New University Based SRF Materials Research Efforts (in the US)

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Snowmass 2005
Materials R&D / WG5

LCRD 2005 – 6 Proposals

Funded:

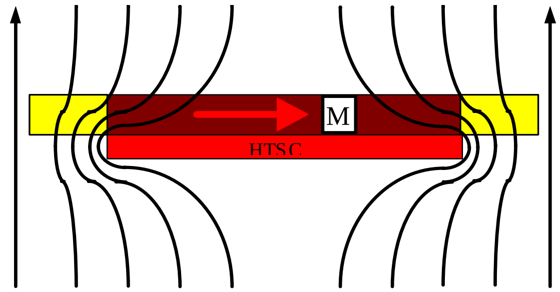
P.Lee:	Magnetic Investigation of High Purity Niobium for Superconducting RF Cavities, new proposal, DOE
D.N. Seidman:	3D Atom-Probe Microscopy on Niobium for SRF Cavities new proposal, DOE
L.Vuskovic:	Investigation of Plasma Etching for Superconducting RF Cavities surface Preparation, new proposal, DOE

Not funded:

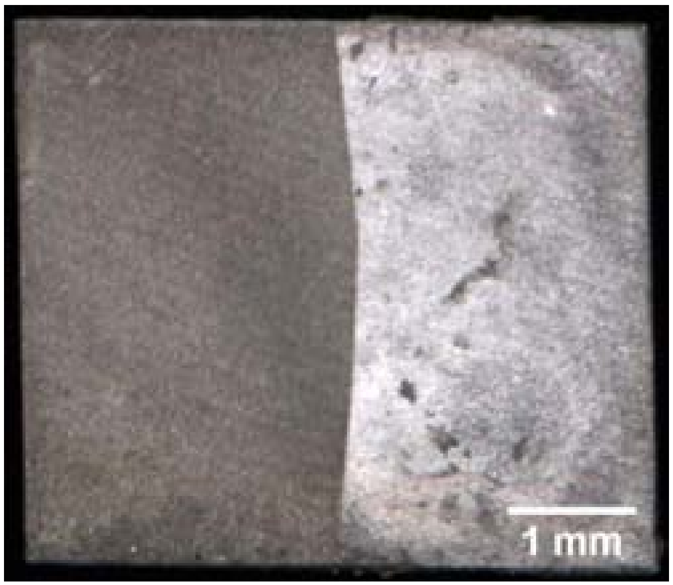
R. Schill:	Investigation of Secondary Electron Emission from Nb Surfaces with Different Surface Treatments, new proposal
V.Nesterenko:	Evaluation of MgB2 for Future Accelerator Cavities, new proposal
D.N. Seidman:	Experimental Study of High Field Limits of RF Cavities, new proposal

Magnetic Flux Penetration
Fnal / University of Wisconsin

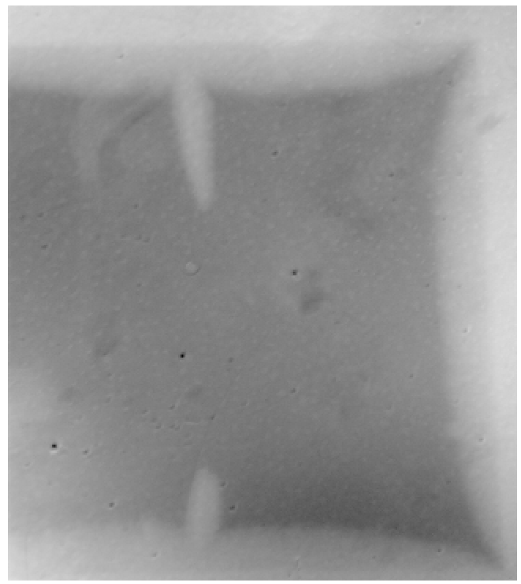
Magneto-optical measurements show clear evidence of “pre-mature” flux penetration into samples via the grain boundary. Example below: large grain material from JLab before processing.



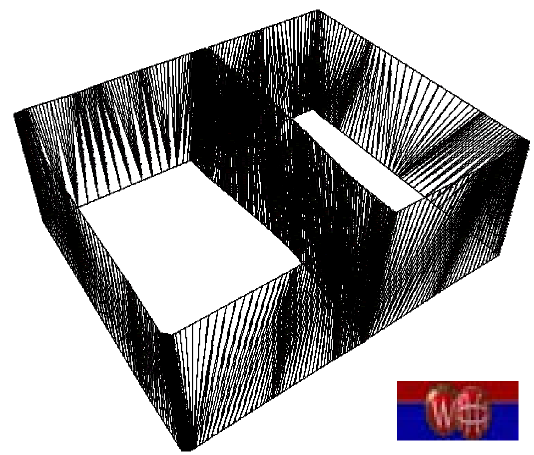
Zero field cooled (ZFC) to the superconducting state, then field applied.



