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液滴エピタキシー法による InP(111)A 基板上 InAs 量子ドットの作製とその 1.3μm 及び 1.55μm 帯発光

Formation of InAs quantum dots on InP(111)A by droplet epitaxy and their optical emission at 1.3μm and 1.55μm

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Introduction Symmetrical quantum dots (QDs) formed on (111) surfaces are highly advantageous for their entangled photon emission. On the other hand, it is difficult to form QDs on the (111) surfaces using the conventional Stranski-Krastanov growth mode [1,2]. In our group, we have realized highly symmetric GaAs QDs/AlGaAs on GaAs (111)A emitting at 700nm using droplet epitaxy (DE) and demonstrated their high quality entangled photon emission recently [3,4]. For the next step, it is now desired to extend the emission wavelength of the symmetric QDs to the telecom-wavelength range for the practical application. In this study, we investigated the DE of symmetric InAs QDs on InAl(Ga)As/InP(111)A.

Experiments The samples were grown on InP(111)A by a solid source molecular beam epitaxy. After growth of $In_{0.52}Al_{0.48}As$ (or $In_{0.52}Al_{0.24}Ga_{0.24}As$) buffer layer at 470°C, 0.4 ML In was supplied to form In droplets at 320°C without As flux. The In droplets were crystallized by a supply of As_4 flux of 3×10^{-5} Torr at 270°C, followed by annealing at 370°C for 5 minutes under As_4 supply. Finally QDs were capped with $In_{0.52}Al_{0.48}As$ (or $In_{0.52}Al_{0.24}Ga_{0.24}As$) at 370°C.

Results and discussion Fig. 1 shows AFM image of InAs QDs on InAlAs just before capping. The density of QDs is $3.5\times10^9/cm^2$. Most of the QDs are highly symmetric, which is due to the three-fold rotational symmetry of the (111) surface. Fig. 2 shows low temperature PL spectra of InAs QDs buried in (a) $In_{0.52}Al_{0.48}As$ and (b) $In_{0.52}Al_{0.24}Ga_{0.24}As$. High-yield broad band PL emissions were observed from both of the QDs. Using the $In_{0.52}Al_{0.48}As$ barrier, the emission is centered at 1.3μm. The spectral multiplet is attributed to ground state emissions from different InAs QD families whose heights vary by a ML step. By using the InAlGaAs barrier (Fig. 2 (b)), the emission wavelength shifts to longer wavelength and a part of the QDs emit PL at 1.55μm.

From the results, we conclude that DE of InAs QDs on InP(111)A is highly promising for realizing on-demand entangled photon emitters at telecom-wavelengths.

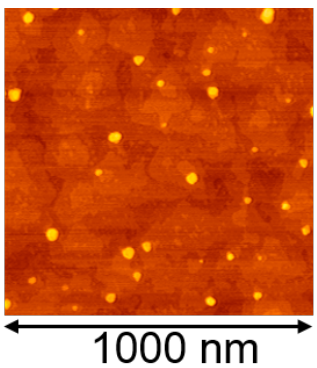

Fig. 1 AFM image of InAs QDs on InAlAs

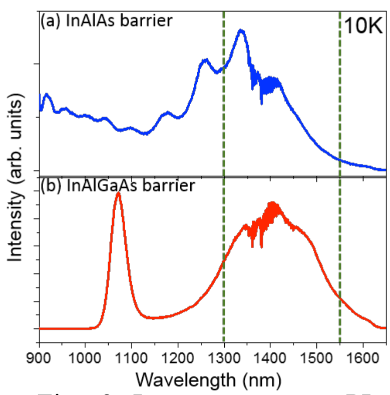

Fig. 2 Low-temperature PL spectra of InAs QDs on (a) InAlAs and (b) InAlGaAs

References

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