SECONDARY ELECTRON EMISSIVE ELECTRODE AND ITS METHOD OF MAKING

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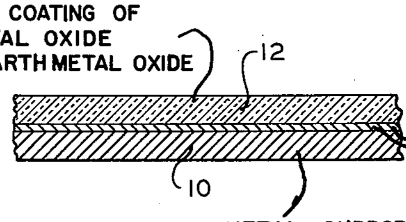

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SECONDARY ELECTRON EMISSIVE ELECTRODE AND ITS METHOD OF MAKING

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This invention relates to electron discharge devices employing secondary electron emission and to electrodes for use therein.

Various proposals have heretofore been made for the construction of amplifying valves in which a primary beam of electrons is caused to impinge on a secondary electron-emitting electrode which emits a larger number of secondary electrons than incident primary electrons. Such devices are particularly suitable for amplification at high frequencies and over a wide range of frequencies, the primary electrons emitted from a thermionic cathode being controlled in intensity by the application of the signals to be amplified to a control electrode, the amplified signals being set up across a load impedance connected to an electrode which collects the emitted secondary electrons.

It is desirable in such devices for operation at high frequencies that the inter-electrode capacities be small and for this reason it is desirable to use electrodes having only a small superficial area and in this case, therefore, it is necessary that the primary electron beam be concentrated or focussed with the result that a high density beam of primary electrons impinges on a very small secondary electron-emitting area. The secondary emissive electrode may comprise a conducting base such as a nickel support having a thin coating of magnesium oxide thereon and it is found that whilst such an electrode emits secondary electrons, even through a high density beam of primary electrons be employed, the life of such an electrode is limited to about 50 hours. It has been thought for some years that the short life of secondary electron-emitting electrodes in general is attributable to the poisoning of the electrode by particles emitted from the thermionic cathode or from residual gases in the device and it is generally the practice to arrange for the secondary electron-emitting electrode to be disposed out of sight of the thermionic cathode in order to avoid as far as possible particles emitted by the cathode from poisoning the secondary electron-emitting electrode. However, we have found that the short life of secondary electron-emitting electrodes is not mainly attributable to the poisoning of the secondary electron-emitting surface as mentioned above, but arises from the de-composition of the material forming the secondary electron-emitting surface followed by the evaporation of one or more of the constituents forming the surface. It is thought for example that when employing magnesium oxide as the secondary electron-emitting material the

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magnesium oxide is decomposed under electron bombardment to magnesium and oxygen and that both these elements may evaporate if the temperature is high enough during electron bombardment whilst if beryllium oxide is employed as the secondary electron-emitting material whilst it is decomposed to beryllium and oxygen under electron bombardment it is probable that only oxygen is evaporated.

The object of the present invention is to provide improvements in the secondary electron-emitting electrodes with a view to increasing the life thereof, particularly when subjected to high density bombardment.

According to the present invention there is provided a secondary electron-emitting electrode having a coating of secondary electron-emitting material thereon which is at least 10^{-4} inches in thickness.

The single figure of the drawing illustrates the electrode of the present invention. In this figure, 10 is a metal support coated with a protective metal film 14 of magnesium upon which is deposited the secondary emissive coating 12 consisting of a mixture of a metal oxide and an alkaline earth metal oxide.

It has been found after various experiments that, by use of an electrode according to the invention, it is possible to provide a discharge device which has a satisfactory life say of several hundred hours, and is also reliable in its behaviour, a result which was not anticipated for it had been thought that a thick coating of material such as usually employed for obtaining secondary electron emission would be almost completely insulating with the result that the discharge device would be erratic in its behaviour. The idea that a thick coating of sufficient density to have a satisfactory life would be insulating was supported by earlier experiments in which magnesium oxide was deposited on the electrode from a magnesium flame, and efforts were made to improve the conductivity of the coating by incorporating therein a substance which had the object of rendering the material electrically conducting. However it was found that the improved conductivity obtained was due not so much to the added substance, but, as it is now believed, to the physical processes to which the material had been subjected and when the material is carefully processed good conductivity can be obtained, probably on account of the state of aggregation of the particles of the coating.

Therefore according to another feature of the invention there is provided a method of producing a secondary electron-emitting electrode wherein secondary electron-emitting material is sintered and deposited on the base of said electrode to form a coating thereon. The material is preferably deposited in a finely divided condition such as that which renders it capable of being deposited cataphoretically. This method results in a coating of good conductivity and high density, the latter property contributing to the longer life of the electrode not only because of the greater quantity of material which it represents but it is believed because there is a greater possibility of the recombination of atoms liberated by disintegration.

