

About the self-assembled III-V-based nano-structures or mysteries of droplet epitaxy

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Introduction: Applications (QD – solar cell, QD – computing etc.) ; Material (GaAs and other III-V materials) ; Technology (epitaxy, MBE, RHEED, equipment); RHEED tracking and image processing; Droplet epitaxy (fundamentals); Kinetics of QD growth; growth of nano-structure ensembles; technological support (technological data processing for support of technology)

Keywords: droplet epitaxy, GaAs and related materials, MBE, RHEED, quantum dot

Introduction.

Applications (QD solar cells, QD computing).

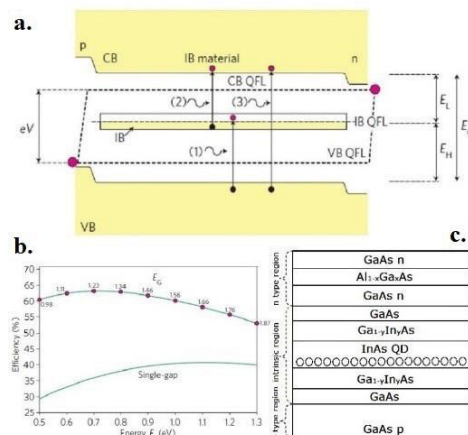


Fig. 1. Electronic structure of a QD solar cell. The figure originate from Ref. [1]. Further literature herein.

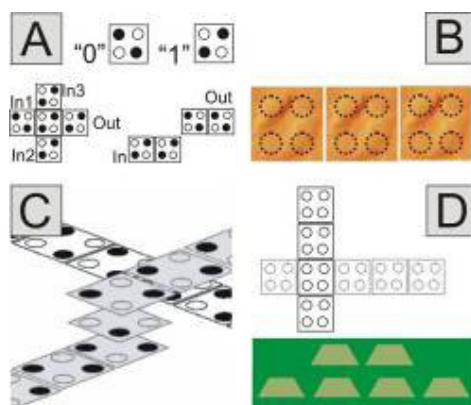


Fig. 2. QCA realized by droplet epitaxially grown QD ensembles. The figure originate from Ref. [2]. Further literature herein.

Technology

Droplet epitaxial fundamentals and the equipment

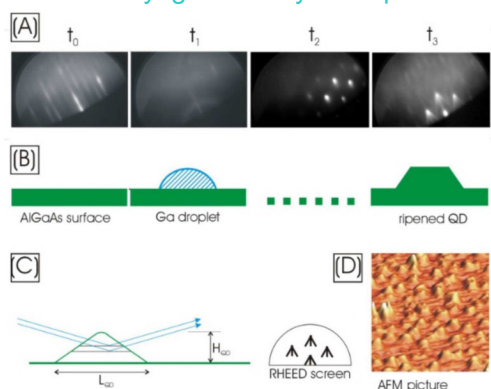


Fig. 3. QD growth by droplet epitaxy. The figure originate from Ref. [3]. Further literature herein

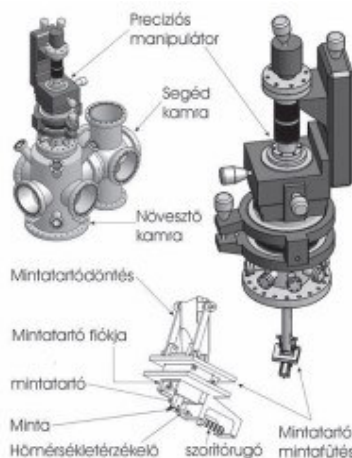


Fig. 4. Main parts of self-developed MBE equipment. The figure originate from Ref. [4]. Further literature herein.

RHEED tracking

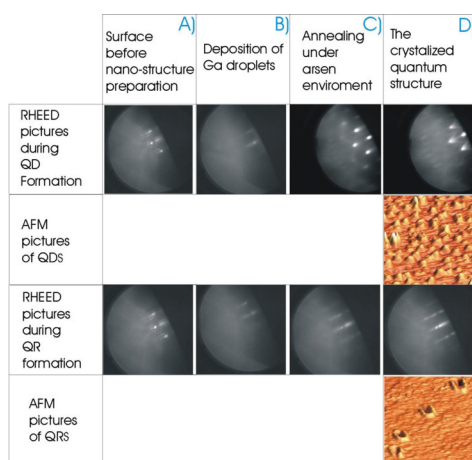


Fig. 5. RHEED patterns observed step by step manner during the evolution of the quantum objects and the AFM picture of the ripened structure. The upper and lower parts concern QD and QR, respectively. The density of QDs and QRs are 3.6×10^{10} and $1.5 \times 10^9 \text{ cm}^{-2}$. [5]

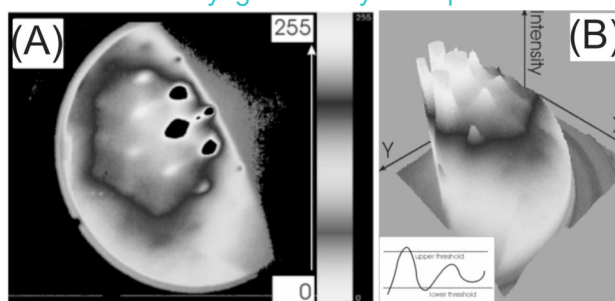


Fig. 6. RHEED picture is displayed after image processing. The intensity distribution after the upper and lower cutting in 2D (see insert). The same in 3D. It makes the intensity around the evolved shapes easier to observe.[6]

