

CRT Dispenser Cathodes Using Molybdenum Rhenium Emitter Surfaces

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Introduction

Dispenser cathodes have been used for the past 40 years in applications such as traveling wave tubes, klystrons, magnetrons, and other high power vacuum devices. Their use in CRT's was restricted to very special applications and for the most part their use was virtually non existent primarily due to the fact that they were considerably more costly than the oxide cathode which worked well enough for almost all applications. However, with the onset of CRT applications which require higher cathode current densities, it has become obvious that the oxide cathode cannot continue to meet the demands much longer. Because of the changing demands of CRT's for high resolution and high brightness, attention has been focused on dispenser cathodes to serve as higher current density electron sources needed to meet these demands. Oxide cathodes are not able to be used in long pulse or d.c. conditions because they are basically semiconductors where electrons come from within the barium oxide matrix from donor sites created by oxygen vacancies in the matrix. Due to resistive heating effects and dielectric charging, the oxide cathode is limited to approximately 2 amps/cm² even with modifications (additions of scandium or indium oxides)(2) Their life at these current densities are limited to 10,000 to 20,000 hours. (3) Dispenser cathodes, on the other hand, represent emission from activated hot metal surfaces where barium and oxygen form a dipole which lowers the work function of tungsten from 4.5 to 2.1 electron volts (e.v.). Since it is an electrically conductive metal surface from which the electrons emit there is not any restriction as to current density or pulse conditions.

Dispenser Cathode Surfaces

It has been reported over the years, the effect of the metal or alloy used as the emitter surface. The original "B" type impregnated dispenser cathodes used tungsten.(4) It was discovered in the 1960's at the Philips Research Laboratories and reported by Zalm and van Stratum that the metal surface has a very definite effect on the emission level of dispenser cathodes.(5) When they deposited osmium ruthenium (OsRu) (80:20) on the tungsten emitter surface they found a considerable reduction in the effective work function, from 2.1 e.v. in the case of tungsten to 1.85 e.v. with osmium ruthenium. This type of cathode was designated as M-Type. They speculated that this work function reduction was due to the use of higher base metal (OsRu) work function which when the barium oxygen dipole was formed on it, the dipole-substrate system work function was lowered. However, this inverse relationship has not been clearly established by other published data. Regardless of the real physical reason for the enhanced emission characteristics it has been clearly shown that there is a reduction in work function where alloys of some of the platinum group metals, osmium, ruthenium and iridium as well as alloys containing rhenium are used as the dispenser cathode metal surface. Falce(6) observed that the above metals when combined with tungsten would produce a minimum work function at an optimum composition. In the case of tungsten and iridium it was between 20 and 40 percent iridium in tungsten as shown in Figure 1.

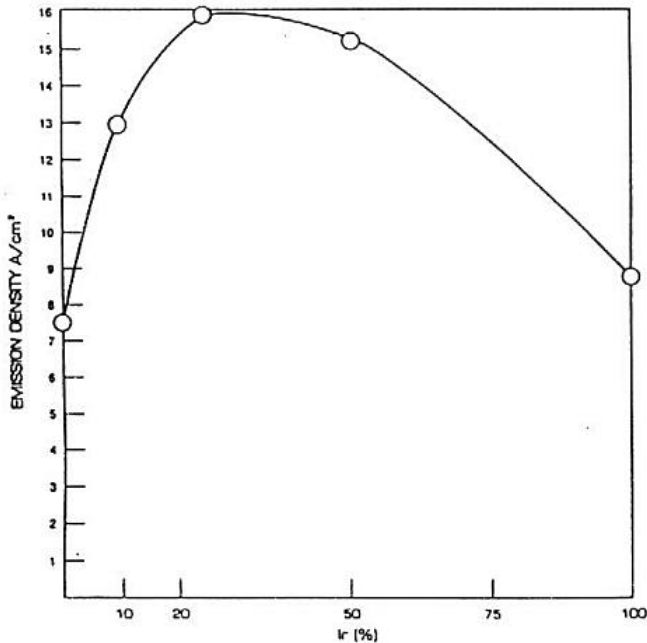


Figure 1. Space Charge Limited Emission Density vs. Percent Iridium at 1100° C.

