UNIPOLAR TRANSISTOR BASED ON CHARGE INJECTION

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We describe a new type of transistor based on hot-electron transfer between two conducting layers in a GaAlAs/GaAs heterojunction structure. One of these layers is the FET channel. The other layer (implemented as a heavily doped GaAs substrate) is separated from the channel by an $Al_xGa_{1-x}As$ graded barrier, with x varying from 0.34 near the channel to 0.1 near the substrate. Because of the barrier asymmetry, application of a positive bias to the substrate results in a low saturated current. Application of a source-to-drain field leads to a heating of channel electrons and an exponential enhancement of charge transfer into the substrate. This situation is analogous to that in a vacuum diode. In our case the substrate serves as an anode and the FET channel represents a hot-electron cathode, whose effective temperature is controlled by the source to drain field.

Hot-electron current into the substrate, measured at 77 K increased by ten orders of magnitude on application of the source-to-drain voltage, V_{SD}, reaching about 100 mA (for a 1 m x 250 m gate geometry) with V_{SD}=1V. The observed family of drain-to-substrate characteristics (with source current as a parameter) is remarkably similar to that for the bipolar transistor in its common-base configuration. At high source-to-drain fields, the hot electron transfer is so efficient that nearly all electrons that leave the source end up in the substrate rather than the drain. Because of the high impedance in the output (substrate) circuit, compared to that in the source-drain circuit, we have a voltage gain. Electrically, the drain plays the role analogous to the bipolar transistor's base. The notable difference is that instead of the minority-carrier injection we are dealing here with charge injection of hot electrons, an entirely unipolar process.