ZnO/ITO anode for organic electro-luminescence devices

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Abstract

A bilayer is used as an anode electrode for organic electroluminescent devices. The bilayer consist of an ultrathjn ZnO layer adjacent to an hole-transporting layer and an Indium tin oxide(ITO) outerlayer. We tried to bring low the barrier between the devices as deposited ZnO films on ITO substrates. We fabricated the organic EL structure consisted of Al as cathode, Al_2O_3 as electro transport layer, Alq3 as luminously layer, triphenyl diamine(TPD) as hole transport layer and ZnO(1 nm)/ITO(150 nm) as anode. The result of this experiment was not good compared with the case of using ITO, Nevertheless, at this structure we obtained the lowest turn-on voltage as the value of 19 V and the good brightness (6200 cd/m^2) of the emission light from the devices. Then the quantum efficiency was to be 1.0%.

1. Objectives and Background

Organic electroluminescence divices(OELDs) have been attracting considerable attention for flat panel display. Tris-(8-hydroxy-quinoline)aluminum(Alq_3) is one of the most widely used materials for OELDs due to its excellent stability and luminescent properties. [1,2] OELDs have a multiplayer structure including a transparent anode, an organic active layer, and a metallic cathode. It has recently improved introducing interlayers between the emitting layer and the cathode. This layer could be formed by deposition a thin layer of metal fluoride[3,4,5] A large number of transparent conducting oxides(TCOs), such as In_2O_3, ZnO, SnO_2, and doped oxides, have been widely studied over the years. Zinc oxide or impurity doped zinc oxide[6] films have been actively investigated as alternate materials to ITO because zinc oxide is a nontoxic, inexpensive and abundant material. It is also chemically stable under hydrogen plasma processes that are commonly used for the production of solar cells[7]. In addition, Transparent insulating ZnO films with higher resistivities can be deposited by introducing oxygen during r.f. magentron sputtering deposition[8].

In this paper it has improved inserting a thin insulating layer between the emitting layer and the anode.

2. Results

It seems quite probable that the growth rate and doping have a strong influence on the electrical properties of ZnO films, because of electrons in ZnO films are supplied from donor sites associated with O-vacancies or high-valence metal ions.

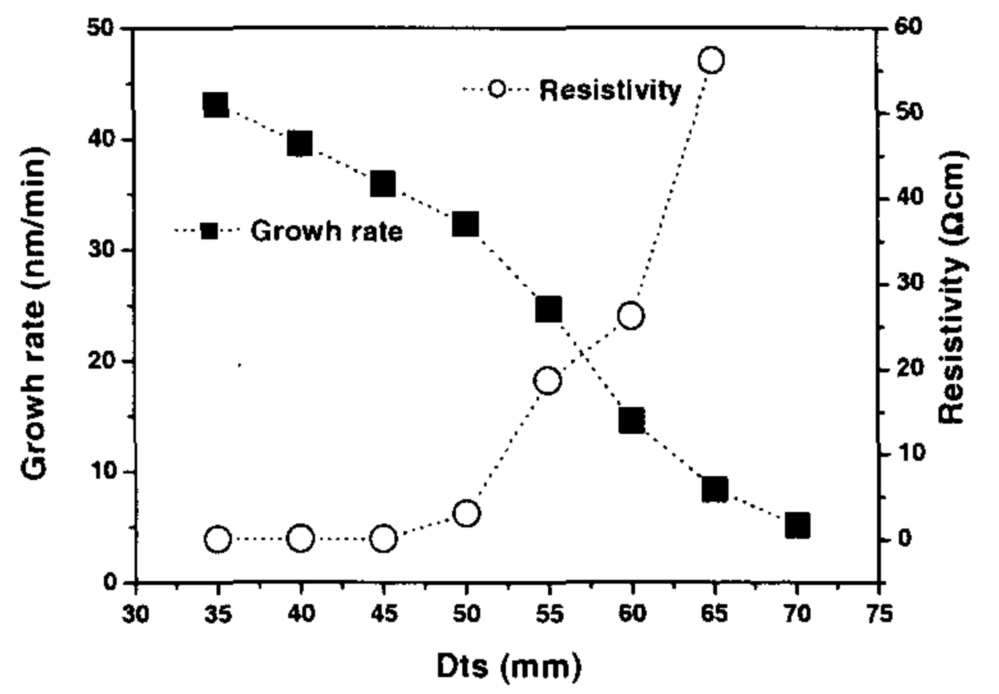

Figure 1: Plot of deposition rate and the electrical resistivity as a function of the D_{ts}.

Figure 1 shows an increasing tendency of the resistivity in the D_{ts} ranges from 50 to 65 mm.(range I) This is due to improved of the crystallinity to become more stoichiometric films with increasing the D_{ts}. When the D_{ts} are below 50 mm, however, resistivity remains near low cost value(range II). This is because the crystallinity of the resulting films being worsened and films becoming non-stoichiometric with decreasing the D_{ts}. Then the low resistivity is due to the dopant such as O-vacancies and Al ions. Thus, the lowest resistivity (9.8×10^{-2} Ωcm) obtained in this study was appeared at D_{ts} of 45 mm.