Top Surface Light Image

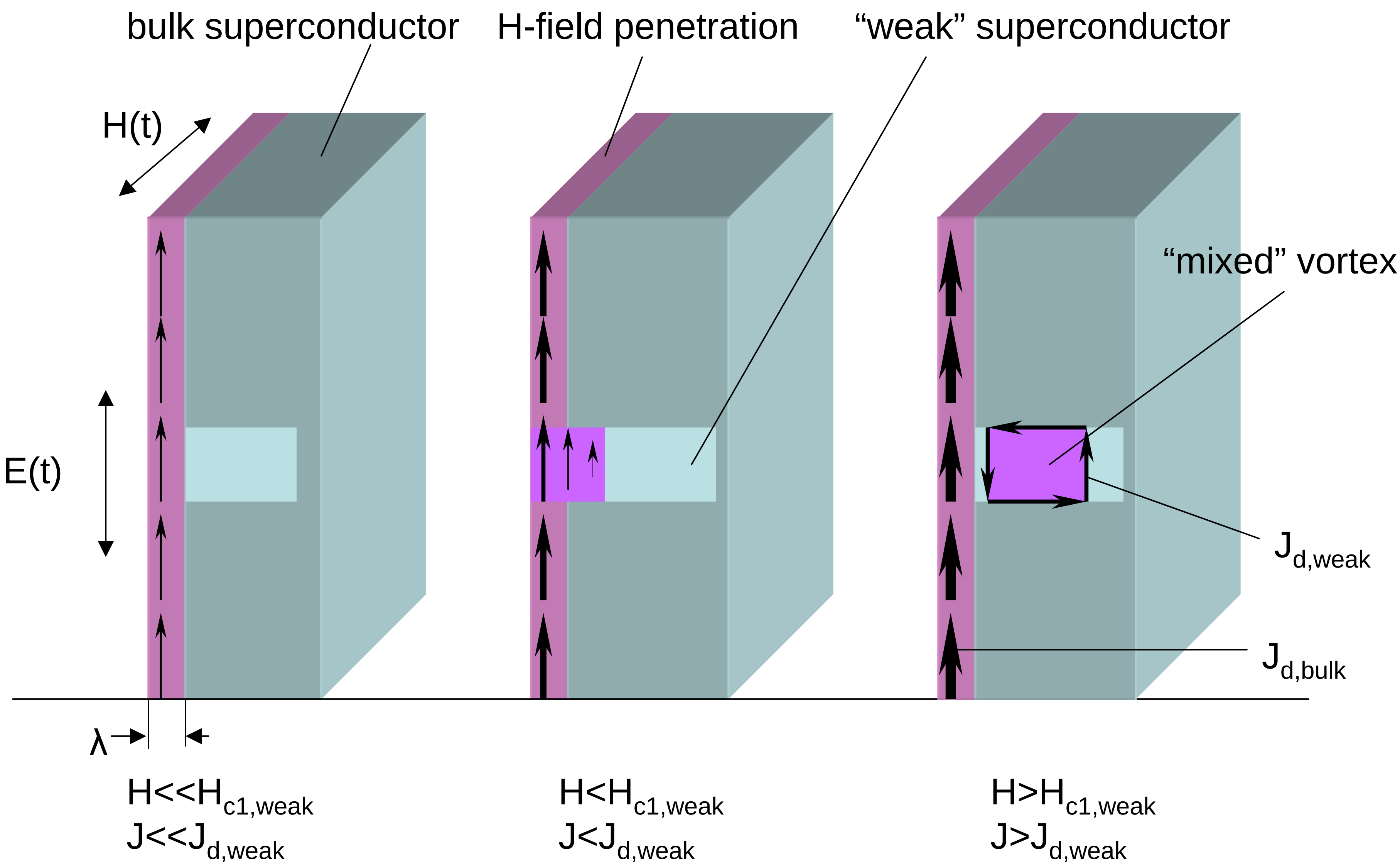


ZFC T=5.6 K H=8.4 mT



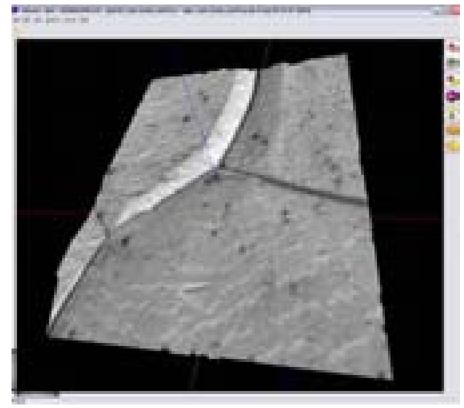
3D Model of GB

Mixed Josephson/Abrikosov vortex penetration

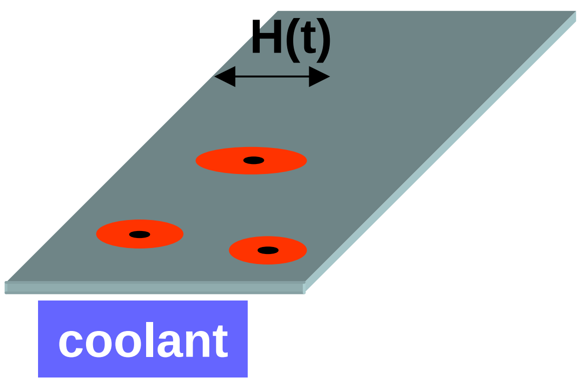


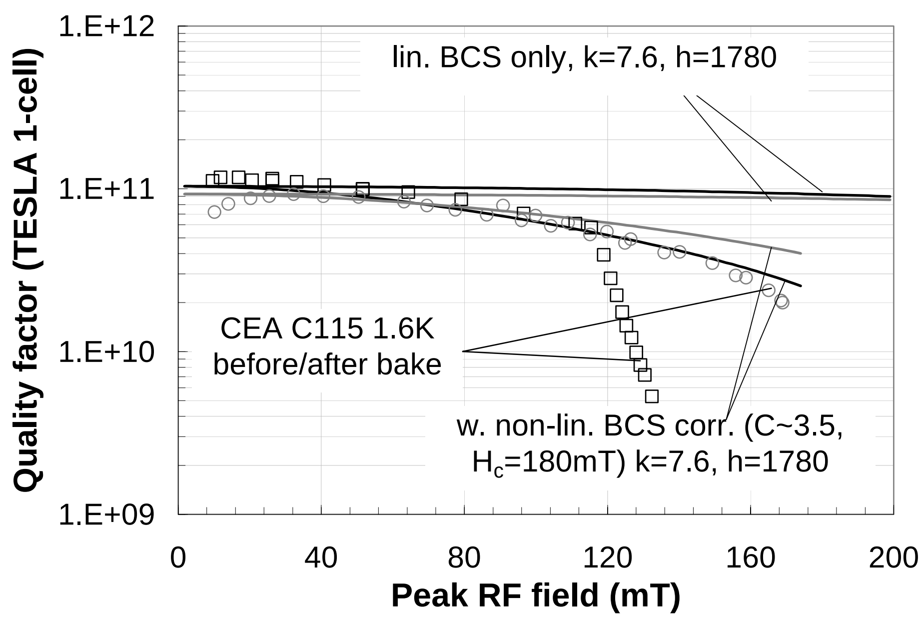
Other Activities
University of Wisconsin

- Microscopy and related material characterization (surface roughness, metallurgical, crystallo-graphical, chemical,..)



