

IMPREGNATED CATHODE

The present invention relates to an impregnated cathode and an electron tube, especially a display tube and a pick up tube, incorporating the impregnated cathode. The invention particularly relates to a cathode
5 having a low work function mono-layer on a surface as required for a particular low temperature operation.

An impregnated cathode previously used for low temperature operation as described in Japanese Laid-Open Patent Application No. 154131/1983 has a
10 porous base body consisting of W and Sc_2O_3 impregnated with electron emissive materials; it also has a mono-layer consisting of Ba, Sc, and O on the cathode surface which forms a low work function surface. However, this mono-layer is defective in the following respects:
15 it is unstable against thermal shock or ion bombardment; it has a short life because of its non-uniform distribution; and its electron emissive property deteriorates in a low electric field.

The object of the present invention is to
20 provide an impregnated cathode which has a mono-layer of low work function which is maintained stably for a longer period and which has a uniform work function on the cathode surface.

According to the present invention there is provided an impregnated cathode having a cathode pellet formed by a refractory porous base body impregnated with electron emissive material and on
 5 said base body at least two layered thin films comprising an under layer consisting of a high melting point metal thin film and an over layer consisting of a high melting point metal layer containing Sc_2O_3 and located over said under layer.

10 An explanation of the invention and embodiments thereof are given by way of example with reference to the accompanying drawings, in which:-

Fig. 1 shows a schematically illustrated cross section of the impregnated cathode embodying
 15 this invention, and

Fig. 2 is a graph comparing the electron emissive properties of a cathode of the present invention and a conventional low temperature operation impregnated cathode.

20 The present invention proposes a cathode having a new structure forming a mono-layer which is stable against thermal shock or ion bombardment and is uniform, using for example a conventional standard type impregnated cathode (which is made by impregnating
 25 a refractory porous base body with electron emissive materials) as a Ba supply source, and providing a high

melting point metal thin film on the cathode surface so as to make the surface smooth, and providing a high melting point metal thin film containing Sc_2O_3 over this surface as an Sc and O supply source.

- 5 The mono-layer consisting of Ba, Sc and O on the conventional cathode surface is formed by combining Sc_2O_3 , which has no reaction with the electron emissive materials at the time of impregnation, with Ba diffusing out of pores in a porous base body, thereby
- 10 ceasing to exist once the supply of Sc_2O_3 is exhausted. In addition, non-reactive Sc_2O_3 remains in a very small quantity, thus being difficult to control.

 In the present invention, a high melting point metal thin film containing Sc_2O_3 , such a thin

15 film of at least one metal selected from W, Mo, Ta, Ir, Os, Re, Ru, Rh, Pd and Pt, is employed as a supply source of Sc_2O_3 . This film desirably has a thickness in the range of 10 nm to 1 μm .

 The surface of the conventional impregnated

20 cathode forming the under layer has pores of 5 μm diameter on average. If the metal thin film mentioned above is directly formed on this surface, some problems will arise. For example, the supply of Ba tends to concentrate on the pores directly under the thin film and the thin

25 film is not likely to be evenly formed. The present invention provides a thin film under layer beneath

this metal thin film so as to prevent such problems. Any suitable high melting point metal thin film may be used for this under layer, but it is desirable to adopt at least one metal which is selected from high melting point noble metals such as Os, Re, Pt, Ru, etc. and has low reactivity with the electron emissive materials. The thickness of this film is also preferably in the range 10 nm to 1 μ m.

It is preferred to provide micro-pores or cracks under artificial control in this thin film under layer, forming a structure which allows Ba to diffuse easily into the thin film over layer. It is recommended that the micropores have a diameter of 10 nm to 2 μ m and that the crack width is preferably in the range from 10 nm to 2 μ m, more preferably 10 nm to 1 μ m.

As the Ba source, such materials as are capable of supplying Ba, as in a pressed cathode, can also be used in addition to the above-mentioned conventional impregnated cathode.

Fig. 1 is a cross section which schematically illustrates an impregnated cathode of this invention. A pellet 1 of 1.4 mm diameter is formed of the cathode base body materials and has a porous tungsten base body 2 prepared by impregnating pores 3 having porosity of from 20 to 25% with the electron emissive materials. The electron emissive materials are a mixture of BaCO_3 ,

CaCO₃ and Al₂O₃ at a mole ratio of 4:1:1. It is alternatively possible to use materials mixed at a different mole ratio or to which different substances are added. It is also possible to use the porous base body of Mo, Ta, Re, Ru, Rh, Pd, Os, Ir or Pt, instead of W, or an alloy of such substances.

