Research Notes

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Contributions should in general not exceed 800 words in length.

Surface Treatment of the Al Cold Cathode for He-Ne Laser

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A lifetime of more than 10,000 hours has been obtained for He-Ne laser tube, by using the type 2024 Al alloy as the cold cathode and the oxygen bombardment method for the cathode surface processing. Details of the surface treatment of the cold cathode and the characterestics of the performance in the laser tube are given.

A great deal of attentions has been paid to the problem of obtaining the long lifetimes of He-Ne laser tubes in which cold cathodes are utilized. It has been found that the material and the surface treatment of the cathode are of overriding importance. Fortunately, it has been shown by Hochuli and Haldemann[1-2] that the alluminum cold cathode (type 2024 alloy) has lower supttering rate as long as the oxide film is present. To preserve the oxide layer, the current density must be less than 0.1 mA/cm^2[3] so that the cathode will not result in sputtering and rapid clean-up. In the present work, some kinds of alluminum alloy pipes with about 16 to 25 mm in diam. and 20 cm in length are used to test the lifetimes of the cold cathode in the laser tube. After polishing, washing and removing the lapping remainders with sodium hydroxide solution of 20% and nitric acid solution of 20%, the surface of the alluminum cathode is treated by two different methods, described as follows.

(1) Anodic oxidation method

The oxide layer is deposited on the outside wall of the alluminum tube in a sulfuric acid solution of 15 to 20% at a temperature of 10 °C by electrolytic process at a current density between 1.5 and 2.0 A/cm^2 for 10 min. The inside wall of the tube is also processed in the same solution, but only with a current density of 0.8 to 1.0 A/cm^2 for 1 min. Then the sulfuric acid solution level is slowly decreased and completely flowed out during 4 min. To seal-off small

(1) U. Hochuli and P. Haldemann. Rev. Sci. Instr. 36, 1493 (1965).
(2) U. Hochuli, P. Haldemann and D. Hardwick, IEEE J. Quantum Electronics EQ-3, 612 (1967).
(3) F. T. Arecchi and E. 0. Schulz-Dubois, ***Laser Handbook, vol. 1,*** (North-Holland, 1972), p. 597.

holes on the wall, the tube is carefully washed and immersed in boiling distilled water for 30 min.

(2) Oxygen bombardment method

The alluminum tube is sealed in a laser tube (Fig. 1) and is connected to a vaccum system. After filling with oxygen at a pressure of 2 Torr in the laser tube, the discharge is started in the tube by adjusting a current density between 5 and 10 mA/cm^2 for 4 to 5 min. Then the oxygen is pumped out from the tube by a fore-pump. Refilling with oxygen to 2 Torr, the discharge is started again. The cycle is repeated 10 times.

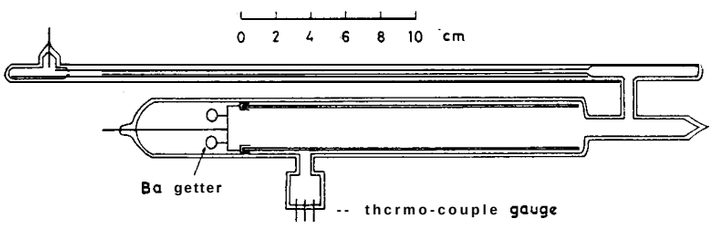

Fig. 1. Construction of the He-Ne laser tube (without Brewster windows).

Avoiding the outgassing, the capillary in the laser tube is also processed by ion bombardment in He-Ne (10:1) gas mixture under a pressure of 2 Torr with a current of 100 mA for 30 min. In order to reduce the occluded gas, the whole laser tube is then baked in an oven at 400 °C for 24 hours. Then the tube is sealed-off from the vaccum system.

