Some Remarks on the Concept of Invisible Clearing Electrodes

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- Why do we need ion clearing
- What is wrong with conventional clearing electrodes
- The concept of "invisible" clearing electrode
- Technological aspects
- Practical experience gained so far
- Conclusion

Why do we need ion clearing

- The presence of ions has led to serious beam intensity limitations
- Examples are the EPA at CERN (for electrons) as well as the AA (CERN) for antiprotons
- But also other machines running with negatively charged particles used ion clearing
- The ions attracted by the beam potential form a kind of cloud, which, when interacting with the circulating beam can cause tune changes and beam break−up

What is wrong with conventional clearing electrodes?

- Conventional clearing electrodes are often similar to a button pick−up, i.e. they are made from a vacuum feed−through with with some metallic stem and a plate seen by the beam.
- Such metallic structures may show resonances, depending on their electrical termination, which in turn can lead to a high beam coupling impedance
- It is not always easy to provide a wideband 50 Ohm charge which can stand several KV DC and has virtually no leakage current (diagnostics of the ion current!)

The concept of “invisible” clearing electrodes

- Since the fields created by the charged particle beam can always be decomposed as a superposition of homogeneous and inhomogeneous plane waves, which see the free space impedance of 377 Ohm, we have have to reduce the interaction with these waves.
- For the clearing current, which is usually in the order of a few micro−Ampere or less, a highly resistive layer does the job.
- The solution is to replace the metallic structure by a alumina structure with highly resistive coating (>>377Ohm surface resistance).Typical values are above 10 KOhm

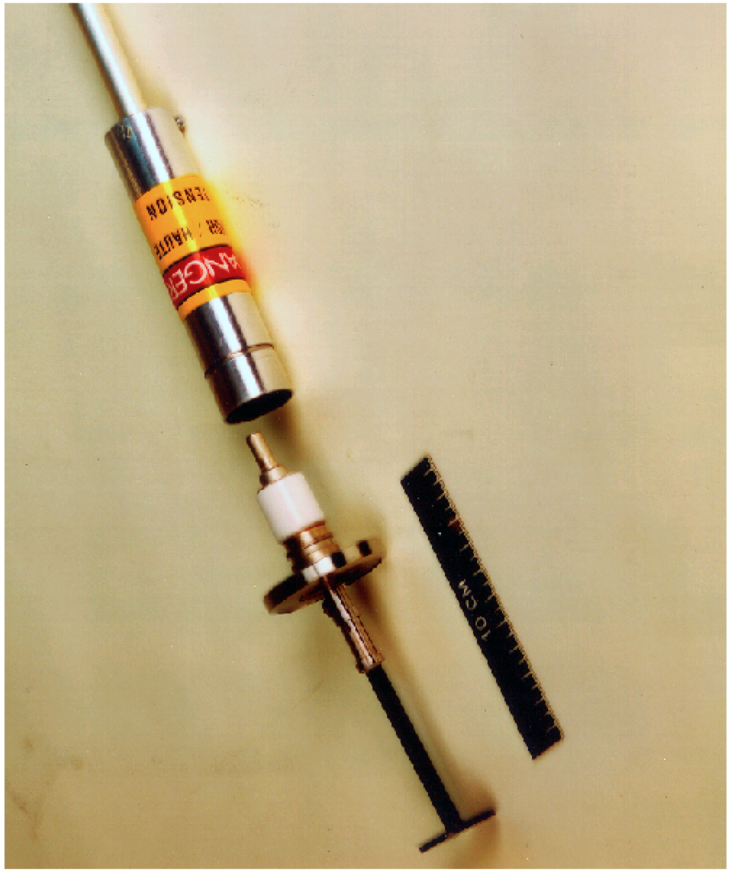
Technological aspects

- The electrodes have to be made from materials which are compatible with ultra high vacuum requirements and which can stand bake−out temperatures up to 300 C.
- Thus the (virtually) only practical choice is alumina for the body of the electrode. It may have cylindrical shape or similar to a plate.
- As for the coating , thick film technology seems to suited best, since a large range of resistivities can be implemented and in contrast to thin film technology, there is no risk that the layer is “scrubbed” away from ion bombardment

Practical Experience Gained so Far

- The first “invisible “ clearing electrodes using the concept of a dielectric body with some UHV compatible resistive coating were used in EPA around 1986.
- The measured reduction in beam coupling impedance wrt conventional electrodes (no 50 Ohm termination on the HV cable) was more than 200 at certain frequencies
- The highly resistive coating forms an in situ RC low−pass and allows any RF termination of the high voltage cable which is often tri−axial for measuring pico−Amps of clearing current.

