Determination of background doping type in type-II superlattice using capacitance-voltage technique with double mesa structure

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The background doping in superlattice absorber is one of the most important material parameters for the design and evaluation of infrared detectors. Due to the highly conductive substrates of these narrow-bandgap materials, it is difficult to conduct Hall measurements to verify the doping type of unintentionally doped materials [1]. This is especially true in Type -II superlattice (T2SL) InAs/AlSb where one of the constituents has a background doping that is n-type (InAs) and the other is background doped p-type (AlSb). Here, we demonstrate a novel technique that uses capacitance-voltage (C-V) measurements using a double mesa structure. Two p-i-n and n-i-p homojunction diodes were grown using 10 ML InAs/10ML AlSb were grown by molecular beam epitaxy. The top, intrinsic, and bottom layers are 300, 1000 and 500 nm thick, respectively. Double mesa devices were then fabricated using standard semiconductor fabrication processes. The first etch was a shallow etch that went past the top contact into the absorber layer. The second etch was a deeper etch that reach the bottom contact. CV measurements were undertaken on devices in which the radius of the deep etch was varied while the radius of the shallow etch was kept constant. The double mesa devices have two built-in junctions at the interfaces: the first is in the shallow mesa between the top contact, and intrinsic layer (1^{st} junction), and the second in the deep mesa between the intrinsic layer and the bottom contact (2^{nd} junction). For the PIN device, the device's capacitance will scale with the deep etch radius if the intrinsic layer is p-type. However, if the intrinsic doping is n-type the capacitance will not scale with the deep etch radius. Figure 1 shows capacitance as a function of deep etch radius. For p-i-n device, the capacitance scales with the deep etch radius, but for n-i-p device the capacitance is independent of the radius. This comparison clearly indicates that the doping type of this unintentionally doped InAs/AlSb T2SL is p-type (~ 3 x 10^{16} cm^{-3}). We plan to perform temperature studies on the doping type of the T2SL. These additional results will be discussed at the presentation.

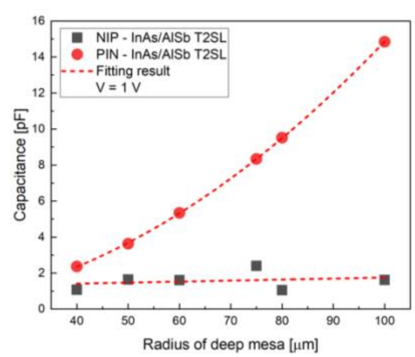

Figure 1 Capacitance vs. deep mesa radius for p-i-n and n-i-p InAs/AlSb T2SL devices

[1] T.V. Chandrasekhar Rao, Jarek Antoszewski, Lorenzo Faraone, J. B. Rodriguez, E. Plis and S. Krishna, Appl. Phys. Lett. 92, 012121 (2008).

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Supplementary Pages

Figure 2 shows the schematic structure of the double mesa structure and its electric field profile. For convenience purpose, GaSb is used for the simulation instead of InAs/AlSb T2SL. The electric field profile was simulated with Silvaco software. Here, we assumed that the intrinsic layer of GaSb is p-type. The contour plot clearly exhibits the dominant junction electric field is located at 2^{nd} junction. Therefore, the capacitance of the device must scale with the deep etch radius.

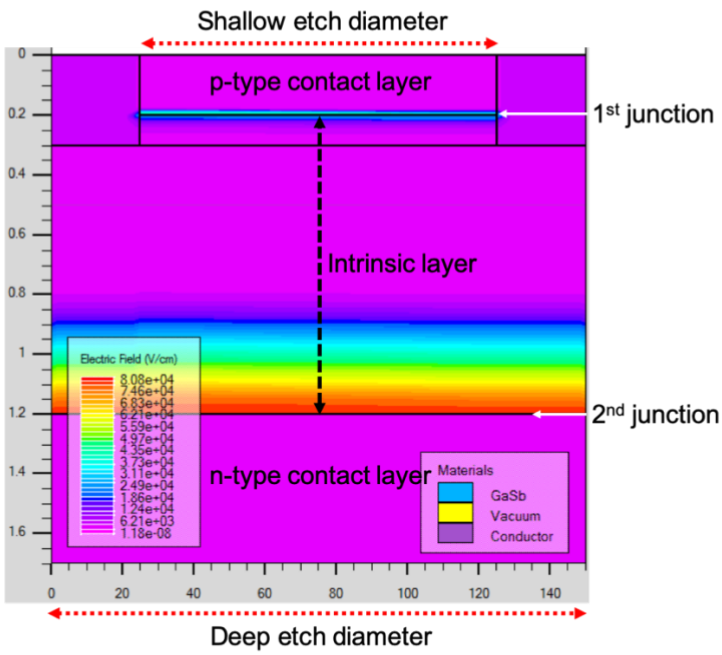

Figure 2 Electric field profile of double mesa structure for p-i-n GaSb device.

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