He also observed that with time and temperature tungsten diffused through the osmium ruthenium film in an M-type cathode so that an optimum composition of tungsten-osmium-ruthenium forms on the surface to produce a work function lower than with osmium ruthenium alone.(7) Figure 2 shows this effect.

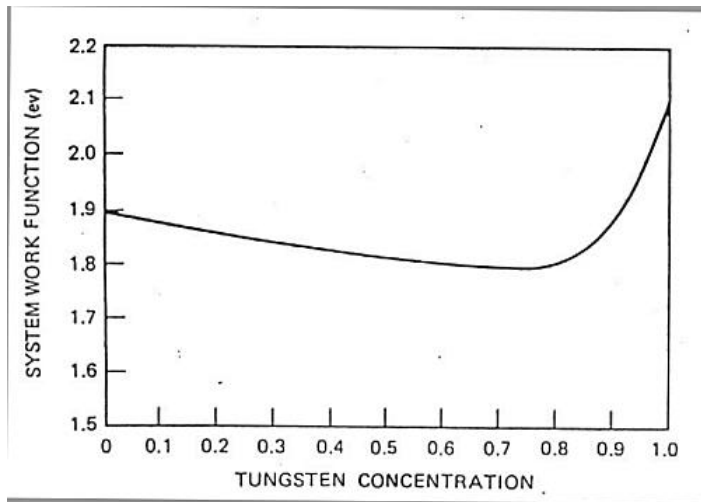


Fig. 2 System Work Function vs. Tungsten Concentration for M Cathode surfaces.

Thomas et al(8) have reported on the dependence of work function on composition for iridium and-tungsten and rhenium and tungsten on CPD and impregnated B-type cathodes

