We report on the refurbishment and testing of the Wisconsin Free Electron Laser (WiFEL) superconducting radiofrequency electron gun with application as an electron injector for DOE accelerators and as a possible future stand-alone tool for electron microscopy. Initial testing at ANL showed the cavity had a very low quality factor, ~10^7, later determined to be due to contamination sometime since the initial assembly. Following ultrasonic cleaning, high-pressure water rinsing, reassembly, and cold testing, the e-gun has largely recovered with Q ~10^9 and surface electric fields ~15 MV/m. We intend that WiFEL be available as a testbed for future high brightness sources and, in particular, for testing an SRF gun photocathode loader design; an essential, and as yet, not sufficiently proven technology. We report here on many operationally important properties of a quarter-wave SRF cavity for application as an e-gun, including microphonics, pressure sensitivity, and mechanical tuning. New electromagnetic simulations show that the WiFEL cavity shape and design can be optimized in several respects.

**ABSTRACT**

We report on the refurbishment and testing of the Wisconsin Free Electron Laser (WiFEL) superconducting radiofrequency electron gun with application as an electron injector for DOE accelerators and as a possible future stand-alone tool for electron microscopy. Initial testing at ANL showed the cavity had a very low quality factor, ~10^7, later determined to be due to contamination sometime since the initial assembly. Following ultrasonic cleaning, high-pressure water rinsing, reassembly, and cold testing, the e-gun has largely recovered with Q~10^9 and surface electric fields ~15 MV/m. We intend that WiFEL be available as a testbed for future high brightness sources and, in particular, for testing an SRF gun photocathode loader design; an essential, and as yet, not sufficiently proven technology. We report here on many operationally important properties of a quarter-wave SRF cavity for application as an e-gun, including microphonics, pressure sensitivity, and mechanical tuning. New electromagnetic simulations show that the WiFEL cavity shape and design can be optimized in several respects.

**COLD RF TESTING**

- Multipacting barrier at V_ac = ~8-30 kV
- Underwent multiple rounds of high power, pulsed RF conditioning
- Maximum CW-sustainable gradient E_{peak} = 14.3 MV/m; maximum pulsed gradient E_{max} = 24 MV/m

**Q DISEASE TESTING**

- Measured Q curve shapes seemed to indicate possible Q disease
- Tested by warming up and leaving the cavity in hydride forming temperature region
- Expected an order of magnitude scale change on Q_0, but very little measurable difference was seen

**PRESSURE SENSITIVITY DF/DP**

- Eigenfrequency sensitivity to external pressure was measured to be -35 Hz/torr

**MECHANICAL TUNER**

- Eigenfrequency sensitivity to mechanical tuner force was measured to be 21.6 Hz/N
- Exercised over relatively small region

**LORENTZ DETUNING**

- Detuning coefficient measurement was taken at multiple field levels
- Effort made to remove pressure sensitivity effect seen while running cavity at high power

**WIFE CAVITY REFURBISHMENT**

- Initial testing at Argonne showed Q_0 = 5 x 10^7, prompted analysis of possible causes
- Investigation with borescope revealed contamination was clearly visible
- Analytical chemistry confirmed as niobium pentoxide, origin unknown, perhaps from plasma processing at UW.

Niobium oxide dust at the bottom of the WiFEL cavity, as seen through the cavity port (top). A close-up view of the contamination, seen through a flexible borescope inserted into the cavity prior to cleaning (bottom).

- Cryostat was disassembled and cavity was removed for cleaning
- Cavity underwent ultrasonic cleaning and high-pressure rinsing (~3 hours)
- Cavity string assembly was completed in clean room

**MICROPHONICS**

- Microphonics were measured both connected to the helium refrigerator and disconnected
- A prominent, low frequency (low Hertz) signal is present while connected to the helium refrigerator

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