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Semiconductor Nano Structures for Quantum Devices

Eun Kyu Kim, Chan Kyeong Hyon and Young Ju Park
Nano Device Research Center, KIST, Seoul 130-650

We have been studied the nano-fabrication of semiconductors such as quantum wells, wires and dots by molecular beam epitaxy (MBE) and metal organic chemical vapor deposition (MOCVD) techniques. Especially, quantum dots (QDs) as a quasi-zero dimensionally quantum system may open new types of device schemes such as resonant tunneling device and single electron transistor. There has been a great deal of development in various types of quantum dot devices utilizing modulated semiconductor structures. Recently, several tunneling devices incorporating such self-assembled QDs have been demonstrated.

The Stranski-Krastanow growth mode using lattice mismatch has the ability of the creation of damage-free QD structures such as In(Ga)As/GaAs, In(Ga)As/InP, and Si(Ge)/Si systems. The strained layers, which were included misfit dislocations with slightly over the critical thickness, were used by employing the lattice mismatched systems, such as SiGe on Si and InGaP on GaAs. The misfit dislocation having strain fields affects the formation of QDs and the interaction between buried dots and surface dots, leading to vertical stack. The misfit dislocations become a strong source of elastic strain. The use of strained layer will be a feasible method for the alignment of QDs since it does not use a mask and lithography technique.

In this work, we have investigated the dependence of GaAs buffer layer on the distribution of InAs QDs grown on 2o-off (100) GaAs substrate and controlled the alignment of QDs flexibly using strained InGaAs/GaAs superlattice system without employing any complicated pre-processes. Also, we will show that the combination of the AFM direct patterning and subsequent quantum dot (QD) growth enables flexible control of the location and the size of the QDs. The direct patterning introduces multi-atomic steps on the GaAs surface, which act as nucleation sites for InAs QDs, meanwhile QDs on an undamaged surface will grow in normal Stranski-Krastanow mode. In order to elucidate the structural and optical properties of InAs

QDs, the measurement of atomic force microscopy (AFM) and transmission electron microscopy (TEM), and photoluminescence (PL) were performed.