A Transistor That Changes Potential of Carriers

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Abstract

A novel potential-changing transistor is designed using two PN junctions with different barrier values. The emitter-base junction has a small potential barrier which is forward biased. The collector-base junction has a large potential barrier and is unbiased. As the charge carriers move from the emitter to the base, most of them are swept to the collector due to the collector-base junction field. Since the collector-base barrier is larger than the emitter-base barrier, the potential of charge carriers is changed.

Description

A potential barrier exists in the PN junction of semiconductors. When carriers move from P side to N side, they experience a drop in potential, or an increase in potential when moving from N side to P side.

There are two PN junctions in a Bipolar Junction Transistor (BJT). They are emitter-base junction and collector-base junction. The two junctions have opposite field directions. When carriers move from the emitter to the collector, the total potential change of carriers is equal to the difference of the two barriers. If two junctions have similar barrier values, the total potential change is close to zero. This is the reason that potential changes are negligible in conventional transistors. However, if the barrier values of the two junctions are significantly different, the total potential change is not zero. For example, germanium-graphene and silicon-graphene have junction barriers of 0.22 eV and 0.64 eV, respectively [1]. Bipolar junction transistors can be made of germanium-graphene-silicon, which serve as emitter, base and collector respectively. The emitter-base is forward biased, and the collector is unbiased connected to the load. The

potential change per carrier passing through the transistor is 0.42 eV. A schematic diagram of a PNP transistor is shown in figure 1. As indicated by the arrows, the collector-base junction has a larger potential barrier than the emitter-base junction.

The output potential can be multiplied by connecting multiple transistors in series, where the base potential of each transistor is controlled at a different value, corresponding to each step of potential change.

Reference:

[1] A vertical silicon-graphene-germanium transistor, Chi Liu, Wei Ma, Maolin Chen, Wencai Ren, Dongming Sun, NATURE COMMUNICATIONS | (2019) 10:4873 | https://doi.org/10.1038/s41467-019-12814-1 | www.nature.com/naturecommunications

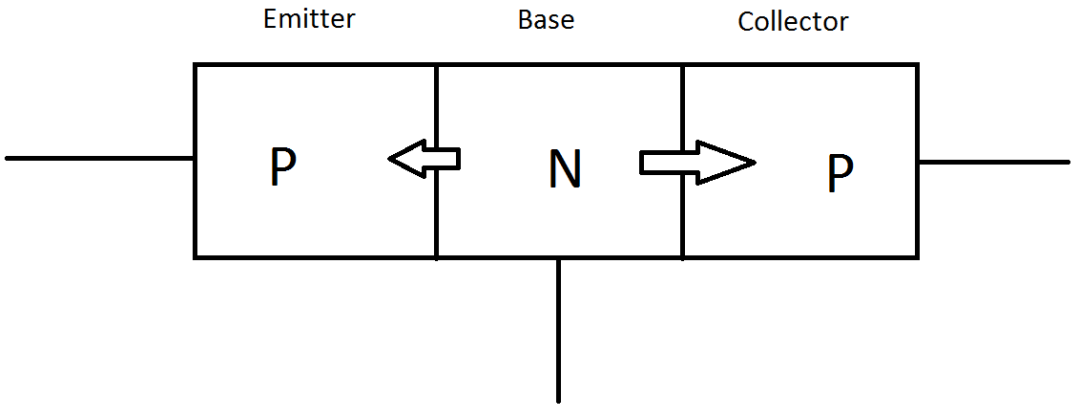

Figure 1: Schematic of a PNP bipolar junction transistor. As indicated by arrows, the collector-base barrier is larger than the emitter-base barrier.