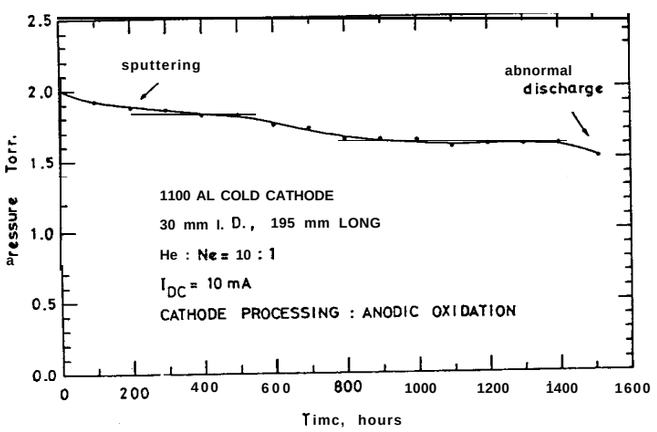

Fig. 2. Pressure versus time.

Fig. 1 shows the construction of the He-Ne laser tube (without Brewster windows) for testing the lifetime of the discharge tube. When the type 1100 AI alloy is used as the cathode material and the anodic oxidation method is adopted for cathode processing, we can see from Fig. 2 that the sputtering occures easily and the total pressure decreases rapidly. However, if the oxygen

bombardment method is used instead for the same cathode, the discharge tube is still working without sputtering after 6,000 hours (Fig. 3). Fig. 4 shows that the discharge tube with 2024 Al cold cathode can operate satisfactorily for 10,000 hours. We believe that it is possible to develop a He-Ne laser tube with a life of longer than 10,000 hours, if the type 2024 Al alloy is chosen as the cathode material and the oxygen bombardment method is used to treat the surface of the cathode.

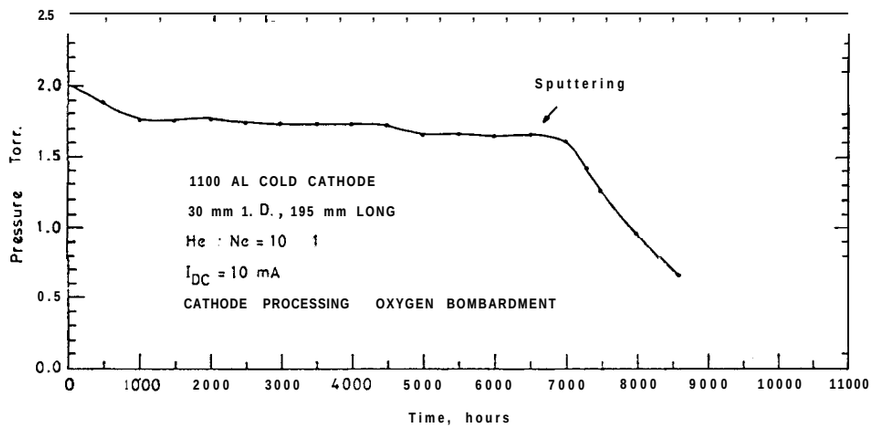

Fig. 3. Pressure versus time.

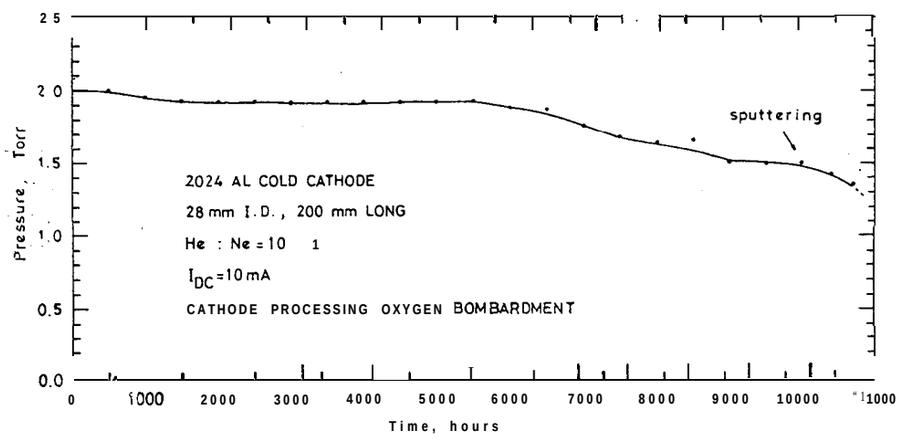

Fig. 4. Pressure versus time,

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