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DEVELOPMENT OF AN ION IMPLANTED THIN ALUMINA BEAM PROFILE MONITOR

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Abstract

It is very important to get a real image of the beam from the injector linac. Therefore, it is desirable to monitor the beam position and beam profile as well as the beam current in the linac. Alumina screen (Desmarquest AF995R, chromium-activated alumina ceramics), is often used as a beam profile monitor for diagnosis of a linac beam. Typical thickness of alumina phosphor screen is about 1mm. Especially for the low energy beam part of the linac, scattered electrons in such a thick screen produce enlarged beam profiles. A thin film phosphor screen with chromium ion implanted alumina has been designed and manufactured to produce a high-precision beam profile monitor.

1. Introduction

The demand of a low-emittance electron linac has increased in these years, for applications such as the free-electron laser, coherent synchrotron radiation, and others. It is very important to transport and accelerate the beam emitted from the cathode with negligible emittance growth.

There is some attempt to build up an emittance measurement system for a low emittance beam[1]. A plastic scintillator which is 10 μm thin and has a fast scintillation characteristic has been adopted to measure the beamlets' image with a high temporal and spatial resolution. Silver (30 Angstrom thin) was deposited on the scintillator surface by vacuum evaporation to avoid charge-up. This experimental set up is for off-line use. An inorganic scintillator with thin thickness is necessary for the injector linac.

We try to make an oxide layer on aluminum surface. With ion implantation technique, we could get a polycrystalline ruby in oxide layer on aluminum surface. As the first trial, we have made preliminary experiments to show the possibility to make nearly 10 μm thin oxide layer on aluminum and to make polycrystalline ruby layer on alumina with chromium ion implantation technique.

2. Experimental

The aluminum anodizing technique has been established and is widely applied to metal surface technology to coat or color the surface of aluminum[2,3]. We applied this technique to produce thin film scintillator.

Aluminum plates of purity 5N were electrically polished in a 3N NaOH bath at room temperature with a dc density of 500 mA/cm^2. Reactions are as follows,

Anode

$$2Al + 3H_2O \rightarrow Al_2O_3 + 6H^+ + 6e^-$$

Cathode

$$6H^+ + 6e^- \rightarrow 3H_2$$

The average direct anodic current was fixed at 20 mA/cm^2. Thickness of alumina layer as a function of oxidation time is shown in Figure 1.

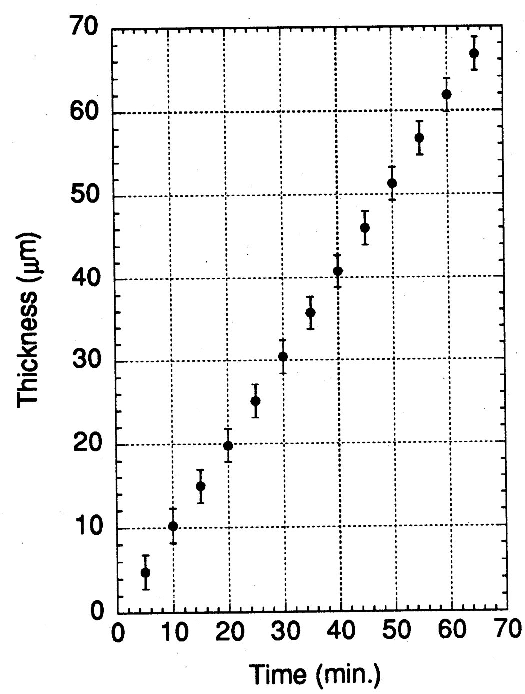

Fig. 1. Thickness of alumina layer as a function of oxidation time.

Compared with other method (for example, vacuum evaporation technique or sputtering technique), one could easily get a nearly 10 μm thin oxide layer with reasonable time by the aluminum anodizing technique.

Alumina plate of thickness 0.125 mm purchased from ASAHIKASEI Co. was prepared as a starting material. Purity of alumina was 99.9wt.% Al_2O_3. Specimen size was 20 mm.x 20 mm. Specimens were implanted at room temperature with 200 keV or 800 keV chromium to fluences in the range 1×10^{12} /cm^2 - 1×10^{16} /cm^2. Chromium ion implantation profiles have been generated for alumina using the simulation code TRIM. Figure 2 shows the implantation profiles for 10 keV to 1 MeV chromium ion in alumina.

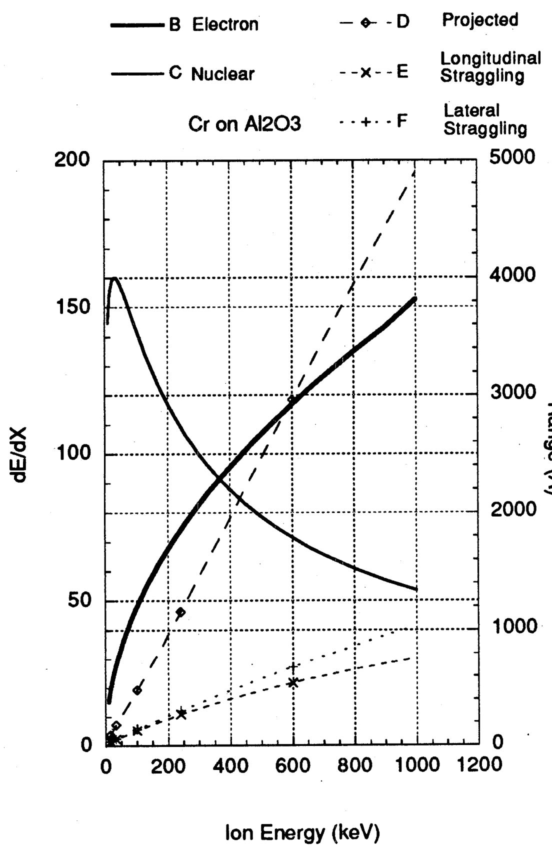

Fig. 2. Implantation profile of Cr in Al_2O_3.

Takasaki Ion Beam Implanter and Tandem Accelerator were used for this implantation experiment.

After implantation, specimens were mounted on the specimen holder of the beam profile monitor test bench in KEK. These specimens were irradiated with 150 keV electron beam from the linac. The intensity of the linac beam was measured using the current monitor. The peak current of the beam was 200 mA. The beam was 5 μs pulse width and 1Hz repetition rate. Emission from the specimen was taken by CCD camera.

3. Results

Optical measurements were done with specimens as implanted. Compared with Desmarquest AF995R, no light emission from implanted alumina was observed yet. Naramoto et al.4) pointed that in the temperature range of 1200 °C to 1300 °C , substitutional damage recovery has taken place in both the Al and O sublattices, and at these temperatures, one begins to see significant Cr incorporation into substitutional lattice sites. Recovery process is necessary to get emission from this specimen.

References

1) Y. Yamazaki, T. Kurihara, H. Kobayashi, I. Sato and A. Asami, Nucl. Instrum. & Methods in Phys. Res. A322 (1992) 139
2) M.Miyagi et al., Applied Optics Vol.26, No.6, (1987) 970
3) D.G.W.Goad and M. Moskovits, J. Appl. Phys. 49 (5) (1978) 2929
4) Naramoto et al., J.Appl.Phys. 54 (1983) 683