HOM Absorber Development for Cornell ERL Cryomodules


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One of the first beamline HOM loads for SRF cavities was developed for the SRF upgrade to CESR at Cornell

- Room temperature load residing exterior to the Vac vessel
- One type of ferrite RF absorber (C-48 and TT2), sputter plated and soldered to Elkonite backing plates with absorption range up to ~10 GHz
- 8-10 loads successfully operating in CESR for >10 years, another dozen or so operating around the globe

A HIP’ed load was simultaneously developed for KEK-B
Cornell ERL Linac Cryomodule

Expected HOM power ~200W per load @ 80K

A steep cryogenic price necessary for high bandwidth absorption
HOM extraction must occur between cavities in a cryomodule.

Waveguide and loop coupling is being explored, e.g., JLAB, KEK. Challenges:
• larger geometry, esp for waveguide
• thermal transitions to exterior room temperature absorber
• sufficient bandwidth coupling

Cryogenic beamline loads have been proto-typed at Cornell (200 W) and DESY (100 W). Challenges:
• material properties in the extreme environment
• close proximity to an SRF cavity (absorber chips)

(KEK, BNL, and other efforts shown at this Workshop)
3 types of RF absorbing tiles implemented to have strong absorption 1 GHz - 40 GHz: TT2, Co2Z, and Ceralloy 137Zr10.

The ferrite tiles were sputtered with Ti-Cu and soldered to substrates with CTE matched as close as possible. The Ceralloy was TiCuSil active brazed to tungsten.
• Despite 80K dunk tests of individual absorber plates, cooling the full assembly caused fracture of the TT2 ferrites during a single-cavity horizontal test.

• **Chips** (not dust) fell into the cavity causing $Q \approx 10^9$ at 1.8K, the test was terminated.

• The Co2Z and Ceralloy showed no problems.
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Remedies:
• try a different substrate for TT2
• use smaller area tiles
• modify the design to make assembly ergonomically easier
• re-establish omitted process steps

The motivation for having 3 types of absorbers is ensuring sufficient absorption bandwidth, critical for BBU.

If necessary, this type of load could perform reliably, but cost and complexity reduction is still desirable.
Goals:

- Broad RF absorption from 1 GHz – 40 GHz (prefer up to 100 GHz but tough to measure $\mu$ & $\varepsilon$).
- Survive cooling to 80K without fractures
- Compatible with beamline high vacuum <10^{-10} T
- Radiation hard
- Low cost and easy to manufacture
- 2.5D and 3D RF models using measured complex $\mu$ & $\varepsilon$, SLANS, Omega3P, MWS, computationally intensive

Mount to He Gas Return Pipe

5K intercepts

80K cooling

RF absorber

Bellows for flex

Simplistic Model
DESY XFEL HOM Load

Development Name | Production | $\varepsilon_r$ | Comment
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C7Y1 (Al Nitride) | 137-CA | 25 | $\varepsilon_r$ too high?
Zr10CB5 | 137Zr10 | 15 | XFEL Load Material

(Isidoro Campisi, CEBAF, ZrC20 Cryogenic insertion loss demonstration)

XFEL collaboration will perform RF testing of each cylinder

Estimation of the $R_s,\text{cer}$

Pillbox cavity for the ceramic test at 300K

Lossy ceramic Zr10CB5: $\varepsilon' = 15$ and $\varepsilon'' = 4$

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HOM Absorber Development for Cornell
ERL Cryomodules
• Samples taken from 2-3 cylinders at various locations
• “Hot pressed” cylinders show large variation in tan δ
• “Pressureless sintering” of tiles shows more consistent properties, not applicable to cylinders
• A broadband RF absorbing material is likely not yet identified

“furnace position has major effect, too much scatter. Additional samples to be sent…”

- Ceradyne
The ERL Linac HOM design is ongoing:
- 200W absorption has ~2K temperature rise for alumina at 80K
- peak stress on the ceramic is manageable
- single convolution bellow with requisite flex
- the HOM beampipe may not need plating
- what about the broadband RF absorber?
Carbon nanotubes (CNT’s) make great RF absorbers using only a few % loading of the matrix in resins. Can exhibit very flat dielectric loss with frequency. Functionalizing CNT’s with Fe & Ni may provide magnetic loss.
Promising new RF Absorbers

- Small samples of alumina ceramic have been sintered with CNT doping
- Initial measurements show similar loss vs. frequency as seen with resins
- Measurements ongoing at higher frequencies and at 80K
- Prospects for large cylinders is encouraging given material science and processing considerations
- More to come at SRF 2009…