Influence of hydrides on InP self-assembled nanostructures grown by MOVPE

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The AlInAs ï InP type II heterostructure is potentially a good material system for opto-microelectronics [1] and can be also an attractive option for exotic novel optoelectronic applications. We have recently opened [2] a new way/perspective on the ñcompatibilityò of these two materials, often grown in complex, lattice matched device structures. We have shown that the epitaxy of the initial several monolayers of InP on $Al_{0.48}In_{0.52}As$ does not follow the expected layer-by-layer ordered growth mode, but forms a variety of nanostructures, including NanoRings (NRs) and Quantum Dots (QDs). The process - happening in a nominally strain free environment - opens new application windows for creating strain free, type II QDs structures, and strain relaxed type I QDs and rings (when extra steps are added). The morphology of our self-organized nanostructures is deeply influenced by growth parameters (growth temperature, V/III ratio, substrate offcut), as reported in previous studies [2].

Here we present the influence of hydride exposure on the final nanostructure shape. We demonstrate that it is possible to control the density of the dots and improve the size uniformity. For example, the arsenization protocols of the original InP structures (Fig. 1) turn out to be the key to the transformation from dots to rings (and domes).

We also demonstrate photoluminescence (observed for the first time) from capped structures, showing very narrow, separate lines (with power dependencies characteristic for single quantum dots) in a very attractive and extraordinarily broad spectral region. This is very hard to achieve with traditional SK type dots, grown either on GaAs or InP. We stress the striking fact that the emission from the dots assembly is spread across over 350 nm (240 meV) through the telecom window (not shown here).

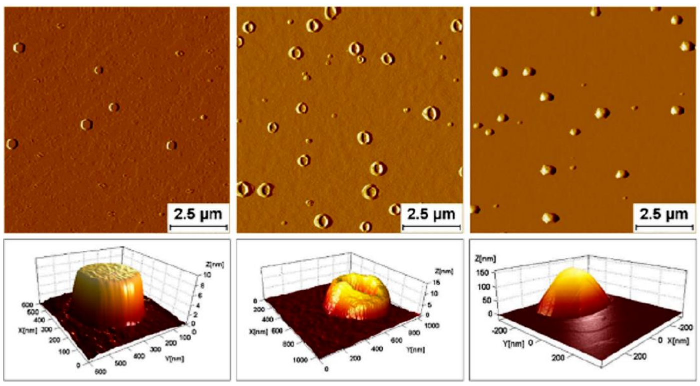

Fig. 1. Morphology of nominally 1 nm InP on $Al_{0.48}In_{0.52}As$ layer, a) cooled down under PH_3, b) exposed to AsH3 flow and cooled down under PH_3, forming rings c) exposed to and cooled down under AsH_3 flow, forming domes. Top row: AFM signal amplitude, bottom row: corresponding zoom-in of reconstructed 3D height images.

[1] E. Lugagne-Delpon, et al., ñInvestigations of MOCVD-grown AlInAs-InP I type II heterostructuresò, Semicond. Sci. Technol. 7 524 (1992)
[2] A. Gocalinska, et al., ñUnusual nanostructures of ñlattice matchedò InP on AlInAsò, Appl. Phys. Lett. 104, 141606 (2014)