Formation of quantum-disk shaped InAs/GaAs quantum dots within GaAs capping layer

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Due to their novel physical properties, self-assembled semiconductor quantum dots (QDs) have been widely investigated to improve the device performance of the infra-red (IR) laser diodes (LDs).[1] It has been known that the optical and electrical properties of the LDs can be strongly affected by the shape and size of QD and the lattice strain.[2-3] Many investigations have been carried out to characterize morphological shape and atomic structures of QDs.[4] As for the QDs with open surface structure, the shape and size-distribution dependence on QDs with an open surface structure have been extensively studied. However, there are few studies on the structural analysis of buried QDs in capping layer even though (for the real device) QDs with a GaAs or an InGaAs capping layer are much more technologically important than QDs with an open surface for the real device applications.

In this work, the structural and morphological properties of 3ML-thick InAs/GaAs(001) quantum dots (QDs) with/without GaAs capping layer are investigated using x-ray scattering, high-resolution transmission electron microscopy (HR-TEM). The QDs without capping layer are under compressive strain with non-uniform status. This strain is gradually relaxed from –7% to –2.3% toward QD apex. However, the QDs with GaAs capping layer is under hydrostatic-like pressure and therefore, the in-plane lattice spacing is nearly matched with GaAs substrate with 0.4% compressive strain status. The QDs without capping layer have {136} low angle facets with droplet shape, however capped QDs have flattened apex with {111} high angle facets. Therefore, the QDs within capping layer are transformed to quantum disk with {111} facets. These facets are determined from transverse scans near (0004) Bragg reflection, phase contrast imaging and annular dark field method of HR-TEM.

References

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