In-situ EUV Irradiation for Etching Residual Removal of AM Mini-LED

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Keywords：Mini-LED, EUV, Porous Structure, Etching Residual

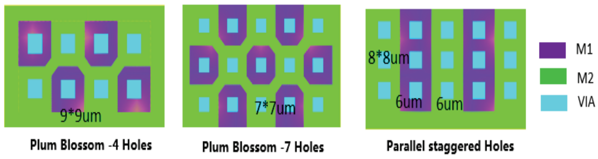
ABSTRACT

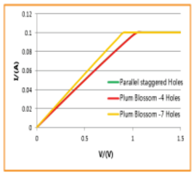
Given the demand of high current drive, AM Mini-LED backplane usually uses dense plum-blossom-type design to optimize hole lapping. However, this porous design leads to a serious M2 etching residual issue. By using in-situ EUV irradiation, the infiltration of etchant to porous structure can be increased and the etching residual can be removed without affecting electrical characteristics of the device.

1 INTRODUCTION

Recently, AM Mini-LED backplane exhibits an excellent contrast due to its high peak brightness and superior black state[1,2]. Therefore, it has become the hotspot for the display industry development[3]. Traditionally, parallel staggered openings are the general strategy to conduct Metal 1 and Metal 2. However, owing to the high contact resistance between M1 and M2, it is not very suitable for high current drive products such as AM Mini-LED. In the previous work, we have found that the dense plum blossom holes design can greatly improve the contact resistance (Fig.1), but there will be the M2 etching residual issue in practical application.

In this paper, we provide a rational strategy of in-situ EUV irradiation to increase the infiltration of etchant and eliminate the etching residual of porous structure. At present, the design has been successfully applied to AM Mini-LED products.





VIA	Plum Blossom -4 Holes	Plum Blossom -7 Holes	Parallel Staggered Holes
Area	324	392	384
Perimeter	144	224	192
Pitch-Row	12	12	12
Facing length	90	154	96

Fig.1 The comparison of common open-pore design

2 EXPERIMENT

Firstly, Metal 1 is deposited on the substrate and Metal 1 pattern is obtained. Then GI/a-Si/N+ and Metal 2 layers are deposited continuously. Halftone mask performs photo process. 1st Wet etch completes the separation of silicon island and the production of Metal 1 hole (1st hole). Then, 1st Dry + 2nd Wet + 2nd Dry + Strip are performed to obtain the Source/Drain Electrode and Active Layer. After completing the 2nd opening and the overlap of Metal 1 and Metal 2, the Passivation and ITO patterns are obtained (Fig.2, 3).

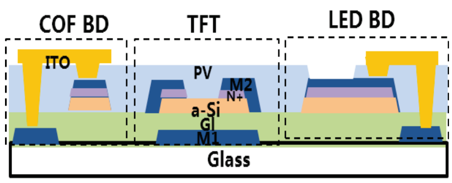


Fig.2 The film structure of the experiment

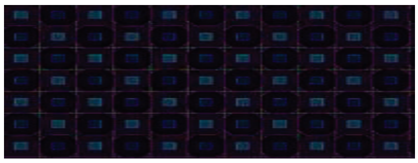


Fig.3 The opening design of the experiment

3 RESULTS AND DISCUSSION

As shown in Fig.4, a difference of the plum blossom holes can be observed after the HTM process. To be more specifically, the abnormal holes present a blue-green or black color. The SEM images in Fig.5 reveal that there is a longer a-Si tail in the abnormal holes, which is in good consistent with the results of EDS (Fig.6). Since the etching rate of a-Si is much higher than SiNx, a serious undercut of a-Si (about 0.4 um) is formed after PV process, which affected the lap joint of ITO. To further confirm the key of the problem, a series of experiments have been examined (Tab.1). The results indicate that 1st Wet plays critical roles in the abnormal site.

