The fabrication of electrodes with low resistance and fine pattern for PDP

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Abstract

We propose the method which is possible to fabricate the electrodes with the fine pattern and low resistance by photolithography and electroplating. The widths of pattern fabricated were 30, 50, 70 and 100um and the thickness could be up to 10μm. The resistivity of the copper electrode electroplated was below 2.0μΩ cm which is about half of photosensitive silver electrode. Dielectric layer was coated on the electrodes by screen printing and the pores harmful to the discharge were not formed after heat treatment. In the viewpoint of resistance and patterning, this method has much higher potential for large area display than other methods like screen printing, photosensitive conductive paste method and sputtering.

Introduction

The electrodes for PDP have been generally fabricated by the methods of photosensitive silver paste, screen printing or sputtering. Screen pringting has a difficulty in fine patterning and there is a difficulty in stress control to form the thick pattern of the metal film by sputtering. So recently the photosensitive paste method has been widely used by the makers because it is possible to pattern the electrodes more fine and thick than above two methods. Figure 1 shows the photosensitive paste method[1,2] for the fabrication of the bus electrodes for ACPDP which is proposed by DuPont. For the bus electrodes for ACPDP, the electrode has two-layer, a black conductive layer and a silver layer. So each layer is coated on the glass by screen printing and dried in the furnace. After that they are irradiated to ultra violet through photomask. In the proper solution, the pattern is developed. Forthcoming heat-treatment process results in the metal(silver) pattern. By this method they could be possible to pattern the line under the width of 50um. The fine patterning of the bus electrodes of ACPDP improve the efficiency and brightness as the amount of the visual light generated at the fluorescent layer is diminished. Also high definition display needs more fine cells and therefore the electrodes for the display have to be more fine also. Above photosensitive process meets the fine patterning But fundamentally as the pastes used in this process is composed of metal powders which scatter or reflect the UV light easily, it is difficult to make fine pattern above certain thickness. As the width of electrode become narrow, the thickness of the electrode must be thicker to meet resistance. So this method has to be improved to make more fine and thick electrodes for large area display.

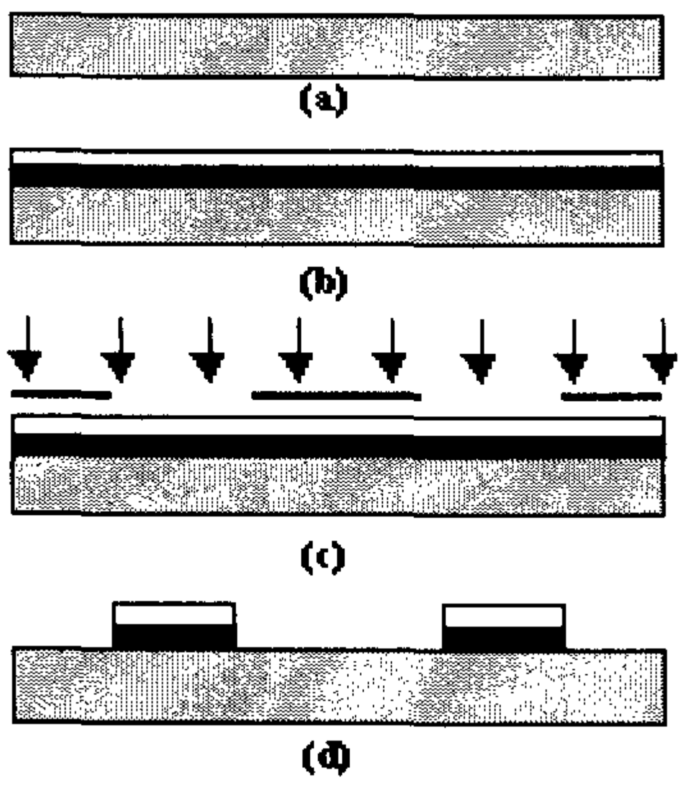


Fig. 1 The photosensitive paste method of bus electrodes for ACPDP (a) glass prepared (b) black conductive layer screen printing and drying, silver paste screen printing and drying (c) exposure (d) development and heat-treatment

From this point of view, it is needed that the electrode could be fabricated by other micro patterning methods possible to make the electrodes with the appropriate thickness. The photolithography using the photoresist offers more fine and thick pattern than above methods. The electroplating has high potential for thick metal film. Moreover the metals electroplated, generally has low resistivity and low stress than the metals coated by other methods[3]. So combining the photolithography and electroplating, it could be possible to make the electrodes with fine pattern and low resistance.

