Ultraviolet-Light-Emission of (0001)-Oriented ZnO Film Prepared by Electrodeposition

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Introduction

(0001)-oriented ZnO is a realistic candidate for a room-temperature ultra-violet light-emitting material due to its band gap energy of 3.3eV and high exciton binding energy of 59meV and have been prepared by heteroepitaxial growth with gas-phase deposition techniques, in which heating processes at above 673K during and/or after the film deposition are indispensable.

Electrodeposition of ZnO films, which has several advantages over gas-phase deposition techniques, has been demonstrated by Izaki and Omi and by Peulon and Lincot. Here we show a low temperature electrodeposition of high quality (0001)-oriented ZnO layer, which emits ultra-violet light due to bound excitons and visible light at room temperature.

Experimental procedure

0.05mol/L zinc nitrate hydrate aqueous solution with pH 5.3 was used for the electrodeposition. The Au coated Si wafer substrates were used as the substrate. The electrodeposition of 200nm-thick-ZnO was performed potentiostatically at 333K by cathodic polarization for electric charge of 0.5coulombcm^{-2} at potentials of –0.50 to –0.80V referenced to Ag/AgCl electrode. Pt sheet was used as the anode.

Results and Discussion

(0001)-oriented ZnO layers with a wurtzite structure have been obtained by the electrodeposition, irrespective of the preparation potential. The degree of (0001) preferred orientation was estimated from the peak intensity of ($10\bar{1}1$) pole figures for wurtzite ZnO. The peak intensity increased when the potential was brought to the negative side up to –0.75V and showed almost constant value at potentials ranging from –0.7 to –0.6V. And, the intensity decreased at a positive potential of –0.5V. The excellent (0001) preferred orientation was obtained at potentials ranging from –0.7 to –0.6V.

Figure shows room-temperature photoluminescence spectra for ZnO layers prepared at several potentials. Photoluminescence peaks could be observed at photon energies of 2.3 and 3.3eV for the ZnO layer prepared at –0.7V. The photoluminescence peak at around 3.3eV was disappeared for ZnO layers with relatively weak (0001) preferred orientation, which were prepared at cathodic potential of –0.5V and –0.8V. The ultraviolet-light at photon energy of 3.30eV was originated from the near band emission due to recombination of bound excitons. The visible light at photon energies of 2.3-2.8eV was identified to deep level emission due to impurities and native defects such as interstitial zinc atoms in ZnO crystal. The intensity ratios of near band emission to deep level emission was estimated to be about 1.5 for ZnO layer prepared at –0.7V. Since the quality of ZnO layer strongly affected the intensity ratio, the near band emission at photon energy of 3.3eV and high intensity ratio are an evidence of the high quality of (0001)-oriented ZnO layer prepared by low-temperature electrodeposition.

Reference

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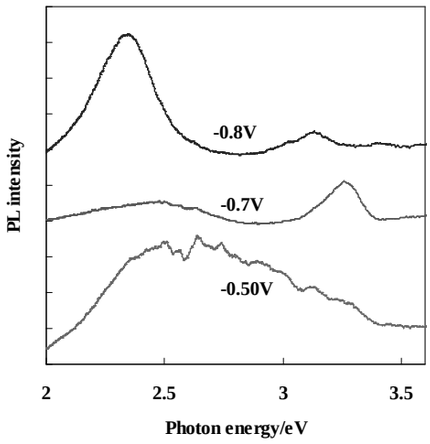

Figure Photoluminescence for ZnO layers prepared at several potentials.