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Growth Control of Twin InSb/GaAs Nano-Stripes by Molecular Beam Epitaxy

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Abstract

InSb has been considered as a promising material for spintronic applications owing to its pronounced spin effects as a result of large intrinsic electronic g-factor. In addition, embedding InSb quantum nanostructures in a GaAs matrix could create type-II band alignment, where radiation lifetimes are longer than those of the typical type-I systems. Such characteristics are promising for memory devices and infrared photonic applications. The growth of InSb/GaAs quantum nanostructures by strain driven mechanism using molecular beam epitaxy with low growth temperature, slow growth rate, Sb soaking process prior to In deposition, and small amount of In deposition typically creates a mixture of twin and single nano-stripe structures with truncated pyramid shape. In this work, we further investigate the growth mechanism of such twin InSb/GaAs nano-stripes by controlling the growth conditions, consisting of nanostructure growth duration and growth temperature. When the growth temperature is kept to less than 300 degrees C and In deposition is set to only a few monolayers, we found that 25-40% of formed nanostructures are twin InSb/GaAs nano-stripes. However, when the In deposition is stopped immediately after the spotty reflection high-energy electron diffraction patterns are observed, the ratio of twin nano-stripes to single ones is increased to 50-60%. We therefore describe the growth mechanism of twin nano-stripes as the early state of single nano-stripe formation, where the twin nano-stripes are initially formed during the first monolayer of InSb formation as a result of large lattice mismatch of 14.6%. When In deposition is increased to a few monolayers, the gap between twin nano-stripes is filled up and consequently forms the single nano-stripes instead. With this particular twin nano-stripe growth mechanism, the preservation of high ratio of twin nano-stripe formation can be expected by further reducing the growth temperature, i.e. less than 260 degrees C. These twin nano-stripes may find applications in the fields of spintronics and novel interference nano-devices.

Keywords

KeyWords Plus: INSB QUANTUM DOTS; GASE; GAAS; NANOSTRUCTURES; MATRIX; INAS

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ABSTRACT

InSb has been considered as a promising material for spintronic applications owing to its pronounced spin effects as a result of large intrinsic electronic g -factor. In addition, embedding InSb quantum nanostructures in a GaAs matrix could create type-II band alignment, where radiation lifetimes are longer than those of the typical type-I systems. Such characteristics are promising for memory devices and infrared photonic applications. The growth of InSb/GaAs quantum nanostructures by strain driven mechanism using molecular beam epitaxy with low growth temperature, slow growth rate, Sb soaking process prior to In deposition, and small amount of In deposition typically creates a mixture of twin and single nano-stripe structures with truncated pyramid shape. In this work, we further investigate the growth mechanism of such twin InSb/GaAs nano-stripes by controlling the growth conditions, consisting of nanostructure growth duration and growth temperature. When the growth temperature is kept to less than 300°C and In deposition is set to only a few monolayers, we found that 25-40% of formed nanostructures are twin InSb/GaAs nano-stripes. However, when the In deposition is stopped immediately after the spotty reflection high-energy electron diffraction patterns are observed, the ratio of twin nano-stripes to single ones is increased to 50-60%. We therefore describe the growth mechanism of twin nano-stripes as the early state of single nano-stripe formation, where the twin nano-stripes are initially formed during the first monolayer of InSb formation as a result of large lattice mismatch of 14.6%. When In deposition is increased to a few monolayers, the gap between twin nano-stripes is filled up and consequently forms the single nano-stripes instead. With this particular twin nano-stripe growth mechanism, the preservation of high ratio of twin nano-stripe formation can be expected by further reducing the growth temperature, i.e. less than 260°C. These twin nano-stripes may find applications in the fields of spintronics and novel interference nano-devices.