According to still another feature of the invention there is provided a method of producing a secondary electron-emitting electrode in an electron discharge device, wherein said electrode having thereon a coating of secondary electron-emitting material is heated in vacuo in said device so as to activate said coating.

In the aforesaid experiments although it was found that an additional substance did not seem to be the critical factor in rendering a thick coating conductive, results were obtained which indicated that a secondary electron-emitting material comprising a mixture of selected substances gives a greatly improved secondary emission coefficient, and it is a preferred feature of an electrode according to the invention that the said coating comprises a refractory oxide such as magnesium oxide, aluminium oxide, or beryllium oxide, and an alkaline earth oxide. It will be understood that more than one such refractory oxide may be used, and also more than one alkaline earth oxide. According to a feature of the invention the said refractory oxide material comprises aluminium oxide or beryllium oxide and an alkaline earth oxide.

It was found by testing a range of compositions for the said coating containing various proportions of alkaline earth oxides that there is a range of compositions namely when the alkaline earth oxide comprises between about 20% to 60% by weight of the material, for which the secondary emission co-efficient is high, in the range 3–6, while at the same time the thermionic emission of the coating is sufficiently low even under the conditions of intense primary bombardment and radiation of heat from the collecting electrode obtaining in a discharge device, to enable the secondary emission electrode to be utilised successfully.

It is not known if the material of these coatings consists merely of mixtures of the oxides after the material has been sintered, or if compounds are formed by the sintering.

A preferred coating, according to the invention comprises magnesium oxide and barium oxide, the latter oxide constituting between about 20% to 60% and preferably about 33% of the total weight of the two said oxides.

The secondary electron-emitting electrode may comprise for example a base of nickel, platinum or gold plated molybdenum. With some metals suitable for use as the base of secondary electron-emitting electrodes it is found that prior to the deposition of the secondary electron-emitting material thereon the base oxidises to such an extent as to form a thin layer which is detrimental to the proper functioning of the electrode. Nickel is found to oxidise in this manner and according to another feature of the invention the base metal is cleaned so as to remove any oxide coating and to prevent the formation of an oxide

layer after cleaning, the base metal is provided with a thin coating of a metal which prevents the formation of a harmful film. Such a metal may be magnesium.

In preparing a secondary electron-emitting electrode according to one embodiment of the invention, a strip or tube of nickel to form the base of said electrode is first cleaned in vacuum at red heat and whilst in vacuum the surface of the electrode has evaporated thereon a thin coating of magnesium, such as a coating of less than 10^{-6} inches thick. For the secondary electron-emitting material it is preferred to use magnesium oxide and barium oxide and to prepare the material about 40% of barium carbonate is mixed with 60% of magnesium oxide, and the mixture is sintered at about 1200° C. in air. The resulting mixture is then transferred to a solution of acetone and nitro-cellulose, the acetone being free from water, and the mixture is then ball milled and electrically activated by shaking. It is then deposited by cataphoresis on the magnesium coated nickel base, the deposition in this embodiment being continued until the coating of the material is between 10^{-4} and 5×10^{-4} inches in thickness, though in some cases a thicker coating may be desirable. The electrode is then assembled in an amplifying valve such as that described in the second paragraph of the specification and the valve is evacuated and the electrode degassed and activated by heating. It has been found that this heating is an important factor in improving the secondary emission coefficient of the electrode, and the electrode is preferably heated to a temperature between about 700° C. and 900° C., usually 800° C., for some minutes. To effect the heating, bombardment by primary electrons may be relied upon, but alternatively or additionally an auxiliary heater may be used inside the secondary electron emitting electrode.

As has been stated, by the use of an electrode according to the invention it is possible to provide a discharge device which has a satisfactory life, of several hundred hours, and, moreover, it may not be necessary to arrange for the secondary electron-emitting electrode to be disposed out of sight of particles emitted from the thermionic cathode, thus facilitating the construction of the device.

We claim:

1. A secondary electron emitting electrode having a coating of a refractory oxide including one or more of the group magnesium oxide, aluminium oxide, and beryllium oxide, combined with an alkaline earth oxide.

2. A secondary electron emitting electrode comprising a coating of magnesium oxide and barium oxide, said barium oxide constituting between 20% to 60% of the total weight of the two said oxides.

3. A secondary electron emitting electrode comprising, a coating of magnesium oxide and barium oxide, said barium oxide constituting approximately 33% of the total weight of the two said oxides.

4. A secondary electron emitting electrode comprising, a conductive base support, a protective metal film over one surface of said conductive base support and a coating including a mixture of metallic oxides including an alkaline earth metal oxide, said alkaline earth metal oxide constituting between 20% to 60% of the total weight of said mixture.

