AN 386

Improved Characterization of Diffusion in Ohmic Contacts on an AlGaAs Laser Diode using Backside SIMS

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Discussion

The performance of semiconductor devices can be affected by the diffusion of metals from the ohmic contacts. Secondary Ion Mass Spectrometry (SIMS) is a proven analytical tool for materials characterization. However, standard SIMS profiling sometimes cannot distinguish diffusion contamination from SIMS artifacts due to limits in depth resolution.

Backside SIMS was used successfully to study the diffusion of a Au/Pt/Ti metal stack on an AlGaAs laser diode as well as to identify unintentional p-type doping. The data illustrates the excellent polishing depth calibration, minimal surface roughness and excellent planar control.

The SIMS sputtering mechanism may introduce roughening of the crater bottom, especially in poly-crystalline materials where material is removed preferentially along the crystal orientation. This results in a significant degradation of the depth resolution and renders the data useless to evaluate the diffusion of ohmic contact materials into the underlying semiconductor. Backside SIMS avoids these problems by polishing away the substrate down to the depth of interest and then profiling from the backside through the semiconductor or substrate into the metal film.

The laser diode was mounted upside down on a substrate with epoxy glue. It was polished on an Allied High Tech Products, Inc. MultiPrep tool with Dia-Grid Diamond Discs. The polishing was completed over several stages while changing the Diamond Disc from coarse to fine until about one micron of material remained before the area of interest. The surface was polished parallel to the initial surface to within 0.01°. A larger angle would adversely impact the depth resolution.

The first example is a laser diode with ohmic contact on the wave-guide. Figure 1 shows a depth profile of the metal contact layers that was acquired by sputtering from the front of the sample. The Ti profile shows a double peak which is due to matrix effects and a slowly decaying signal due to sputter roughening. The curve extends well into the semiconductor layer and settles at a level which is significantly higher than the instrument background. The Au profile also suggests a high level of Au in the semiconductor structure.

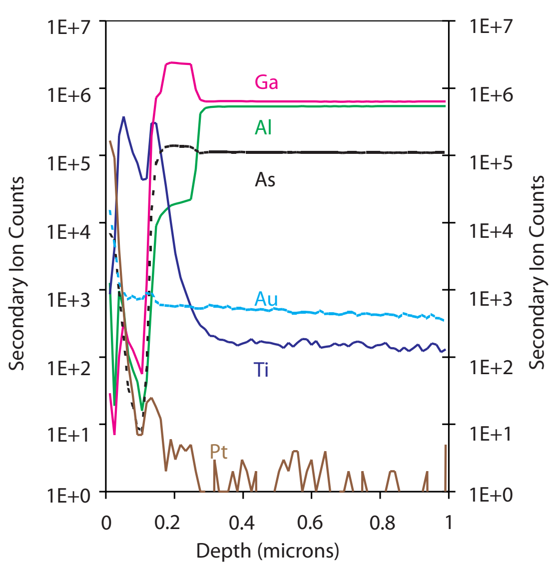

Figure 1. SIMS depth profile of the metal contact layers that was acquired by sputtering from the front of the sample

