Using the Desorption Mass Spectrometry Technique to Optimize Sb Flux in GaSbBi Growth

Jedidiah McCoy, Chunte Lu, Ron Kaspi
Air Force Research Laboratory, Directed Energy Directorate, AFRL/RDLTD, Albuquerque, NM 87117, USA

Bismuth incorporation into $GaSb_xBi_{1-x}$ is of interest because the bandgap is substantially reduced within manageable levels of strain. However, MBE growth of this alloy has yet to mature. This is because achieving substantial (>10%) Bi incorporation while maintaining good crystal quality is challenging. To assist Bi competition over Sb in group V incorporation, growths must be conducted at relatively low substrate temperatures (<300 ℃) with near-stoichiometric V/III flux ratios [1]. Because these conditions are outside of the typical GaSb growth window, it becomes imperative to precisely establish the Sb/Ga flux ratio as it is observed to have a large effect on Bi incorporation.

In this study, we utilized the desorption mass spectrometry (DMS) technique to establish a near-stoichiometric Sb/Ga flux ratio at the growth temperature of interest. The DMS technique allows for in-situ monitoring of desorbed Sb so that fine-tuning of the Sb/Ga flux ratio can be accomplished. Using this methodology, $GaSb_{1-x}Bi_x$ layers were deposited at temperatures ranging from as low as 125 ℃ to 300 ℃. Bismuth incorporation exceeding 15% was achieved as well as room temperature luminescence approaching 4 μm, as shown in figure 1.

The DMS technique was also used to explore the $GaSb_{1-x}Bi_x$ growth surface. This was done by interrupting the growth sequence and raising the substrate temperature thereby releasing any unincorporated Bi at the surface, which could then be quantified using the desorption spectra, see figure 2. A correlation between this steady-state concentration of unincorporated Bi with growth conditions such as substrate temperature and Bi flux will be discussed.

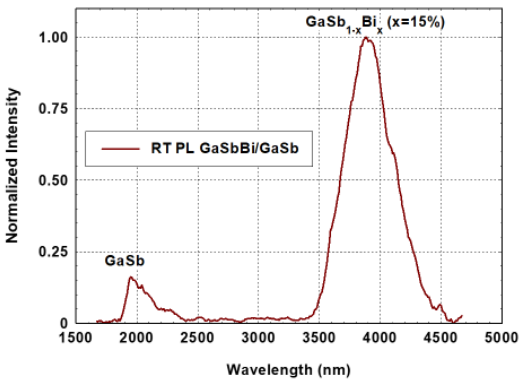

Figure 1: Photoluminescence signal from GaSbBi/GaSb growth.

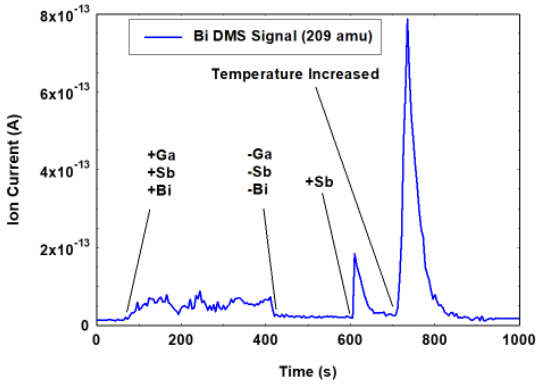

Figure 2: Bi desorption signal during and after growth revealing Bi surface chemistry.

[1] M. K. Rajpalke, et al., J. Appl. Phys. 116, 043511 (2014).