WBS 3.9.3.1
BCP Processing (FNAL MOU)   H. Padamsee

Technical Progress

Our BCP, HPR and cavity testing systems have been upgraded to accommodate 9-cell ILC cavities. The first 9-cell cavity from Fermilab (ACCEL #8) was treated with BCP twice and tested twice at 2 K. In the first cycle, 50 um material was removed, based on information from ACCEL that they had already removed 50 um during fabrication of cells. The low field Q was excellent (10^10) but the maximum field was limited at 17 MV/m by a quench. There was no field emission judging from the absence of x-rays.

In the second cycle another 60 um of material was removed. The test result was excellent. The low power Q was > 10^10, and the maximum field reached 26 MV/m, again without field emission or x-rays. There was no quench. The max field was limited by the high-field Q-drop. The Q vs E curve was exactly as expected for a cavity treated with BCP. The result is particularly remarkable since this cavity has not been heat treated at 800 C.

The test also proved that our facilities for HPR, clean room and test stand are good for field emission free performance up to 26 MV/m. The results were reported in Fermilab News and ILC Newsline.

The success has therefore cleared this cavity treatment by electropolishing.

We have installed a new feature to our BCP system to stir the acid slowly during BCP to get uniform material removal.

With the increased global emphasis on electropolishing, we decided to accelerate our vertical EP set up. We have already proven that this method works for single cells. Our single cell cavities reach 35 - 47 MV/m after vertical EP. ACCEL has kindly loaned us another 9-cell ILC cavity and has indicated interest in collaborating with us on developing the vertical EP method. The apparatus of extending vertical EP to 9-cells is now ready and the ACCEL loaner has been electropolished 60 um. Ultrasonic thickness measurements show that the material removal is uniform from cell to cell.

Goals and Plans for the remainder of FY06 and Beyond

We intend to EP the above mentioned cavity another 60 um to reach the necessary amount of material removal, and follow-up with a 10 um EP with fresh acid, pursuing the KEK method to get the best results with single cells. After EP, we plan to bake the cavity at 110 C for 48 hours and carry out the cold test. We anticipate the test in September.

The next steps will depend on the results. We may need to send the cavity to Jlab or Fermilab for the 800 C bake to remove H, as part of the standard preparation procedure. Subsequently we plan to carry out “tight-loop EP” to check for yield.

We have a second ACCEL cavity from Fermilab which could be added to the EP treatment if it is successful.

We aim to prepare and test the new cavities from AES which are projected to be available early next year. If our EP process works we have the option to carry out either BCP or EP with the new cavities.

Success in the vertical EP will increase the US capability for EP.

WBS 3.9.9 Research in Superconducting Radio Frequency

Technical Progress

We are exploring improved cavity designs that lower the surface magnetic field, thereby raising the maximum possible accelerating field in superconducting cavities.

Work continued on our first re-entrant shape cavity which has a surface magnetic field 10% lower than the baseline shape for the ILC cavity. We reported last year on our first cavity which reached a world record of 47MV/m. We fabricated a second cavity, and after post-purifying it in our furnace to raise the RRR (purity) we sent it to KEK for their surface treatments. KEK did barrel polishing to smooth the equator weld followed by electropolishing 80 microns and high pressure rinsing. We are pleased to report that in several tests, KEK exceeded 50 MV/m accelerating field. The Cornell re-entrant shape cavity now holds the world record for accelerating field at 52 MV/m. The results of this collaborative effort are reported in ILC Newsline.

We fabricated another two re-entrant cavities with a smaller (60 mm) aperture. This geometry has a further magnetic field reduction of 6% over the 70 mm aperture re-entrant cavity. One of the cavities was post-purified as with the 70 mm aperture re-entrant cavity. Both small aperture re-entrant cavities were sent to KEK for barrel polishing the equator welds. One KEK cavity has returned to us and KEK will test the other one.

AES company is fabricating a 9-cell re-entrant cavity. We supplied the RF design and AES finished the mechanical design of the parts. They are also developing all the tooling. AES is responsible for fabricating the complete cavity and tuning the cells to achieve a flat field profile. We reviewed their fabrication plan in January 06.

They have already completed the half-cells and sent them to Cornell. CMM measurements carried out at Cornell show successful forming. We have electropolished these half-cells in the open half-cell configuration so that we can pay careful attention to the quality of EP and surface finish, especially in the re-entrant region. After electropolishing the half-cells at Cornell we returned the cavities to AES for completion.

Extra parts have been made for a 3-cell cavity, which will be completed at Cornell.

Goals and Plans for the remainder of FY06 and Beyond

When the 9-cell is complete we plan to apply vertical EP. We plan to invite industry personnel to participate in our EP and final preparation for the 9-cell cavities as a first step in transferring SRF technology to industry.

We plan to complete a 3-cell re-entrant cavity at Cornell and carry out vertical EP and tests.

WBS 3.9.10 New Cavity Shapes and New Materials

Technical Progress

We fabricated and tested one large-grain single cell cavity at 1500 MHz. The treatment was standard BCP. The cold test was accompanied by our high sensitivity thermometry diagnostics.

The large grain cavity showed a high-field Q-slope with onset at 20 MV/m, comparable to results in previous fine grain cavities. After baking at 120 C for 48 hours, the Q-slope was gone and the maximum field reached was 27.5 MV/m, but was limited by a quench.

Our thermometry showed that in the Q-slope regime the hottest spots are NOT on the grain boundaries. This means that grain boundaries are not the main culprits for the large RF losses at high fields. But the heating in a large grain cavity is spread out over a smaller area than the Q-slope heating in a fine grain cavity.

The results have just been published in a paper at EPAC 06.

Goals and Plans for the remainder of FY06 and Beyond

We have received several large grain Nb sheets from China, and are preparing to fabricate several single cells re-entrant cavities and one 3-cell re-entrant cavity from this material. The dies are ready. We plan to compare the performance of large grain cavities prepared by BCP with EP preparation.