Nanoscale Study of AlGaN/GaN multi-Quantum Wells by Comparative Atom Probe Tomography, Scanning Transmission Electron Microscopy and Micro-Photoluminescence

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Heterostructures such as quantum wells and dots of the III-N family have been playing for the last two decades a major role in the development of opto-electronic devices. In particular, GaN/AlGaN nanostructures are employed for UV LEDs, high electron-mobility transistors and intersubband optoelectronic devices operating in the near-IR spectral range [1]. Mastering the structure and composition of these systems is crucial for the development of all related applications, as their optical properties are determined by the engineered quantum confinement at the nanoscale. In the last few years, atom probe tomography (APT) has been consolidating its role as a powerful tool for the analysis of semiconductor systems, both as a standalone technique and as one complementary to scanning transmission electron microscopy (STEM), allowing to surpass some limits of the latter due to its three-dimensional nature [2][3]. In this contribution we analyzed by micro-photoluminescence (µPL), STEM and APT an AlGaN/GaN multi-quantum well system. The information obtained by STEM and APT, in particular the 3D chemical mapping, allows us to calculate the PL emission energies in the framework of an effective mass model and to compare them with the measured ones. The results allow us to discuss how interface definition and carrier localization influence the optical properties of the system.

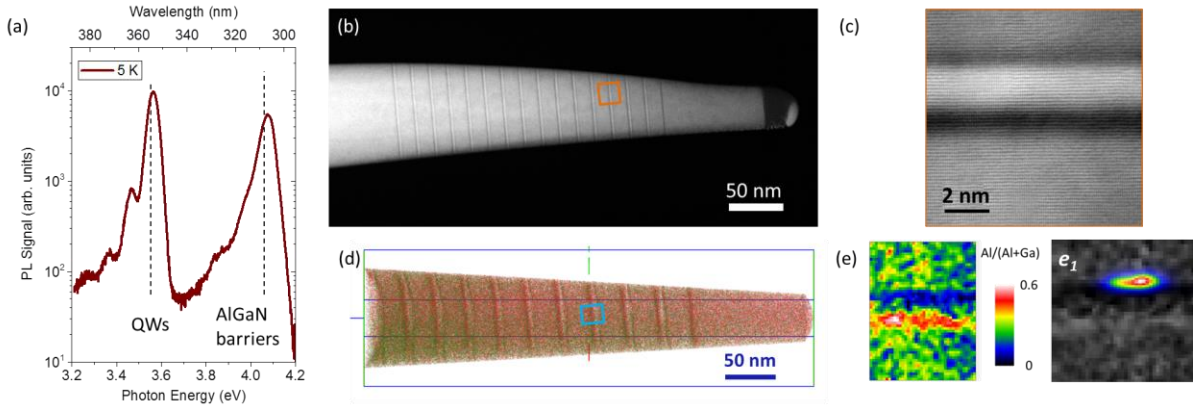

Figure 1. A comparative study on a GaN-AlGaN multi-QW set. (a) µ-PL exhibits spectral features which can be attributed to quantum well and barrier emission (b,c) HR-TEM performed on atom probe samples allow assessing the crystallography and yield first information about the interface definition; (d,e) finally, the 3D reconstruction obtained by APT assesses the distribution of Ga and Al, which makes it possible to calculate the spectral properties of the system in the framework of a 3D effective mass approximation (probability distribution of the electronic groundstate wavefunction is shown).

[1] S. Sakr et al., *Appl. Phys. Lett.* **102**, 011135 (2013)
[2] L. Mancini et al. *Appl. Phys. Lett.* **105**, 243106 (2014)
[3] L.Rigutti et al., *Nano Lett.*, **14** (1), pp 107–114 (2014)