Alloy Coated Controlled Porosity Dispenser (CPD) Cathodes for High Current Density Application

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***Abstract*— A CPD cathode emitting button, fabricated out of active sintered bunch of tungsten wire (ϕ=50μm), offers excellent uniformity in the pore size and its distribution across the surface. A CPD cathode has been alloy coated and tested for emission capability. The emission density has been found > 20A/cm² thereby making it a potential candidate for high current density application.**

Keywords*— *Controlled Porosity Dispenser (CPD) Cathode, Active Sintering, Space Charge Limited-Temperature Limited (SCL-TL), Scanning Electron Microscope(SEM).

Introduction:

Most of the microwave tubes require a high quality electron source (cathode) to efficiently perform their respective functions. A conventional B-type impregnated cathode has an emitting button, made out of porous tungsten in which the pores are distributed in random sizes and shapes across the surface. The variation in the pore size, pore distribution, and inter-pore connectivity play a significant role in the barium coverage over the surface, resulting in reduced effective work (φ) function and emission uniformity [1]. Emission uniformity resulting from narrow φ distribution reduces noise at the output and also enables the cathode to be operated at a relatively lower temperature to obtain the required current density.

Alloy coated CPD cathode:

A cathode wherein the distribution and size of the pores can be directly controlled would represent a Controlled Porosity Dispenser (CPD) cathode. The emitting button is obtained from actively sintered W-wire bunch. Conventional sintering methodology as reported by L. Ives et al. requires high temperature operation for longer duration [2]. Active sintering methodology has been adopted wherein Ni infiltration (1% by wt.) helps in lowering the sintering temperature and the duration [3]. The SEM image of such a CPD emitting button is shown in Fig. 1. Alloy coated CPD cathode has been developed and characterized for emission capability.

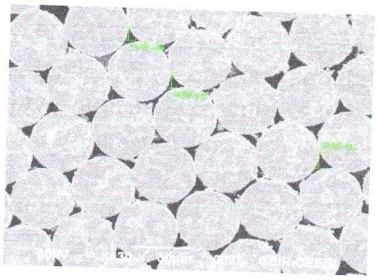

Fig. 1: SEM image of CPD emitting pellet (prepared out of 50 μm wires) with average pore diameter of 11μm.[3].

The fabrication of a B-type CPD cathode assembly, mainly, involved: (a) Uniformly Ni-coat the wires, (b) making bunch, out of Φ50μm W-wire and pressing under hot condition, (c) machining of bunch using wire cutting to obtain pellets, (d) removal the excess Ni through vacuum firing,(d) impregnate the pellets with barium-calcium-aluminates, and (e) integration of the impregnated pellets with potted heater assembly. The B-Type cathode surface is sputter coated with ternary alloy (W:2Re:2Os) using DC triode sputter coating system as shown in Fig. 2. The coating parameters are (a) Filament

Wattage: 250 W, (b) Anode voltage : 70 V, (c) Anode current: 0.5 A, (d) Target voltage/current: 2 kV/6 mA, (e) Argon pressure : 5 X 10-3 Torr.

Fig. 1. : DC Triode sputtering set-up for triple alloy coating of CPD Cathode.

Emission measurements:

The alloy coated CPD cathode was tested for emission measurement. The cathode is assembled in analytical system fitted with a molybdenum anode. The chamber is the evacuated to ultra high vacuum with the help of rotary, turbo, and ion pump. The cathode was initially heated to dull red to ensure removal of any surface contamination. Activation of cathode is very important in order to oxygenate the active monolayer over the surface. This oxygenating process being diffusion phenomena takes time and is temperature dependent. A temperature of 1000^0C for 1 to 2 hours accomplishes good activation. Anode degassing is carried out by drawing large current till the anode is dull red. The temperature of the cathode is measured using optical pyrometer which works on the principle of filament disappearance method. For a given cathode temperature, the pulsed voltage is varied and anode current is measured using CRO. The I-V data plotted on a 2/3 scale, where Y ordinate corresponds to 2/3rd power of linear scale but the captioning is in A/cm^2 and Voltage on X ordinate is linear scale, is shown in Fig 2. The frequency is 34Hz and ON time for the pulse is 5µsec for every measurement made. Low duty ratio enables safe measurements without anode getting red hot at higher voltage pulse. The cathode anode spacing has been kept slightly more than 1mm in all the cathode measurement.

The emission density is found to be in excess of 20 A/cm^2. Note the uniformity in the emission from the fact that the SCL-TL transition is sharp. The sharper the transition, the more is the uniformity of work function across the surface. This can attributed to the uniform pore parameters across the cross section resulting in uniform barium coverage and hence narrow work function distribution. The initial results are encouraging and experimental study is required to optimize suitable wire gauge using the data obtained from emission and evaporation rate measurements. Emission mapping using THEM (Thermionic emission microscope) is another area to fully understand the spatial emission distribution.

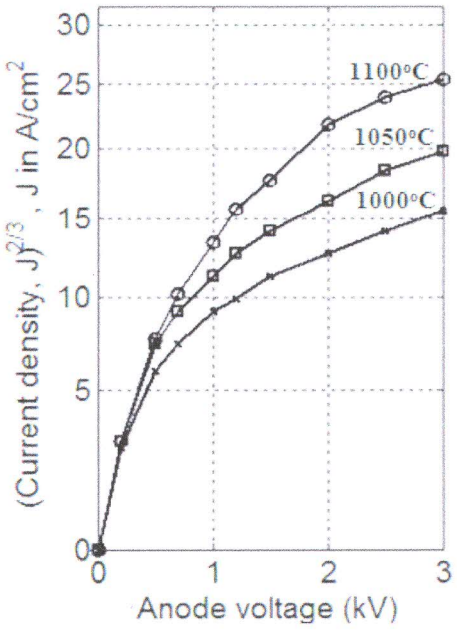

Fig. 2: Pulsed Cutrrent2/3 vs. Voltage characteristics of CPD Cathodes (Y ordinate translated to 2/3 power scale but the captioning is in A/cm^2)

Conclusion:

The high emission density coupled with emission uniformity makes the CPD cathode a potential candidate for terahertz device application. The CPD pellet offers excellent uniformity in the pore parameters which is difficult to obtain in the case of pressed powder pellets. The pore parameters can be tailored as per the requirement by proper

choice of wire gauge. Encouraging results have been obtained in making CPD cathode pellets; however, a few voids/gaps have been found on the surface and requires effort to improvise the fabrication technology for a practical cathode.

References

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