RF CAVITY DIAGNOSTICS, DESIGN and ACOUSTIC EMISSION TESTS-Accelerator Phyisics

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I. OVERVIEW

(A) Acoustic Emission

Elastic waves are generated in a materials which experiences abrupt changes in stress or strain. This phenomenon is known as acoustic emission AE and can be detected by means of ultrasonic transducers coupled to the material. Due to the simplicity of detection method, monitoring of acoustic emissions should be considered for accelerator beamline elements when continuous fault detection is required. We propose to use AE for studying onset of breakdown in RF cavities.

Vibration and Electrical breakdowns in Rf cavities can be monitored in a passive approach, either by mounting (a) accelerometers (1-5KHz), and (b) piezoelectric transducers (200 kHz). Accelerometers mounted to circuit elements may make a useful tool in the detection of transient and steady-state mechanical noise in beamline, and well suited to the lower frequency range.

Piezoelectric transducers are best suited to detecting onset and breakdown characteristics at higher frequencies (150 - 500 kHz) and will permit ambient background noise to be filtered out. A set of piezoelectric transducers can be mounted to an RF cavity in such a way that their resonant frequency is in the range of the signal of interest . Through a signal conditioning stage, bandpass pre-amplifier can eliminate ambient noise. This signal is then fed through a threshold and integration unit which produces an analogue pulse proportional to the energy content of the sensor output voltage. A determination of the source location of each breakdown event may be feasible based on arrival time differences of the carefully placed tranducers and a standard “clustering” analysis .

We propose to study the noise characteristics of onset and cavity breakdown by both reproducing conditions in our labs and mounting transducers to operating cavities in Fermilab and SLAC.

(B) Surface Emission Physics , Leakage Current and Breakdown in RF Cavities

It is commonly recognized that cleanliness and surface finish of RF cavities plays a major role in abnormal leakage current and breakdown . Over the past 3 years we have been involved in the NC machining and testing of Cu RF cavitiies and are aware first hand of the problems in going to high accelerating gradients.

Enhanced Field Emission (EFE) from large area electrodes is thought to be caused by specific emittng sites with surface defects. These sites can show emissions at a few MV/m. Some observations are:

(1) Particulate contaminants are powerful field emitters.
(2) Scratches and other geometrical defects can act as emitters.

(3) A few emitters may dominate current and breakdown problems.
(4) Irregular shaped conducting particles emit more than smooth.
(5) Some emitters may “melt” in a burn-in procedure in which a new surfaces exposed to an intense electric field.

These observations lead on to believe that surface finish and cleanliness are very important in the fabrication process as well as choice of cavity material and/or coating.

We propose to set up a small facility to test large area electrodes in our lab and experiment with surface finishes and and coatings. We are particularly interested in looking at the high melting point and low resistivity metals, Rhodium, Molybdenum, Iridium, and Tungsten, their allows Pt-Ir 75-25, Pt-W 96-4, Pt-Ru 90-10, Cu-W 60-40 as well as Copper and Aluminium. For example Indium alloys are commonly used in production of high quality spark-plugs!

II. WORK, GOALS, DELIVERABLES

A) We will install piezoelectric trannsducers with conditioning electronics on on Fermilab Lab G RF cavity and other potential sites to investigate the technical requirements of their use as advanced warning devices and analyze clustering signal patterns. In house AE tests will be performed on RF cavity-type structures, inducing leakage current and breakdown. This testing bed will evolve in to more complex testing described in (B).

(B) We will set up a facility in house to test large area electrodes both fabricated in our shop and acquired under a variety of conditions. UV, AE, dark current will be monitored under various surface activation mechanisms- needle, ball, UV laser, etc, in gaseous atmospheres, vacuum. Certain metallic coated surfaces will be procured and tested for leakage current and breakdown. Surfaces will be microscopically inspected.

III. FUTURE

Projects (A) and (B) will continue into FY03-04 contingent with funding levels. In particular it will take some time to set up testing systems in vacuum. Dr. Ostrovsky is a expert in RF and surface physics and will work with our group during the year and as a summer employee.

IV. BUDGET

	FY02	**FY03**	**FY04**
(1 TRANSDUCERS	5K	5K	5K
(2) SIGNAL CONDITIONING	10K		
(3) MATERIALS/SUPPLIES	10K	10K	10K
(4) CURRENT METER	5K		
(5) RF GENERATOR		10K	
(6) DC HV SUPPLY	5K		
(7) UV LASER		10K	
(8) INSPECTION MICROSCOPE	10K		
(9) HVAC SYSTEM		20K	
(10) SALARY/LABOR	20K	20K	20K