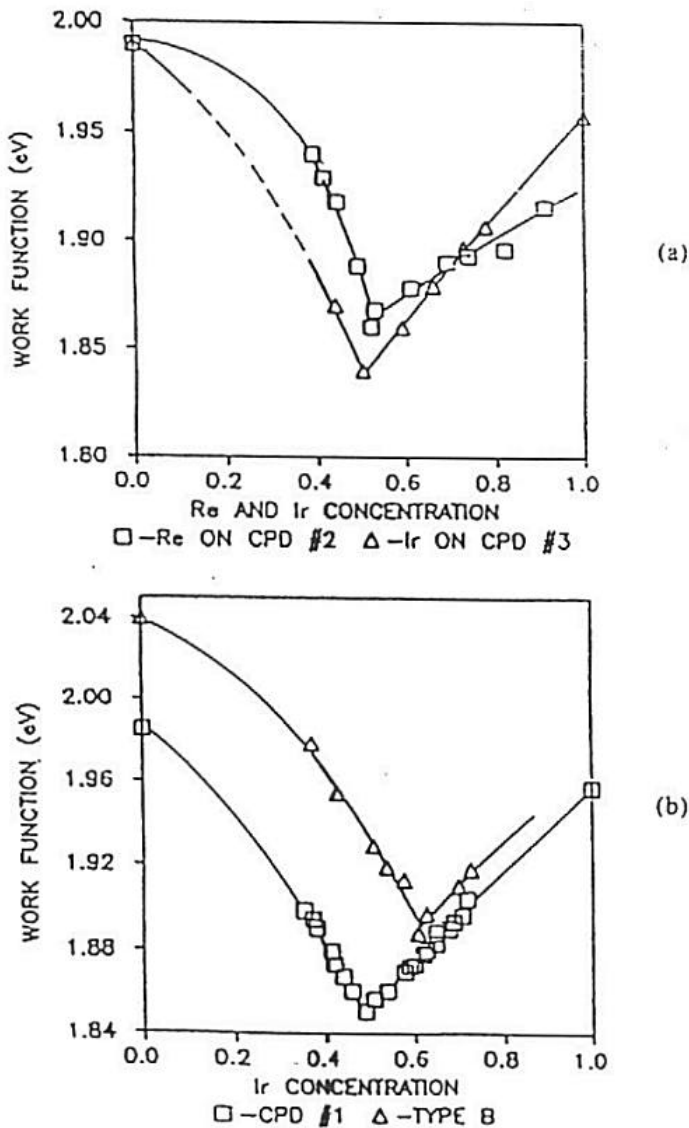


Fig. 3 Work function versus alloy Composition for CPD and type B cathodes. (a) Ir/W. (b) Re/W and Ir/W.

Emitters referred to as Scandate cathodes have been under study for a number of years. A recent version developed by Philips Research Laboratory, and reported by Hasker,(9) has demonstrated high emission at low temperatures with work functions reported to be as low as 1.3 to 1.6 e.v. The cathode utilizes a standard impregnated tungsten matrix with a pressed and sintered top layer of tungsten mixed with Scandium oxide (5c2 03). Yamamoto(10) of Hitachi has reported similar results with a similar composition sputter deposited on a standard tungsten matrix impregnated cathode.

Molybdenum Rhenium Surfaces

At the 1991 Society for Information Display (SID) symposium the development of a new Controlled Porosity Dispenser (CPD) cathode was reported on which used a tungsten rhenium alloy surface. In fact, all dispenser cathode surfaces up to this time included tungsten in some form since even the coated surface cathodes have tungsten at the surface due to migration through the film from the substrate. In the CPD cathode development that utilized tungsten rhenium, the emitter surface was a formed cap of the material. The cap fit over a reservoir containing a barium ceramic and was laser welded to a support cup which contained the heater. Considerable difficulty was encountered in the fabrication of the tungsten rhenium cap because of the brittleness and lack of ductility of the tungsten rhenium alloy. A search for an alternate material took place. Molybdenum rhenium alloys were selected because they are more ductile and formable and yielded excellent emission properties.

Results

A great number of cathodes were fabricated with Molybdenum rhenium emitter caps. Data is shown in Figure 4 for a molybdenum rhenium surface cathodes where current in amps/cm² is plotted versus voltage. By drawing a line which is a linear extrapolation from the temperature limited region and extends to the intersection of the left hand ordinate, one can approximate the saturated emission of J₀. Figure 5 shows the same presentation of data for a tungsten rhenium surface cathode. Figure 6 is a computer calculated and presented comparison of J₀ versus temperature for both Molybdenum rhenium, (Mo-Re) and tungsten rhenium (W-Re) cathodes. The data indicates a slightly higher J₀ with Mo-Re.

