Ultra-low density of InAs quantum dots grown by droplet epitaxy

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As it is well known, self-assembling processes during epitaxial growth provide random distributions of quantum dots (QD) with high optical quality. However, the simultaneous control of density and size is not straightforward [1]. The QD formed in nanoholes fabricated by droplet epitaxy (DE) technique provide us a decoupled control on their size and density. Particularly, in this work, we achieve InAs QDs on GaAs (001) with control in size and density. On one hand, the size, and therefore the emission wavelength, is controlled by the amount of InAs deposited to fill the nanoholes, without reaching the critical thickness. We can tune the emission wavelength from 900 nm to 1040 nm preserving the density [2]. On the other hand, the density of nanoholes formed by the nanodrilling process corresponds to exactly the density of QDs. Our approach to adjust the density of nanoholes is to change the deposition rate of Ga to form the droplets on the surface. In this way we succeed in getting InAs QD densities from $5 \times 10^6 \text{ cm}^{-2}$ to $10^9 \text{ cm}^{-2}$. Moreover, mounds are formed on top of each nanostructure, when they are capped with GaAs, providing us with a way to locate one single QD for quantum devices as single photon sources [2]. Fig. 1 shows atomic force microscopy (AFM) images of samples with the same density ($1.5 \times 10^7 \text{ nanostructure} \cdot \text{cm}^{-2}$) of nanoholes filled with 1.3 ML of InAs (a) and mounds formed after capping InAs QDs with 70 nm of GaAs together empty nanoholes fabricated on the top surface. AFM results also show a dependence of the width and depth of the nanoholes with the density. Micro photoluminescence results will be shown as a further test of the correlation between QD and mounds.

![AFM images](attachment:image_url)

Fig 1: Atomic force microscopy (AFM) images of samples with a density of $1.5 \times 10^7 \text{ nanostructure} \cdot \text{cm}^{-2}$ of (a) nanoholes filled with 1.3 ML of InAs and (b) the resulting surface after capping the QD with 70 nm of GaAs and fabricating new nanoholes at the top surface. Observe the mounds with the same density ($1.5 \times 10^7 \text{ mounds} \cdot \text{cm}^{-2}$) formed after capping InAs QDs.


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