5. A secondary electron emitting electrode

comprising, an oxidizable metal base support, a normally non-oxidizable protective metal film on a surface of said metal base support, a coating of secondary electron emitting materials on said protective film, said coating including a mixture of magnesium oxide and barium oxide, said barium oxide constituting between 20% and 60% of the total weight of said mixture.

6. A secondary electron emitting electrode comprising, an oxidizable metal base support, a protective film of magnesium metal over one surface of said metal base support, a coating cataphoretically deposited upon said magnesium film, said coating including a sintered mixture of any one of the group including magnesium oxide, aluminum oxide or beryllium oxide with an alkaline earth oxide.

7. A secondary electron emitting electrode comprising, an oxidizable metal base support, a normally non-oxidizable protective metal film on a surface of said metal base support, a coating of secondary electron emitting materials on said protective film, said coating including a mixture of a refractory oxide of the group including magnesium oxide, aluminum oxide, or beryllium oxide with an alkaline earth oxide.

8. A method of producing a secondary electron emitting electrode comprising the steps of, sintering a mixture of a refractory oxide with an alkaline earth metal oxide, and depositing said sintered mixture on a support to form a secondary emitting coating thereon.

9. A method of producing a secondary electron emitting electrode comprising the steps of, sintering a mixture of a refractory oxide of the group including magnesium oxide, aluminum oxide, or beryllium oxide with an alkaline earth metal oxide, and depositing said sintered oxide mixture on a conductive support to form a coating thereon.

10. A method of producing a secondary electron emitting electrode comprising the steps of, sintering a mixture of a refractory oxide of the group including magnesium oxide, aluminum oxide or beryllium oxide with an alkaline earth metal oxide comprising between 20% and 60% by weight of the mixture, and depositing said sintered oxide mixture upon a conductive support as a coating.

11. A method of producing a secondary electron emitting electrode comprising the steps of, sintering a mixture of a refractory oxide of the group including magnesium oxide, aluminum oxide or beryllium oxide with an alkaline earth metal carbonate comprising between 20% and 60% by weight of said mixture, and depositing said sintered oxide mixture upon a conductive support as a coating.

12. The method of producing a secondary electron emitting electrode comprising the steps of, sintering a mixture of refractory metal oxide and barium carbonate, said barium carbonate comprising approximately 40% by weight of said mixture, depositing by cataphoresis said sintered mixture upon a conductive support.

13. A method of producing a secondary electron emitting electrode including an oxidizable metal base, said method comprising the steps of, removing all oxide film from a surface of said metal base, coating the cleaned surface of said metal base with a thin protective conductive film, depositing a secondary electron emitting coating on said protective film.

14. A method of producing a secondary electron emitting electrode including a nickel metal base, said method comprising the steps of, removing any oxide film from a surface of said nickel metal base, protectively coating said cleaned surface of said nickel metal base with a thin metal film, depositing on said protective metal film a coating including a mixture of a refractory oxide and an alkaline earth oxide.

15. A method of producing a secondary electron emitting electrode including a nickel metal base, said method comprising the steps of, cleaning a surface of said nickel metal base to remove any oxide film therefrom, protectively coating the cleaned surface of said nickel metal base with a thin magnesium metal film, depositing on said magnesium film a coating comprising a sintered mixture of a refractory oxide of the group including magnesium oxide, aluminum oxide or beryllium oxide with barium oxide, and heating said electrode in a vacuum to a temperature between 700° C. and 900° C.

16. A method of producing a secondary electron emitting electrode including a nickel metal base, said method comprising the steps of, cleaning a surface of said nickel metal base to remove any oxide film therefrom, protectively coating the cleaned surface of said nickel metal base with a thin magnesium film, sintering in air at approximately 1200° C. a mixture of magnesium oxide and barium carbonate composing 40% by weight of said mixture, depositing by cataphoresis said sintered mixture on the surface of said magnesium film, and heating said electrode to approximately 800° C. in vacuum.

17. A method of producing a secondary electron emitting electrode including a coating of secondary electron emitting material formed from metallic oxides, said method comprising the steps of, sintering together a metallic oxide and an alkaline earth metal carbonate, and depositing said sintered material on said electrode to form a coating thereof.

18. A method of producing a secondary electron emitting electrode including a coating of secondary electron material formed from metallic oxides, said method comprising the steps, of sintering together a metallic oxide and an alkaline earth carbonate, and depositing by cataphoresis said sintered material on said electrode to form a coating thereof.

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