Note on Vertical Test Results of Cavity TE1AES005

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Cavity TE1AES005 is a single-cell Tesla-shape cavity manufactured by AES Corporation. The cavity was originally processed (BCP) and tested at Cornell, where it reached a maximum gradient of 26.7MV/m with a Q_0 there of 1.2 x 10^9 and a low-field Q_0 of 1.0 x 10^{10}. The cavity was then sent to Fermilab, where it was electro-polished (EP), HPR'd, and assembled/evacuated exclusively at the ANL/FNAL facility using procedures recently developed over the course of several single-cell processing cycles. After the EP process, inspection of the cavity revealed a scratch on one of the beamline flange sealing surfaces. This flange surface underwent polishing in order to remove the scratch, and the cavity then underwent a subsequent HPR, assembly/evacuation, and successful leak check. It was then transported back to FNAL, to the VCTF at IB1, where it was mounted on the test stand, connected to the pumping system, and instrumented with the prototype single-cell diode thermometry system.

The cavity was cooled down from 4K to 2K, and some Q_0 vs T measurements were performed in the temperature region just above the λ-point transition. Once at 2.00K, CW measurements of Q_0 vs E were performed. The cavity reached a maximum gradient of 31.3MV/m with a Q_0 there of 9.5 x 10^8. There was no field emission observed, nor were there any multipacting barriers. There was one instance of "quench" perhaps due to MP or FE at a gradient of 23MV/m, but this was an isolated transient effect that did not reappear. After this quench, however, the cavity Q_0 was somewhat reduced. This can be seen in the "jog" in the Q_0 vs E curve shown in Figure 1, the first run to high gradient. Measurements were also taken from maximum gradient on down, and the Q_0 vs E curve from this data (see Figure 2) does not show this effect, indicating a small irreversible* change in cavity surface properties after this event. This is not uncommon when a field emitter has been energetically processed away – the "residue" from such processing can "condense" onto the cavity surface, increasing the effective R_s. For comparison, the results for the vertical test at Cornell after BCP are included in Figure 2. While the cavity maximum gradient and low field Q_0 have improved from 26.7 MV/m to 31.3MV/m and 1 x 10^{10} to 1.5 x 10^{10}, respectively, the cavity still exhibits substantial Q-drop behaviour, beginning around 25-26MV/m (and exhibited such behaviour during the Cornell test, but at a gradient of about 20MV/m). This cavity would appear to be a good candidate for a 120º C bake, which would likely reduce or eliminate the Q-drop, and potentially lead to improved cavity performance.

After performing the Q_0 vs E run at 2K, the cavity was further cooled down to 1.52K while Q_0 measurements were made. From these measurements, we find the cavity had a residual surface resistance of about 6.7 ± 0.3 nΩ (see Figure 3). This value of R_s is consistent with that measured recently on similarly processed single-cell cavities.

Diode thermometry was mounted to this cavity and scans were performed at various times during Q_0 vs E runs at 2K. The thermometry system however did not reveal any of the “hot-spots” that would be expected to accompany such a strong Q-drop (barring FE loading). It is now believed that there was a fault in the readout system or instrumentation cabling, which prevented the acquisition of thermometry data. This will be addressed before the next cavity test.

* In this context, irreversible implies during the present cold test. It is possible that the “condensates” that lead to the increased effective surface resistance would vaporize and be pumped away by the cavity vacuum system upon warmup if not too strongly adhered to the cavity surface. Additionally, it is highly likely they would be removed by a subsequent HPR.

