

Epitaxy Growth of InSb and InAs Quantum Nanostructures on GaSb Substrate by Droplet Epitaxy

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In epitaxial growth, two main methods have been employed to form quantum nanostructures (QNs) over the past three decades: the Stranski–Krastanov (S–K) mode and the droplet epitaxy (DE) method [1, 2]. Among them, DE offers the unique advantage of enabling the formation of QNs even under lattice-matched conditions, unlike the S–K mode [3]. This technique has been successfully applied not only to lattice-matched systems such as GaAs/AlGaAs but also to lattice-mismatched systems such as InAs/GaAs [2,3]. Recently, it has been reported that QNs can also be formed in the type-II band alignment system of InAs/GaSb, which is lattice-mismatched [4].

In this work, we fabricated InSb and InAs QNs, including quantum dots (QDs) and quantum rings (QRs), by DE using molecular beam epitaxy (MBE). Surface reconstructions during the DE process were monitored using reflection high-energy electron diffraction (RHEED). For the formation of InSb QNs on GaSb (100) substrates, a buffer layer was first grown, showing streaky (2×5) RHEED patterns at a substrate temperature (T_s) of 50 °C, indicating a relatively flat surface. Upon supplying 2 ML of indium, the RHEED patterns changed from streaky to spotty and arrowhead-like, suggesting the formation of nanostructures (Fig.1(a-d)). Scanning electron microscopy (SEM) images revealed rectangular nanostructures elongated along the [-110] direction (Fig.1(e)). These nanostructures are attributed to the formation of InSb resulting from the reaction between indium and residual Sb atoms on the (2×5) reconstructed surface during indium deposition. These results demonstrate that high-quality InSb/GaSb nanostructures can be successfully fabricated using the DE. For the formation of InAs QNs on GaSb surfaces, indium droplets were first formed on a modified GaSb surface and then crystallized under an As_2 beam equivalent pressure (BEP) of 1.5×10^{-5} Torr at a T_s of 300 °C. In addition, InAs QDs were formed at T_s below 100 °C. The effects of T_s and modified growth conditions on the QNs morphology will be discussed.

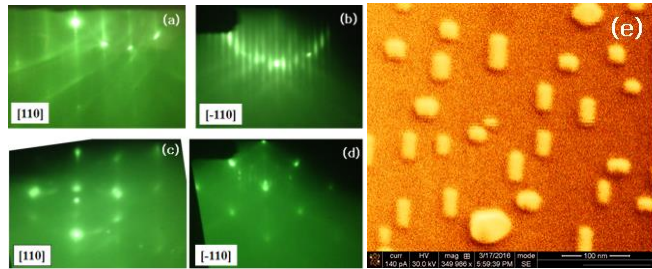


Fig.1. RHEED patterns of (a, b) GaSb (2×5) and (c, d) after indium supply, (e) SEM image of InSb QNs on GaSb (100) surface.

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[3] J. S. Kim et al, Appl. Phys. Lett. 88, 241911 (2006)

[4] V. Dahiya et al, J. Cry. Growth 492, 71 (2018)

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