Spectromicroscopic investigation of semiconductor quantum dots

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With x-ray photoemission electron microscopy we obtained twodimensional maps of the in-plane surface composition of InAs/GaAs [1] and Ge/Si [2] self-assembled quantum dots. This provides complementary information to cross-sectional studies of dots, which could open the way to a full 3D mapping of the dot composition and to a better knowledge of their formation mechanisms. Besides, the extreme surface sensitivity of our technique (photoelectron escape depth 0.5 nm) yields information essentially on the composition of the growth front. Our data clearly demonstrate that the surface composition of the dots is neither pure InAs (Ge) nor homogeneous InGaAs (SiGe), but we observe a concentration gradient from the center (high In (Ge) concentration) to the borders (lower In (Ge) concentration) of the dots.

In addition, in the case of InAs/GaAs we observe a strong In segregation to the surface of the dots and of the surrounding wetting layer. Such segregation, well known for two-dimensional InAs/GaAs growth, had not been directly observed so far on top of the dots, and should be considered to model size and composition of GaAs-overgrown structures.

The data obtained from the Ge/Si islands show the existence of a correlation between the base area of the self-assembled islands and their average surface Si content: the larger the lateral dimensions of the 3D structures, the higher their relative Si concentration. The deposition temperature determines the characteristics of this relation, pointing to a thermal activation of kinetic diffusion processes.

[1] G. Biasiol, S. Heun, G. B. Golinelli, A. Locatelli, T. O. Mentes, F. Z. Guo, C. Hofer, C. Teichert, and L. Sorba, Appl. Phys. Lett. 87, 223106 (2005).

[2] F. Ratto, F. Rosei, A. Locatelli, S. Cherifi, S. Fontana, S. Heun, P.-D. Szkutnik, A. Sgarlata, M. De Crescenzi, and N. Motta, J. Appl. Phys. 97, 043516 (2005).

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