Characterization of Contact Resistivity on InAs/GaSb Interface

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In SiGe BJTs, growth of a polysilicon extrinsic base over a dielectric spacer reduces the capacitance between the base and the collector (C_{BC}) [1]. In InP heterojunction bipolar transistors (HBTs), the same technique can be applied, with low resistivity polycrystalline material employed as the extrinsic base layer and buried SiO_2/SiN surrounding a collector pedestal. P-type polycrystalline GaSb is potentially a good candidate to be used as an extrinsic base material[2], but its bulk resistivity is still relatively high compared with n-type polycrystalline InAs, which has demonstrated very low bulk and metal contact resistivity[3].

In this work, we propose to use p-type GaSb capped with n-type InAs as the extrinsic base layer. It has been widely known that InAs-GaSb heterostructure forms a broken-gap band lineup and it is possible for the p-type GaSb's valence band electrons to transfer into the conduction band of the neighboring n-type InAs, giving rise to an ohmic p-n junction. The electronic properties of InAs-GaSb heterostructure have been studied extensively, but most studies have focused on the negative differential resistance in this material system. In this paper, we examine the contact resistivity on the n-type InAs / p-type GaSb interface at low current density (<1E4 A/cm^2) and its dependence on the doping densities on both sides of the junction.

A series of test samples were grown on semi-insulating InP wafers in a Varian Gen II MBE system. The test structure consisted of a 500Å GaAsSb layer (lattice matched to InP), a 400Å layer grading from GaAsSb to GaSb, and a 100Å GaSb layer. These three layers were doped with carbon. A top 1000Å Si-doped InAs layer was then grown. This layer structure was designed for the extrinsic base of an HBT, therefore the total layer thickness was constrained by process design considerations. The doping density in GaSb layer was varied from 2E19cm^{-3} to 8E19cm^{-3}, while in the neighboring InAs layer it was varied from 1E17cm^{-3} to 5E19cm^{-3}. The lowest contact resistivity on the InAs-GaSb interface was 4.2E-7 Ω-cm^2, obtained for the sample with the highest doping densities on both sides of the junction.

Two reference samples were grown and tested for comparison. The first reference sample with a p+InAs/n+InAs tunneling junction showed an interfacial contact resistivity of 1.3E-5 Ω-cm^2 between the p-n interface, one order of magnitude higher than those of InAs/GaSb samples. The second reference sample consisted of a thin AlSb barrier layer displaced from an n-type InAs / p-type GaSb interface and the interfacial contact resistivity obtained was 5.4E-7 Ω-cm^2.

The lowest contact resistivity obtained, 4.2E-7 Ω-cm^2, can be compared to that between metal and highly p-doped InGaAs, where values of 1E-7 Ω-cm^2 to 1E-6 Ω-cm^2 have been obtained[4]. With moderate reduction in the interfacial resistance, p-type GaSb capped with n-type InAs can be employed as an extrinsic base material in InP HBTs, or in other device structures where low access resistance is required.

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