First, a Ta cup 4 is plugged with the pellet 1 and then the Ta cup 4 is laser-welded in the upper end of a Ta sleeve 5. Instead of laser welding, soldering is also recommended. The cathode pellet 1 is heated by a heater 7 which has core wire 6 coated with alumina and is arranged in the lower part of the Ta sleeve 5. This so far is a standard impregnated cathode, serving as a Ba source. The amount of Ba supplied depends on the temperature at which cathode pellet 1 is heated, but it can be adjusted by altering the mole ratios in the composition of the above electron emissive materials or by incorporating activators such as Zr, Hf, Ti, Cr, Mn, Si and Al in said base body material.

An Os layer of about 500 nm in thickness is attached, using electron beam bombardment heating, as a high melting point metal thin film 8 on the surface of the pellet 1. As the material of this film, noble metals like Ru, Rh, Pd, Ir, Pt, Re may typically be used instead of Os, or a high melting point metal

such as Mo, W and Ta or an alloy of two or more of these elements. A thickness of 10 nm to 1 μ m is appropriate for this film. The Sc_2O_3 source is provided by attaching a thin film 9 consisting of W and Sc_2O_3 and 10 nm to 1 μ m thick, using vacuum sputtering. Instead of W, it is also appropriate to use Mo, Re, Ru, Rh, Pd, Os, Ir, Pt and Ta or an alloy of these substances. 10 weight% is chosen for the content of Sc_2O_3 in W in this case, and it is recommended to select this content in the range from 1 to 50 weight%.

Using this cathode of the invention, saturation current density is measured by applying a high voltage pulse 5 μ s wide and at a repetition rate of 100 Hz to an anode with a cathode/anode diode configuration. The result of this is shown in Fig. 2. Line 10 in Fig. 2 denotes the emission characteristics of the cathode which contains 10 weight% of Sc_2O_3 and which has W thin film 9 about 100 nm thick and Os thin film 8 about 500 nm thick. The conventional cathode having no thin films 8 and 9 mentioned above has a characteristic initially identical to line 10 but the characteristic degrades as illustrated by line 11 after removal of mono-layer consisting of Ba, Sc and O due to sputtering in an Ar atmosphere of 5×10^{-5} Torr. In contrast the cathode in this invention suffers almost no electron emission deterioration subsequent to the mono-layer

removal, and is restored to characteristic 10 when heated at 1150°C for a period of 15 min in the event that cathode does show some deterioration. The cathode of the invention, in addition, has remarkably improved electron emission characteristics under low electric field as compared with the cathode having no smoothing treatment film.

It is clear from what has been described that in the present invention, if the mono-layer consisting of Ba, Sc and O which are all essential to maintain a low work function condition is destroyed, there can be observed no deterioration in the electron emission characteristic because a mono-layer is newly supplied. If there should be deterioration in this characteristic, the cathode forms a complete mono-layer if heated at about 1150°C for roughly 15 to 30 min, thus maintaining its characteristics of a long service life and a low temperature operation.

Further since smoothing treatment by the high melting point metal thin film reduces deterioration in the electron emission under a low electric field, application to various electron tubes such as normal display tubes has created low temperature operational effects.

CLAIMS

1. An impregnated cathode having a cathode pellet formed by a refractory porous base body impregnated with electron emissive material and on said base body at least two layered thin films comprising an under layer consisting of a high melting point metal thin film and an over layer consisting of a high melting point metal layer containing Sc_2O_3 and located over said under layer.
2. An impregnated cathode according to claim 1, wherein the metal of said high melting point metal thin film is at least one metal selected from W, Mo, Ta, Re, Ru, Rh, Pd, Os, Ir and Pt.
3. An impregnated cathode according to claim 1 or claim 2, wherein the thickness of said under layer is in the range 10 nm to 1 μm , and the thickness of said over layer is in the range 10 nm to 1 μm .
4. An impregnated cathode according to any one of claims 1 to 3, wherein said under layer has small pores or cracks and the diameter of said small pores or the width of the cracks is in the range 10 nm to 2 μm .



5. An impregnated cathode according to any one of the preceding claims wherein the under layer is a smooth film.

5 6. An impregnated cathode substantially as herein described with reference to and as shown in Fig. 1 of the accompanying drawings.

7. An electron tube which has an impregnated cathode according to any one of the preceding claims.

