Explanation of Mo Undercut and Cu Loss during LCD Panel Fabrication

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ABSTRACT

The phenomenon of Mo undercut and Cu loss is generally discovered during the manufacturing process of LCD display, which could be explained by galvanic corrosion of Mo followed by crevice corrosion of Cu. If Mo is replaced with more antioxided and anticorrosive ones, the above problems can be fundamentally solved.

1 INTRODUCTION

As the development of LCD display, the demand of high order panel with larger size, more pixels and better resolution is becoming more and more pressing. With lower electrical resistivity and thus lower RC-Delay time, copper (Cu) replaces aluminum (Al) as the new metal material for display fabrications. Nevertheless, copper process still exhibits some problems, especially poor adhesion with the glass substrate and easy diffusion to the active layer. As a result, a typical metal barrier material is employed just beneath the copper layer to overcome the above mentioned problems. Molybdenum (Mo), as a cheap material with good adhesion with the glass and good prevention of Cu diffusion to the amorphous silica layer，is chose to be a superior barrier material candidate for the Cu process fabrication. Mo, however, exhibits some headache issues, such as poor resistance to both acid and base, which normally contributes to corrosion problems and thus panel issues during display fabrication process.

2 EXPERIMENT

Recently, the formation of Mo undercut and Cu loss have been found during the panel processing with their forming process shown in Fig. 1. After the one-step wet etching of the Mo/Cu layers (1400 station), a seemingly small gap was formed between Mo and Cu layers. After the stripper process of the photoresist (1800 station), the gap becomes larger with more severe Mo and Cu loss. Then after the coverage of the metal layer by the gate insulator (2200 station), the gap expands and the small Cu loss hole shows up with the beneath Mo also be corroded thinner. As the glass experiences the following panel fabrication process, the loss hole becomes larger and the remaining Mo becomes thinner as shown in Fig.1d.

More metal line sites are cut after T300 station (array test) as shown in Fig. 2. To our surprise, different forms of Cu loss holes are found. Some metal lines only exhibit one

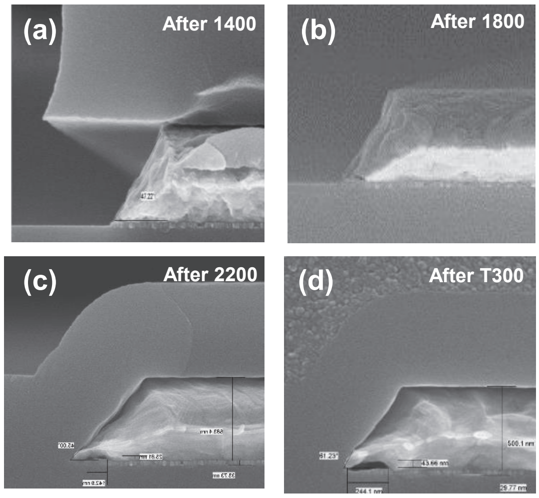

Fig. 1 The formation of Mo undercut and Cu loss during manufacturing process of LCD display with the respectively taper morphology after (a) wet etching (1400 station), (b) stripper of photoresist (1800 station), (c) gate insulator deposition (2200 station) and (d) array test (T300 station).

Cu loss holes while some lines experience two continuous Cu loss holes. Surprisingly, even three Cu loss holes are found in some sites as shown in Fig. 2c. Here comes the question that how to contribute to these typical forms of Cu loss and why some sites exhibit only one Cu loss hole while other places show two or even three holes.

