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Design and Modelling of Ge/GaAs Hetero-structure Bipolar Transistor

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Abstract : The presented heterostructure n-p-n bipolar transistor is comprised of Ge/GaAs heterojunctions consisting of 0.15μm thick emitter and 0.65μm collector junctions. High diffusivity of carriers in GaAs base was major motivation of current design. We avoided grading of the base which is common in heterojunction bipolar transistors, in order to keep the electron diffusivity as high as possible. The electrons injected into the 0.25μm thick p-type GaAs base with not very high doping (1017cm-3). The designed HBT enables cut off frequency on the order of 150GHz. The Ge/GaAs heterojunctions presented in our paper have proved to work better than comparable HBTs having GaAs bases and emitter/collector junctions made, for example, of AlGaAs/GaAs or other III-V compound semiconductors. The difference in lattice constants between Ge and GaAs is less than 2%. Therefore, there is no need of transition layers between Ge emitter and GaAs base. Significant difference in energy gap of these two materials presents new scope for improving performance of the emitter. With the complete structure being modelled and simulated using TCAD SILVACO, the collector/ emitter offset voltage of the device has been limited to a reasonable value of 63 millivolts by the dint of low energy band gap value associated with Ge emitter. The efficiency of the emitter in our HBT is 86%. Use of Germanium in the emitter and collector regions presents new opportunities for integration of this vertical device structure into silicon substrate.

Keywords : Germanium, Gallium Arsenide, heterojunction bipolar transistor, high cut-off frequency
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