- Theoretical work by <u>A. Gurevich</u>:
  - “hot spot model”
  - Non-linear BCS resistance
  - Thermal Feedback model





UW – mid-term program

Achievements:

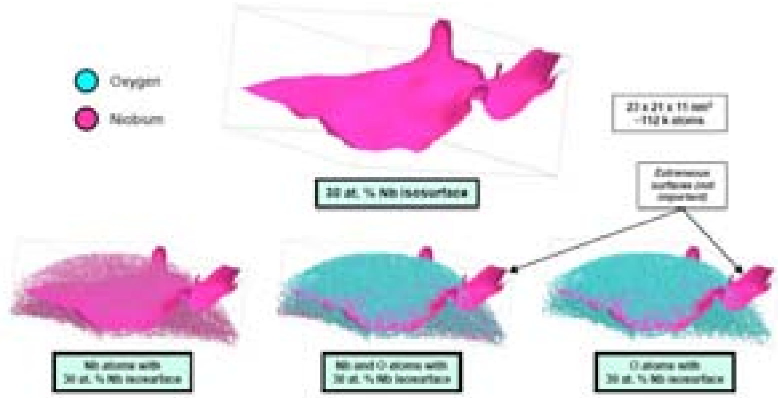
- Evidence of pre-mature flux penetration through GBs; (Mixed Abrikosov-Josephson flux lines a la Gurevich)

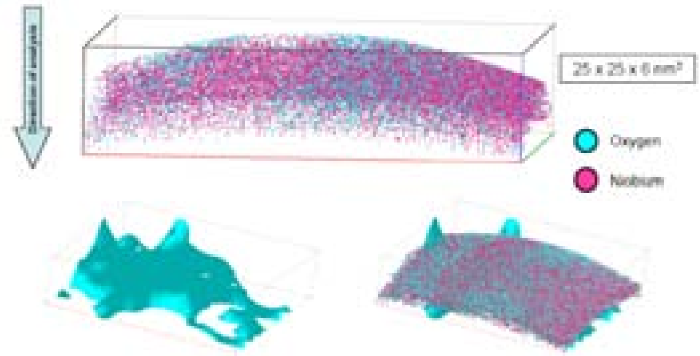
Mid-term program:

