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Accelerated life ac conductivity measurements of CRT oxide cathodes

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Abstract

The ac conductivity measurements have been carried out for the activated Ba/SrO cathode with additional 5% Ni powder for every 100 h acceleration life time at the temperature around 1125 K. The ac conductivity was studied as a function of temperature in the range 300–1200 K after conversion and activation of the cathode at 1200 K for 1 h in two cathodes face to face closed configuration. The experimental results prove that the hopping conductivity dominate in the temperature range 625–770 K through the traps of the WO_3 associate with activation energy $E_a = 0.87$ eV, whereas from 500–625 K it is most likely to be through the traps of the Al_2O_3 with activation energy of $E_a = 1.05$ eV. The hopping conductivity at the low temperature range 300–500 K is based on Ni powder link with some Ba contaminants in the oxide layer stricture which indicates very low activation energy $E_a = 0.06$ eV.

Keywords: Oxide cathode; Ba and Sr oxides; Electron emission; Electrical conductivity; CRT

1. Introduction

One of the last generations of oxide cathode supplied by LG Philips was Ba/SrO with an additional 5% Ni powder by weight. The aim of using the additional powder is to lower the resistivity of the oxide coating. In the recent years, few papers mentioned the complexity of the oxide cathode conductivity [1,2].

Geartner from Philips applied a new procedure to determine the oxide cathode electrical conductivity by measuring the emission current density using the close-spaced planar diode configuration in a UHV chamber. This method is very successful in determining the total electrical conductivity of the oxide cathode at the operation temperature [3,4]. The disadvantage in this procedure is that it does not give good detail about the conductivity mechanism involved in the electron transportation process,

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especially in the low temperature. This method evidences the relationship between the emission and the conductivity.

Later in 2004, the experimental result of the same generation of oxide cathode investigated by the face to face method was reported. This method created a sintered type cathode with low density of pores. The sintering made the activation energy to be much closer to the BaO bulk activation energy [5].

The measurement method as mentioned in the abstract is two cathodes contacted to each other face to face to create a semi-closed system. The Ba lost by this system is much less than the open system (a single standard cathode in a dummy tube or in a close-spaced planar diode configuration in a UHV chamber) contaminated inside the pores and between the grains [5,9].

The long time operation of this semi-closed system accumulated the Ba as layers on the surface grains and involved another resistance in the resistivity network of the cathode. The effect of the Ba layers found at low temperature range 300–600 K became very clear after several hundreds of operation hours [5,6].

The conductivity and the activation energy characteristics are strongly dependent on the life test condition.

The SEM and EDX of the lower percentage of Ni powder 2.5% cathode have shown a reduction of nickel at the surface with longer activation time [5].

The dielectric properties of the Ba/SrO cathode with no additional Ni powder were investigated in terms of spectroscopic measurements of ac conductance G at temperature range 300–1100 K. It shows that the conductance at room temperature is in the range of 10^{-11} S [7].

Jenkins from L.G. Philips investigated the outer surface of the emissive layer by using in situ SIMS. Aluminium was found on the emitter surface after conversion and a significantly high level of Mg–Ba compound also was formed after ageing as well as the predictably high level of surface free barium [8].

2. Experimental

The cathodes used in this study were supplied by L.G. Philips Displays and were mounted, face to face in pairs in a specially designed holder inside a glass chamber, following the Loosjes and Vink procedure [9].

L.G. Philips Display Components developed new compositions for the emissive layer of their oxide cathodes. The cathodes comprise a top layer of a Ni 5% powder cermets with surface area of 0.0165 cm^2 and layer thickness of approximately 65 ± 10 μm deposited onto a Nickel alloy cap [2].

The ac conductance measurements were performed at various temperatures in the range 300–1200 K at 100 h intervals up to a total of 600 h. Baseline measurements were made immediately after activation of the cathodes. ac electrical measurements were performed perpendicular to the activated layer via connections made to the nickel cathode substrate to an hp-4284 precision LRC electrometer. The precise experimental set-up has been described in a previous publication [10].

3. Results and discussion

The ac conductivity was investigated in terms of spectroscopic measurements of ac conductance G at temperatures ranging from 300 to 1200 K. As shown in Fig. 1, the ac conductance is dependent upon temperature with two different activation energies for the temperature ranges $T \leq 870$ K and $T \geq 870$ K. At the temperature $T \geq 870$ K, the conductivity becomes independent of frequency. For the temperature range

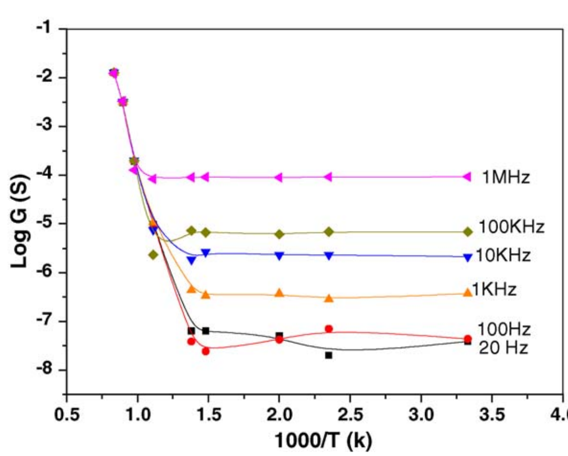

Fig. 1. Conductance as a function of temperature at different frequencies for the 100 h run.