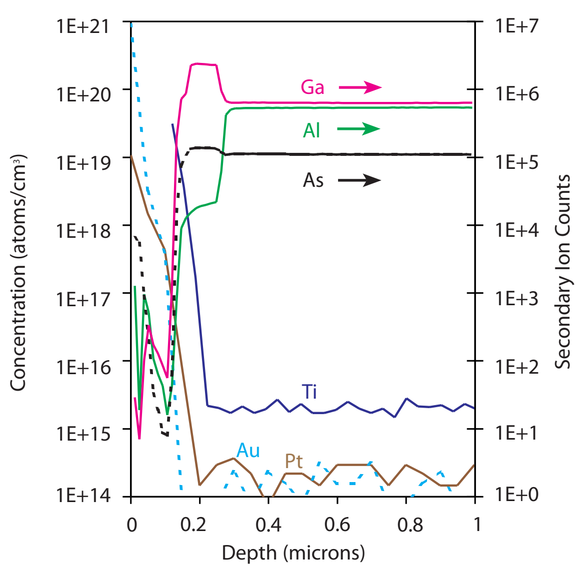

Figure 2. Backside SIMS depth profile of the metal contact layer

The results of the Backside SIMS analysis are shown in Figure 2 with the depth scale reversed to allow for easy comparison to the initial data. The Au, Pt and Ti profiles indicate a sharp drop from the maximum concentrations in the contact layers to the much lower background levels in the semiconductor.

A second problem was investigated of unintentional doping in the laser diode. Profiling for Zn, a p-type dopant, through the contact layers was attempted without success. The interference from memory effects of the metal layers is too high to detect low concentrations of Zn. The Backside SIMS Zn depth profiles with detection limits of 2E+15 at/cm^3 from two laser diodes are plotted in figures 3 and 4. The unintentional doping of Zn at a concentration of about 1E+18 at/cm^3 near the active region is clearly detected in the "Bad" device.

The data acquired by Backside SIMS confirmed that there was no measurable diffusion of the metal contacts into the semiconductor. In addition, this technique allowed for the detection of unintentional doping by Zn in the "Bad" Laser diode.

Backside SIMS offers a powerful extension of the mature SIMS technique to study materials issues which were previously not possible or were deferred to less sensitive techniques for the lack of a practical SIMS solution.

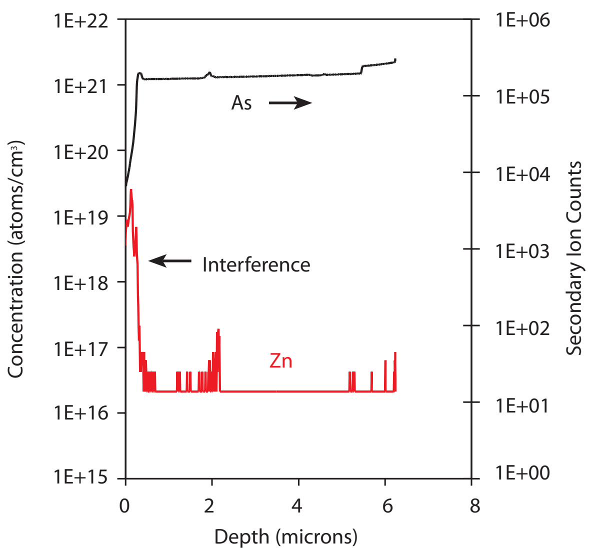

Figure 3. Backside SIMS depth profile of Zn in "Good" device

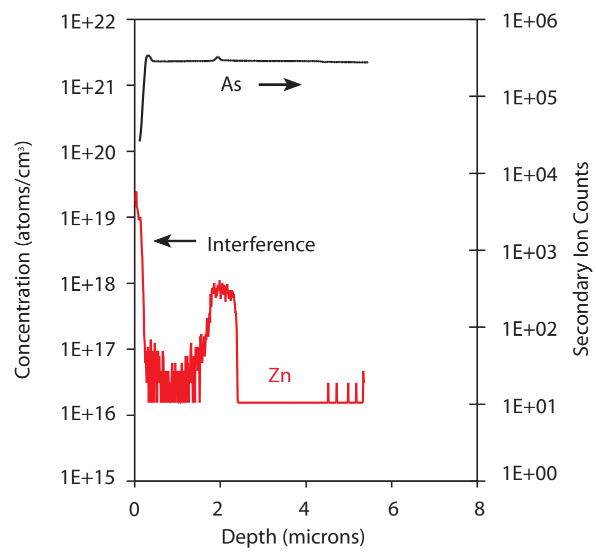

Figure 4. Backside SIMS depth profile of Zn in "Bad" device

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