Advances in characterization of III-Nitrides by Secondary Ion Mass Spectrometry

Patrick Van Lierde, Chunsheng Tian, R. S. Hockett
Charles Evans & Associates
810 Kifer Road, Sunnyvale, CA 94086

Pablo Cantu Alejandro, Stacia Keller, and Steven P. DenBaars
Electrical and Computer Engineering and Materials Departments, University of California, Santa Barbara, CA 93106

Recent developments in the III-Nitrides have prompted the expansion of our capabilities for the characterization of these materials by Secondary Ion Mass Spectrometry (SIMS). The list of elements of interest, be it as dopant or impurity, has increased steadily. Also, opto-electronic (LED and Laser Diode) and transistor (HEMT and MESFET) devices have shrunk in size and consist of more complex layer structures. The improvements are threefold: Firstly, increased accuracy of concentration measurements for dopants and impurities based on a new suite of Relative Sensitivity Factors (RSF's) for GaN and AlGaN. Secondly, optimization of a Cameca IMS-6f SIMS instrument to be able to profile areas as small as 30 x 30 microns. This allows for the characterization of individual die and processed wafers. Thirdly, develop advanced sample preparation methods for Failure Analysis and Reverse Engineering.

The RSF's were derived from implanted GaN and AlGaN on sapphire wafer pieces. The doses were calibrated from the implanter and cross checked with witness pieces against our extensive library of Si reference standard materials and RBS. The Al mole fraction was determined by XRD and RBS.

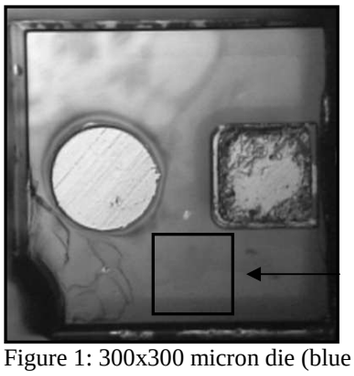

Figure 1: 300x300 micron die (blue LED)

A blue LED was depackaged and prepared for SIMS analysis. III-Nitrides, and AlGaN in particular, suffer from defects due to lattice mismatch with underlying layers or strain introduced during the growth process. The roughness, due to these defects, of the epi surface adversely affects the depth resolution which in turn limits the usefulness of the SIMS data to evaluate the diffusion of dopants or layer sequence. In order to minimize the effects from the surface roughness, the LED die was polished on an Allied Tech Products, Inc. MultiPrep tool with Dia-Grid Diamond Discs. The die is shown in figure 1 after surface polishing. The square illustrates the SIMS crater size. The data including the Mg doping profile is shown in figure 2. The Al and In traces indicate the position of the AlGaN and InGaN layers including the three InGaN quantum wells (QW).

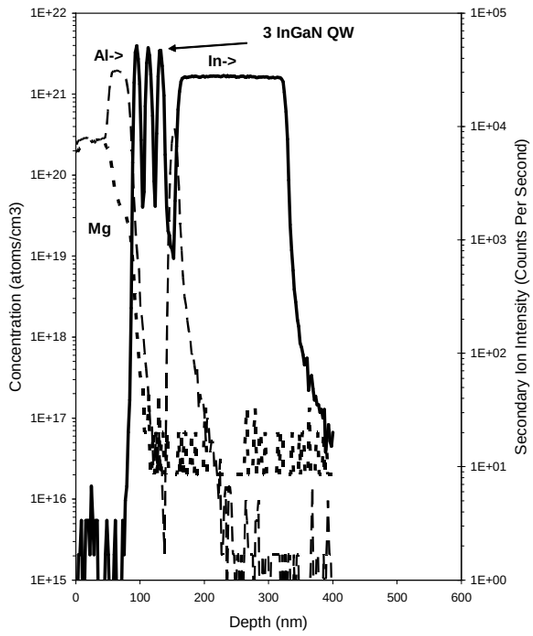

Figure 2: SIMS depth profile of Mg in AlGaN/InGaN die

The implanted GaN and AlGaN samples used for this study where made with the support of DARPA/SUVOS.