Quench studies for ILC cavities


ABSTRACT: Quench limits accelerating gradient in SRF cavities to a gradient lower than theoretically expected for superconducting niobium. Identification of the quenching site with thermometry and OST, optical inspection, and replica of the culprit is an ongoing effort at Jefferson Lab aimed at better understanding of this limiting phenomenon. In this poster we summarize experiments that have been and are being developed at JLab for quench studies and highlight some of our findings with several SRF cavities that were limited by quench.

Optical inspection

Part of the defect identification and characterization is optical inspection. Many defects that cause quench are visible geometrical features on the inner surface that can be resolved with optical inspection systems. These systems provide information on the location of the features and their dimensions.

Dual mode excitation

The idea is to excite two modes in the 9-cell cavity limited by the same quench. Depending on the nature of the quench we expect two scenarios:

1. If it is a thermal quench, then the limitation during excitation of two modes will be $H_{12}^2 = H_1^2 = H_2^2$, where $H_1$ and $H_2$ are fields in each mode.

2. If it is a magnetic quench, then the scaling will be $H_{12}^2 = H_1^2 - H_2^2$.

Twin cat-eye feature in TB9NR001 was found with the optical inspection system at the predicted quench location.

Quench understanding

2-cell ILC shape conventional thermometry as well as newly-built high resolution thermometry has been used to characterize quenches and quench preheating.

- Preheating before and after high field FE event in TB9NR002 has been recorded with the 2-cell thermometry.
- Heating distribution and field dependence at the artificial geometrical defect in C1-3 cavity was measured with high resolution thermometry.
- Larger pit of twin cat-eye feature in TB9NR001 was identified as the culprit causing quench at 17 MV/m in a mode and pre-heating field dependence for both pits was measured.

Quench mitigation

Often the number of features revealed by the visual inspection on the surface is too many for a local mechanical grinding. In such cases centrifugal barrel polishing can produced mirror-like surface over the whole surface area, as was recently demonstrated at Fermilab. We are working towards turning existing Irfab centrifugal barrel polishing machine into a convenient tool for resetting surface of problematic cavities.

- Preliminary studies have been done on samples to measure the residual contamination and roughness of the surface following Fermilab's recipe.
- 6 new 1-cell cavities are being made for CBP optimization as part of ICP development at JLab.

CONCLUSION: In this contribution we summarized experiments that have been and are being developed at JLab for quench studies. Quench identification with thermometry and second sound, quench characterization with optical inspection, thermometry, and replica are standard processes at JLab aimed at understanding quenches. Recently developed high resolution thermometry was specifically created for quench region heat evolution and high resolution quench spot characterization. Dual mode excitation and artificial pits measurements were designed to probe the nature of quench and experimentally evaluate contribution from topology to quench. Studies under way to develop quench mitigation techniques, such as electron beam remelting and centrifugal barrel polishing.

Original text