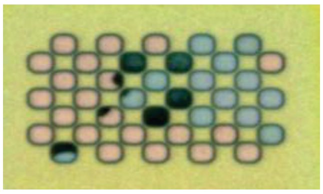


Fig.4 Areas with abnormal openings

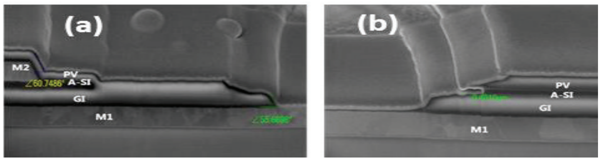


Fig.5 The comparison of normal and abnormal hole. The SEM of the (a) Normal Hole, (b)Abnormal Hole

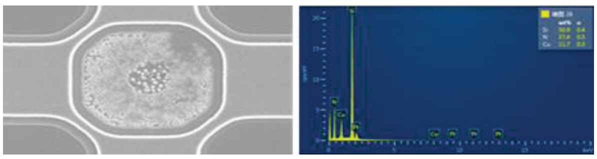


Fig.6 Analysis of EDS components of abnormal holes

Verification condition	HTM PHO Opening	1st Wet Etch Opening
Reference（EUV Off Befor 1st Wet）	OK	NG
PH Dev time：60s→70s	OK	NG
PH SS： 330→300	OK	NG
WET1 Spy flow:50→65L/min	OK	NG

Tab.1 Verification experiment

Subsequently, We performed an in-situ EUV irradiation treatment before the 1st Wet (Fig.7). Notably, with the increasing of EUV irradiation time, the M2 residues are gradually removed and finally eliminated completely. As shown in Fig.8, on the 1st Wet, air bubbles can be formed easily on the holes' surface of porous structure, which prevent etchant from further etching metal. But in-situ EUV irradiation can not only enhance the hydrophilicity of metal surface, but also improve the invasiveness of the etchant, which finally surmounts the M2 etching residual issue.In addition, as can be seen from Fig. 9, the in-situ EUV treatment before 1st Wet has no effect on the electrical properties of the device. Furthermore, the AM Mini-LED backpanel with high-density plum blossom 7-holes can be lighted successfully (Fig.10), further confirming that the 'in-situ EUV' treatment can be a superb way for the M2 etching residual removal.

Fig.7 The comparison of EUV on or off before 1st Wet

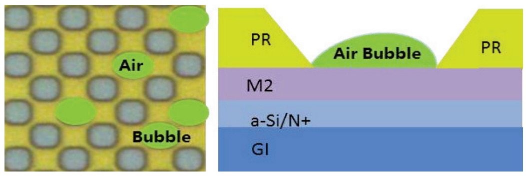
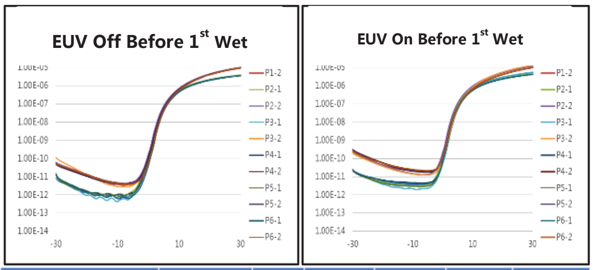


Fig.8 Schematic representation for etching residual principle



	u(cm2/V S)	Vth(V)	SS(V/dec)	Ioff	Ion	Ion/Ioff
EUV Off Befor 1st Wet	0.40	2.93	1.37	2.05E-12	9.83E-07	4.80E+05
EUV On Befor 1st Wet	0.45	2.73	1.32	2.85E-12	1.12E-06	4.24E+05

Fig.9 The comparisons of the electrical properties of EUV on/off before 1st Wet

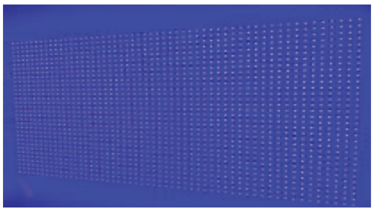


Fig.10 The digital photo of the lighted AM Mini-LED backpanel with high-density plum-blossom-7 holes structure

4 CONCLUSIONS

In summary, this paper report an in-situ EUV irradiation strategy for the M2 etching residual issue, which can enhance the hydrophilicity of metal surface and improve the invasiveness of the etchant without affecting electrical characteristics of the device.

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