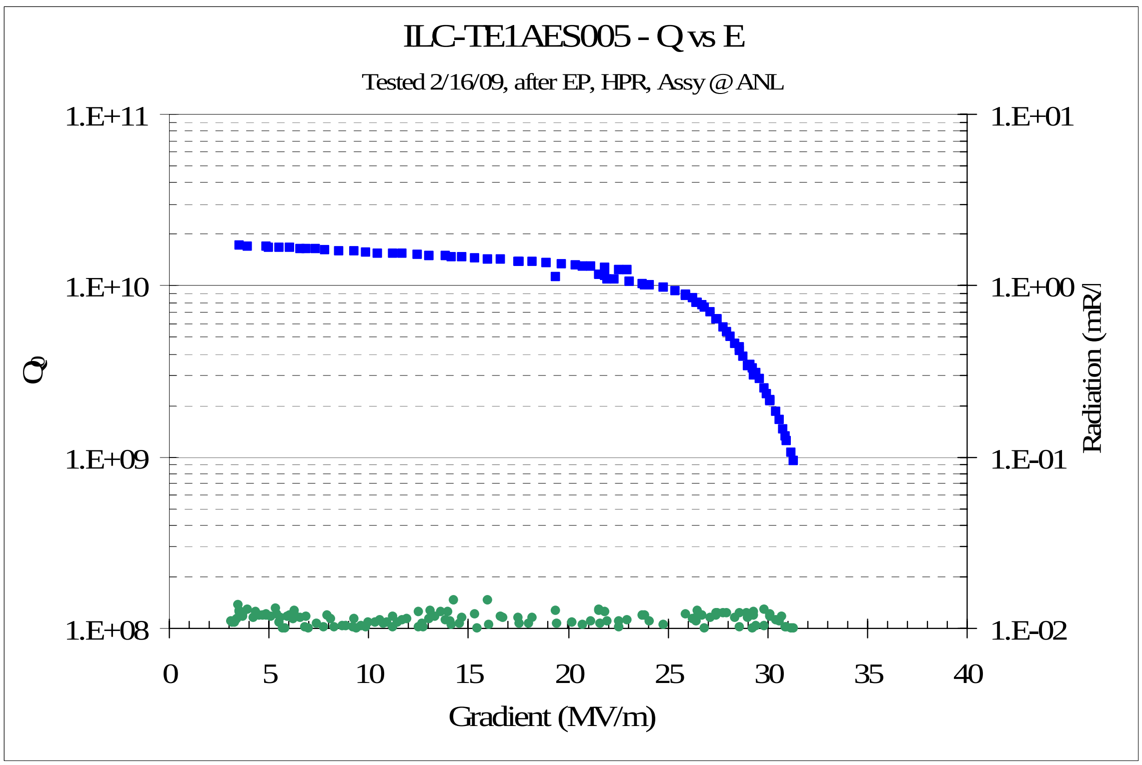

Figure 1.) Initial Q_0 vs E run at 2K

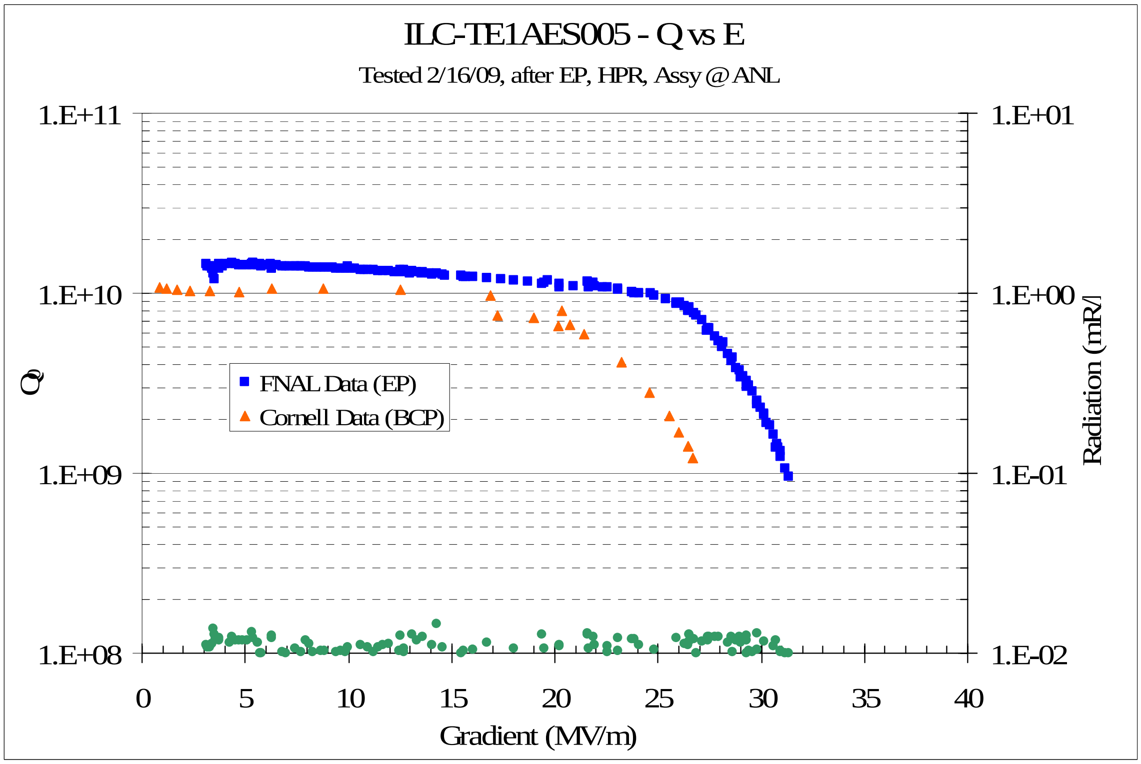

Figure 2.) Final Q_0 vs E run at 2K. Data