GROWTH OF IAs AND InP NANOSTRUCTURE ON GaP SUBSTRATE FOR PHOTONICS ON SILICON

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Realizing active nanostructure on GaP substrate (nearly the same lattice parameter with the silicon) which emits in the transparency region of the Silicon is the first step to achieve a light-emitter monolithically grown on Silicon.[1] This would lead to reach the so-called electronic-optical very large scale integration. In(As)P nanostructure embedded on GaP substrate is attractive because of its predicted direct low bandgap energy, and also because large lattice mismatch between InAs and GaP (≈ 11%) ensures quantum dots formation. For these reasons, the InAsP/GaP system is interesting for practical use, but also for theoretical understanding.

First, growth of InAs QDs on GaP has been performed and structural datas were extracted from Atomic Force Microscopy (AFM) measurements. The amount of deposited InAs is changed to observe the influence of thickness on structural properties of InAs QDs (diameter and density). An increase of density and a decrease of diameter with increasing of thickness deposited is observed. The critical thickness for the formation of InAs Qds is measured to be 1.2-1.5ML, assuming a stransky-krastanov growth mode, as shown in fig. 1(a). These results are in opposition with those found by Leon et al. [2]

From these pictures, it is also shown that the measured volume of quantum dots is larger than the deposited InAs Volume (fig. 1(b)), which tends to prove that QDs are not pure InAs dots. However, photoluminescence has not been observed from these quantum dots. It is interpreted in term of partial plastic strain relaxation in QDs.

We also tried to grow InP QDs on GaP with a variation of thickness changed from 2 to 6 ML, without any capping layer for AFM measurements (cf. Fig. 2). Critical thickness is determined to be between 2 and 2.3 ML. Structural properties are extracted from theses datas. Comparison is also made with the work presented by Hatami et al. [3] The question of growth mode is discussed. [4]

Finally, photoluminescence is performed using a CW 405 nm, 50 mW laser from 10 K to room temperature. While no signal can be found on the rich variety of various samples performed on the InAs/GaP system, a clear signal can be extracted until 140 K for both GaP substrate and InP nanostructures. The structures defined for the AFM on previous samples (with 2, 3, 4, 5 and 6 ML), are capped. However, no shift of the wavelength can be measured, raising the question of the nature of optical emission, that could be due to the wetting layer, to QDs constant shape, or to energy levels due to interfaces. Further experiments will be performed to understand this behavior.

In conclusion, InAs and InP nanostructures have been grown on GaP substrate by MBE. AFM images confirm the formation of InAs and InP QDs and photoluminescence signal has been detected in the InP/GaP system.

References:

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Figures:

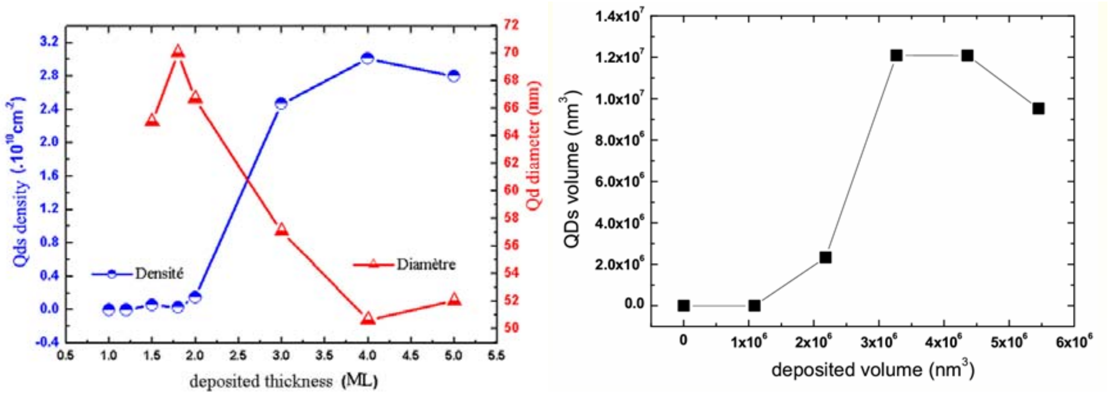

Fig. 1 : (a) Evolution of the density and diameter of InAs/GaP QDs with thickness (grown under 0,3 SCCM AsH_3 et 450°C) and (b) estimation of the QDs volume as a function of the deposited InAs volume

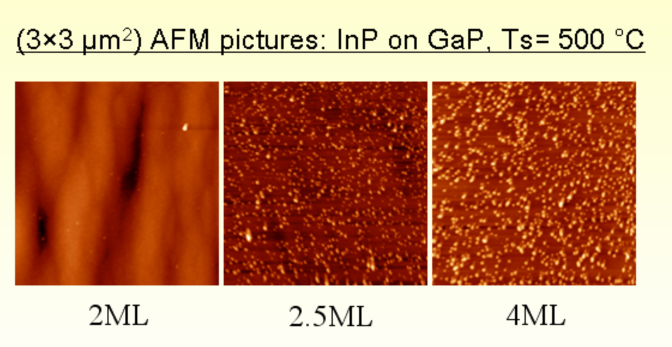

Fig. 2 : 3*3 µm² AFM pictures from InP/GaP quantum dots with respectively 2, 2.5 and 4 ML deposited

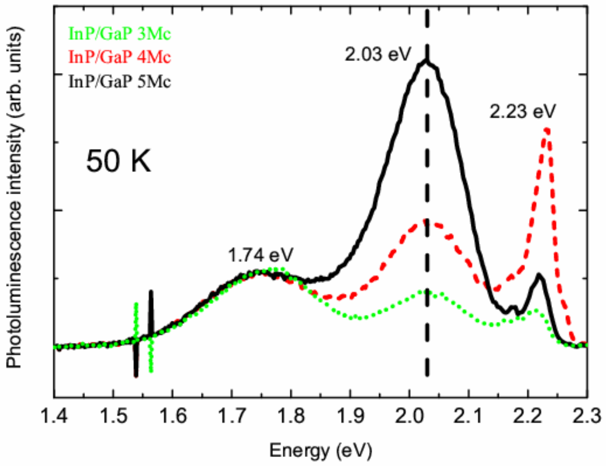

Fig. 3 : Photoluminescence emission from InP deposited on GaP with respectively 2, 2.5 and 4 ML of InP grown