Luminescence of 10-stack Submonolayer InAs Nanostructures at the 2D-3D Transition

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Stacked submonolayer (SML)–grown InAs/GaAs nanostructures have been gaining interest as alternative to the well-known Stranski-Krastanov (SK) InAs nanostructures.[1] Compared to SK growth, stacked SML growth involves the cycled deposition of SML-thick InAs and ML-thick GaAs. We recently reported evidence of 2D-3D growth transition in SML nanostructures,[2] characterized by a redshift and broadening of the photoluminescence (PL).[3] This transition leads to the existence of two distinct kinds of stacked SML nanostructures: 2D islands and 3D structures.[4] In this study, the PL wavelength of 10-stack SML nanostructures is finely controlled across the 2D-3D growth transition by varying the amount of deposited InAs in the last cycle. A coexistence of 2D and 3D SML nanostructures at the transition will be shown by the presence of two distinct PL peaks.

All samples were grown by MBE on s.i. GaAs (001) substrates. The general sample structure is similar to those in previous works.[2,3] The 10-stack SML nanostructures were grown at 500°C, after oxide desorption at 600°C and a 100-nm GaAs buffer growth at 590°C. To finely control the PL wavelength of the 10-stack SML nanostructures, the amount of InAs in the 10^{th} and last deposition cycle was varied from 0.4 to 0.9 ML, whereas the first 9 InAs depositions were kept at 0.4 ML. The GaAs spacer was kept at 2.0 ML/cycle. After SML deposition, samples were capped with 50-nm GaAs. All sample were characterized by low temperature PL, with Ti-sapphire laser excitation at 1.25 W/cm^2 (λ_{ex} = 740nm) and detection by an InGaAs photodiode array.

Shown in Fig. 1(a) are the PL spectra from the 10-stack SML samples with varied last cycle deposited InAs. For the 0.4 and 0.6 ML samples, a single sharp peak is observed, indicating 2D SML nanostructures,[3] whereas for the 0.8 and 0.9 ML samples, a single broad and redshifted peak is observed, indicating 3D SML nanostructures.[3] For the 0.7 ML sample, two distinct peaks can be observed: a sharp peak at short wavelength (915nm) and a broad peak at longer wavelength (933nm), which indicate a coexistence of 2D and 3D SML nanostructures. This result suggests that very near the 2D-3D transition both 2D and 3D SML nanostructures are present. Shown in Fig. 1(b) are plots of the peak wavelength positions of the 2D and 3D SML nanostructures from the data in Fig. 1(a). The results show that the 2D PL peak initially redshifts with increase deposited InAs. At the 2D-3D transition, the 2D PL peak slightly blue shifts which coincides with the onset of the 3D PL peak, suggesting material transfer from 2D to 3D SML nanostructures. Beyond the transition, only the 3D PL peak is observed and continuously redshifts with increasing deposited InAs.

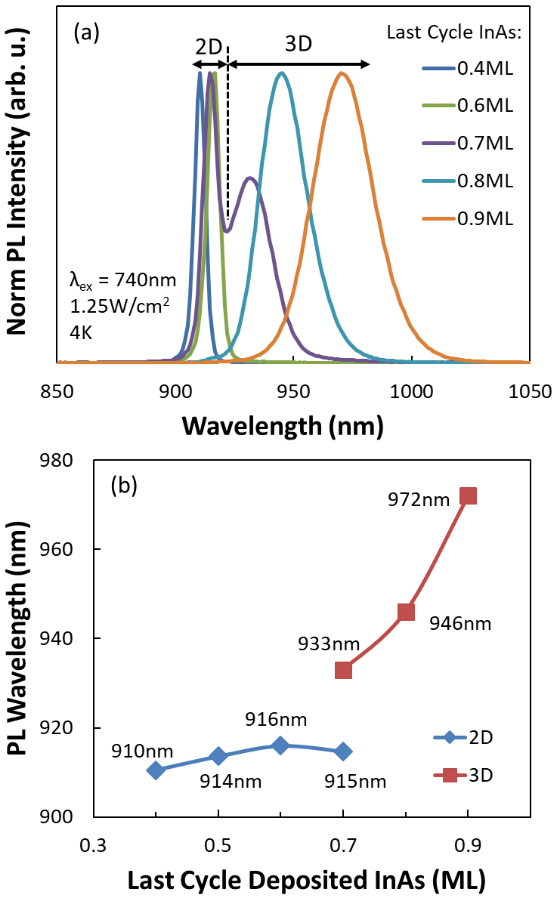

Figure 1. (a) 4K Photoluminescence spectra of 10-stack SML nanostructures with varied last cycle deposited InAs, and (b) Peak positions of 2D and 3D peaks extracted from data in (a).

In conclusion, fine tuning of the PL of 10-stack SML nanostructures at the 2D-3D transition has been demonstrate. At the transition, a coexistence of 2D and 3D SML nanostructures has been observed.

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References:

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