

[23-T14]

Fabrication of Semiconductor Nano-Structures for Quantum Devices

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The size of QDs on 2°-off (100) GaAs substrate is normally less than the terrace widths, which are transformed by bunching effect mainly due to Ga diffusion during the growth. On the other hand, the misfit dislocation having strain fields affects the formation of QDs and the interaction between buried dots and surface dots, leading to vertical stacks. The use of strained layer will be also a feasible method for the alignment of QDs since it does not use a mask and lithography technique[5]. In this work, we have investigated the dependence of GaAs buffer layer on the distribution of InAs QDs grown on 2°-off (100) GaAs substrate and controlled the alignment of QDs flexibly using strained InGaAs/GaAs superlattice system without employing any complicated pre-processes.

The epitaxial layers were grown by the metal organic vapor phase epitaxy(MOVPE) and the molecular beam epitaxy(MBE) techniques. The growth temperature, the growth thickness, and the interrupt time of InAs QD are 430°C, 2.5ML, and 20sec, respectively. AsH₃ partial pressure and V/III ratio are 1.2×10^{-3} atm and 225, respectively. In the MBE method, we deposited 0.5 μm thick GaAs buffer layer at a growth rate of 1 ML/s on GaAs (001) substrate. During the buffer layer growth, substrate temperature was 580°C. After the buffer layer was prepared, substrate temperature was lowered to 480°C for the formation of InGaAs/GaAs strained layers and InAs QDs. In order to investigate the applicability of the InAs QDs on the strained superlattice, the measurement of atomic force microscopy(AFM) and photoluminescence(PL) were performed.

[Figure 1] shows the AFM images of the wirelike QDs grown on 2°-off (100) GaAs substrates with various thicknesses of the GaAs buffer layers of 43, 70, and 120ML, respectively. The terrace widths of the GaAs buffer layers with the thicknesses of 43, 70, and 120ML were 55, 75, and 91 nm, respectively. The optimal thickness of the InAs layer for fabricating wirelike InAs QDs were 2, 2.3, and 2.5 ML, respectively. Therefore, the interval of wirelike QDs grown on 2°-off (100) GaAs substrates could be well controlled by changing the thicknesses of the InAs active layers and of the GaAs buffer layers.

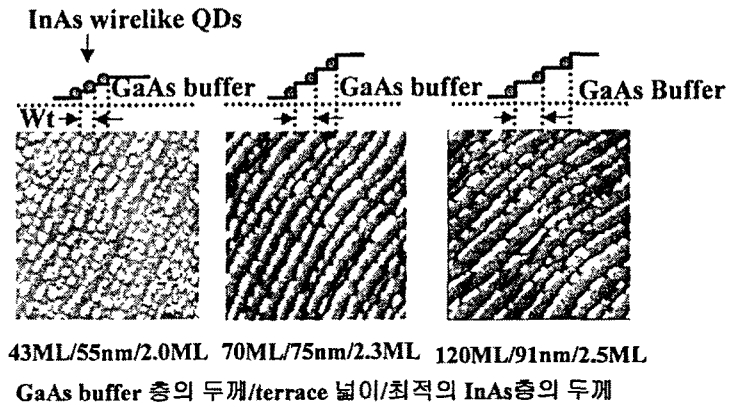


Fig. 1. $1 \times 1 \mu\text{m}^2$ atomic force microscopy images of wirelike InAs QDs on 2° -off (100) GaAs substrates.