XSTM Experiment

Sample Structure

InGaAs Quantum Dots

1. Reversed Truncated Cone
   - average dot thickness of about 5 nm
   - lateral size of the dots varying between 10 and 20 nm
   - inhomogeneous indium composition
   - indium rich center in form of a reversed truncated cone
   - dot border
   - observed three different dot types
     - dots with an indium distribution characterized by a reversed truncated In-rich cone
     - quantum ring-like structures with lack of indium right at the position where the highest indium concentration is found in type-1 dots
     - nanovoids, characterized by a real material hole in the center and In atoms forming above the void a second wetting layer for strain accommodation

Analysis of the Stoichiometry

Indium distribution is characterized by a reversed truncated In-rich cone with a maximum In content of about 60%.

Conclusion

1. Quantum Dots
   - kidney shaped structures with average thickness of about 5 nm
   - corresponding to the cross section of a quantum dot with a crater-like depression
   - lack of indium right at the position where the highest indium concentration is found in type-1 dots

2. Nanovoids
   - shape and size of the nanovoids varies with the sample bias
   - larger size at positive sample bias indicates a lack of Ga atoms and an ionic formation of the inner surface of the void
   - depth of the material hole more than one atomic step and no opposite structures are observed, ruling out the possibility of a cleavage-related artifact

3. Schematic model of the development of the three quantum dot types
   - subsequent overgrowth of small type-1 dots leading to a reversed truncated In-rich cone
   - for the type-2 dots covered by a thinner overlayer the long growth interruption results to an outward diffusion of the In-rich material and leads to crater-like depression

Electronic and Structural Contrast

Negative bias voltage: Sensitive to cations like As
   - Image taken at -2.1 V

Positive bias voltage: Sensitive to anions like Ga, In
   - Image taken at -2.1 V

Low bias voltage: Structural plus electronic contrast
   - Image taken at -3.0 V

High bias voltage: Only structural contrast from strain relaxation
   - strain-induced outward relaxation tip

References


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