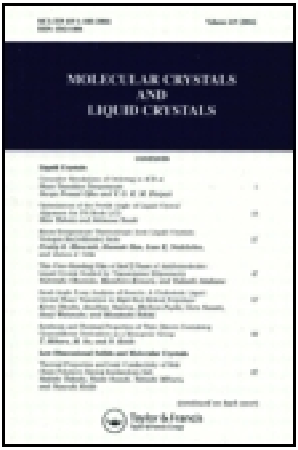

Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

Field Emission Characteristics of an Oxidized Porous Polysilicon Field Emitter Using Al_2O_3 Layer as a Passivation

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Version of record first published: 10 Nov 2009

To cite this article: Gwon-Heon Ryu, Jin-Eui Kim, Tae-Yong Lee & Sie-Young Choi (2009): Field Emission Characteristics of an Oxidized Porous Polysilicon Field Emitter Using Al_2O_3 Layer as a Passivation, Molecular Crystals and Liquid Crystals, 514:1, 283/[613]-288/[618]

To link to this article: http://dx.doi.org/10.1080/15421400903241041

Mol. Cryst. Liq. Cryst., Vol. 514, pp. 283/[613]–288/[618], 2009

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400903241041

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Field Emission Characteristics of an Oxidized Porous Polysilicon Field Emitter Using Al_2O_3 Layer as a Passivation

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The field emission characteristics of an oxidized porous polysilicon were investigated with different $Al_2O_3/Ti/Pt$ thickness. The $Al_2O_3/Ti/Pt$ emitter showed stable electron emission characteristic compared with the conventional Ti/Pt electrode. The Al_2O_3 layer efficiently blocked the diffusion of emitter metal, which resulted in more reliable emission characteristics. $Al_2O_3/Ti/Pt$ electrode thickness at 2 nm/2 nm/7 nm showed the highest emission efficiency of 0.37% at Vps = 17 V. The investigated field emission life time of samples also demonstrated their stability over 40 minutes.

Keywords: Al_2O_3 as a passivation; field emitter; porous polysilicon

INTRODUCTION

The rapid progress of PDP(plasma display panel), LCD(liquid crystal display) and OLED(organic light emitting device) technologies has been accelerating to replace CRT(cathode ray tube) and move towards FPDs(flat panel displays). However, there are still constant demands for new FPD technology that can realize a higher natural picture as well as lower power consumption. FEDs (field emission displays) [1,2] have also been studied intensively with various geometric

This work was supported by the Regional Innovation Center Program (ADMRC) of the Ministry of Knowledge Economy and the second phase of the Brain Korea 21 program in 2008.

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structures to obtain a longer life time and higher characteristics. Recently, a new type of emitter [3,4], oxidized porous polysilicon (OPPS), was proposed as the most promising candidate for the field emission display because of its simple fabrication process, stable performance at lower vacuum atmosphere, and highly directional electron emission at a low voltage of 20 V. Although OPPS has been proposed, there are still many issues to overcome. Especially, the Emission life time is not enough to operate due to the large driving current and the sample doesn't occur reliably because the thin metal electrode is below 10 nm. The thin metal electrode should be thermally stable in itself and maintain the clear interface between metal and oxide. Diffusion of emitter metal due to the Joule's heat induced by the high density of driving current degrades the insulating performance and finally induces the breakdown of insulator. To prevent the breakdown and degeneration, therefore, the detail process of the OPPS field emitter [3–9] needs to be investigated to improve its emission life time and reliability for the application to the display device.

In this study, the field emission characteristics of different thicknesses of the Al_2O_3/Ti/Pt multi-layer electrode were investigated. The Al_2O_3 as a passivation layer could protect the upper electrode from degeneration. Therefore it is possible to extend the emission life time and reliability compared with only the upper electrode.

