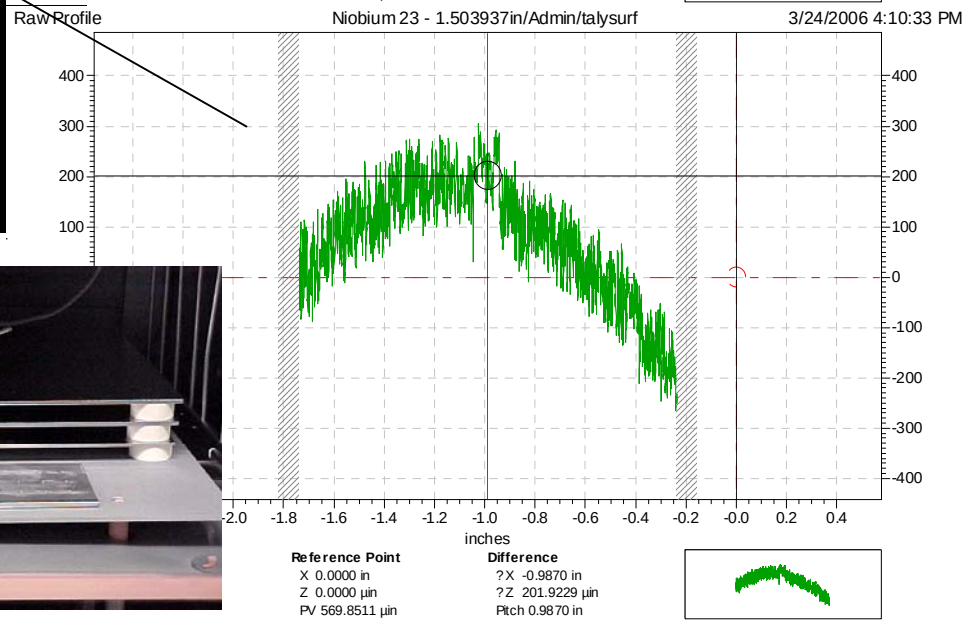


Rectangular Nb sample of size 11 X 1.4 X 0.3 cm supplied by FNAL. ***Drawing not to the scale***

Material is very soft during/after heat treatment!







Imprint of puck?

Mai 18th 2006