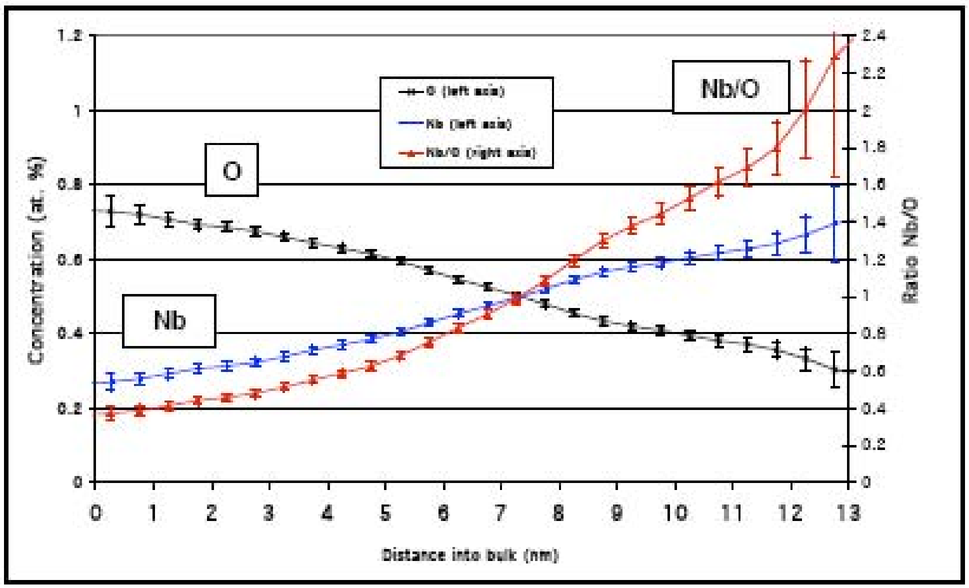
- Disentangle topology from "chemistry"
- Measure grain boundary Hc, Jd
- Understand "defects" other than GB
- Theoretical support – surface resistance contribution from vortex penetration, ..etc!

