I. Abstract

We have developed the unique Ag alloy for ITO/Ag/ITO multilayer as alternative to ITO for display electrode. This Ag alloy enables to form stable ultra-thin film, which is important for transparent ITO/Ag/ITO structure. This technology is expected to be applied to various emerging devices such as flexible displays.

II. Introduction

Indium-Tin Oxide (ITO) has been widely used as transparent conducting material for various display devices. Whereas this material has some problems, such as the conductivity and the flexibility. High conductivity is required for responsivity when the panel size becomes larger. Flexibility is required at bending or folding. For those reasons, many effort has been made to develop alternatives to ITO.

ITO/Ag/ITO multilayer structure is one of the alternatives to ITO, which has a high transmittance and low resistance. One of the biggest challenge for ITO/Ag/ITO structure is the instability of ultra-thin Ag film, in other words, the degradation by the Ag agglomeration. Theoretically, when Ag film becomes thinner, the film transmittance becomes lower due to the decrease of the film absorption. Actually, Ag film becomes discontinuous (the aggregated Ag islands) when the film is thinner than a certain thickness. As the result, the optics and electronic characteristics degrades considerably. Furthermore, a thermal factor promotes the film agglomeration. Therefore, thermal resistance is also a big challenge.

In this study, we report about the Ag alloy with some additive elements, which overcome the challenges above. We expect that this Ag alloy enables the practical ITO/Ag/ITO structure as the alternative to ITO.

III. Experimental

Table 1. Sputtering conditions of ITO and Ag

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<table>
<thead>
<tr>
<th>Target size (mm²)</th>
<th>DC Power (W)</th>
<th>Gas Pressure (mTorr)</th>
<th>Dynamic Rate (mm/minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>125 x 178</td>
<td>200</td>
<td>Ar:O₂:Ar</td>
<td>2.2 x 10^{-3}</td>
</tr>
<tr>
<td>125 x 200</td>
<td>200</td>
<td>Ar:O₂:Ar</td>
<td>2.2 x 10^{-3}</td>
</tr>
<tr>
<td>60 x 120</td>
<td>200</td>
<td>Ar:O₂:Ar</td>
<td>2.2 x 10^{-3}</td>
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<tr>
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IV. Results and Discussions

Comparison with pure Ag and the Ag alloy

At the all thickness, pure Ag films aggregated. On the other hand, the Ag alloy didn’t aggregate even at 5nm. The Ag alloy showed lower sheet resistance and few change of resistance after THT. This result shows that the Ag alloy enables to suppress the agglomeration of Ag and to form good ultra-thin film which has also high durability.

Fig. 1 SEM images of as-deposited pure Ag and the Ag alloy films (deposited on ITO)

Fig. 2 Sheet resistance of as-deposited pure Ag and the Ag alloy films before and after THT

V. Conclusion

1. We have developed the Ag alloy which enables to form ultra-thin film without agglomeration.
2. ITO/Ag/ITO multilayer using the Ag alloy shows good property. (sheet resistance, transmittance, durability and flexibility)
3. The Ag alloy suppresses the surface diffusion of Ag by the additive element which segregates on the surface.