Uni-edit Sample of Level 2 English Editing
(Materials and Quantum Dots)

Comment [A1]: Please see: www.uni-edit.net ozysmile@gmail.com

Low Density InAs Quantum Dots Grown on InP(001) ~~by~~ using Solid-Source Molecular Beam Epitaxy ~~Applying~~with a Post-Growth Annealing Process

Low density InAs quantum dots (QDs) with a large lateral size were grown on InP(001) ~~by~~ using solid-source molecular beam epitaxy with a post-growth annealing process. A decrease of QD density with the amount of InAs deposition was shown using~~by~~ atomic force microscopy, and a density of 5×10^8 QDs/cm^2 was obtained with ~~a~~ 0.8 monolayer (ML) InAs deposition. Moreover, we found that the growth mechanism of QDs ~~significantly~~ changed significantly depending on the amount of InAs deposition in the vicinity of the critical thickness, even if the same annealing condition was applied. Near-field photoluminescence spectroscopy of single QDs demonstrated the high optical qualities~~y~~ of ~~the~~ low density QDs.

1. Introduction

Single self-assembled quantum dots (QDs) have attracted a great deal of attention as ~~a~~ building blocks of quantum information processing devices, such as ~~a~~ single photon emitters for quantum cryptography.[1)] They have advantages in terms of controllable emission wavelengths[2)] and sharp linewidths[3)] over other candidates for single photon emitters. In order to ~~apply~~ use QDs ~~to~~ as single photon emitters for optical fiber-based quantum cryptography, QDs emitting at the optical telecommunication wavelength of 1.55 μm are desirable. InAs QDs on an InP substrate are a promising material because they emit a photon at this wavelength due to a smaller lattice mismatch (~3.2-%), which permits larger QDs than other candidates such as InAs/GaAs QDs.[4] Also, the heights of InAs/InP QDs ~~is~~are adjustable by the double-cap method; that is~~, i.e.~~, the emission wavelengths ~~is~~are precisely controllable.[2]

Improv~~ement of~~ing the photon extraction efficiency from a QD is another challenge in~~to~~ realizing~~e~~ a workable single photon emitter because the efficiency is lowered by a high refractive index of matrix material. One promising way to overcome this problem is to confine a single QD in a microcavity, such as a photonic crystal microcavity. However, it is necessary to reduce the QD density to confine only one QD in a cavity because high-densit~~y~~ies of quantum dashes (QDas) or quantum sticks are inherently formed in InAs/InP(001) systems.[5,6] Recently, Michon *et al.* have reported very low density InAs/InP QDs grown by metal-organic vapor phase epitaxy.[7] By simultaneously ~~R~~reducing ~~simultaneously~~the InAs and InP cap layer growth rates, they obtained a QD density of 9×10^7 QDs/cm^2 with an average lateral size of 42.9 nm. Although the density was satisfactorily reduced, larger-sized QDs are more advantageous for radiation control because the exciton oscillator strength increases with the lateral size of a QD. We have shown that a post-growth ripening process of InAs QDas is an effective method to produce low density InAs QDs on InP(001).[8] In this study, we employed another post-growth annealing process to grow large-sized InAs QDs on InP(001) at a low density. By controlling both the annealing process and the amount of InAs deposition, a QD density of 5×10^8 QDs/cm^2 was attained.

Comment [BM2]: CHECK: The 'QDa' acronym is rarely used in this paper and is easily confused with the more common 'QD'. You might like to use 'quantum dash' in full in its next use to avoid confusion.

Comment [BM3]: CHECK: Do you mean that 'quantum sticks' is another name for 'quantum dashes', or that they are different types of structure? If they are the same, then you could say 'quantum dashes, also known as quantum sticks'.

Comment [BM4]: CHECK : Do you mean 'exciton' or 'excitation' ?

Comment [BM5]: CHECK : Do you mean 'ripening' or 'annealing' ?

2. Experimental Methods

Seven uncapped QD samples (samples A– to G) were prepared. All samples were grown by solid-source molecular beam epitaxy (SSMBE) in a RIBER Compac21 reactor equipped with As_2 and P_2 valved cracker cells. The growth can be followed on the reflection ~~high energy~~high-energy electron diffraction (RHEED) pattern. A 250 nm InP buffer layer was deposited on an InP(001) semi-insulating substrate. InAs was grown on the buffer layer at 520 °C with an As_2 overpressure of 2×10^{-6} Torr and ~~with~~ a monolayer (ML) growth rate of 0.2 ~~monolayer (~~ML~~)~~/s. The deposited InAs thickness was in the 0.6–1.4 ML range. Depending on the

Comment [BM6]: CHECK: Introducing the acronym inside the measurement units seemed awkward, so I moved it to an earlier position. Please check this usage.

Comment [BM7]: CHECK: If ML stands for 'monolayer' then what are the units for these numbers? Please clarify.

InAs thickness, three-dimensional (3D) growth is or not observed on the RHEED pattern during the InAs growth. Low density InAs islands were then formed during a post-growth annealing process at the growth temperature under the As_2 overpressure of 2×10^{-6} Torr for times ranging from 80 s to 240 s.

Comment [BM8]: CHECK: Do you mean 'is not' or 'may or may not be'? Please clarify.