Faceting of nano-structures

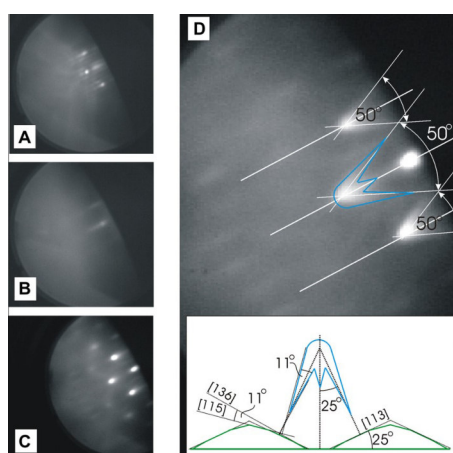


Fig. 7. The change of the RHEED pattern in different stages of the QD formation. (A) The RHEED pattern of the initial AlGaAs surface. (B) The RHEED pattern after the Ga deposition. (C) The RHEED pattern after the opening of the arsenic cell; the dotted pattern represents monocrystalline transmission character (see text). (D) The appearance of the chevron-tails after the annealing stage and (insert) its explanation. The chevron-tails appear only in later stage of the crystallization, when the shape of the nanostructure becomes characteristic. These chevron-tails are not sharp but rather broadened [7].

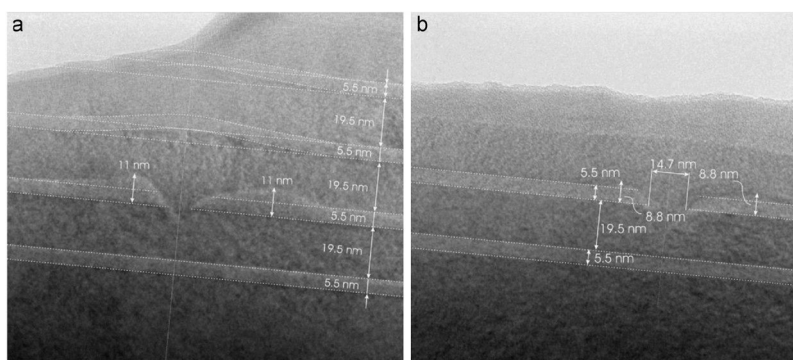


Fig. 8. (a) TEM picture of an inverted NH-QD and its environment. The lines serve as guides to eye to recognize the structures. The structures consists of a AlAs (5.5 nm)/AlGaAs (19.5 nm) superlattice with a NH-QD in the center. (b) Second NH-QD

Growth kinetics and nano-positioning

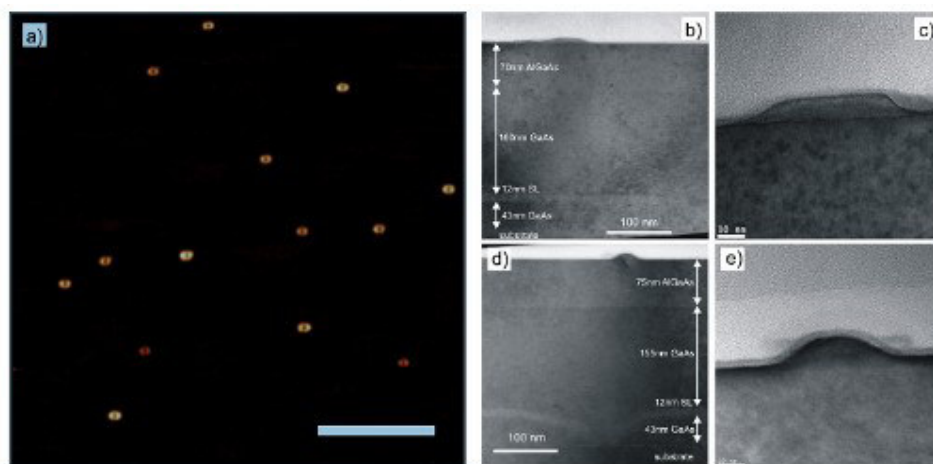


Fig. 9. Panel a: $2 \times 2 \mu\text{m}^2$ AFM scan of the surface of sample A. Panels b to e show cross sectional HR-TEM image of the sample. Panels c and e show larger magnification of the same nanostructures in panels b and d, respectively.[9]

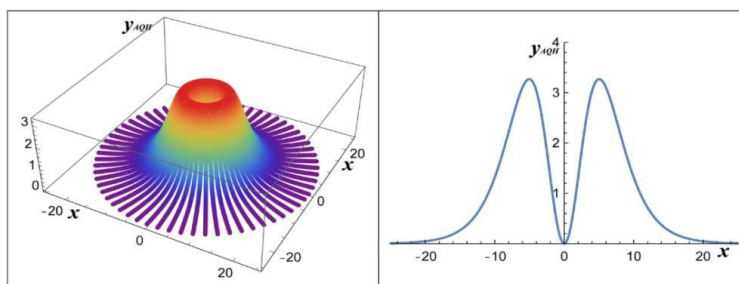


Fig. 10. 3D and the 2D cross section of a typical QR.

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