Cornell University
Laboratory for Elementary-Particle Physics

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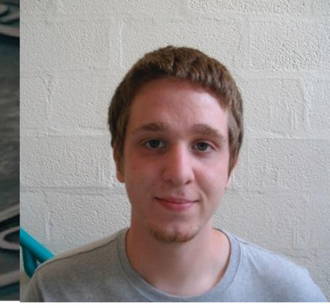
SRCCS 2010



Summer Research for Community College Students – 2010

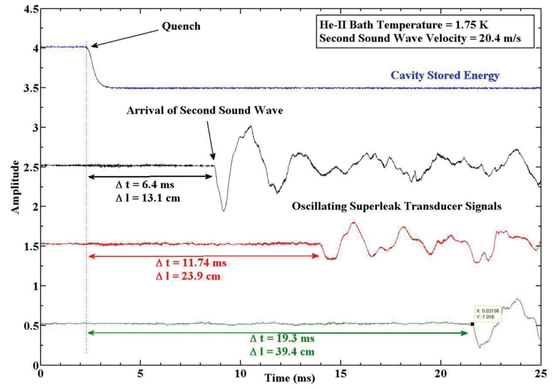
Optical Inspection of Niobium SRF Cavities

Introduction

Niobium SRF cavities have very important applications, particularly in particle accelerator machines, due to their high Q-factors and the good mechanical properties of niobium. The International Linear Collider will require some 18,000 nine cell niobium cavities. Such a project demands the ability to consistently produce high quality cavities which meet project specifications. Currently this ability does not exist. Cavities often fall short of their theoretical field limits due to Q-slopes and are limited by quenches. Much research is being done to understand the causes of these phenomena and develop methods of eliminating them. Groups like CLASSE at Cornell University are developing fabrication techniques and procedures to produce consistent high-quality cavities which can live up to their theoretical potential in the near future.

Optical Inspection of Cavities

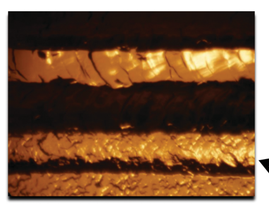
Quenches are the transition of a cavity to the normal conducting state due to a region of heating and are believed to be to caused by small defects in the surface of the cavity.



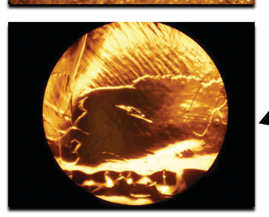
Using a system of oscillating superleak transducers (OSTs) developed here at Cornell, one can determine the distance between each individual OST and the location the quench began. One can then triangulate the area of the quench origin.

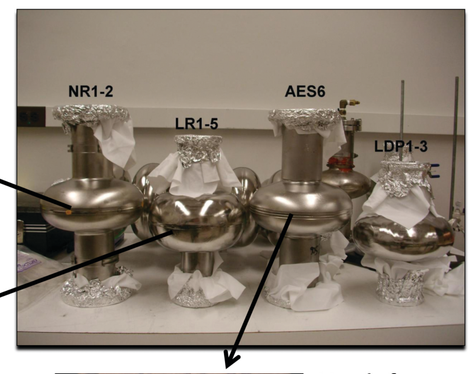
Once a quench location has been identified optical inspection of the region is performed to look for any visible defects in the surface.

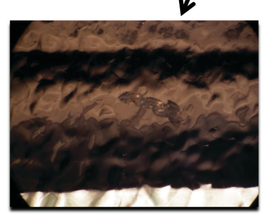
No apparent defects in the quench region for this cavity



Large grained cavity, the quench regions displays many jagged features







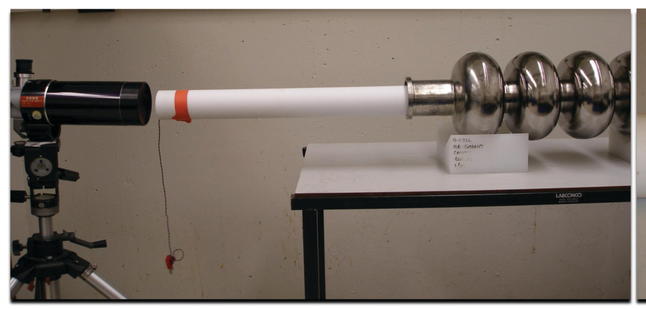
No defects were found in the quench region of this cavity but defects in other regions were discovered

