# High Field Q-Slope Onset in EP and BCP Cavities Before Bake

Joshua Wiener and Hasan Padamsee
Laboratory for Elementary Particle Physics
Cornell University, Ithaca, New York, 14853, USA

*Abstract*

Two common chemical treatments used in modern cavity preparation are electropolishing and buffered chemical polishing along with high pressure rinsing. Both treatments show high field Q-drops around $E_{acc}$ = 20 – 30 MV/m before mild baking. The BCP prepared surface generally has macro-roughness of several μm (steps at grain boundaries) due to different etch rates of different grains. The EP surface has macro-roughness less than 0.5 μm. Surprisingly, the high field Q-drop for BCP and EP cavities appears essentially similar, despite the large difference in surface macro-roughness. The purpose of this study is to determine if there is any systematic difference in the onset field of high field Q-slope between these two chemical treatments, given the large data set available. We also compare the maximum field reached for these two treatments. The results show that without bake the smooth EP surface does have a slightly higher onset field (10 – 15%) for the high field Q-drop and a slightly higher maximum gradient on average.

### *Data*

Cavity test data was taken from the DESY Tesla database [1]. To ensure that high-field Q-slope and no other phenomena is observed, the data set is restricted to 1-cell and 9-cell tests with little or no field emission and to cavities which have not been baked since the last chemical treatment. To exclude a few tests that may have been plagued by the H-Q disease, only tests with flat Q vs E curves until $E_{acc}$ = 15 MV/m were considered. Thirty-five 1-cell tests (11 BCP treated, 24 EP treated) and fifteen 9-cell tests (7 BCP treated and 8 EP treated) were found in the data base to fit these selection criteria. All tests were before bake.

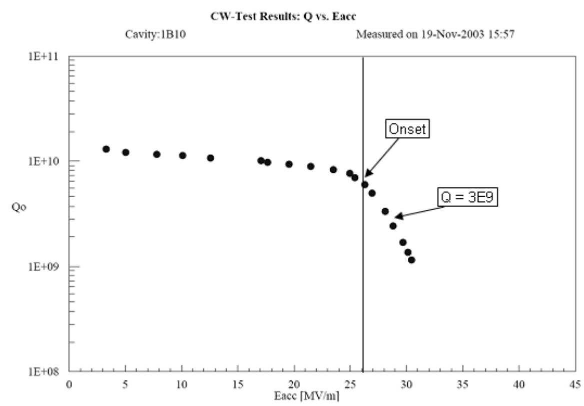
The onset field was defined as follows. A typical Q curve in the data set has a flat or nearly flat (medium field Q-slope) region and a high field Q-slope region. The point used to mark the onset of high field Q-slope is the point where the slope of the curve is midway between the slopes of these two regions. Usually this point could also be described as the point which best appeared to visually separate the two regions. See figures 1 and 2 for two examples.

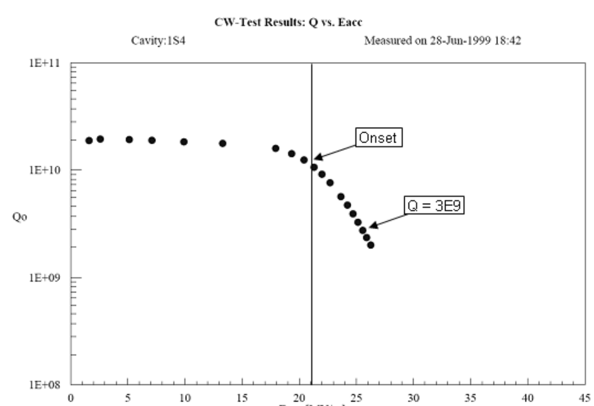
The field level at which Q = $3x10^9$ was also recorded for each 1-cell cavity test in the data set. None of the 9-cell cavity tests used fell below this value, and so the maximum field reached was used instead.

