Nanostructure mapping of GaAs and Ge (111)A quantum dots using island scaling and radial distribution scaling analysis

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Tensile strained quantum dot (TSQD) nanostructures present new and exciting properties, including a reduction in the band gap [1], Type I and II carrier confinement [2], and an opportunity for entangled photon emission due to low fine structure splitting [1]. These interesting TSQD properties enable potential applications in quantum, optic, and information devices [1]. We utilized molecular beam epitaxy (MBE) to synthesize self-assembled GaAs and Ge TSQDs on InAlAs(111)A surfaces. We control TSQD structural properties (i.e. volume, height, and diameter) by changing basic MBE parameters such as growth temperature, rate, and deposition amount [2]. Understanding how these parameters affect QD properties is key to successfully integrating these nanostructures into future devices. We use island scaling (IS) and radial distribution scaling (RDS) to determine how variations in MBE growth parameters and materials affect TSQD structural properties. RDS enables us to qualitatively determine the diffusion coefficient; as well as the probability of finding TSQDs at a certain distance from an arbitrary origin [3]. Although RDS has been used extensively to study traditional compressively strained QDs [4], this represents the first use of IS and RDS to explore the growth of Ge and GaAs TSQDs on InAlAs(111)A. We have seen marked differences between Ge and GaAs TSQD self-assembly, despite the fact that from the point of view of tensile strain, these two TSQD systems are similar.

We will present IS and RDS curves for Ge and GaAs TSQDs grown at 535 °C with depositions ranging from 0.2–0.6 bilayers and 3–4.5 monolayers, respectively. Compared to GaAs TSQDs, our IS results suggest narrower size distributions for Ge TSQDs, while RDS displays higher probabilities of finding Ge TSQDs closer to an arbitrary origin. This investigation will allow us to more fully understand the differences in the processes by which Ge and GaAs TSQDs self-assemble, leading to even closer control over their structural properties.

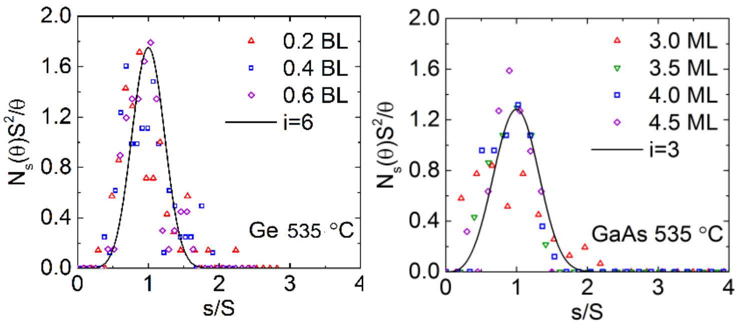

Fig. 1. IS analysis performed on (left) Ge and (right) GaAs TSQDs grown at the same temperature. *S* is the average size of the QDs, θ is the atomic coverage, *i* is the critical cluster size, and *s* is the size of a QD separated into bins. A narrower size distribution is observed for TSQDs made of Ge compared to those made of GaAs.

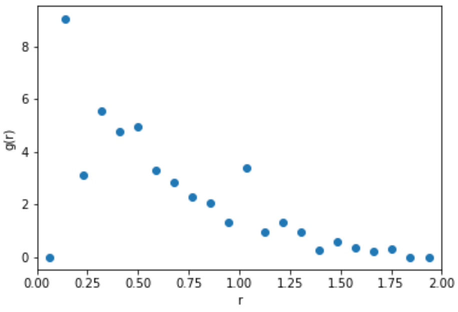

Fig. 2. RDS analysis performed on GaAs TSQDs grown at 535 °C. *r* is the distance required to move on a sample surface in order to encounter a TSQD while *g*(*r*) is the probability of finding TSQDs at that distance.

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