Update on fundamental SRF R&D at FNAL

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Fermilab
Overview of experiments

- High field quench studies
  - Quench site localization and cutout

- Post-baking losses
  - Dissipative areas in the absence of HFQS

- RF layer profiling via HF rinsing

- Near-surface hydrogen enrichment and evolution

- High field Q-slope studies
  - EP cutout (RF test with thermometry – current visit)

- Medium field Q-slope studies
  - $T$ and treatment dependence

- SRF University collaboration (Northwestern, UIC, NHMFL/FSU)
High field quench and post-baking losses

- 1.3 GHz fine grain single cell
- EP+120°C bake at ANL/FNAL
- RF tested at JLab with thermometry last year (collaboration with G. Ciocci)
Lossy areas AFTER mild baking

150-10 hot spot

130-7 hot spot

90-7 cold spot

150-10 hot spot
130-7 hot spot
130-7 hot spot
130-7 hot spot

Border between stars-no stars
150-10 hot spot

![Graph showing the relationship between Hpeak (mT) and dT (mK).]
150-10 hot spot
90-7 cold spot

![Graph showing temperature change with magnetic field strength](graph)

![Microscopic image marked with date 30/JAN/11](image)
*TEM – Pure Nb*  
Y. Kim, D. Seidman – Northwestern Univ.

**NbH precipitates near dendritically shaped dislocations**

![Image showing TEM micrograph of Nb with NbH precipitates near dislocations and SAD patterns.](image)

- Nb 110 zone
- Simulated SAD pattern
- NbH precipitates near slip bands
- SAD pattern

In-situ cooling of Nb cavity sample:

R. Tao and R. Klie
Effects of in-situ cooling:

Room temperature

Superlattice at 95K

NbH (110) ?

R. Tao and R. Klie
Superlattice at 96 K:

Superlattice totally disappears once back to room temperature.

R. Tao and R. Klie
Hydrogen near-surface enrichment

Elastic recoil detection shows hydrogen enrichment in all samples.
Hydrogen studies by Elastic Recoil Detection

Drastically different RF losses – exactly same H depth profile!

Same amount of hydrogen but precipitated/not precipitated?
Quench at 160 mT
Site localized and cut out

Carbon spots - the only feature found so far
A. Polyanskii, Z. H. Sung

MO imaging - the observation of the flux penetration

- Top

00%

- Top

23%

- Top

35%

- Top

46%

- bottom

Flux penetration is aligned to the deformed direction

\( N_z = 0.6667, \quad N_{\text{enh}} = 1/(1-N_z) = 3.001 \)

\( T=6K, H=0, \text{Remn after } H=80 \text{ mT} \)

\( N_z = 0.653, \quad N_{\text{enh}} = 2.882 \)

\( T=7K, H=0, \text{Remn after } H=52 \text{ mT} \)

\( N_z = 0.649, \quad N_{\text{enh}} = 2.858 \)

\( T=6K, H=0, \text{Remn after } H=96 \text{ mT} \)

\( N_z = 0.637, \quad N_{\text{enh}} = 2.257 \)

\( T=8K, H=0, \text{Remn after } H=32 \text{ mT} \)
RF layer profiling by HF rinsing

- Anodizing experiments indicated about 20 nm of mild baking modified layer (Ereemeev et al, SRF’2005,TuAO8; Ciovati et al, PRST AB 10, 062002 (2007)) – ~10 HF rinse steps
- In principle might be possible to distinguish what layer(s) responsible for what regions of Q(E) curve
- High Q₀ at low and medium fields after 2 rinses
Medium field $Q$-slope studies

- Project X – CW linac – dynamic losses are a very significant cost factor
  - Two 650 MHz TESLA shape cavity sections of $\beta=0.61$ and 0.9 currently planned to be operated at $E_{\text{acc}}=17$ MV/m ($H_{\text{peak}}=72$ mT)
  - No clear understanding of how to maximize $Q_o$ at medium fields if not concerned with “as-high-gradient-as-possible”
    - Residual resistance, MFQS significant factors

- Need to choose from the available chemical/mechanical/heat treatments (and study the mechanism of losses)
Effects of bath T/surface finish
Thanks