Investigation of the focus characteristics of a triode structure in FED

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Abstract
In a field emission display panel, the triode structure [1] has been used to decrease the driving voltage. Because a very strong electric field has been applied in front of the field emitters, the electron beam usually diverges seriously in a normal triode structure [2][3]. In this paper, a new triode structure with an additional focus electrode has been proposed [4]. A numerical program has been used to calculate the focus characteristic of this triode structure. This paper also analyzes the variation of the current density distribution on the screen with different focus voltages.

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1. Introduction
Nowadays field emission displays (FED) are drawing attention as one of the most promising flat panel displays. In a normal field-emission display panel, a triode structure has been used to realize low driving voltage [5] and high brightness. Because the velocity of secondary electron is often small, the driving voltage can be decreased by the modulation of the secondary electrons.

A few triodes, such as under gate triode, have been proposed in recent years [4]. There is a very strong field in front of the field emitters to generate the emission current, and the electron beam is divergent in both normal-gate and under-gate triode structure. It is well known that the divergent electron beam causes a large spot on the screen and seriously influences the resolution. This paper designs a tunnel and an additional electrode to focus the electron beam.

2. Simulation Model
As shown in Fig. 1, two glass funnels (insulator funnel) are used as the electron tunnel. The gate electrode is
located on the bottom side of the glass funnel. To focus the electron beam, the focus electrode and acceleration electrode are also deposited on the glass funnels. In this paper, the voltages of cathode, gate electrode, acceleration electrode and anode are 0V, 80V, 500V and 2000V respectively. The diameter of the bottom hop is 0.2mm, and the middle hop is 0.4mm.

Fig. 1. The simulation model.

Apart from the glass funnel, this paper also studies the focus performance of the electron beam while an MgO layer is coated on the inner surface of the glass funnel respectively. From the simulation results, the influence of the coating material on the spot profile is obtained.

In Fig. 1, the electrons are emitted from the cathode due to high electric field. A part of the electron beam is focused and accelerated to the anode. The rest of the electrons may bombard the insulator funnel and they will generate a great deal of secondary electrons. Fig. 2 and Fig. 3 show the electron trajectories in an electron tunnel when the voltage of the focus electrode is −100V and 0V respectively.

Fig. 2. The electron trajectories in an electron tunnel when the voltage of the focus electrode is −100V.

Fig. 3. The electron trajectories in an electron tunnel when the voltage of the focus electrode is 0V.
Fig. 4 shows the electron trajectories in an electron tunnel when the voltage of the focus electrode is 200V.

Fig. 5 shows the variation of spot size with different focus voltage when an MgO layer is coated on the inner surface of the glass funnel.

When the voltage of the focus electrode is very low, such as –100V, there is a very strong convergent electric field near the focus electrode. Therefore, the electron beam is over-focused in this region, as shown in Fig. 2. As a result, the spot size is quite large on the anode. When the focus voltage increases, the electric field intensity near the focus electrode becomes weak. Therefore, the electron beam can be focused quite well, as shown in Fig. 3. However, if the focus voltage is quite high, the electric field is too weak to focus the electron beam. Consequently, the spot size on the anode is large due to the under-focused electron beam. If the focus voltage increases continuously, the voltage difference between focus electrode and acceleration electrode is so small that some secondary electrons cannot be pulled out from the aperture of acceleration electrode. Although the electron beam diverges quite seriously, the variation of spot size is not so large due to the small number of electrons bombarded on the anode as shown in Fig. 4.

3. Conclusion

In this paper, a new triode structure with a focus electrode is studied. In this triode, the secondary electrons are the main electron source. As regards secondary emission, the material properties play an important role in the transport process. Because the coefficient of the secondary emission in MgO is quite high, an MgO layer is coated on the inner surface of the glass funnel. The variation of spot size with different focus voltages is obtained. As the simulation results show, the optimal focus voltage in this structure is about 25V.

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