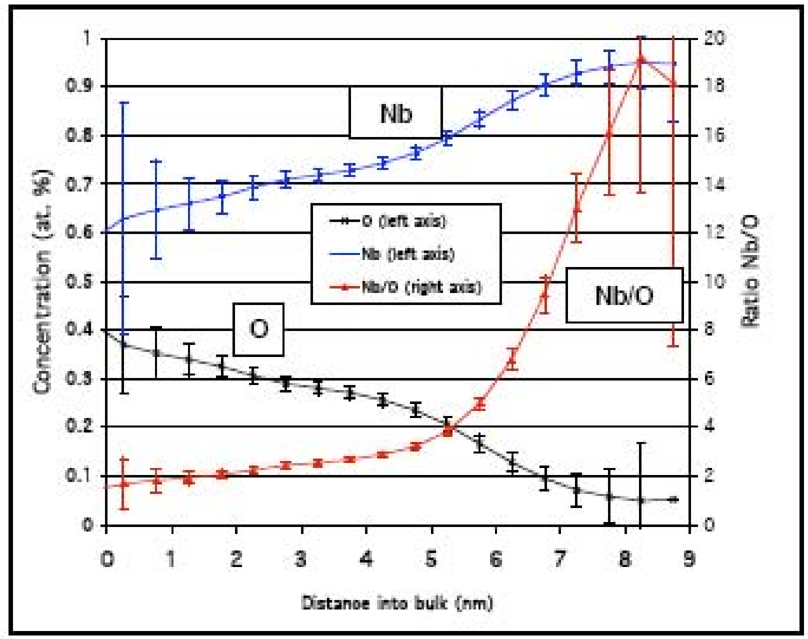
P. Lee

3D atomic probe at NU / Fnal







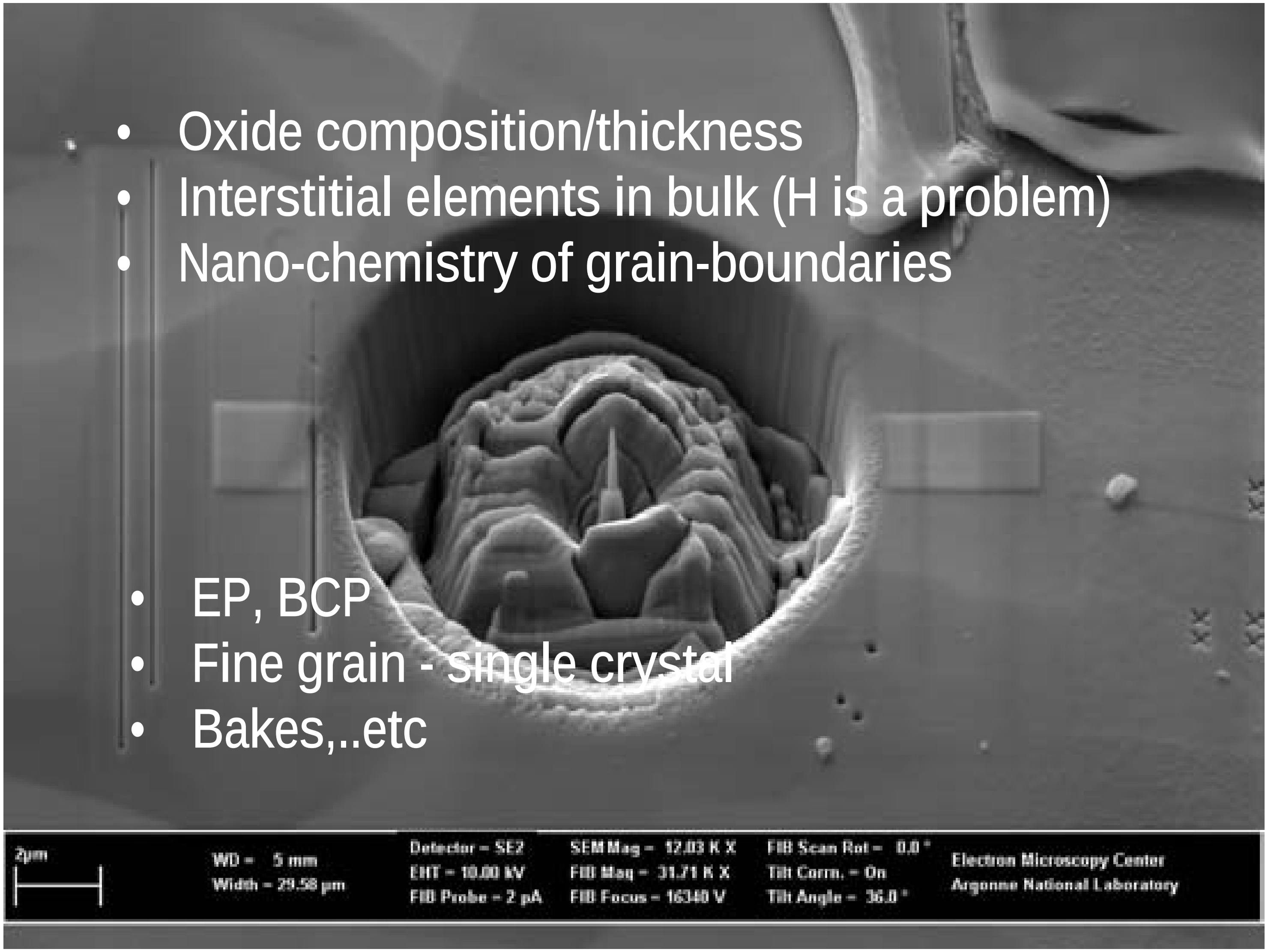


First results: Smooth transition from Nb_2O_5 to Nb with 5-10% interstitial O, ~20 nm oxide

NU - mid-term program

- Oxide composition/thickness
- Interstitial elements in bulk (H is a problem)
- Nano-chemistry of grain-boundaries

- EP, BCP
- Fine grain - single crystal
- Bakes,..etc



JLab/ODU – Plasma-Etching

A.M. Valente / L. Vuskovic:
Plasma-etching:

- Takes place under vacuum.
- Allows “control” on the final oxidation phase
- Allows the possibility to avoid final oxidation

Combines well w. other JLab programs:

L. Phillips: TE011 cavity

G. Wu: Plasma Coating

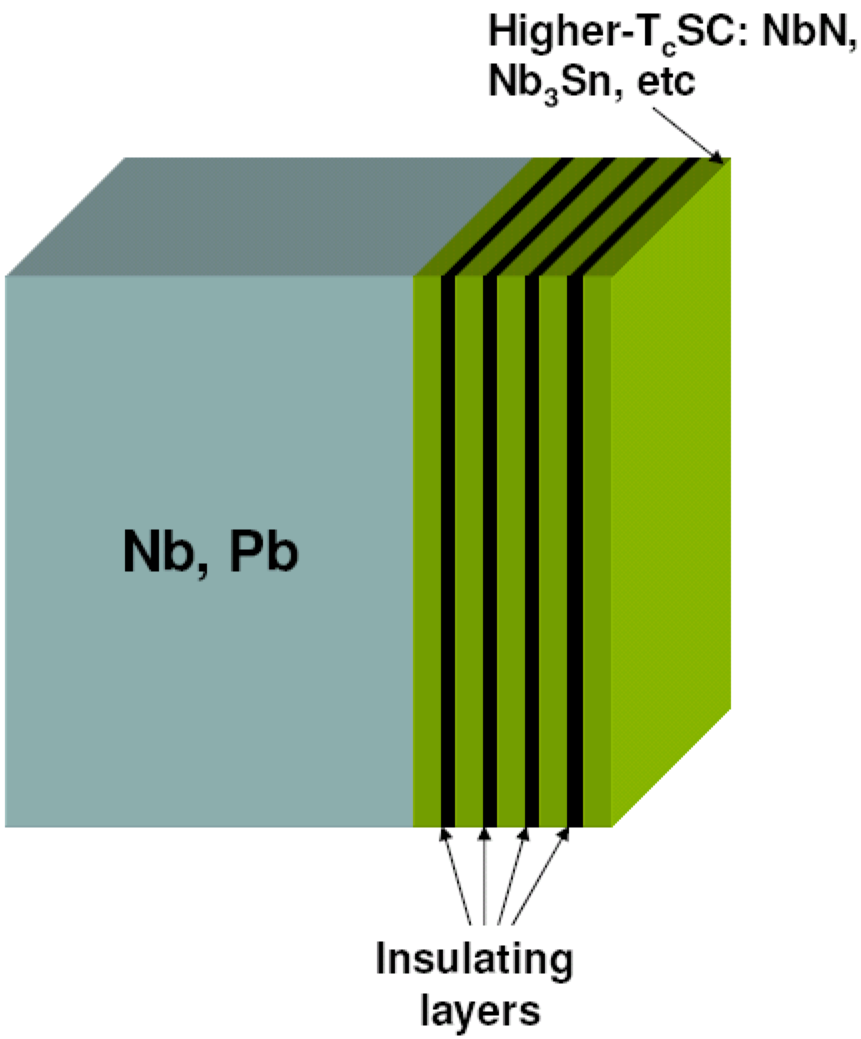
1) plasma oxidation in Ar-O after plasma etching (stable surfaces with a much higher pentoxide to sub-oxide ratios?)