Experimental procedure

Figure 2 depicts the process for bus electrode fabrication by electroplating. To electroplate the metal on the certain ceramic or glass, the surface of the the substrate has to be conductive. There are some methods like electroless plating and vacuum deposition to form the conductive layer on the glass but we used the sputtering for the formation of conductive double layer. First layer was titanium for adhesion, second layer was copper for electroplating. After that, the photoresist(positive AZ4620 with the thickness of 10um) was patterned on the sputtered metal surface by photolithography. The conductive metals like copper or silver were selectively grown by electroplating method at the exposed

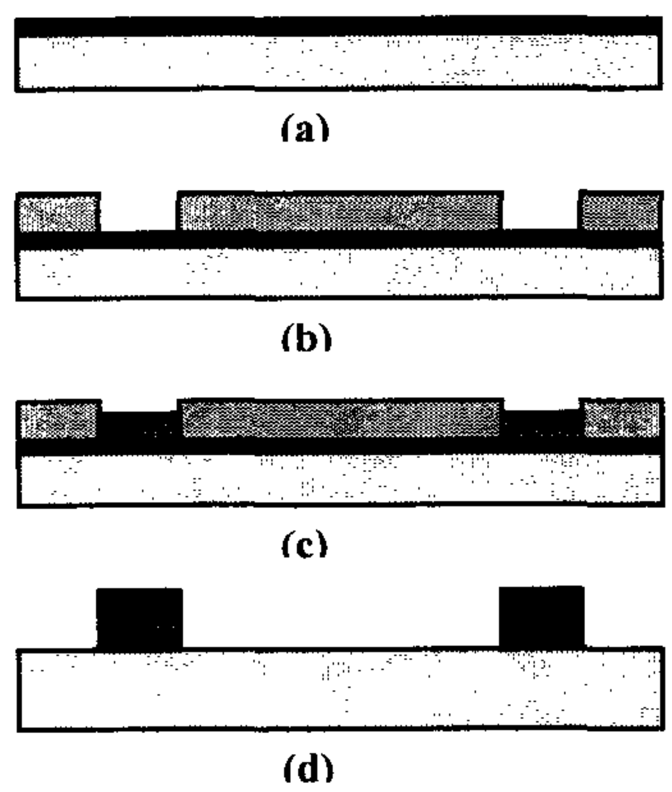


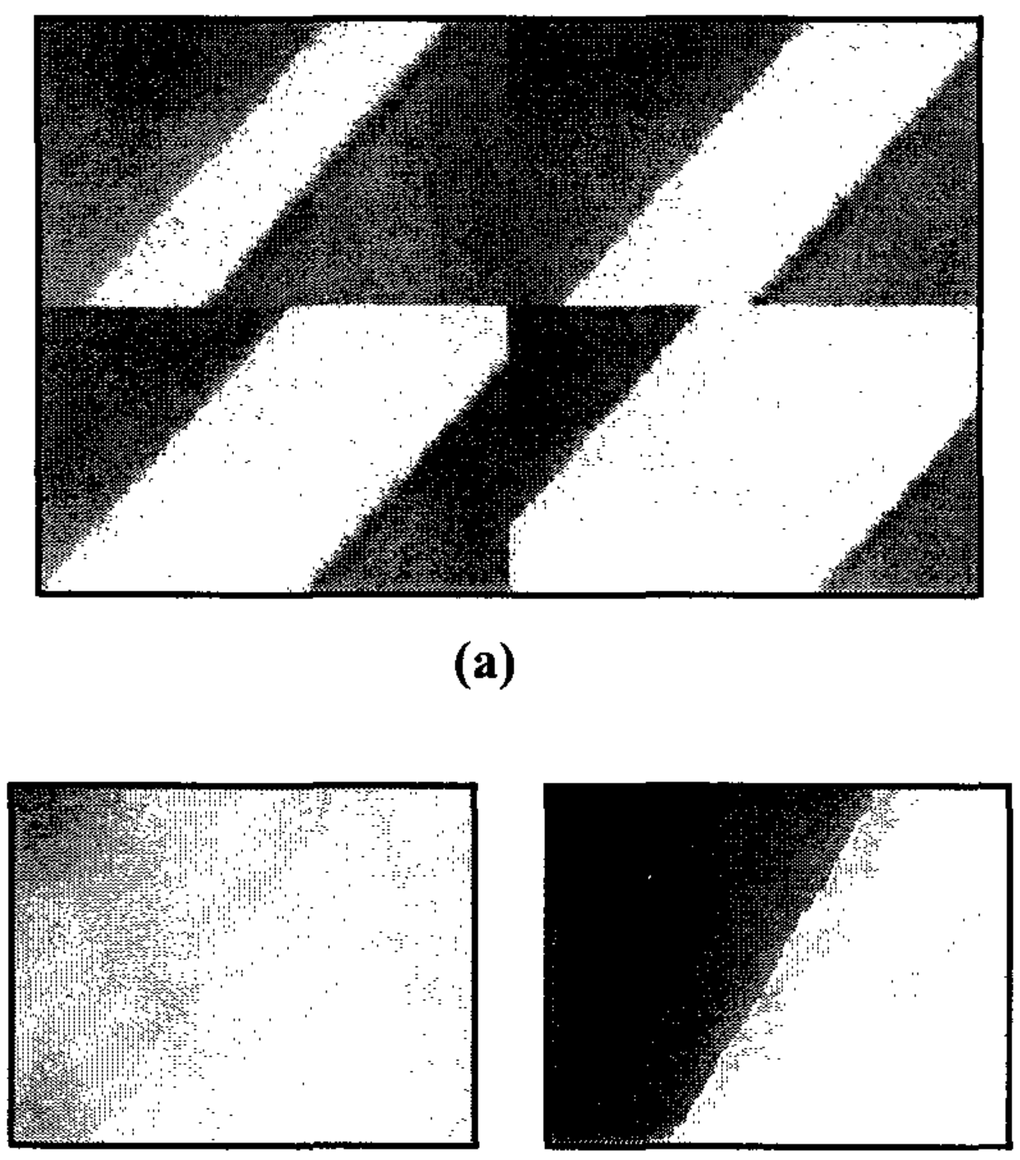
Fig. 2 Electroplating method for electrode patterning (a) seed layer formation on the glass surface (b) photoresist patterning by photolithography (c) electroplating (d) removal of photoresist and seed layer

area of photoresist. The copper sulfate solution was used for copper electroplating and the silver cyanide solution was used for silver plating. After plating the metals, the photoresist and the conductive layers under the photoresist were removed by proper solutions. If the oxidation or diffusion of the electroplated metals could be occured, the protective layers might be formed by electroplating, sputtering, electroless plating and so on. Here protective layer of chromium(Cr) for copper was deposited by sputtering after Fig. 2 (c) process. The chromium layer on the photoresist was removed during the stage of Fig. 2 (d) by lift-off. In case of silver, the protective layer was not formed but if the diffusion occurs, the protective layer like chromium should be capped by proper method. To investigate the patternability, electrodes with various thickness were fabricated and had the widths of 30,50,70 and 100um. For the measurement of resistance, the electrodes with the length of 60cm and width of 50um was plated. To investigate the reaction between dielectric layer and electrode, the paste composed of PbO, SiO_2 and Na_2O was screen-printed on the electrodes and sintered.

