Innovative self-assembling of QDs in InAs/GaAs multistacked structures: in-line correlation and ordering

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The use of Quantum Dots (QDs) in the fabrication of sophisticated devices requires a control on their spatial order and size uniformity. Over the last decades, great advances have been achieved by combining bottom-up and top-down growth methods, such as electron-beam or optical lithography pre-patterning of the surface, or by multilayer stacking in heteroepitaxy of highly mismatched semiconductors [1].

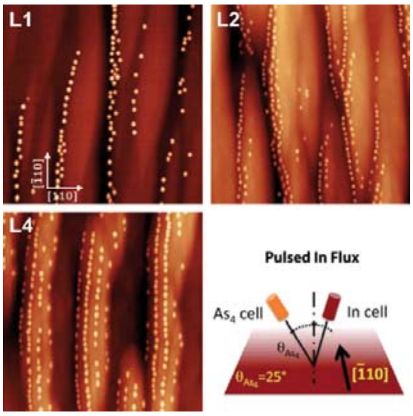

Fig.1

In the case of InAs/GaAs(001) multilayers, by applying an innovative Molecular Beam Epitaxy (MBE) growth of self-assembled QDs, we succeeded in growing distanced sets of ordered *n*-fold parallel chains of QDs along the $[\bar{1}10]$ direction after the deposition of exactly *n* layers (GaAs spacer plus InAs QDs), with *n* as small as 2 [2]. In the AFM topographies of the samples L*n*, the alignment of the chains is related to the mound structure elongated in the $[\bar{1}10]$ direction (see Fig.1). The impressive self-organization of the QDs is explained in terms of a driven Indium surface diffusion by some different mechanisms acting in the growth process, at critical conditions [3].

From the AFM image of the L4 sample and the cross sectional Transmission Electron Microscopy (TEM) image of the (-110) plane – Fig. 2 – we observe that the mound side hosting the QDs widens towards the Arsenic flux, so as to accommodate an additional unstacked QD chain every new layer.

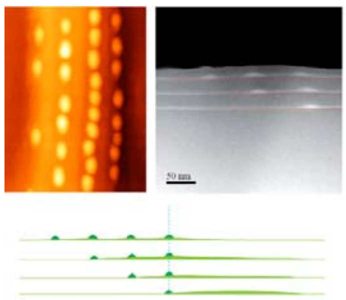
Fig.2

We measured the in-line distances along the QD chains to study the correlation among them. The analysis of the in-line distance distributions shows a progressive ordering of the QD positions with average distance of about 75 nm, as the number of layers was increased. Finite Element Method simulations – Fig.3 – of an experimental InAs/GaAs(001) multilayer confirmed this trend which is driven mainly by the propagation of the elastic strain field through the layers [4].

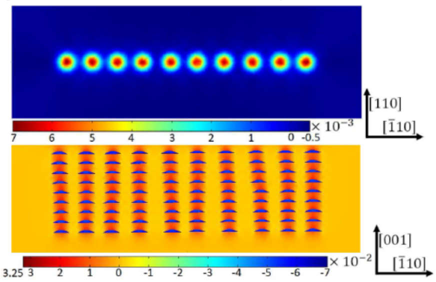

Fig.3

We concluded that the strain field of the buried QDs plays a crucial role in rendering the in-line distances between the QDs uniform, whereas the alignment of the single QD chain is mainly related to the morphological features of the mounded surface.

[1]Springholz G., Holy V. *Lateral Alignment of Epitaxial Quantum Dots*, Nano Science and Technolgy, Springer Berlin Heidelberg, 2007, pp. 247-303
[2] Arciprete F., Placidi E., Magri R., Fanfoni M., Balzarotti A., Patella F., *ACS Nano*, **7** (2013) 3868
[3] Placidi E., Arciprete F., Latini V., Latini S., Magri R., Scuderi M., Nicotra G., Patella F., *Applied Physics Letters*, **105** (2014) 111905
[4] Latini V., Placidi E., Arciprete F., Patella F., *Journal of Crystal Growth*, **419** (2015) 138