**Abstract**

The first 9-cell LSF shape cavity LSF9-1 was successfully constructed in-house with an improved process at JLab. The cavity was shipped to KEK for mechanical adjustment, treatment and surface processing. Cold testing was carried out at JLab VTA facility instrumented with a suite of Kyoto instruments. The favourable measured values of the bath pressure detuning sensitivity and Lorentz force detuning coefficient validate our in-cell stiffener design. Pass-band measurements indicate 4 out of 9 cells are capable of reaching a gradient > 45 MV/m, up to 51 MV/m in 2 cells. Cornell OST detectors identified the current quench source. Multipacting-like barriers observed in end cells are investigated both analytically and numerically. The cavity has now received a light EP of 40 micron surface removal at the joint ANL/FNAL facility and further cold testing at JLab is underway. Two new 9-cell LSF shape cavities are being constructed including one made of large-grain niobium material.

**Background and Introduction**

The idea of cavity shaping for higher ultimate acceleration gradients has been proposed for some time, KEK’s Low Loss/Ichiro and Cornell’s Re-entrant being examples, both seeking a lower S/t max at the expense of a higher E acc /E ecc. Experimental verification in single-cell cavities of those shapes was very successful including record Eacc of 59 MV/m. That success established a path for achieving higher Eacc well beyond 35 MV/m and it was well captured in the ILC Technical Design Report (TDR). Pushing multi-cell cavities of those shapes to higher E max was however prevented by FE - a bottle neck although not a fundamental limit.

The Low-Surface-Field (LSF) shape, conceived at SLAC, seeks not only a lower S/t max but also a lower E acc /E ecc; therefore it has the advantage of raising ultimate Eacc at reduced FE.

Test results of LSF shape single-cell and 5-cell prototype cavities have been previously reported. In this contribution, we present the fabrication, processing and preliminary testing results of the first 9-cell LSF shape cavity LSF9-1.

**Cavity Fabrication and Processing**

Half-cell shape accuracy measurement using a laser scanner (L). Shape deviation statistics and evolution [R].

LSF9-1 EP processing (L) and its end and group brush cleaning (R) at KEK STF.

**Cryogenic RF Testing and Results**

- During the initial power rise with the ni mode excited, off-mapping revealed transient local “cold hot spots” at strip X10 & X20 attached to in cells that are attributable to activation and processing of local field extrema (movie left).
- When the cavity was excited in the 4Pi mode, separate hot spots apparant at X1 & X2 attached to the end cell times right before the cavity uses the quench limit at a field of 17 MV/m in the end cells (image below).
- End cell y hot spots attributed to MP.
- Systematic analytical calculations reveal out load MP barrier.
- Unusual hot DI water seal of cavity ever eight required to cause an increase in MV.

**Summary**

In summary, the first 9-cell LSF shape cavity has been successfully fabricated and tested in a joint in-ternational effort. The highest gradient attained is 25 MV/m so far. 4 of 9 cells demonstrated capability of reaching a gradient of > 45 MV/m including 2 capable of 51 MV/m. Test results confirmed our stiffener scheme with an average df/dP of -133 Hz/Torr and Lorentz for detuning of ~2.7 Hz/(MV/m²), on par with the values measured in the standard TESLA 9-cell cavities tested in the similar configuration at JLab.

Presently, continued testing of LSF9-1 is on-going. Two new 9-cell LSF shape cavities including one made of large-grain niobium material are being fabricated.