Sub-nanometrically resolved chemical maps and their benefits for quantum cascade laser design and fabrication

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Quantum cascade lasers (QCL) are devices with an unparalleled potential for laser emission with an emission energy fine-tuned down to the meV. These devices are, however, extremely complex to model and manufacture: they often comprise 30 or more stages, each stage itself containing about 20 wells and barriers, some of which are only a few Angstrom thick. Precisely controlling the composition and thickness of each individual well and barrier in every stage is crucial in attaining the desired emission in the final device. In this context, sub-nanometrically resolved chemical mappings are instrumental in the fabrication of a QCL. Such mappings provide both modelling and epitaxial teams the necessary feedback to identify deviations from a nominal structure, optimize both the design and the fabrication process, and, finally, demonstrate a QCL with the desired emission. However, even with the latest generation of transmission electron microscopes, equipped with state of the art EDX systems it is not possible to measure the composition of the finest wells. Thus, the quantification of the HAADF signal provides the only means to obtain chemical mappings with the desired resolution. The present contribution illustrates how sub-nanometrically resolved chemical mappings, obtained by quantifying the HAADF contrast, are instrumental for the design and fabrication of InGaAs/InAlAs QCLs.