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SUPERCONDUCTING RF CAVITY DEVELOPMENT WITH UK INDUSTRY

A.E. Wheelhouse, R. Bate, R.K. Buckley, P. Goudket, A.R. Goulden, J. Orrett, P.A. McIntosh, ASTeC, STFC, Daresbury Laboratory, Warrington, UK.
J. Everard, N. Shakespeare, Shakespeare Engineering, South Woodham Ferrers, Essex, UK.
P Kneisel, S. Manning, R.A. Rimmer, Thomas Jefferson National Accelerator Facility, 12000 Jefferson Avenue, Newport News, VA23606, USA

Abstract

The aim of the PIPSS project is to develop the capability of UK industry in the manufacturing of superconducting RF cavities.

Deliverables:-

- Knowledge transfer – Documented process of delivering and testing a cavity
- Cavity should operate at 1.3 GHz, have defined tolerances and a physical length.
- Quench limit of the cavity > 15 MV/m.
- Cavity to have a Q_0 > 1x 10^{10} at 2K
- The cavity should have no detectable leaks and be able to pump down to a vacuum of 10^{-9} Torr

Cavity Design & Manufacture

Cavity Design:-

- Cavity designed based on the TESLA geometry
- Steps incorporated at the equator and beam-pipe interfaces to ensure easy interlocking and location of adjacent parts

Cavity Manufacture:-

- Successful trials performed with copper
- First niobium half cell was distorted
  - Dragged due to sheet thickness
- Second attempt with niobium was successful
- Beam-pipes were spun
  - Reduction in wall thickness minimal (~0.75 mm)
- Three sets of cavity parts produced

Cavity Processing

Electron Beam Welding:-

- Welding performed at Jefferson Laboratory on their electron beam (EB) welder with 6-axis of freedom
- Cavity #01 and #03 successfully welded
- Cavity #02 – Final equator weld suffered from a lot of 'flashing'
  - Suspect contamination on the weld surface was trapped in between the two steps at the equator interface
  - Pushed around the weld joint by the electron beam
  - Can result in a puncture due to the build up of the contamination levels
  - A visual examination of the cavity externally and internally indicated that the weld appeared to be leak tight
- ⇨ Future joint designs will incorporate a butt joint

Buffered Chemical Polishing (BCP):-

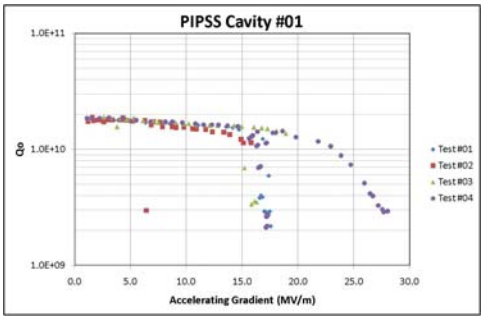
- Acid mixture - HF (49%), HNO_3 (65%), H_3PO_4 (85%), 1:1:1 mixture
- BCP etch post welding removes around 100 - 150 µm of the internal surface of the cavity. Required for:-
  - Impurities or inclusions created during manufacture
  - Films produced during the welding process
- BCP etch post vacuum bake (10 hours at 600ºC) removes 30µm
  - Ensures the internal surface is clean prior to a high pressure rinsing
- Etch rate is typically 8 µm/min
- Frequency change is typically 11 kHz/µm

- A BCP etch facility has been developed at Daresbury Laboratory using an existing fume cupboard
- First BCP etch successfully performed on Cavity #02
  - Two etch runs performed - 85 µm removed

RF Tests

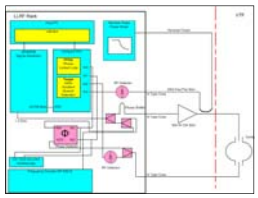
Cavity #01:-

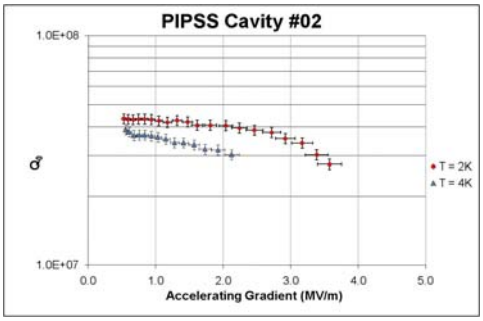
- Cavity tests performed at Jefferson Laboratory
- Initial tests the cavity achieved 15.7 MV/m with a Q_0 of 1.15 x 10^{10} at a temperature of 2K.
- Exhibited multipactor at 15.7 MV/m
- CW and pulsed conditioning increased the gradient 17.6 MV/m with a Q_0 of 2.17 x 10^9.
- Further processing of the cavity was performed
  - Further BCP etch
  - Vacuum furnace run at 600°C for 10 hours
  - Further high pressure rinses
- Final tests the cavity achieved 22.94 MV/m with a Q_0 of 1.06 x 10^{10} at a temperature of 2K.
- Still exhibiting multipactor at around 16 – 18 MV/m



Cavity #02:-

- Cavity tests performed at Daresbury Laboratory in a newly installed vertical test facility
- The RF system uses a phase lock loop (PLL) system to match the frequency of the RF source to the frequency of the cavity
- Preliminary test results to date are poor
  - Strong 'Q-disease' and low field Q_0 performance
- Possibly caused by hydrogen in the bulk material
  - Poor temperature control during the BCP process
  - Insufficient material was removed
- Cavity to be re-processed and tested





Summary

- Cavity #01 exceeded target specification
- Verification of a purpose built test facility at Daresbury Laboratory was successfully performed
- Cavity #02 further processing to be performed
- ⇨ Overall tests performed demonstrate that UK industry has the capability to fabricate SRF components to the required standards

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