2) dielectric layers

3) thin superconducting layers;- i.e. NbN which is quite stable in the

presence of air.

Another Gurevich Idea



Multilayer coating of SC cavities: alternating SC and insulating layers with $d < \lambda$

Higher T_c thin layers provide magnetic screening of the bulk SC cavity (Nb, Pb) without vortex penetration

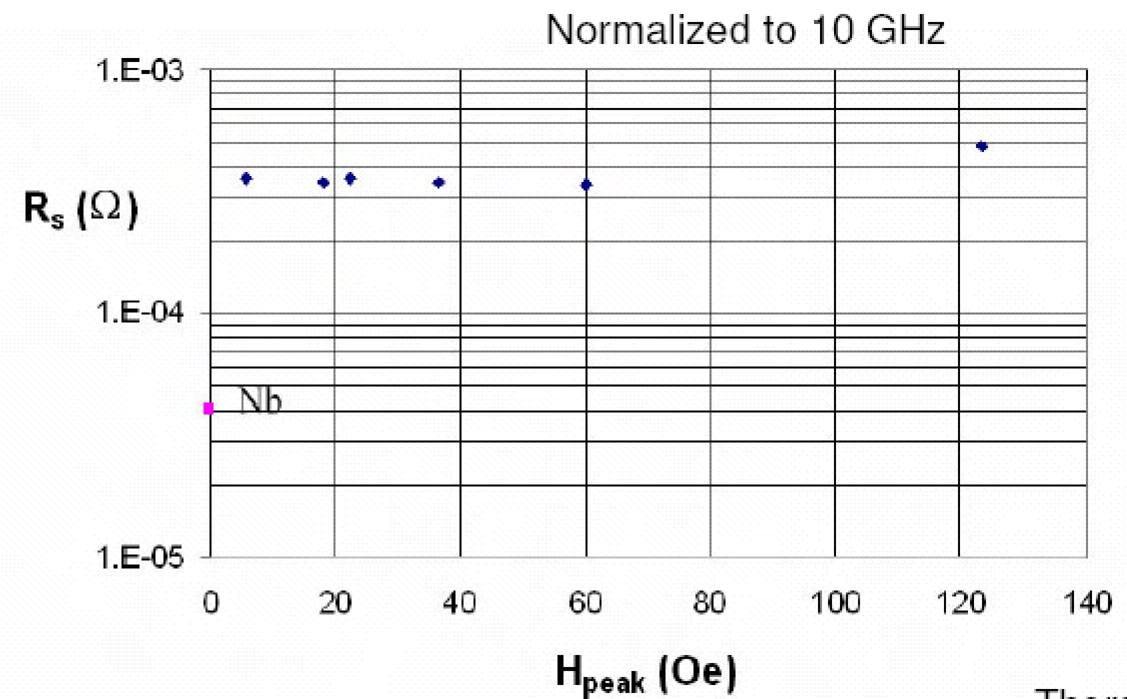
For NbN films with d = 20 nm, the rf field can be as high as 4.2 T !

No open ends for the cavity geometry to prevent flux leaks in the insulating layers

A. Gurevich

LANL/UC – MgB2 Development

T. Tajima / STI / Padamsee / Geng / Romanenko:



~400 nm film was grown on 1.5 cm Nb at STI.
First attempt to coat on a Nb substrate. The Nb substrate was rough (R_a ~ 400 nm).

Measurement at Cornell with TE_{011} Nb cavity at 4.2 K.

There was only one test and the result needs to be confirmed with others.

ANL/NU – Field Emission

Atom Probe samples look like field emission (breakdown) sites.

- Atom Probe work is useful for two reasons:
  1) It provides a detailed look at high electric field on materials.
  2) It provides a way of looking at surface composition.

