

Photoluminescence Evolution of Submonolayer Nanostructures at the 2D-3D Transition

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InAs/GaAs nanostructures assembled by stacked submonolayer (SML) growth is one of the promising alternatives to the conventional Stranki-Krastanov (SK) InAs nanostructures.¹ While recent reports have clarified the existence of a transition from 2D (layer-to-layer) to 3D growth regime,^{2,3} the SML transition is still not well understood. In the present report, the time evolution of the SML transition is investigated by introducing a growth interruption before GaAs capping and photoluminescence (PL) measurements. The interruption allows for the growth transition to occur and capping effectively freezes the state of the transition, as shown in Fig. 1. By varying the interruption time, it is possible to probe the time evolution of the growth transition.

All samples were grown by MBE on s.i. GaAs (001) substrates. For each sample: oxide was desorbed at 600°C, followed by a 100-nm GaAs buffer was grown at 590°C. The temperature was then brought down to 500°C, where a 30-nm GaAs layer and the 10-stack InAs/GaAs SML nanostructures were grown. The SML nanostructures consist of alternate depositions of InAs and GaAs, which are repeated until 10 InAs stacks are grown. The InAs and GaAs were kept constant at 0.44ML and 2.0ML per period, respectively. After the SML growth, 50-nm GaAs capping was performed after a growth interruption (from 0 to 120s). Samples were then taken out of the MBE and PL measurements were performed.

Shown in Fig. 2 are the PL spectra of samples with varying interruption durations. For the 0s sample, only a single narrow peak that corresponds to 2D SML nanostructures is observed.⁴ For 15s and 30s samples, a second broad peak can be observed, which correspond to the 3D SML. Finally, for the 120s sample, the 2D SML peak significantly decreases while the 3D SML peak becomes broader and become multimodal, suggesting the formation of different modal sizes of the 3D SML nanostructures.

In conclusion, the results suggest that varying the interruption duration before GaAs capping effectively freezes samples at different stages along the 2D-3D SML transition, and thus allows for the time evolution of the 2D-3D transition to be investigated.

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References:

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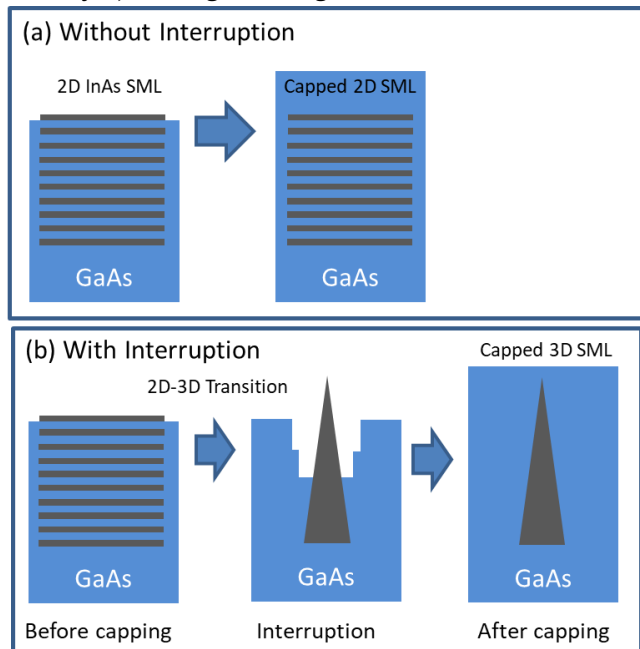


Figure 1. Diagram of SML samples: (a) without and (b) with interruption before capping. The interruption allows for 2D-3D growth transition to occur before capping.

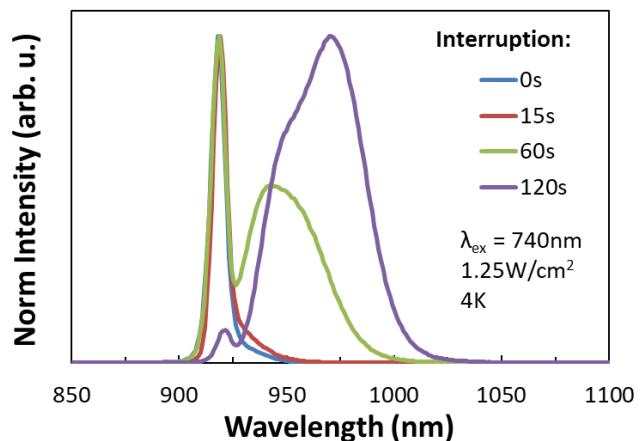


Figure 2. PL spectra for varying interruption durations.