Results and Discussion

Figure 3 shows optical microscopies of 5 um thick Electrodes with the width of 30, 50, 70 and 100um. Patternability is superior to other methods as predicted. After heat treatment for dielectric layer forming on the electrodes, any pores were not viewed at the interface of the dielectric layer and electrodes.

The thickness and resistance profile of copper electrode is shown at figure 4. Electroplating times were 10, 20 and 30minutes. The thicknesses of electrodes are 3.1, 6.3 and 9.1um respectively. The resistances of each samples are 78, 38 and 25Ω. Thickness is increased proportionally as increasing the electrodeposition time. The resistance is reduced proportionally as the thickness increased.



(a)

(b) (c)

Fig. 3 Optical microscopies of the electrodes
(a) copper patterns of 30, 50, 70 and 100um
(b), (c) after dielectric layer formation. b is copper electrode and c is silver electrode. Both of them are the patterns of 50um width. Any pores is not formed at the interface of dielectric layer and metal electrodes

The resistivity calculated approximately from the resistance is about 1.90uΩcm. This is much lower than FODEL(photosensitive silver process of DuPont) process of which the resistivity is over 4uΩcm. After formation of dielectric layer, the resistances of each patterns changed to the values of 84, 40 and 26Ω respectively which are slightly increased as compared with as-deposited patterns. Many a factor effects the resistance after heat-treatment because restructuring of materials and micro reactions like diffusion, oxidation and alloying could be occurred during the process. More study is needed about that.