EXPERIMENTAL

Figure 1 shows the process procedure for the fabrication of the OPPS field emitters used in this work. A polysilicon layer with a thickness of 1.75 μm was deposited on the 7 line patterned n+ doped p-type (100) silicon substrate using low-pressure chemical-vapor deposition (LPCVD) methods. The samples were anodized in HF(49%): ethanol = 1 : 1 solution at current density of 10 mA/cm^2 for 15 seconds. After anodization, the samples were oxidized at a temperature of 900°C for 60 min. The Al_2O_3/Ti/Pt passivation layer and upper electrode that was prepared with three different thicknesses of 2 nm/2 nm/7 nm, 3 nm/2 nm/7 nm, and 4 nm/2 nm/7 nm was deposited on 7 lines using a 2-inch sputter. The bias voltage Vps was applied to the top Pt electrode, and the anode voltage VA above the Pt electrode was kept at a positive potential to collect the emitted electrons. Figure 2 shows the schematic diagram of the 7×7 array OPPS field emitters and the electrical connection for the analysis of its field emission characteristics.

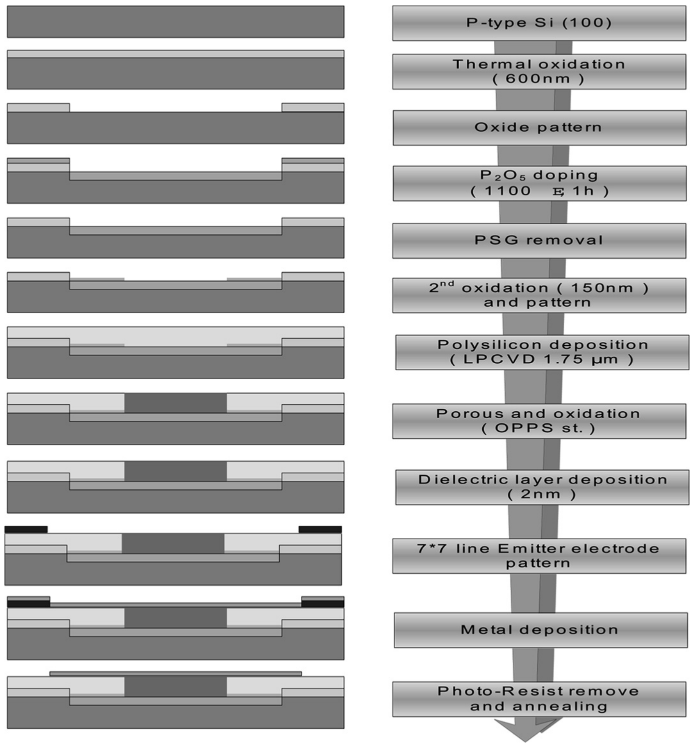

FIGURE 1 Fabrication of the OPPS field emitter.

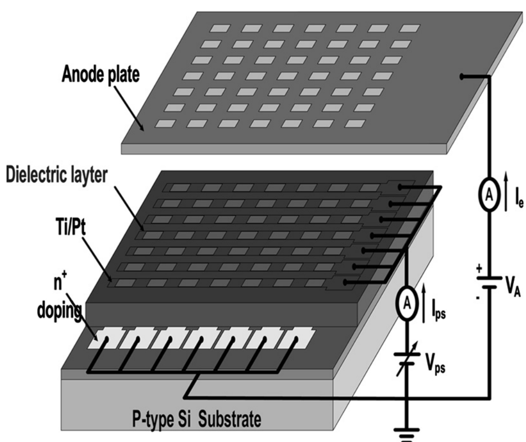

FIGURE 2 Schematic diagram of the OPPS field emitters with dielectric layer and the electrical connection for the analysis of its field emission characteristics.

RESULT AND DISCUSSION

Figure 3 shows the relationship between the current flow through the OPPS layer(Ips) and emitted current(Ie), and emission efficiency. The applied voltage to the top Pt electrode varied from 0 V to 20 V. The electron emission started at 7 V and gradually increases with increasing Vps. The starting point of the electron emission accords with the abrupt increase in Ips, which means the electron can tunnel through the OPPS by the applied electric field and the hot electrons can be generated which can tunnel through the oxide and emitter electrode. During the tunneling through the emitter electrode, the thin metal electrode should be thermally stable in itself and maintain the clear interface between metal and oxide. Diffusion of emitter metal due to the Joule's heat induced by the high density of driving current degrades the insulating performance and finally induces the breakdown of insulator. Therefore to add the Al_2O_3 layer which is kind of passivation can protect the emitter metal from the degeneration. The emission efficiency also increases with increasing Vps and the emission efficiency is saturated. The best emission efficiency among dielectric layer was observed at the 2 nm/2 nm/7 nm Al_2O_3/Ti/Pt electrode. Figure 4 shows the field emission life time of OPPS

