Fabrication of transparent conductive films with Ag mesh patterns using a monolayer of polystyrene shperes

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We show the fabrication of Ag mesh as a transparent conductive electrode using a polystyrene (PS) sphere template. To fabricate the Ag mesh pattern, monolayers of PS spheres with different diameters, such as 1, 3, and 10 μm, were investigated as a template. Since thick thickness and wide line width of Ag line degrade the transmittance, both heat pretreatment and wet etching are used to control the open ratio of Ag mesh films. The trade-off between transmittace and conductivity forces us to use larger diameter PS spheres. 10 micron PS spheres are chosen as the template for the Ps sphere monolayer, and the trasmittance and the sheet resistance are 70% and 15 Ω/sq . To improve the transmittance and conductivity of the films, we conducted O2 plasma treatment on the PS monolayer.

1. Introduction

All Thin transparent conducting films are crucial for liquid crystal displays (LCDs), flat panel displays, touch panels, organic light-emitting diodes (OLEDs), solar cells, smart windows, and other applications [1]. Currently, indium tin oxide (ITO), a transparent conducting oxide (TCO), is the industry standard due to its low resistivity (10^{-3}–10^{-4} Ω · cm) and high transparency in the visible spectrum (80%–90%). However, ITO has many disadvantages, such as rarity, high cost, possible exhaustion, process temperature limitations, and brittleness on a flexible substrate. In particular, as display technology moves toward flexible displays, ITO will become completely unsuitable due to its brittleness.

In this study, the transparent electrode with Ag mesh patterns is described. The monolayer of polystyrene (PS) spheres polystyrene spheres was prepared as a template to form the mesh pattern and coated with Ag ink. The heat pretreatment of PS monolayer and Ag wet etching processes can control the line of Ag mesh electrodes. We obtained Ag mesh films with 70 % transmittace and 15 Ω/sq sheet resistance. And, we conducted the O2 plasma treatment on the PS monolayer to improve the adhesion between Ag and substrate.

2.Experiments

We filled a water tank with deionized (DI) water. When a PS solution was dropped on the DI water, the PS spheres rapidly spread and self-assembled into a PS sphere monolayer on the DI water surface. After dropping a proper amount of PS solution, the monolayer was condensed by pushing it toward the wall using a bar. Finally, the transferred PS sphere monolayer on the PET substrate was dried by removing the DI water. Ag ink was dropped onto the surface of the PS sphere monolayer film. And then, the sample was heated on the hot-plate at 90 ℃ for 10 min. And, The PS was removed by immersing in toluene for 3 min. The Ag was cured in an annealing process at 140 ℃ for 10 min on a hot plate.

3. Result

We investigated that the heat pretreatment process of PS monolayer improve transmittance of the Ag mesh electrode.

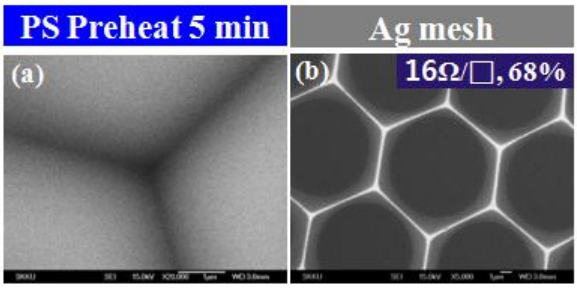

figure 1. FE-SEM images of (a) the PS sphere monolayer after heat treatment for 5 min, (b) the Ag mesh electrode fabricated using the preheated monolayer for 5 min.

4. Conclusion

We investigated that the heat pretreatment of PS monolayer and Ag wet etching processes can control electrical and optical properties of Ag mesh electrodes.

5. References

[1] Pang S, Hernandez Y, Feng X and M¨ullen K, Adv. Mater. **1** (2011) 23 2779.