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液滴エピタキシー法による格子緩和した InAlAs/InAs/GaAs(111)A 上の 1.55 ミクロン発光する InAs 量子ドットの作製

Formation of InAs quantum dots emitting at 1.55μm using droplet epitaxy on metamorphic InAlAs/InAs/GaAs(111)A

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Introduction InAs quantum dots (QDs) have been extensively investigated for the application to the light emitters in optical-fiber telecommunication (telecom) devices [1, 2]. To achieve 1.55-μm wavelength emission, InP-based system has been often used [2, 3]. However, the use of GaAs-based QD systems that emit 1.55μm is still highly desired when we consider the cost, thermal conductivity, and implementation of highly efficient distributed Bragg reflectors (DBRs) [4]. Recently, we obtained a crucial result that the insertion of an ultra-thin InAs layer helps us to grow high-quality metamorphic InAlAs buffer layers on GaAs (111)A substrates [5]. Here, we report the growth of symmetric InAs QDs that emit photons at around 1.55μm on these buffer layers.

Experiments The samples were grown on GaAs (111)A by solid source molecular beam epitaxy. After the growth of a 50-nm GaAs buffer layer at 500 ℃, we grew 3 monolayers (MLs) of InAs at 470°C. Then, 100 nm-thick $In_{0.52}Al_{0.48}As$ was grown at the same temperature. For the formation of InAs QDs on $In_{0.52}Al_{0.48}As$, firstly, 0.4 ML indium was supplied at 320℃ without an As_4 flux. Next we supplied an As_4 flux of 3.0×10^{-5} Torr at 270℃ for crystallization of indium droplets into InAs QDs. After annealing at 370℃ for 5 min under an As_4 flux, InAs QDs were capped by a 75-nm $In_{0.52}Al_{0.48}As$ at 370℃. Finally, the samples were annealed at 470℃ for 5 min to improve crystal quality. The samples were characterized by atomic force microscope (AFM) and photoluminescence (PL).

Results and discussion Figure 1 (a) shows an AFM image of uncapped InAs QDs on the metamorphic $In_{0.52}Al_{0.48}As$/InAs/ GaAs(111)A. Well-defined InAs QDs were formed. The density of QDs is 5×10^9 /cm^2, and averaged lateral size and height are 41 and 1.6 nm. The distribution of them is around ±25%. Most of the QDs exhibit highly symmetrical shape owing to the three-folded rotational symmetry of the (111) growth plane. Figure 1 (b) shows the PL spectrum of capped InAs QDs measured at 9 K. Broad spectrum that covers 1.55μm-wavelength range is observed. The broad emission is consistent with the large size distribution of QDs. The PL spectrum consists of multiple peaks. We attribute them to different groups of QDs whose heights vary by a ML step. In addition, the PL emission from the QDs is visible up to room temperature as shown in Fig. 1 (c), indicating superior crystalline quality of the InAs QDs. From the results, we believe that the technique exploited here is promising to realize InAs QDs emitting at 1.55μm on GaAs substrates.

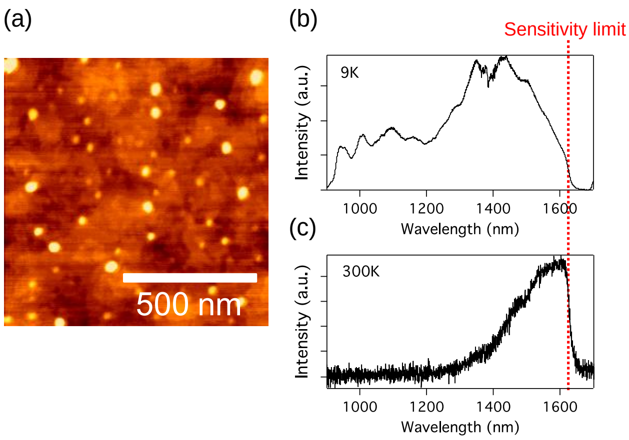

Fig. 1 (a) AFM image of uncapped InAs QDs on $In_{0.52}Al_{0.48}As$/InAs/GaAs(111)A, and PL spectra of capped InAs QDs measured at (b) 9 K and (c) 300K.

References

[1] K. Akahara, et al., Physica Status Solidi A **208**, 425 (2011).
[2] Q. Gong, R. Nötzel, et al., Appl. Phys. Lett. **84**, 275 (2004).
[3] N. Ha, et al., Appl. Phys. Lett. **104**, 143106 (2014).
[4] V. S. Mikhrin, et al.,Semiconductors, **40**, 342 (2006).
[5] T. Mano, N. Ha, et al., JSAP Spring meeting 17a-E11-7 (2014).