A Novel Growth Method of Axial $ZnO/Zn_{1-x}Mg_xO$ Quantum Well in a Microrod

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To date, the majority of published results for ZnO nanostructures have been related to various nanoobjects of pure ZnO without any additional quantum structures. However, more sophisticated structures are commonly required in many applications. For example, modern semiconductor lasers typically contain many epitaxial layers that form cladding, waveguide, electron blocking and active regions. There have been very few reports on ZnO nanowires with any $Zn_{1-x}Mg_xO/ZnO/Zn_{1-x}Mg_xO$ quantum structures. Unfortunately, the emission of single quantum wells (SQWs) obtained previously using metalorganic vapor-phase epitaxy or pulsed laser deposition was either broad or it contained several parasite sharp lines at the spectral position of the SQW.

Here, we report on a fabrication and optical properties of an axial $Zn_{1-x}Mg_xO/ZnO/Zn_{1-x}Mg_xO$ quantum well grown by molecular beam epitaxy (MBE) on a ZnO microrod prepared using a hydrothermal method. Based on cathodoluminescence (CL) spectra and the results of numerical modeling, we determine the SQW width as 4 nm, as intended at the growth stage. SQW thickness is confirmed using transmission electron microscopy. The emission of quantum well-confined excitons persists up to room temperature (RT) (Fig. 1). The strong RT CL indicates that increase of electron-hole overlap due to the quantum confinement of carriers efficiently limits an influence of non-radiative processes. The linewidth of the SQW emission line at 5 K standing at 18–19 meV indicates a good structural quality of the sample. We use the fabricated structure to determine the carrier diffusion length (>280 nm) in ZnO using spatially resolved CL. Micro-photoluminescence results suggest, moreover, a strong increase of the electron-phonon coupling strength with increasing microrod size.

The present work proves that MBE growth of a quantum structure on top of hydrothermally grown ZnO microrods, free of an undesired quantum structure formation in the space between the microrods and without any parasitic core-shell structures has been successfully performed.

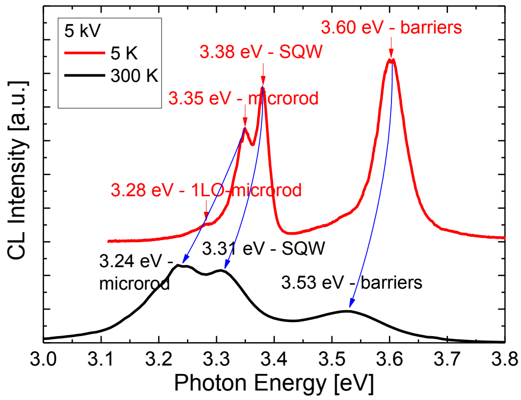

Figure 1. Cathodoluminescence spectrum of axial $Zn_{1-x}Mg_xO/ZnO/Zn_{1-x}Mg_xO$ quantum well grown on a ZnO microrod at 5 K and 300 K. The main emission peaks are labeled in the graph. The spectra are vertically shifted for clarity.

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