A corrosion mechanism is proposed as shown in Fig. 3 in aim to explain the Mo undercut and Cu loss phenomenon in our system. In the environment of etching acid, both Mo and Cu exhibit the general corrosion, leading to a tiny gap between Cu and Mo layers. Then the substrate with patterned Cu/Mo layers undergoes the removal process of the photoresist, where the removal solvent is alkaline. As Mo is an amphoteric metal, the stripper solvent could corrode Mo easily. Just like the schematic diagram in Fig. 3b, Mo/Cu layers form a galvanic cell where Cu acts as the cathode and Mo is the anode.[1] As a result, Mo is oxided inside the gap and the compound $Mo(OH)_3$ is formed with the help of oxygen. On the outer surface of the Cu layer, the reduction reaction happens with the formation of hydroxyl ion. Then the gap between two metal layers

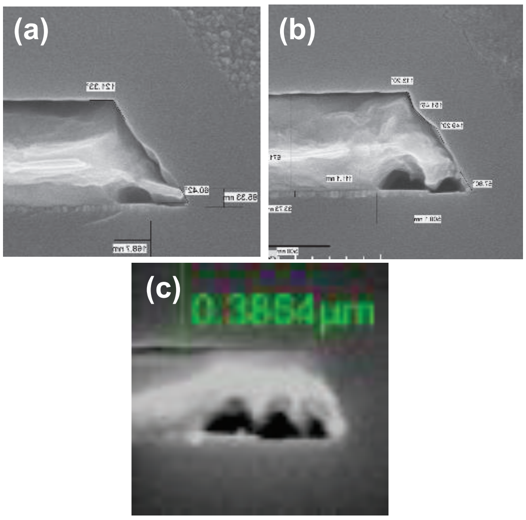

Fig. 2 Different degree of Mo undercut and Cu loss after T300 station with (a) one Cu empty hole, (b) two Cu empty holes and (c) three Cu empty holes.

becomes larger due to the galvanic corrosion[1] of Mo. As the corrosion goes on, the oxygen is depleted within the gap that induces the concentration difference of oxygen inside and outside the gap. The oxided Mo ion also begins to hydrolyze to produce H^+, contributing to the acid environment within the gap. Simultaneously, the reduction reaction continues on the outer surface of Cu while no reaction happens on the inner Cu surface inside the gap, leading to the potential drop along the Cu layer. The concentration difference of oxygen and the potential drop are two perfect driving force that induce the crevice corrosion[2] of Cu layer, creating the hole loss as depicted in Fig. 3d. Gradually, H^+ is accumulated within the gap and the loss hole expands (Fig. 3d). As the hole and the gap become larger, the driving force of crevice corrosion decrease along with the decrease of the concentration difference of oxygen inside and outside the gap. However, the deepest side inside the gap exhibit the highest inner and outer concentration difference of oxygen, which highly possibly acts at the new starting point to induce the new hole-type crevice corrosion (Fig. 3d). Finally Cu loss with two holes or even three holes could be observed after the T300 manufacturing station.

3 DISCUSSION

With the aim to weaken Mo undercut and Cu loss, the barrier layer of Cu is intentionally replaced with titamium (Ti), molybdenum-titamium alloy (MoTi) and indium tin oxide (ITO) (Fig. 4). Similarly, the glass of these samples after T300 station are cut to compare their corrosive status with the Cu/Mo system. To our surprise, all the Ti, MoTi and ITO based samples exhibit perfect metal taper morphology without undercut and Cu loss. It could be interpreted that Ti, MoTi and ITO exhibit good resistance to both acid and alkaline and thus there will be no gap between Cu and the barrier layer. As a result, the following