### *Results*

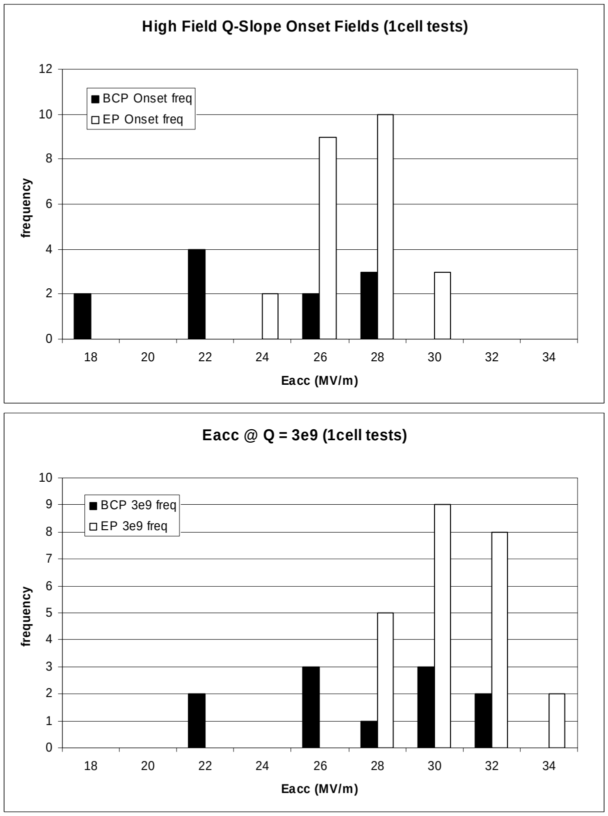
The 1-cell results for high field Q-slope onset and Q = $3x10^9$ fields are shown in figures 3 and 4. For EP treated cavities, the average onset field is 26.4 MV/m and the average field at Q = $3x10^9$ is 29.8 MV/m. For BCP treated cavities, the average onset field is 23 MV/m and the average field at Q = $3x10^9$ is 27 MV/m. Thus the Q-drop onset field for BCP cavities is nearly 14% lower than for EP cavities, and the field at Q = $3x10^9$ is 10% lower.

The 9-cell results are shown in figures 5 and 6. For EP treated cavities, the average onset field is 26.9 MV/m and the average maximum field is 29.8 MV/m. For BCP treated cavities, the average onset field is 24.4 MV/m and the average maximum field is 28.3 MV/m. Here the onset field for Q-drop is about 10% lower for BCP cavities and the average maximum about 5% lower.

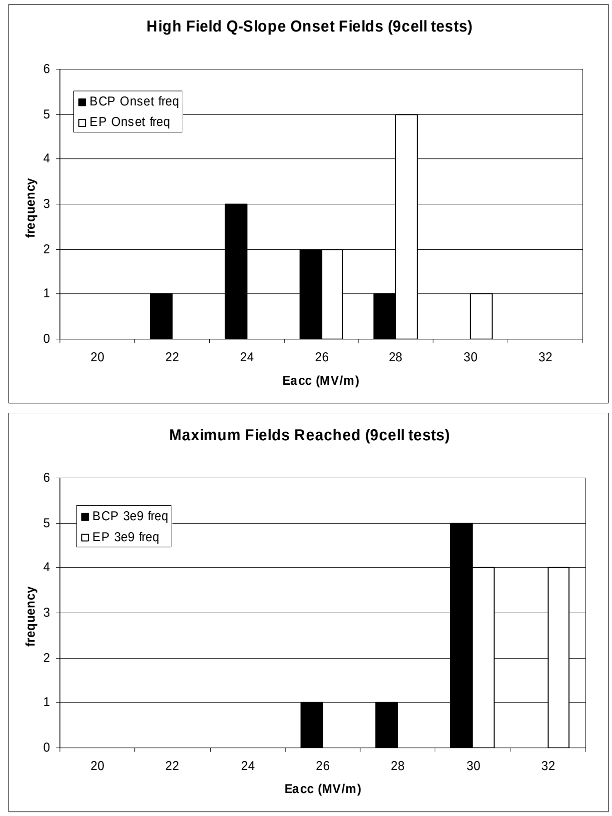



Figures 1 & 2: Sample graphs with chosen onset fields.




Figures 3 & 4: Onset field and Q=3x10$^9$ field histograms for the 1-cell cavity test data set.




Figures 5 & 6: Onset field and max field histograms for the 9-cell cavity test data set.

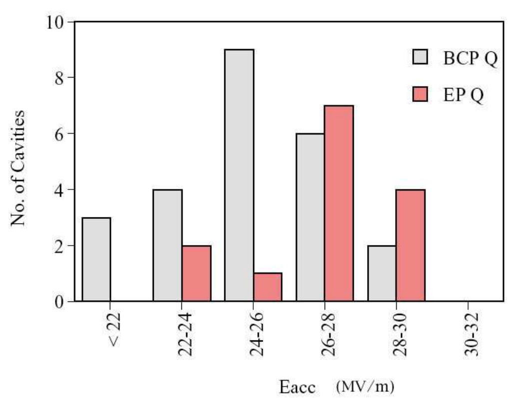



Figure 7: Distribution of maximum fields reached for many BCP and EP 1-cell cavities, both before bake. (Note: The information from Figures 2 and 7 from [2] were combined to compare BCP and EP cavities before bake.)