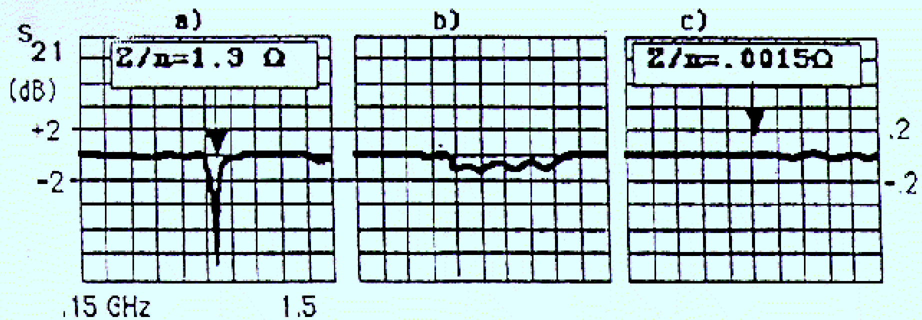
Example of a resistively coated button electrode



Experience with UHV−compatible microwave absorbingmaterials at CERN / Caspers, F ;
CERN−PS−93−10−AR.
Workshop on Microwave−absorbing Materials for Accelerators (MAMAs), Newport News, VA, USA,
22 − 24 Feb 1993

Collective effects in the LEP Electron Positron Accumulator (EPA) / Bartalucci, S ; et al.
CERN−PS−87−39−LPI. –
In: 1987 Particle Accelerator Conference ,
Washington, DC, USA, 16 − 19 Mar 1987 − pp.1234−1236

Impedance of invisible button type clearing electrodes



LONGITUDINAL IMPEDANCE: $Z = 2 Z_o (10^{(S_{21}/20)} - 1)$; $Z_o = 125\ \Omega$

S_{21} : TRANSMISSION COEFFICIENT

Clearing electrode longitudinal impedance bench measurement. a) metallic, b) metallic with rf filter, c) ceramic with resistive coating and rf filter.

Conclusion

- The concept of making low beam coupling impedance clearing electrodes by using resistively coated dielectric bodies has proven its efficiency and reliability, both wrt impedance reduction and vacuum aspects.
- However the residual impedance is not zero; we have still to consider the impedance by the dielectric body of electrode itself as well as the impedance e.g. from the mounting hole (discontinuity) in the beam−pipe.
- The thick−film resistive coating technology may also be applied elsewhere to avoid highly isolating surfaces seen by the beam

How to make emission protection paint

Emissionsschutzfarbe

1. Vorbereitung

1.1 Alle Teile nach Reinigung in abgedecktem Gefäß staubfrei lagern. Fussel und andere lose Partikel unmittelbar vor der Beschichtung mit Stickstoff wie unter 1.2 abblasen.

1.2 Vor Beschichtung und nochmals vor Einbau Oberflächen mit gefiltertem (0,8 my). nachgereinigtem Stickstoff abblasen.

2. Herstellung der Emissionsschutzfarbe

2.1 (227 +- 1) g Chrom (III)-Oxid mit einer Teilchengröße unter 0,3 mm (Artikelnummer 2484 der Fa. Merck/Darmstadt) als Pulver in einem 500-ml-Becherglas einwägen und in, nach Abschnitt 1.gereinigte, Kugelmühle mit einem Durchmesser von 100 mm vorlegen.

2.2 113 ml deionisiertes Wasser mit 67 ml und nach Pkt. 1.1 filtriertes Wasserglas K-Sil PS-6 der Fa. Weyland-Sylvania/Hersfeld, beide abgemessen im Zylinder aus Polyethylen, in eben dieser Reihenfolge zum Farbpulver geben; dazu ca. 50 Porzellankugeln mit 15 mm Durchmesser.

2.3 Kugelmühle mit Flachdichtung und Deckel mittles Schraubbügel verschließen. auf die Drehwalzen legen, Antrieb einschalten.

2.4 Farbe mind. 24 Stunden durchmengen lassen. Nach längerer Standzeit (Datum vermerken) vor Gebrauch.

2.5 Kugelmühle mit Bügel über Deckel stets verschlossen halten. Bei beginnender Gelierung der Farbe den Rest verwerfen.
Entnommene, jedoch nicht aufgebrauchte Tagesmenge an Farbe ebenfalls verwerfen.

3. Beschichtung

3.1 Farbe in der Kugelmühle schwenken, den Pinsel (Rotmarder, Grösse 6) in sie eintauchen und ihn leicht abschleudern (Entfernung überschüssiger Farbe). Pinsel leicht neigen, so daß seine Borsten abwärts zeigen (gleichmäßiges Verfließen der Farbe). Pinsel auf das Endstück des Teils setzen und ihn langsam zum Ende hin bewegen, so daß die gesamte Oberfläche zwischen den metallischen Enden bestrichen wird. Dort Pinsel langsam abheben (Vermeidung von Nasen).

3.2 Objekt dem Werkzeug entnehmen und Cr 203-Schicht an Luft trocknen lassen.

3.3 Überzug visuell begutachten und Teile mit Beschädigungen, Rissen, Blasen oder Fremdpartikel aussortieren. Ablösen des Farbüberzuges nach Abschnitt 5.

4. Ausheizen

4.1 Isolatoren mit Ausheizwerkzeug in den 1 Std. vorher mit N2 gespülten Ofen stellen.

4.2 Diesen auf 320 °C hochheizen und die Temperatur 2 Stunden lang halten.

4.3 Teile im Ofen abkühlen lassen. (< 100 °C)

These instructions are from an unknown source in industry and used for UHV tubes like X−ray devices