These images can provide clues into the physics behind quenches and Q-slope and help researches improve their fabrication techniques. Locating defects early allows them to be repaired before expensive and time-consuming tests are performed. In the future we hope to identify areas where a quench may occur without having to test the cavities.

New Inspection System

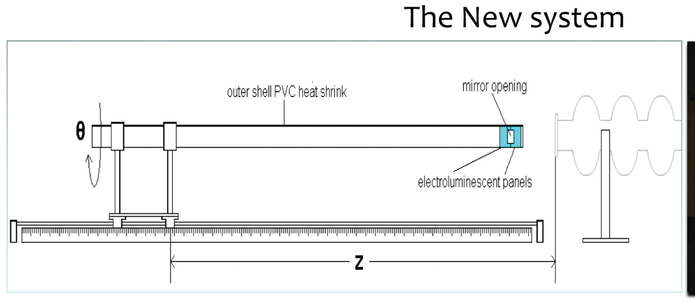
In order to inspect the inner surfaces of cavities a special system is required to peer into the cavity and provide a source of light. The previous system had several limitations and a new system for inspection has been developed.

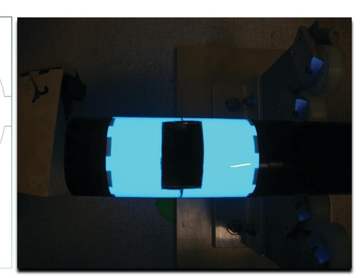
The old System



-Light source is point-like which produces glare and uneven lighting
-No system to measure where you are in a cavity and record locations of defects
-Tube is unsupported and must rest inside the cavity
-Must re-align microscope with mirror for every new cavity which is time consuming

The New system



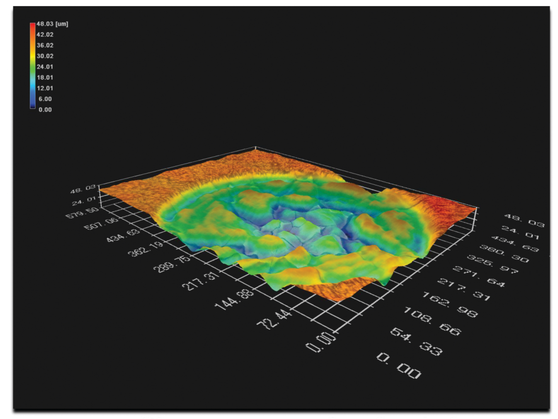


-Electroluminescent panels provide uniform lighting
-Z, θ coordinate system to measure the location of defects accurately
-Tube is supported and mounted to rails and does not touch cavity
-System is always aligned and set-up time is minimal

The new system will provide a faster way of inspecting cavities, produce better images and tell you exactly where a defect is located which can be useful for computer simulations or other means of analysis.

Epoxy Molds of defects

Inspection photographs can provide a lot of information but they do not convey depth very accurately. One approach to obtaining more information about surface defects is to take a mold of the region where the defect is located in order to perform profilometry measurements.



A profilometry graph of a defect

A silicone epoxy is poured into the desired cell and allowed to cure. When removed any defects on the surface of cavity will be imprinted on the silicon mold.

A test pour in a cut-open cavity. Many bubbles are visible, to remove gas the epoxy is out-gassed under vacuum.

Methods of injecting the epoxy and removing it successfully once cured are part of ongoing research.

Once removed, a hard resin cast is taken of the mold so profilometry can be performed and a digital map of the defect can be made.

LEPP, the Cornell University Laboratory for Elementary-Particle Physics, has joined with CHESS to become the Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE). LEPP's primary source of support is the National Science Foundation.
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