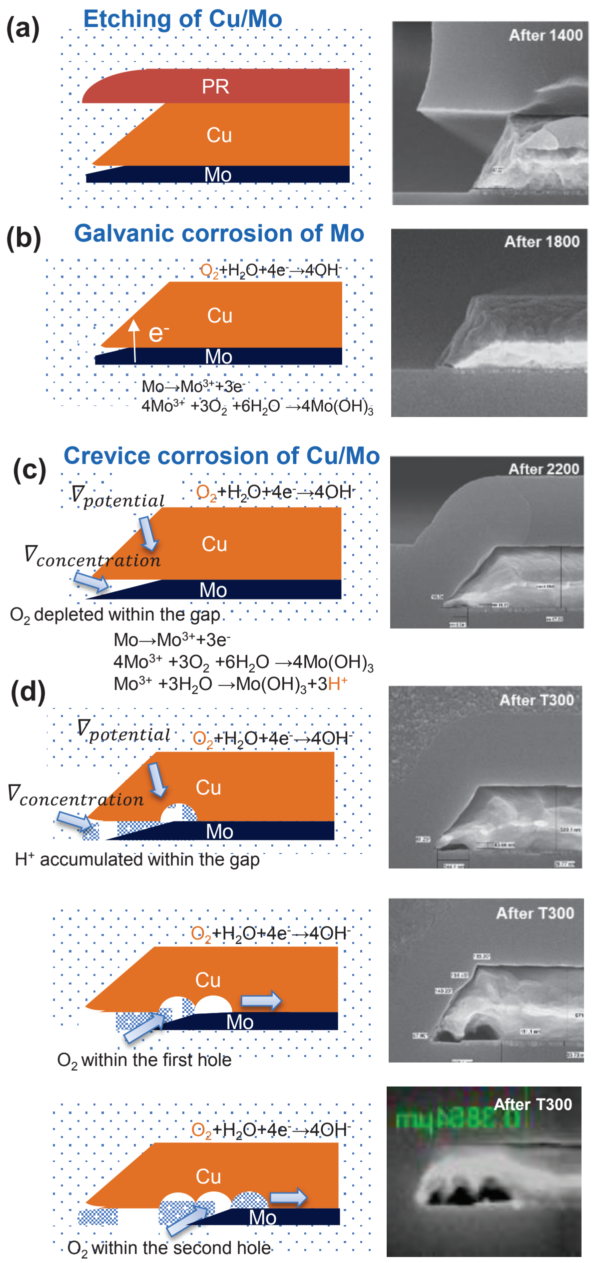

Fig. 3 The proposed mechanism of the formation of Mo undercut and Cu loss.

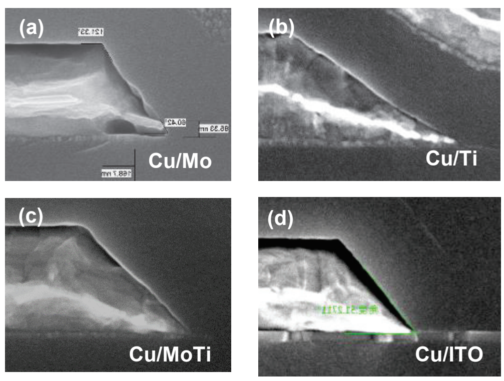

Fig. 4 Undercut and Cu loss phenomenon with the barrier material (a) Mo, (b) Ti, (c) MoTi alloy and (d) ITO.

galvanic corrision and the crevice corrosion exhibited by Cu/Mo layers could be refrained fundamentally. As a result, the corrosion problem could be solved by replacing the barrier material Mo with another antioxided and anticorrosive material during panel manufacturing.

4 CONCLUSIONS

As a common problem during panel fabrication, Mo undercut and Cu loss is comprehensively analyzed and then settled in this paper. Firstly, SEM fabrication is employed to capture different Mo undercut and Cu loss phenomenon after different processing stations. Surprisingly, different shapes of Cu loss are discovered after the array test station. To explain this special phenomenon, a convincing mechanism is put forward tightly according to the corrosion SEM pictures after different processing stations. Due to poor resistance to oxidation and corrosion of Mo, a small crevice is formed after 1800 station, which induces the following crevice corrosion of Cu because of the concentration difference of oxygen inside and outside the gap and the potential drop along the Cu layer. Finally, different degrees of crevice corrosion contribute to different morphology of Cu loss holes. If Mo is substituted with other materials like Ti， MoTi or ITO, the undercut and Cu loss problem can be completely solved because the galvanic corrosion of the barrier material could be prevented at the beginning, which provides us precious experience when choosing the appropriate barrier material for different panel production processes of display technology.

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