	Emitter in Cavity	Atom Probe Sample
Surface field	4 – 8 GV/m	4 – 40 GV/m
Size	~100 nm	~100 nm
Temperature	300+ K	20 – 300 K
Pulsing	200 - 12000 MHz	0.2 MHz
Stored energy	1 – 100 J	< 10^{-6} J

J. Norem / D. Seidman / J. Sebastian / K. Yoon:

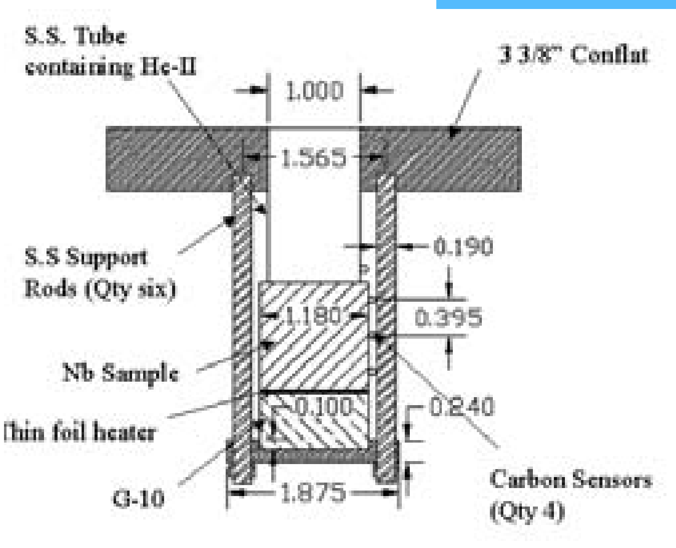
We need more university involvement!

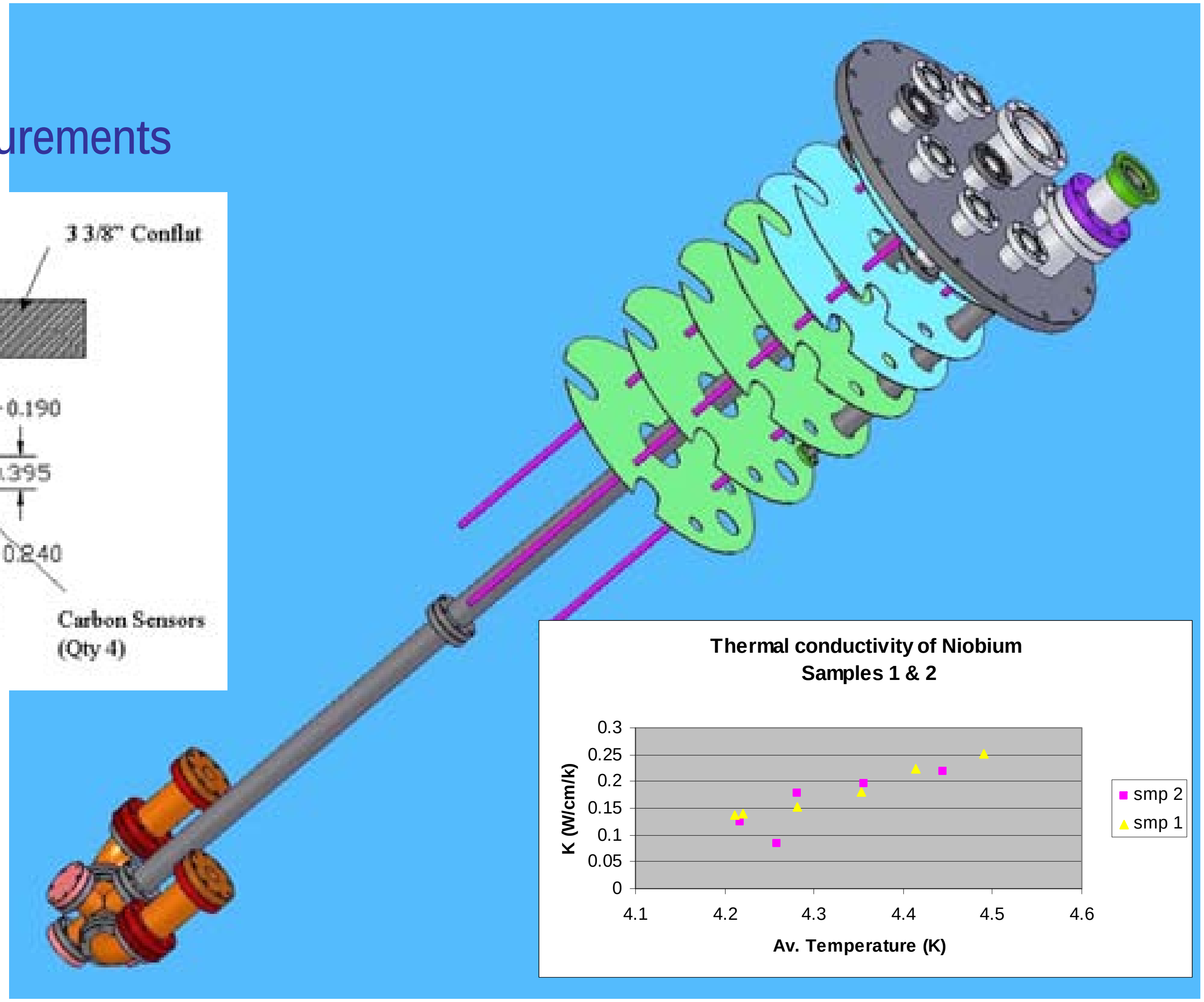
- Chemical analysis (3DAP, XPS, SIMS, AES,…)
- Superconducting properties (magnetization, STM, SQUID microscopy, ….)
- Low and high power RF properties (sample in host cavity tests, microwave microscopy, ??)
- Microscopy, surface roughness
- Defect detection – ECS, SQUID-ECS,..
- More ideas??

