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J. Park<sup>1\*</sup>, E. G. Lee<sup>1</sup>, and G. D. Hong<sup>2</sup>

<sup>1</sup>*Department of Physics, Chungnam National University, Daejeon, Korea*  
<sup>2</sup>*Department of Materials Engineering, Sungkyunkwan University, Suwon, Korea*

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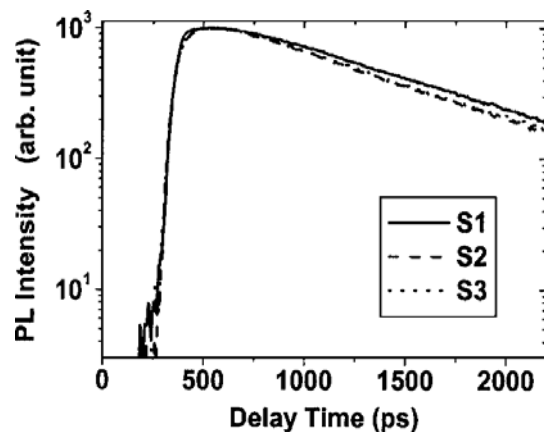
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Despite the large lattice mismatch between InAs and GaAs, almost defect-free InAs quantum dots (QDs) can be grown in a GaAs matrix by carefully choosing the growth parameters. A recent study on the strain relaxation as a function of the nominal thickness of the InAs layer shows that strain relaxation induces defects and dislocations, resulting in diminished QD device performance. The pathway by which carrier numbers are reduced in QDs may be different from that in quantum wells, since QDs are strong and intrinsic localization centers for carriers. One interesting question is whether carrier reduction occurs before or after capture into the QD. This information may be important for the design of QD devices.

Here we have examined two defect free QD samples (S1, S2) and one defect-containing QD sample (S3). The similarity of the lifetimes of these systems indicates that the carriers are strongly confined in the QDs, with no carrier transfer from the QDs to nearby defects. The lower PL intensity of S3 compared to that of S2 can be mainly attributed to the loss of carriers to defects before the carriers enter the QDs. As the temperature increased, the PL intensity of the S2 decreased much faster than that of S3. However, the lifetimes of the two samples were almost the same, even at 150 K [1]. From these experimental results, we can conclude that the rapid reduction in the PL intensity with increasing temperature for S3 is due to increased capture of carriers by defects before the carriers enter the QDs.

When carriers are created in the wetting layer the nonradiative recombination pathway in the GaAs barrier cannot influence the PL intensity. This is the reason of the increase in the PL yield ratio from 10 % to 30 %. When carriers are generated directly in the QD, we can ignore defects in the GaAs barrier and the wetting layer. The PL yield ratio with direct excitation is the highest, 55%, due to the reduction in carrier capture by defects before entering the QDs and negligible carrier transfer from QDs to defects.

We found that the carriers captured in QDs are robust and are not lost to nearby defects, even at elevated temperature, and that the lower emission efficiency of QDs with defects compared to the corresponding defect-free QDs is due to the capture of carriers to defects before entering into the QDs.



[1] E. G. Lee, M. D. Kim, and D. Lee, J. Korean Phys. Soc. 48, 1228 (2006)

\*J. Park, e-mail: findsome@cnu.ac.kr, Tel: +82-42-821-7473, Fax: +82-42-822-8011