Summary of Evening Discussion of Cures for Emission (H. Padamsee)

The format of the discussion was to summarize the accumulated experience, and to comment on the positive and negative aspects of each technique.
(It would be best to collect statistics on all tests but the discussion format and large group setting did not permit this. So only max Epk was recorded. But the data exists and should be reviewed.)

The discussion gravitated around the following techniques: heat treatment at T >1200 C, high pressure water rinsing, high pulsed power processing.

Heat Treatment (HT)
Without chemistry of RF surface after HT, but rinsing with methanol or water.
DC experience on cm^2 samples : Geneva and Wuppertal
Always gives field emission free surface up to 200 MV/m
RF:
Cornell: 10 tests on 1-cell, 1.5 GHz, max Epk = 60 MV/m
5-cells 1.5 GHz, 3 tests, max Epk = 40 MV/m
Wuppertal: 5 tests on 9-cells, 3 GHz, max Epk = 40 MV/m

Disadvantages: cost, yield strength decrease, not in-situ

High Pressure Water Rinsing

CEBAF
Comments: it works great!
200 tests on 1.5 GHz cavities (30 x 5-cell and several 1-cell) : max Epk = 45 MV/m on multi-cell

DESY
4 x 9- cells, max Epk = 38 MV/m

KEK 40 x 1-cell, max Epk = 70 MV/m

Disadvantages: not an in-situ process for recovery.

High Power Pulsed RF Processing

Comments: field emission can be eliminated during test

Cornell: 6 tests on 9-cell at 3 GHz, max Epk = 40 MV/m
3 tests on three 5-cell at 1.3 GHz, Max Epk = 71 MV/m

DESY
10 tests on several 9-cell cavities at 1.3 GHz
Max Epk = 46 MV/m

Comments: In principle in-situ treatment for accelerators.
This has been tried successfully as an in-situ techniqe to recover field by using up to 60 kW at CERN, 5 KW at CEBAF and Saclay, and 1-2 kW in heavy ion accelerators.

Disadvantages:
-Need high power coupler and high power klystron, but these must be available for the accelerator operation in most cases.
-Possibly lowers Q

There was some discussion of He processing and drying methods, but there was no new outcome.

Summary of Discussions (Chairman - H. Padamsee)

Nature of Field Emission/Emitters

The thrust of the discussion was to classify available evidence from different laboratories in an attempt to synthesize the evidence and approach a better understanding.

The evidence was characterized as RF or DC experience.

1) There was general agreement that many field emission sites identified from RF and DC studies belong to the class : metallic microparticles.

2) Evidence from Saclay points to the conclusion that insulating particles, such as alumina, in DC fields do not emit, but that in RF fields they do emit. An explanation for the difference was that when such particles heat up in the RF field, they become conducting, and so fall in class of "metallic" particles.

3) There is now plenty of evidence both from RF and DC that irregularly shaped particles, such as particles with jagged microfeatures are field emitters. Also special experiments (Saclay) on smooth iron and nickel spherical particles do not emit. These studies are in support of a tip-on-tip model explanation for beta values of about 100.

4) There is new evidence from dissected cavities at Cornell where an active (not-processed) emission site showed no foreign particle; but rather a flat region resembling a thin residue or coating.

5) Does the interface play a role in field emission?

Several items of documented behavior point to YES
- emitters turn on in electric field (many labs)
- emitters turn on after 400 C heating (Geneva, Wuppertal)
- emitters turn off after T > 1200 C heating (Geneva, Wuppertal)

6) Does condensed gas play a role in field emission?

Several experiments suggest YES

- warm up and cooldown of a cavity activates new sites (DESY, Cornell).
- deliberate condensation of a gas activates a site, warm up and pump down de-activates the same site; re-admission of gas re-activates the same site (Cornell)

7) There was no time to explore other issues, such as whether anyone found inclusions in the bulk can be emitters.