Mechanism of Nitrogen Doping of Zinc Oxide Nanoparticles by Arc Plasma and Study of Their p-type Characteristics

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Introduction

The application of ZnO in light-emitting devices (LEDs) has been investigated for many years. However, acceptor doping has remained challenging, and the key factors that would lead to reproducible and stable p-type doping have not yet been identified [1]. Despite the difficulties in achieving p-type conductivity, our group has successfully developed nitrogen-doped p-type ZnO nanoparticles (NPs) using a DC arc plasma gas evaporation method and fabricated homojunction LEDs [2]. In this study, we investigated how the nitrogen doping conditions affect the p-type properties of nitrogen-doped ZnO NPs and the LEDs, and attempted to elucidate the mechanism.

Experimental

N-doped ZnO NPs were fabricated by the DC arc discharge method by employing a mixture of gas plasma of N_2 and O_2 as the N source and oxygen source respectively in conjunction with zinc plasma initiated by dc arc current. The plasma parameters like temperature and density were monitored by varying arc current and chamber pressure to obtain stable nitrogen doped ZnO NPs and further studied by OES (optical emission spectroscopy) methods. Finally, ZnO NPs-based solution-processed LEDs were fabricated [2].

Results and discussion

Optical emission spectra recorded from dc arc plasma during ZnO nanoparticle synthesis are shown in figure 1. The intensity of atomic N at the 869 nm line increased as the arc current was increased but intensity was reduced as the chamber pressure was increased. ZnO NPs generated at 150T 50A showed the highest nitrogen concentration in the ZnO nanoparticles as detected by thermal conductivity measurements while the plasma temperature was lowest as shown in figure 2, resulted in enhanced light emission/electroluminescence when compared with other fabrication conditions. The fabricated LEDs had an ultraviolet near-band-emission of around 380 nm as shown in EL spectra in figure 3. The mechanism will be discussed in detail.

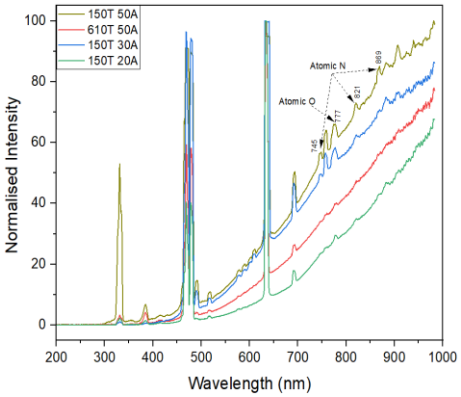

Figure 1. OES spectra during synthesis.

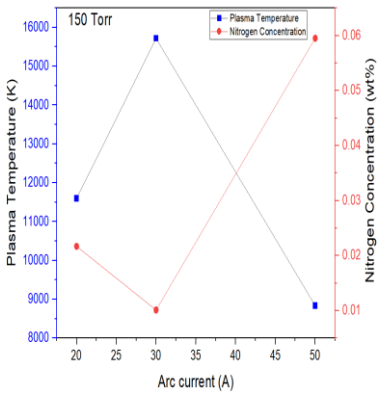

Figure 2. Plasma temp. and N concentration.

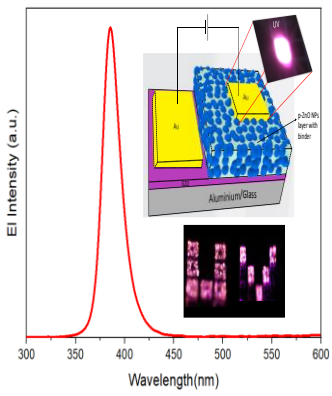

Figure 3. EL Spectra, Inset: UV-LED.

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References

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