# 유기금속화학기상증착법을 이용한 $ZnO/Zn_{0.8}Mg_{0.2}O$ coaxial nanorod single-quantum-well 구조의 제조 및 양자 구속 효과 특성 평가

# Quantum confinement observed in $ZnO/Zn_{0.8}Mg_{0.2}O$ coaxial nanorod single-quantum-well structures

배준영[a], 장의순[a], 박원일[a], 이규철[a,*], T. Yatsui[b], M. Ohtsu[b]
[a]포항공대 신소재공학과 반도체 나노막대 연구단, [b]Japan Science and Technology Agency
[*]gcyi@postech.ac.kr

One-dimensional (1D) semiconductor nanorod heterostructures are potentially ideal functional components for nanometer-scale electronics and optoelectronics, due to their high aspect ratio offering easy manipulation for nanodevice fabrications.(1-2) Especially, if novel coaxial semiconductor nanorod quantum structures with a well-defined compositional profile along the radial direction of nanorods can be realized, new nanoelectronic devices including nanowaveguides, nanocapacitors, light-emitting nanodevices, and high electron mobility nanotransistors would be obtained.(3) Despite significant progress in nanorod quantum structures, meanwhile, coaxial nanorod quantum structures have rarely been reported. Here we report on fabrication and photoluminescent (PL) properties of $ZnO/Zn_{0.8}Mg_{0.2}O$ coaxial nanorod single-quantum-well structures (SQWs).

Catalyst-free metalorganic vapor-phase epitaxy was employed for precise controls of well widths and compositions of the coaxial nanorod SQWs. The synthesis of core ZnO nanorods was carried out using diethylzinc (DEZn) and oxygen as the reactants with argon as the carrier gas. Depending on the growth conditions, the mean diameters of ZnO nanorods were in the range of 20 - 50 nm. Subsequent deposition of $Zn_{0.8}Mg_{0.2}O$ shell layer was performed by addition of bis-cyclopentadienyl-Mg ($Cp_2Mg$) as the Mg precursor at the same chamber, resulting in $Zn_{0.8}Mg_{0.2}O$ layer coating on entire ZnO surfaces. By growing the ZnO and $Zn_{0.8}Mg_{0.2}O$ layers alternatively, ZnO/ZnMgO coaxial quantum well layer was fabricated (Figure 1). The growth times of ZnO well layers in the samples were 5, 15, 30, 60, 90sec, respectively. After the ZnO quantum well layer deposition, the $Zn_{0.8}Mg_{0.2}O$ barrier layer was deposited one more time. From far-field PL spectra of $ZnO/Zn_{0.8}Mg_{0.2}O$ coaxial nanorod SQWs in Figure 2, we observed the discrete energy level in a cylindrical ZnO quantum-well layer and a PL peak blue-shift dependent on the ZnO well layer width resulting from a quantum confinement effect. From monochromatic PL images of $ZnO/Zn_{0.8}Mg_{0.2}O$ coaxial nanorod SQWs obtained at a photon energy of 3.467 eV ($I_{QW}^{ZnO}$) depending on the ZnO well layer width and a donor bound exiton energy of 3.365 eV ($D_oX^{ZnO}$), it was found that $ZnO/Zn_{0.8}Mg_{0.2}O$ coaxial SQWs was well made on all the surface of ZnO nanorods.

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## REFERENCES


1. M. S. Gudiksen, L. J. Lauhon, J. Wang, D. C. Smith, and C. M. Lieber, Nature 415, 617 (2002); L. J. Lauhon, M. S. Gudiksen, D. Wang, and C. M. Lieber, ibid. 420, 57 (2002).
2. Y. Wu, R. Fan, and P. Yang, Nano Lett. 2, 83 (2002).
3. J. Hu, Y. Bando, Z. Liu, T. Sekiguchi, D. Golberg, and J. Zhan, J. Am. Chem. Soc. 125, 11306 (2003)


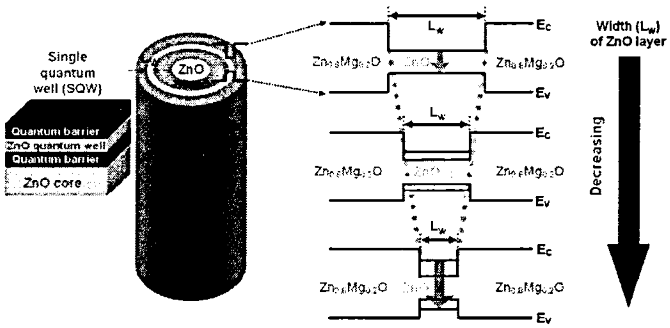


Fig. 1. Schematic of coaxial nanorod SQWs consisting of $Zn_{0.8}Mg_{0.2}O/ZnO/Zn_{0.8}Mg_{0.2}O$ on the full surface of ZnO nanorods and SQWs electronic band diagram.

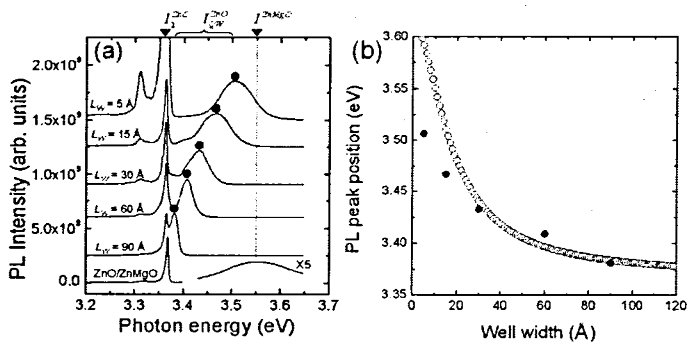


Fig. 2. (a) 10 K far-field PL spectra of $ZnO/Zn_{0.8}Mg_{0.2}O$ coaxial nanorod heterostructure and coaxial nanorod SQWs with different ZnO well layer widths and (b) ZnO well layer width vs. PL peak energy position in $ZnO/Zn_{0.8}Mg_{0.2}O$ nanorod SQWs (closed circles) and theoretically calculated values (open circles).