CHAPTER SIX

Conclusions

In this thesis, the formation and optical properties of low density InAs quantum dots and area-controlled InAs quantum dots was closely investigated for high efficient single photon emitters. In chapter.2, formation and optical properties of InAs quantum dots with low densities and long emission wavelengths were investigated. First, low density quantum dots ($\sim 10^8 cm^{-2}$) were achieved using high growth temperature. High growth temperature leads to a reduction in QD density and also increasing in QD size. With these low density quantum dots, we performed the macro PL measurements at room temperature and micro PL measurements at 5K. Both PL measurements proved the good optical quality of low density quantum dots. Particularly, in the micro PL measurements at 5K, single dot spectroscopy has been achieved without any structure and clear exciton/biexciton behavior has been observed. Next, we fabricated ultra low density ($<10^7 cm^{-2}$) quantum dots using low InAs coverage. As a result of micro PL, only a few peaks from individual dots has been achieved. For ultra low density growths$\sim 10^6 cm^{-2}$, only a single peak has been observed throughout the wide range wavelength. Such ultra low QD density makes the fabrication of single photon sources easy. Then we have succeeded to achieve the light emissions over 1.3um at 5K using InGaAs strain reducing layer. The emission wavelengths of InAs QDs were red-shifted about 1um due to the reduced strain by InGaAs SRL.

In chapter.3, fabrication of patterned SiO_2/GaAs substrates for selective growth was introduced. First, SiO_2 mask was deposited by using sputtering system. After sputtering, resist was coated over the surface of a SiO_2/GaAs substrate homogeneously using a spin coater. Then the designed pattern was transferred to resist by using electron beam lithography and development. Finally, the designed pattern was transferred to SiO_2 mask using wet etching and resist was subsequently removed by removal.

In chapter.4, preliminary study of growth conditions for area-controlled quantum dots was described. Because of the growth enhancement within the exposed window from the masked region, the growth conditions of quantum dots on patterned SiO_2/GaAs substrates was quite different from those of non-patterned substrates and thus we had to decrease the depositing amount of materials. We found that only nearby SiO_2 region affect the formation of area-controlled quantum dots. Owing to this fact, we changed the pattern designs in order to perform further analysis. Instead of only $10\times10\mu m^2$ patterned area in one sample, we made a line structure by repeating $10\times10\mu m^2$ patterns. Such line structure allows us to perform AFM analysis and also to measure PL luminescence much easily.

In chapter.5, formation and optical properties of area-controlled quantum dots are studied. First, area-controlled quantum dots were grown by using growth conditions which were figured out in chapter.4. InAs coverage dependence and SiO_2 quality dependence of formation of area-quantum dots were studied. Then we found that thermal etching effect allows us to make low density quantum dots which were desirable for combination with photonic crystals. Next, PL characteristics of area-controlled quantum dots were investigated. For all samples, we could achieve emissions from quantum dots, and we succeed to obtain the PL emissions even at room temperature. It is considered that thermal etching yields the removal of damaged interface and thus enables us to grow quantum dots with good optical quality.

We think that this work is successful attempt for the high efficient single photon emitters and for other applications which need the positioning of quantum dots. .

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Presentation List

１)

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