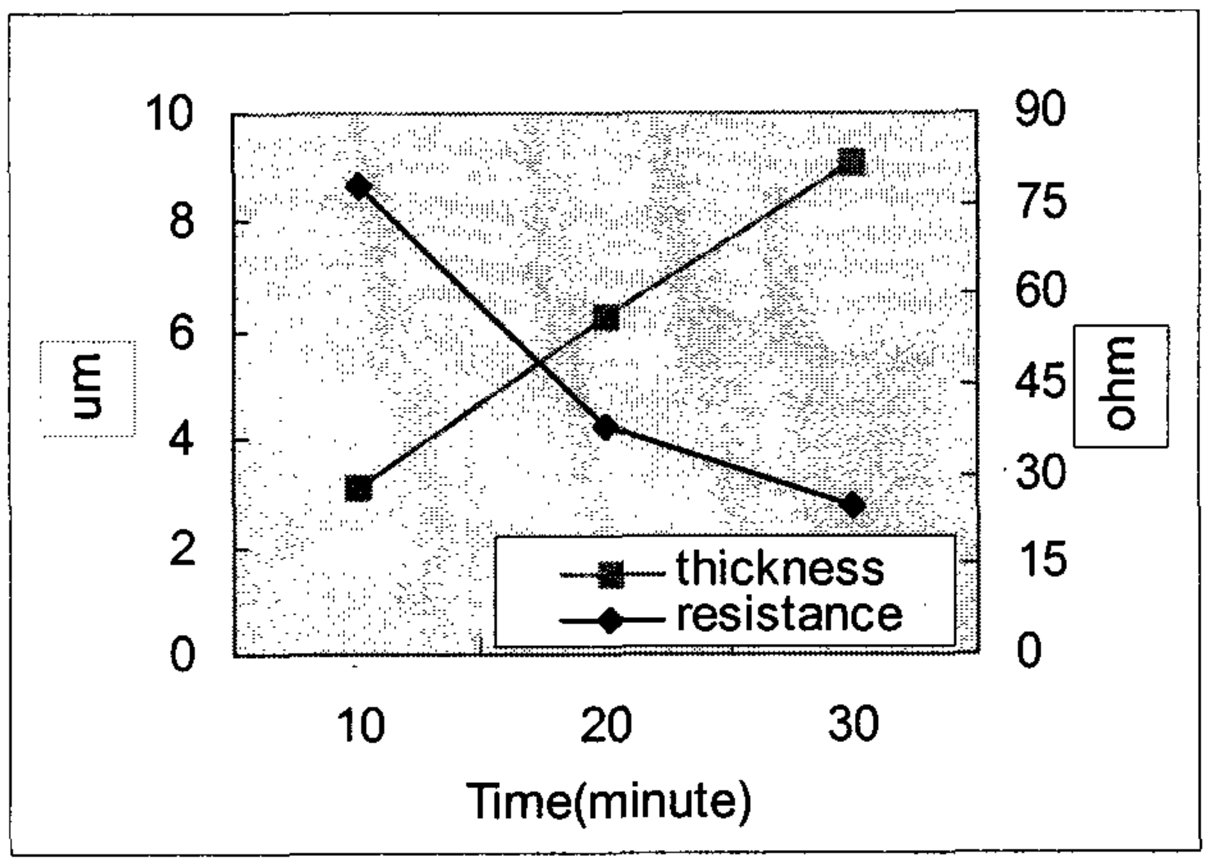


Fig. 4 The change of thickness and resistance by electroplating time(length 60cm, width 50um). The thickness is increased as increasing the plating time and the resistance is decreased as thickness increased . The resistance is very low compared with other methods.

Conclusion

The electrodes were selectively formed in the photoresist pattern on the glass by electroplating. 30um fine pattern suitable for high definition display could be fabricated and its resistivity was below 2uΩcm which is much lower than other methods like photosensitive paste process. After formation of dielectric layer, the resistance was changed very slightly and pore was not formed in the dielectric layer. So this process or related process like electroless plating has excellent potential for large area display especially ACPDP.

References

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[3] R. F. Bunshah 'Deposition Technologies for Films and Coatings' NOYES PUBLICATIONS P431 1982