MSU –Thermal Properties

A. Aizas, T. Grimm:

Kapitza and κ measurements





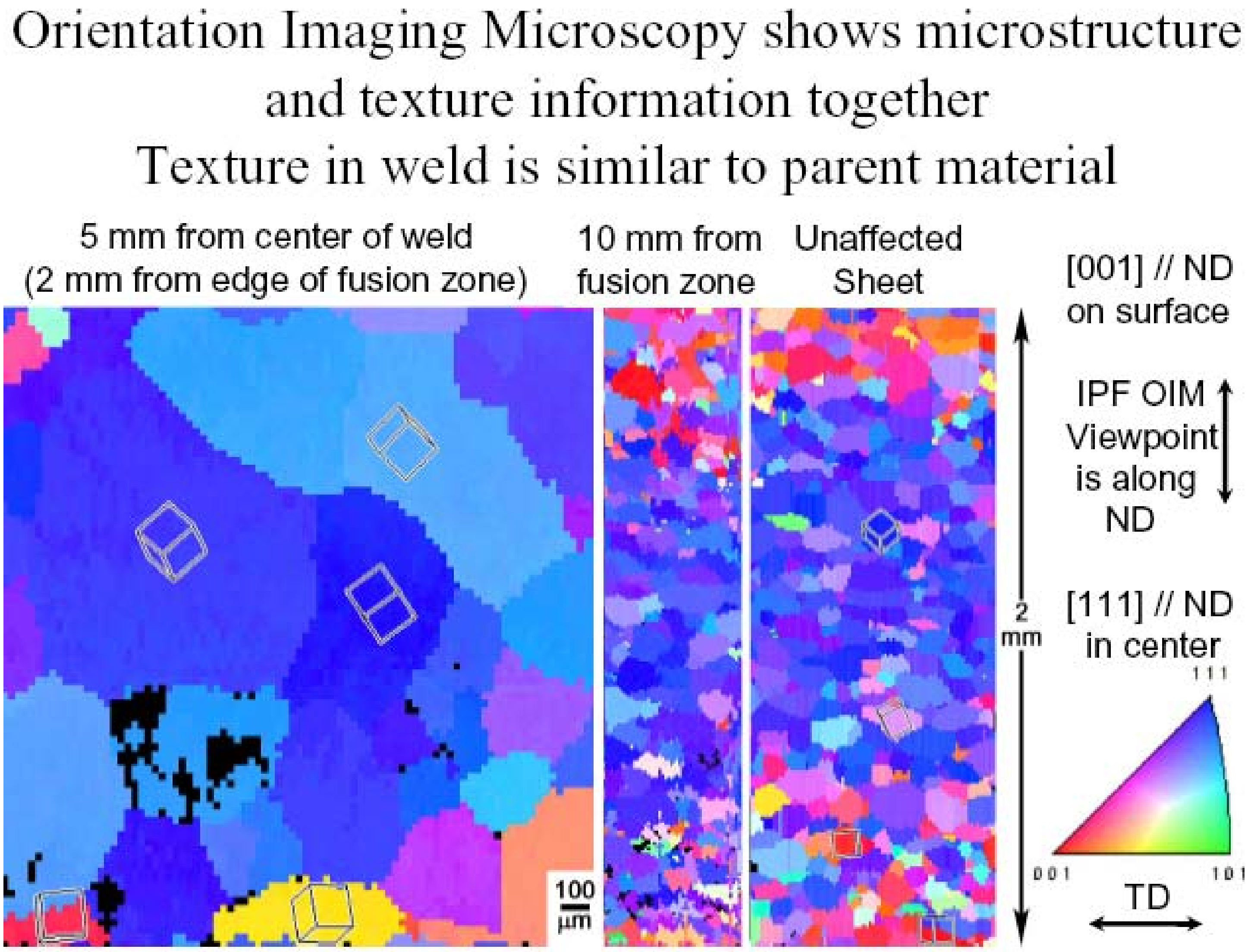
MSU – Mechanical Properties

H. Jiang,
T. Bieler:

mechanical properties,

formability, texture, creep

Next: single crystal material



Laser Annealing Experiments with Niobium

W.R. Frisken, Physics and Astronomy, York Univ.,Toronto, Canada
L.N. Hand, Physics and CCMR, Cornell University, Ithaca NY, USA
G.H. Chapman, J. Wang, C.-H. Choo, and Y. Tu, School of Engineering Science, Simon Fraser Univ., Burnaby B.C., Canada