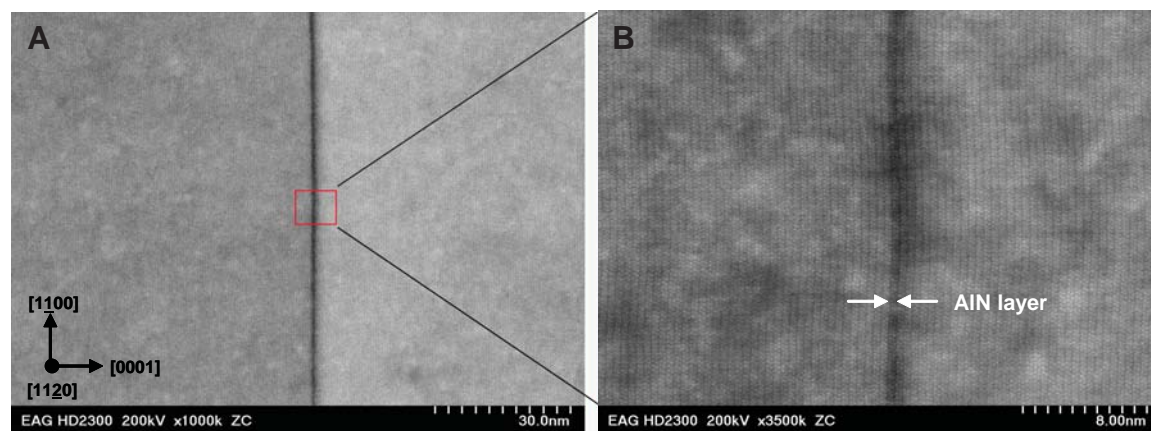


Introduction

Scanning Transmission Electron Microscopy (STEM) utilizing a high angle annular dark field (HAADF) detector is capable of providing atomic resolution images of crystalline samples with excellent elemental contrast (Z-Contrast). In the case of compound semiconductor samples such as light emitting diodes (LED), laser diodes (LD), Hetero-junction Bipolar Transistor (HBT), and high electron mobility transistors (HEMT), the ultra thin layers of differing composition such as single or multiple quantum wells (MQW's) can be easily distinguished and measured. Additionally, when coupled with Energy Dispersive X-ray Spectroscopy (EDS), the STEM is an excellent tool for performing high resolution, semi-quantitative elemental analysis with a spatial resolution of 2-3 nm.

Discussion

For the example images shown in Figure 1, a commercially available GaN based LED was cross-sectioned using a Focused Ion Beam (FIB) and imaged by STEM along the [1120] zone axis. A sub-nanometer AlN layer is observable between thicker AlGaIn and GaN layers (Figure 1A). The AlN layer, having a lower average atomic number than the layers around it, appears darker. Figure 1B is a higher magnification, lattice resolution image of the red outlined region in Figure 1A, showing the AlN layer is one to two unit cells thick.



Figures 1 A&B. Z-contrast images of an ultra-thin, ~0.5 – 1.1 nm, AlN layer between AlGaIn and GaN observed in a cross-section of a commercially available GaN based LED. The lattice fringes are clearly visible in Figure 1B.

Figure 2 demonstrates an EDS line scan profile of the elements within a multiple quantum well structure of a GaN-based LED. The EDS information is overlaid on the corresponding Z-Contrast image. The layer compositions and transitions are well defined and an EDS resolution of 3nm is achieved.

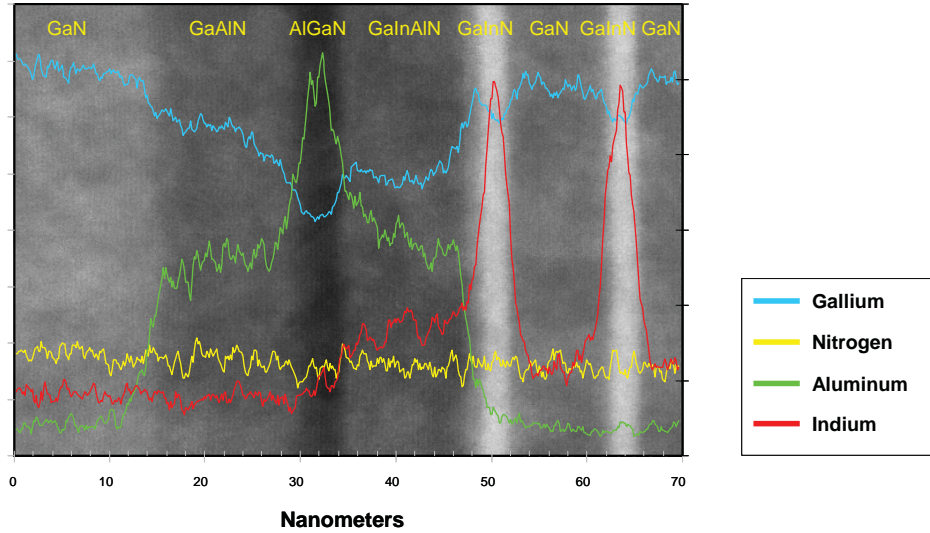


Figure 2. EDS elemental line scan profiles overlaid on a corresponding Z-Contrast image of MQW's observed in a commercially available GaN-based LED.

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EAG Corporate Offices, 810 Kifer Road, Sunnyvale, CA 94086 phone: 408 530 3500

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