Séminaire le 14 octobre 2016 à 11h en salle 44 du C2N-site Orsay

Correlated Atom Probe Tomography and optical spectroscopy analyses of nitride nanostructures

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In this seminar I will present our work on nanoscale analyses of nitride nanostructures such as InGaN/GaN quantum wells (QWs) in nanowires and GaN/AlN Stranski-Krastanov quantum dots (QDs). These nanostructures are investigated by correlating their structural properties assessed by Atomic Probe Tomography and STEM with their optical signature addressed by micro-photoluminescence and time-resolved photoluminescence. Experimental results are compared with 3D effective mass modeling, which account for the experimental 3D composition of the nanostructures. The multi-microscopy approach allows for studying different system dependent features, namely the effect of stacking faults on the optical properties of single InGaN/GaN QWs (illustrated in Fig. 1) and the influence of GaN/AlN QDs morphology and thickness fluctuations on transition energies, charge carriers localization, and biexciton-exciton cascade processes. The ensemble of the results obtained for the two III-N nanostructures systems shows how the developed approach ensures the best exploitation of the information obtained from the different analyses, allowing for a precision of characterization, which can be hardly matched by other techniques.

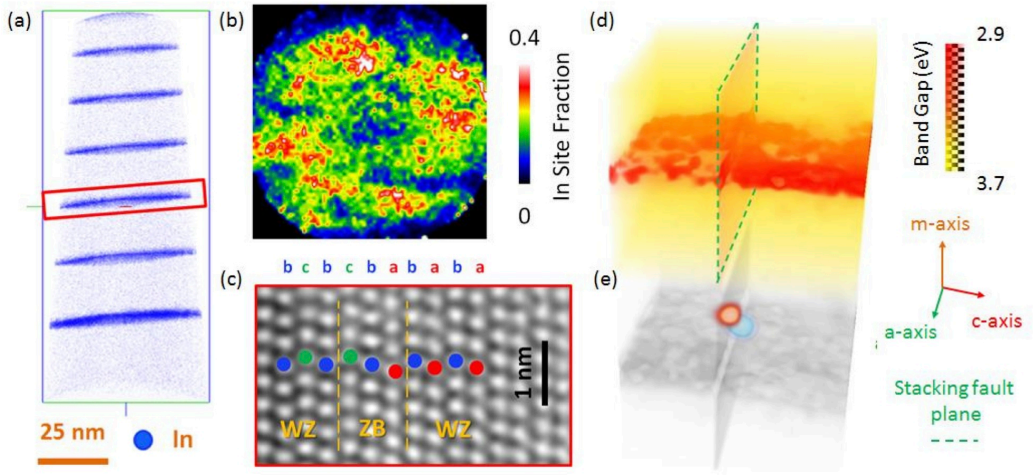

Figure 1. (a) APT reconstructed position of In atoms of six InGaN/GaN QWs. (b) Cross sections of the 3D In site fraction map obtained from the reconstructed QW highlighted by the red rectangle in (a) along the m-plane (top), within the triangular well. (c) HAADF image with atomic resolution showing the cubic (ZB) inclusion within the hexagonal matrix (WZ) corresponding to a stacking fault (SF). (d) and (e) show respectively the effective mass calculated band gap spatial distribution computed within a sub-volume containing a section of the reconstructed QW considered in (a) and (b), and the corresponding electron (light blue) and heavy hole (red) ground state envelop functions probability distributions. For simulating the influence of SFs on electron and hole states, calculations were performed considering a ZB plane crossing the QW (green dashed line).