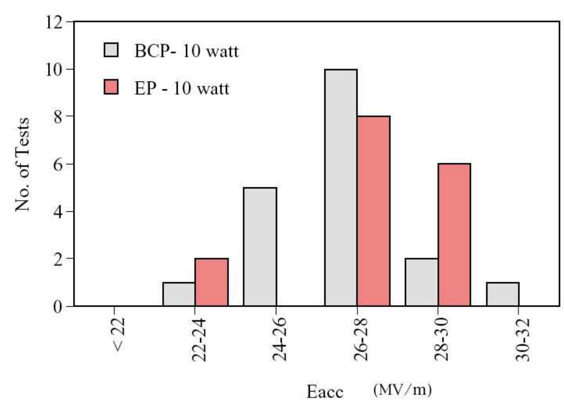



Figure 8 Distribution of field values at 10 watt dissipation for BCP and EP cavities.

## *Discussion*

The results show that the high field Q-drop begins at 10 – 14% higher field in EP cavities than in BCP cavities. This analysis strengthens the trends established by data analyzed by Hao et al [2]. We reproduce their data in the two histograms below, re-plotted to compare BCP and EP unbaked cavities.

It has been clearly established that roughness does not play the dominant role in the high field Q-drop because mild baking (120°C – 48 hours) has a large effect in healing the Q-drop, especially for EP cavities. Clearly such baking does not change the surface roughness. However, these results show that roughness may play a subsidiary role in the onset field and severity of the Q-slope, so that the smoother EP surface shows slightly superior behavior.

Table 1: List of Cavity Tests Used

| Cavity – 1cell | Test Date | Test No | Treatment |
|---|---|---|---|
| 1AC1 | 7/18/2001 | 1 | BCP |
| 1AC2 | 11/29/2001 | 1 | BCP |
| 1AC2 | 4/10/2002 | 2 | EP |
| 1AC2 | 7/2/2003 | 8 | EP |
| 1AC2 | 6/9/2004 | 14 | EP |
| 1AC3 | 6/21/2006 | 4 | BCP |
| 1AC4 | 11/22/2005 | 2 | EP |
| 1AC4 | 8/16/2006 | 7 | BCP |
| 1AC5 | 10/12/2006 | 2 | BCP |
| 1AC7 | 2/14/2007 | 4 | EP |
| 1B1 | 9/26/2001 | 2 | BCP |
| 1B1 | 4/11/2002 | 5 | EP |
| 1B3 | 3/27/2002 | 2 | EP |
| 1B3 | 8/22/2002 | 3 | BCP |
| 1B5 | 10/13/1999 | 1 | EP |
| 1B5 | 2/6/2002 | 9 | EP |
| 1B8 | 4/23/2003 | 7 | EP |
| 1B10 | 11/19/2003 | 1 | EP |
| 1B11 | 10/22/2003 | 1 | EP |
| 1DE1 | 5/10/2005 | 1 | EP |
| 1DE1 | 12/5/2006 | 4 | EP |
| 1DE3 | 8/24/2005 | 2 | EP |
| 1DE3 | 2/8/2006 | 4 | EP |
| 1DE10 | 3/8/2006 | 1 | EP |
| 1NC3 | 6/27/2001 | 1 | BCP |
| 1P4 | 7/11/2000 | 7 | BCP |
| 1P6 | 10/19/2001 | 1 | EP |
| 1P6 | 7/4/2002 | 5 | BCP |
| 1P6 | 4/9/2003 | 9 | EP |
| 1S1 | 6/14/2001 | 1 | EP |
| 1S1 | 6/10/2003 | 4 | EP |
| 1S2 | 6/5/2003 | 1 | EP |
| 1S3 | 10/27/2000 | 1 | EP |
| 1S3 | 5/12/2004 | 8 | EP |
| 1S4 | 6/28/1999 | 1 | BCP |

| Cavity - 9cell | Test Date | Test No | Treatment |
|---|---|---|---|
| AC70 | 10/21/2003 | 5 | EP |
| AC72 | 1/22/2002 | 1 | EP |
| AC76 | 4/5/2005 | 9 | EP |
| AC78 | 10/2/2001 | 1 | BCP |
| AC81 | 9/13/2005 | 7 | EP |
| AC112 | 12/12/2006 | 2 | BCP |
| C21 | 10/20/2005 | 16 | BCP |
| C44 | 12/9/1998 | 1 | BCP |
| S31 | 11/11/1998 | 3 | BCP |
| S34 | 9/1/1999 | 2 | BCP |
| S35 | 4/15/2003 | 6 | BCP |
| Z82 | 11/25/2005 | 6 | EP |
| Z87 | 6/9/2005 | 1 | EP |
| Z101 | 2/13/2007 | 3 | EP |
| Z107 | 2/26/2007 | 2 | EP |

## References


[1] TESLA Technology Collaboration Cavity Database, RF Tests *http://tesla-new.desy.de/cavity_database/rf_tests/index_eng.html*

[2] J. Hao et al., "Low Temperature Heat Treatment Effect on High-Field EP Cavities," SRF2003 Workshop, MoP16.