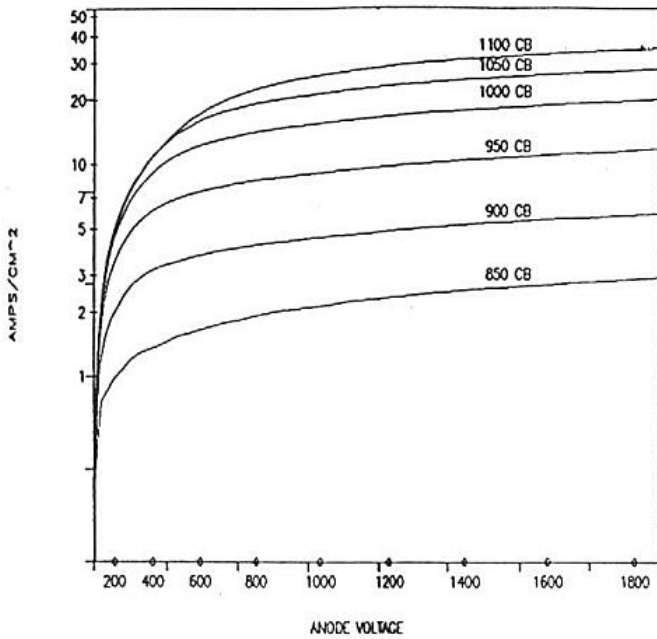


Fig. 4 Current Density vs Voltage for Molybdenum Rhenium Cathode

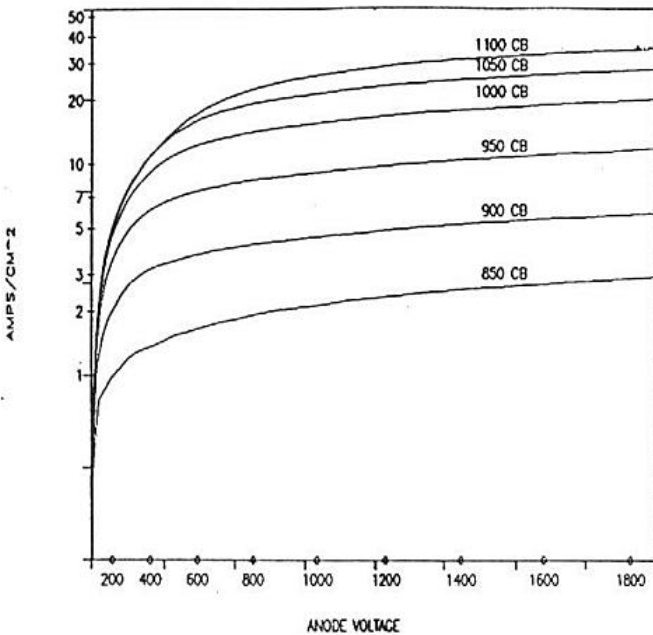


Fig. 5 Current Density vs Voltage for Tungsten Rhenium Cathode

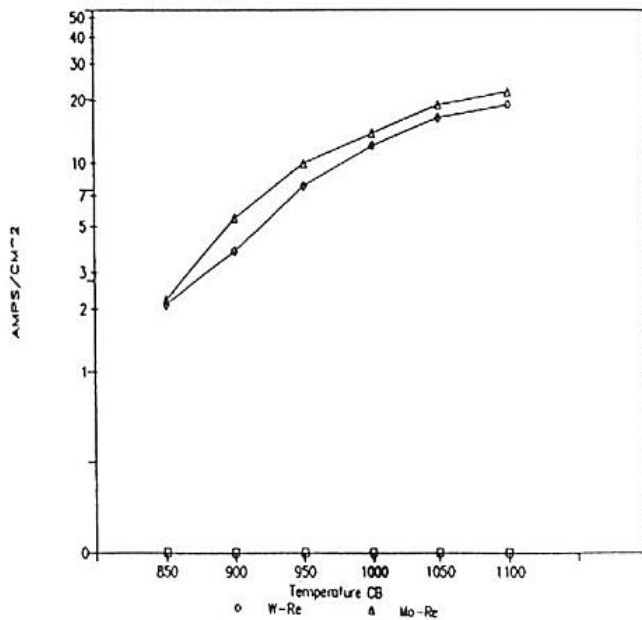


Fig. 6 Saturated Current Density (J_0) vs Temperature comparing Tungsten Rhenium and Molybdenum Rhenium

Conclusion

It is significant that a material such as Mo-Re can be used as an emitter surface for it enables relatively easy fabrication of cathode components and for CRT's. This helps to reduce the costs of fabrication of high current dispenser cathodes. The high cost of conventional impregnated dispenser cathode has been a limitation to their use in the past. This material breakthrough offers considerable opportunity combined with CPD cathode techniques to bring dispenser cathode costs down to a tolerable and useful level without sacrificing emission performance.

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