Improvement of the field emission characteristics of an oxidized porous polysilicon field emitter using Pt/Ti emitter-electrode

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Field emission displays (FEDs) have drawn much attention as a future high definition television owing to their features as thin panel thickness, high brightness, quick response, wide viewing angle, and low power consumption. [1,2] At present, an oxidized porous polysilicon(OPPS) field emitter, a new type of field emitter, was proposed the most favorable candidate for field emission displays because of its simple fabrication process , low angular dispersion, and low voltage emission characteristics.[3] Due to the several crucial drawbacks, however it is difficult to apply the OPPS field emitter to the display products. Main drawbacks of the conventional OPPS field emitter are low emission efficiency and short life time. In order to overcome those drawbacks, first of all, the material and the thickness of emitter metals should be well selected for reliable and efficient electron emission.

In this study, we investigated the field emission characteristics of an oxidized porous polysilicon field emitter using Pt/Ti emitter-electrode.

A polysilicon layer with a thickness of 1.75 μm was deposited on n+ doped p-type (100) silicon substrate and anodized in HF(49%):ethanol=1:1 solution at current density of 10mA/cm^2 and with space between electrodes of 10cm. The porous polysilicon was oxidized in dry oxygen atmosphere with a oxygen flow rate of 31/min and a temperature of 900^{o}C for 60 minutes. Pt/Ti, Au/NiCr, and Pt electrodes were deposited using DC sputter with a thickness of 5nm/2nm, 5nm/2nm, and 7nm, respectively.

Figure 1 shows the relationship between I_{ps} and I_e for the Pt/Ti, Au/NiCr and Pt emitter electrodes. The electron emission starts at the V_{ps} of 7V and gradually increases with increasing the V_{ps}. The starting point of electron emission accords with the abrupt increase of I_{ps}, which means the tunneling of electron through the OPPS by applied electric field and the generation of hot electrons which can tunnel the oxide and emitter electrode. The OPPS field emitter which has a Pt/Ti emitter electrode with thickness of 5nm/2nm shows the smallest Ips and the largest Ie among three different OPPS field emitters. The NiCr/Au and Pt emitters show less efficient emission characteristics

Figure 2 shows the emission efficiency (100 × I_e/I_{ps}) of OPPS field emitters. The Pt/Ti emitter shows the highest efficiency of 1.60% at the Vps of 10V. Other emitters show the efficiency of below 0.2%. The abrupt increase of emission current and efficiency owing to thin Ti layer shows that thin Ti layer plays an important role in adhesion of Pt and coverage of porous surface of an OPPS emitter, which results in the uniform distribution of electric field on an OPPS surface. Figure 3 shows the variation of brightness for the Pt/Ti OPPS field emitter with increasing the V_{ps}. The brightness increases linearly with V_{ps} and reaches 6260 cd/m^2 at the V_{ps} of 20V and the I_e of 310 μA /cm^2. Figure 4 shows current variation with applying continuous V_{ps} for the Pt/Ti and the Au/NiCr OPPS field emitters. With the V_{ps} of 15V, the Au/NiCr OPPS field emitter shows the abrupt degradation due to the diffusion of emitter metals into the oxide and polysilicon, while Pt/ Ti OPPS emitter shows more reliable emission characteristics compared with Au/NiCr OPPS field emitter, which shows that the Ti layer efficiently blocks the diffusion of emitter metals and a Pt is more reliable than a Au as an emitter electrode.

In summary, we investigated the emission characteristics of Pt/Ti OPPS field emitter. The Pt/Ti emitter shows the highest efficiency of 1.60% at the Vps of 10V. The brightness increases linearly with Vps and reaches 6260 cd/m^2 at the V_{ps} of 20V and the I_e of 310 μA/cm^2. Thin Ti layer played an important role in adhesion of Pt and coverage of porous surface of OPPS emitter and effectively blocked the diffusion of Pt. Accordingly, the Pt/Ti OPPS emitter will be sufficiently applicable to high quality field emission display devices.

References

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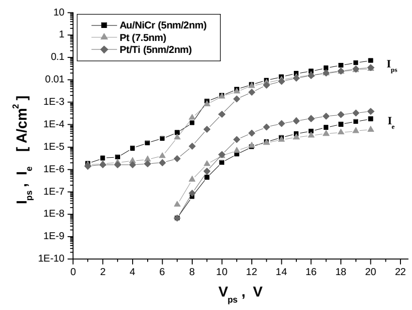

Fig.1. Relationship between diode I_{ps} and I_e for the Pt/Ti,Au/Nicr and Pt emitter electrodes.

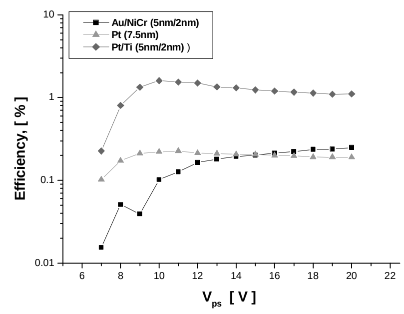

Fig. for the Pt/Ti, Au/NiCr and Pt emitter electrodes.

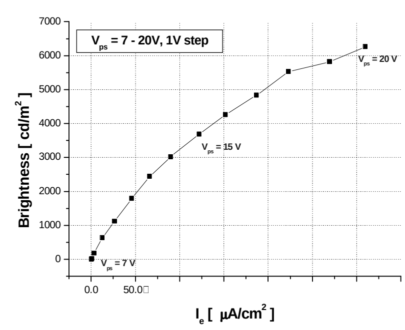

Fig. 3. Variation of brightness for the Pt/Ti OPPS field emitter with increasing the V_{ps}.

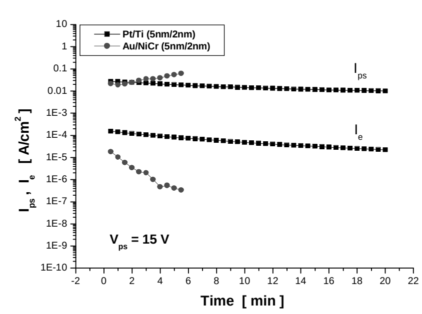

Fig. 4. Reliablity measurement for Pt/Ti and the Au/NiCr OPPS field emitters.