from the previous test at Cornell is shown for comparison.

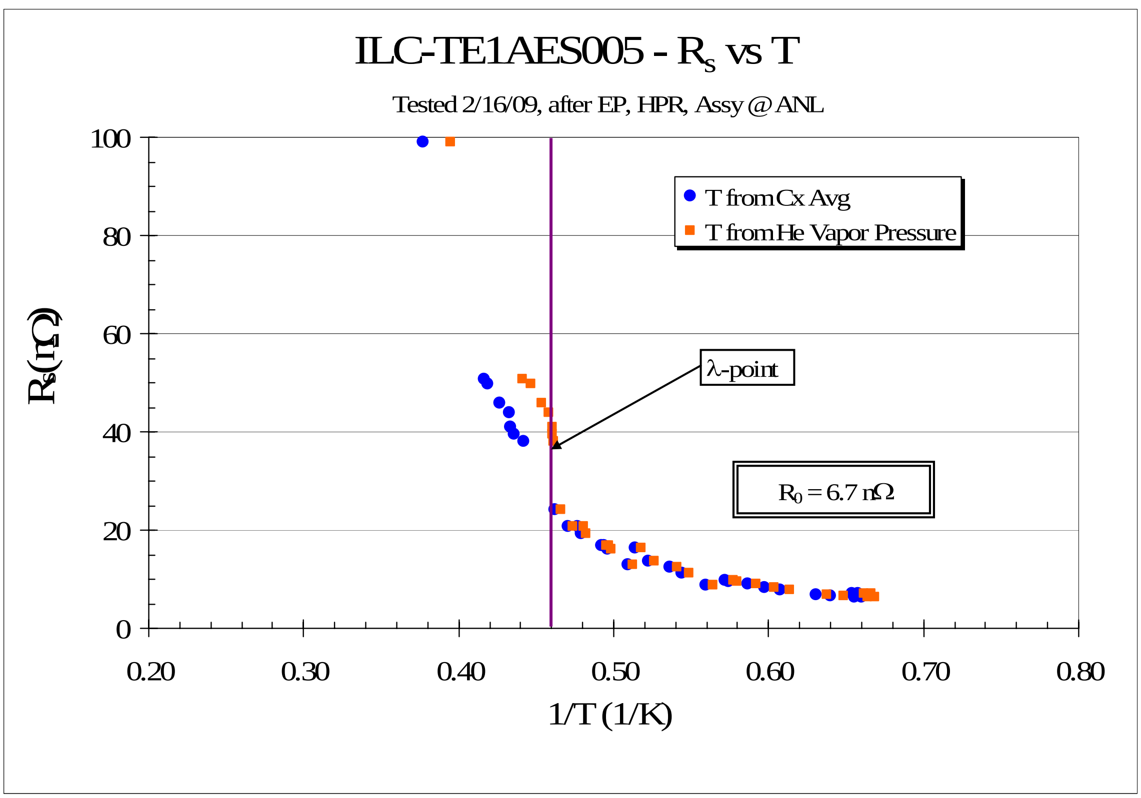

Figure 3.) R_s vs 1/T, yielding a residual resistance of 6.7± 0.3 nΩ