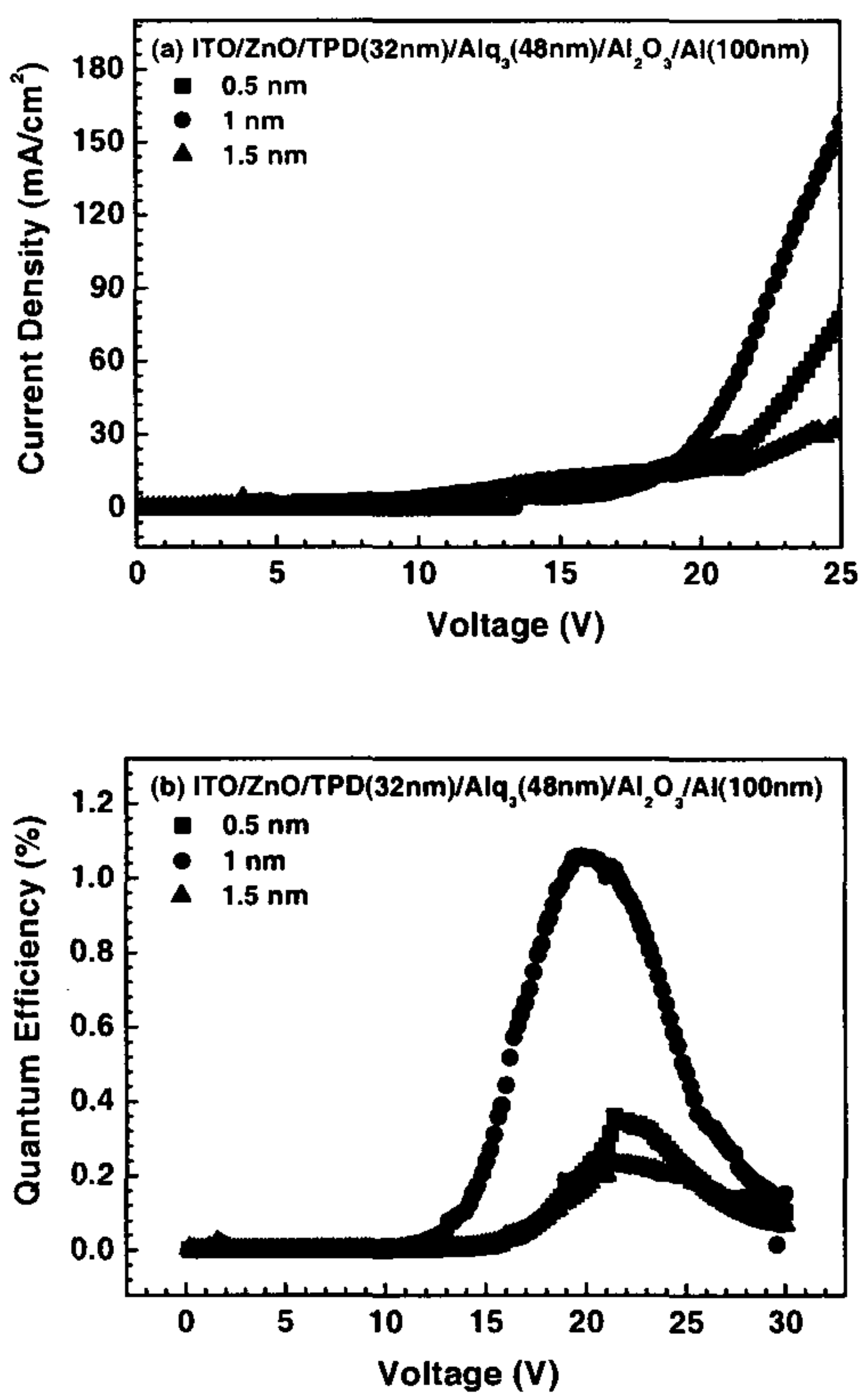

Figure 2: (a) I-V characteristics and (b) quantum efficiency of the device as a function of the ZnO thickness(0.5, 1, 1.5 nm)

Enhanced quantum efficiency was observed in polymer ELDs through inserting a tunneling barrier[9]. In this work, we tried to bring low the barrier between the devices as deposited ZnO films(range I) on ITO substrates. We fabricated the organic EL structure consisted of Al as cathode, Al_2O_3 as electro transport layer, Alq_3 as luminously layer, triphenyl diamine(TPD) as hole transport layer and ZnO(1 nm)/ITO(150 nm) as anode. The result of this experiment was not good compared with the case of using ITO, Nevertheless, at this structure we obtained the lowest turn-on voltage as the value of 19 V and the good brightness (6200 cd/m^2) of the emission light from the devices. Then the quantum efficiency was to be 1.0%.

3. Impact

In summary, ITO was found to be useful as a anode for OELDs by interposing a thin (1nm) ZnO layer between ITO and TPD. It was observed that the the presence of ZnO at the ITO-TPD interface caused band bending of TPD, thus influencing the hole-injection barrier height.

4. Acknowledgements

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5. References

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