Fabrication of quasi-Gaussian-shaped nanoholes by MBE local droplet etching

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Nanoholes are of significant importance in the research of current nanotechnologies. For one thing, they are frequently used as the growth templates for quantum dots, nanowires, nanopillars and many other advanced nanoarchtectures [1]; for another, nanohole is an ideal platform for the research of photonic confinement in nanophotonics, and polariton trapping in the condensed-matter physics [2].

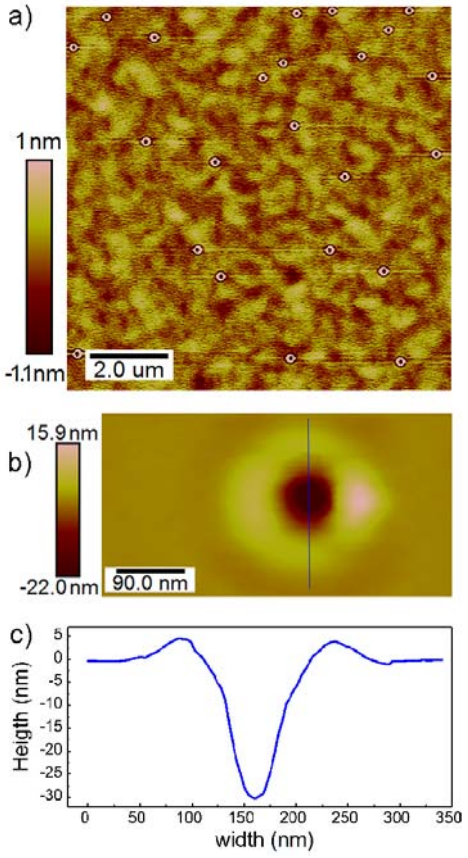

Fig. 1: The AFM images of the surface morphology of the MBE local droplet etched sample. a) the AFM image of a 10×10 um^2 area; b) the AFM image a single nanohole; c) the depth profile of the single hole measured in Fig. 1(b).

The fabrications of nanoholes are generally achieved by lithographic, dry/wet etching, and focused ion beam (FIB) milling etc. Here we present the fabrication of quasi-Gaussian-shaped nanoholes by in-situ MBE local droplet etching method on the surface of III-V semiconductor wafers. The unique advantage of this technique is the compatibility with subsequent MBE growths.

The process starts with the generation of metallic droplets on the AlGaAs surface in Volmer-Weber growth mode by depositing several monolayer of Al at a temperature between 630 °C and 700 °C without As flux, subsequently an additional annealing step without As flux is followed to transfer Al metal droplet into nanoholes with the help of atomic diffusion [3].

The Atomic Force Microscopy (AFM) measurement shows that the hole density is around 2.3×10^7 cm^{-2} and hole depth is around 30 nm at the etching temperature of 630 °C, as shown in Fig 1. These holes have a depth of 30 nm and were surrounded by smooth sidewalls, In addition, these nanoholes have Gaussian-shaped profiles, as depicted in Fig 1(b-c). Highly efficient photon confinement can be achieved [4], if such holes could be introduced into a well-designed microcavity.

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