유기금속화학기상증착법을 이용하여 성장시킨 ZnO 에피박막의 시간분해, 시간집적 발광 특성평가

Time-resolved and time-integrated photoluminescence in ZnO epilayers grown by metal-organic vapor epitaxy

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There has been great interest in the growth and optical characterizations of ZnO thin films for ultraviolet (UV) photonic device applications[1]. From the PL spectra, PL peaks associated with free excitons and stimulated emission in ZnO epilayers have been observed at room temperature, implying that an exciton-related recombination process can be utilized for optoelectronic devices. However, little research has been conducted on the vapor phase epitaxial growth of ZnO thin films. In this research, we focus on radiative recombination in ZnO epilayers grown by MOVPE. Details on the conditions of film growth have been previously reported[2]. A typical PL spectrum of ZnO films measured at 10 K using a He-Cd laser is shown in Figure 1. The dominant peak at 3.366 eV is tentatively ascribed to the exciton transition (I_2) bound to neutral donors. The exciton peak of the MOVPE-grown film showed the narrow full-width at half-maximum (FWHM) value of 7 meV. Sharp excitonic emission and weak deep level emission indicate that the MOVPE-grown film is of high optical quality. In Figure 2, the PL spectrum at 10 K shows five distinct peaks at 3.366, 3.334, 3.263, 3.236, and 3.190 eV and three shoulder features at 3.385, 3.297, and 3.224 eV. The dominant peak at 3.366 eV is tentatively ascribed to neutral donor bound excitons, and the other peak at 3.334 eV is tentatively attributed to the excitonic transition bound to a neutral acceptor or a deep donor. The weak shoulder at 3.385 eV is presumably due to the recombination of free excitons. The shoulders at 3.297 and 3.224 eV presumably result from LO phonon replicas of the bound exciton at 3.366 eV. The peaks at 3.263 and 3.190 eV are also tentatively attributed to LO phonon replicas of the bound exciton peak at 3.334 eV, and the shoulder at 3.297 eV is attributed to that of the free exciton peak at 3.385 eV. Temperature-dependent PL intensities also provides additional evidence for the origins of PL peaks. As shown in Figure 1, the luminescence spectra at 10 K are dominated by the bound excitons at 3.366 eV and 3.334 eV. However, as temperature increased, the intensity of the bound excitons decreased since the bound excitons dissociated and became free excitons. Hence, the bound exciton peaks and all of their phonon replicas almost disappeared at temperatures above 160 K. To ascertain free exciton lifetime, TRPL experiments have been carried out at 300 K for the ZnO epilayer. Figure 3 shows TRPL of the ZnO film measured

at the 3.26 eV free exciton band. The decay profile fits well by a biexponential function without introducing a rise time. the time constants are 180 ps and 1.0 ns with their relative amplitudes of 2.8 to 1. The short time constant is comparable to the 200 ps exciton lifetime for the ZnO film prepared by plasma enhanced molecular beam epitaxy[3].

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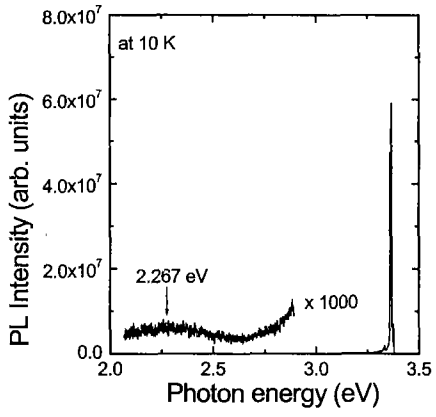


Fig. 1. PL spectrum of ZnO at 10 K.

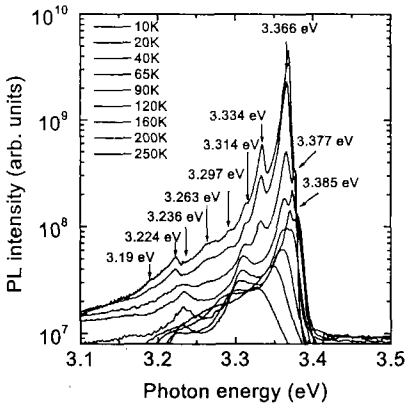
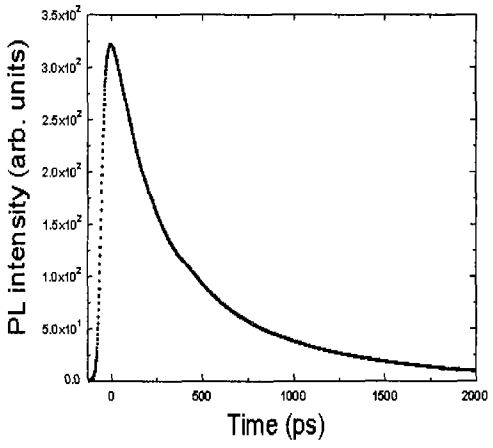


Fig. 2. Temperature-dependent PL spectra of ZnO epilayers



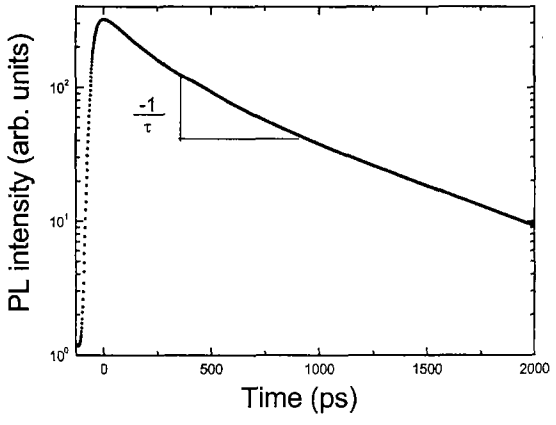


Fig.3. Time-resolved photoluminescence data.