CONDUCTIVE COATING FOR CERAMIC BEAM TUBES
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Introduction

The ceramic beam tubes used in the fast kicker magnets at NAL require a conductive coating in the inside wall to bleed off the surface charge and shunt the electric field around the magnet gap, yet have negligible effect on the magnetic field. The coating must have a low outgassing rate so as not to affect the vacuum system adversely.

Tube size and shape varied to fit different magnets. Tubes range from 40 to 45 in long. Two round tubes, 1-7/8 in and 2-3/4 in in diameter, and a rectangular tube 2-1/2 in by 4-1/2 in are used.

A system that could be carried out in our own laboratory, without a high set-up cost, using equipment on hand or easily built by laboratory personnel was desired. Several metal and conductive glazes were tested. The coating ultimately chosen was indium oxide in the form In2O3. This was found to have the proper resistance range at the operating temperature of 20° to 50°C, as well as good vacuum characteristics for operation at 10⁻⁶ Torr.

Application

The coating, in the form of indium metal, is vacuum deposited from a tungsten filament stretched through the length of the tube. It is then oxidized in an air furnace. Figure 1 shows the set-up used to coat the tubes at NAL.

Tube Preparation

The tubes used were 99.5 Al2O3, Mandrel cast; ends metalized and flanges brazed on. The tubes were thus finished with high temperature processing before the coating process was begun.

To receive the indium layer, it is important to remove all surface contaminants and to prepare the tube inner surface. Two methods were used to smooth out and produce a uniform surface on the inside wall. In short samples up to 10 in, sandblasting with 80 grit alumina worked well. In the case of the long tubes, dry-ball milling with 114 glass balls and 80 grit alumina, using the tube itself as the mill set-up worked very well. Two hours at 30 r/min produced a good surface.

After surface preparation, the surface is cleaned with a chromic acid solution, washed well with tap water, followed by distilled water, with a final rinse of ethyl alcohol.

Filament Preparation

Several types of filaments were used: Nichrome, solid .040 and stranded 2-.020 and tungsten, .060 solid, loose lay twisted of 3-.020 wires, and 3-.020 standard right twisted.

Our first filaments were stranded Nichrome. These worked well for short tubes during the early tests. Care must be used to prevent the melting of the Nichrome. Tungsten, loose lay, of 3-.020 wires, proved to be the best choice.

In the event the resistance values are incorrect or the deposit faulty, the substrate may be cleaned in chromic acid, CrO3, which has an excess of sulfuric acid H2SO4 present or hydrochloric acid, HCl. Soaking for 24 or 36 hours is sometimes required to completely remove the In2O3.

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Fig. 1 Vacuum Coater Setup

Fig. 2 Coating Resistance For Indium Used

Fig. 3 Oxidizing Furnace

Fig. 4 Resistance Change In Vacuum