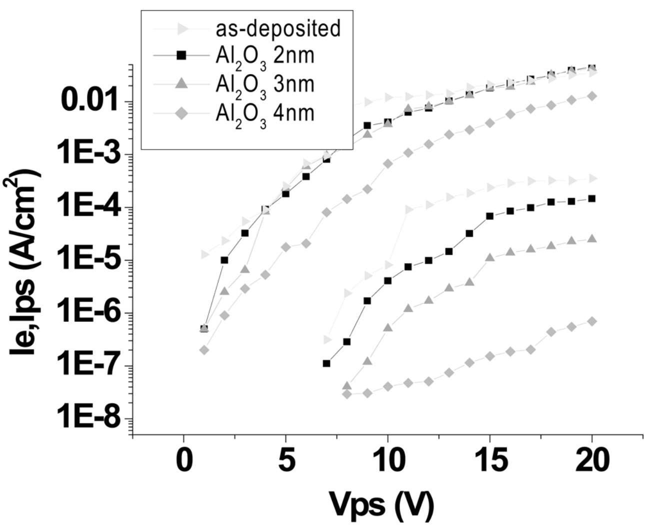

FIGURE 3 The Electrical characteristics of different dielectric layer thickness in OPPS field emitters. (a) relationship between Ips and Ie, and (b) emission efficiency.

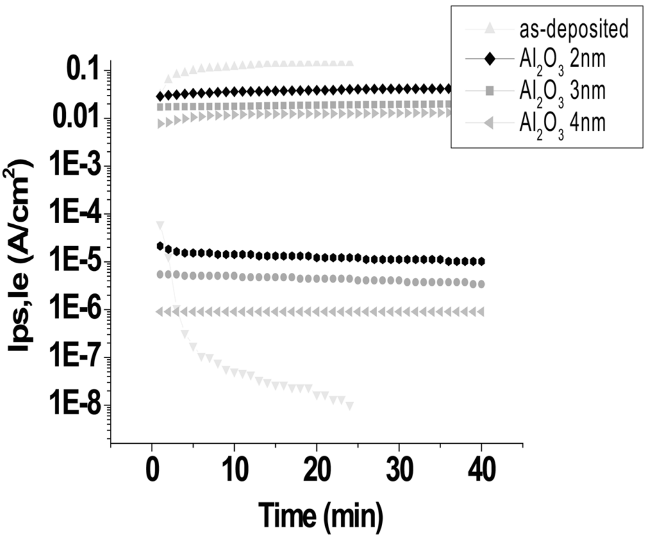

FIGURE 4 The emission life times of different dielectric layer thickness OPPS field emitters. (a) relationship between Ips and Ie at 17 V, (b) as deposited and 3 nm Al_2O_3 at 10 V, 15 V respectively.

with a dielectric layer. The field emission life times were stable over 40 minutes at 17 V except for the OPPS without a dielectric layer which could not endure due to the large driving current because of the thin metal electrode of below 10 nm. Also the results of the emission life time as deposited at 10 V and 3 nm of dielectric layer at 15 V, respectively, which emitted current(Ie) were very similar and the same as the results at 17 V. Therefore we can figure out the dielectric layer protects the upper electrode from degeneration.

CONCLUSIONS

The electron emission characteristics of different thicknesses of Al_2O_3/Ti/Pt multi-layer electrode and the OPPS emitters that were patterned on a 7×7 array were investigated. The most efficient thickness was found to be 2 nm/2 nm/7 nm multi-layer electrode. The sample shows the highest efficiency of 0.37% at the Vps of 17 V. Also, stable Ips, Ie and efficiency were confirmed over 40 minutes. Accordingly, the OPPS with a dielectric layer as a passivation will be sufficiently applicable to high quality field emission display devices.

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