CLAIMS

We claim:

1. A vertical bipolar junction transistor (VBJT) comprising:

an emitter substructure, the emitter substructure having an emitter layer made from an emitter semiconductor;

a collector made of a collector semiconductor;

an intrinsic base, the intrinsic base made of one of a lightly doped or moderately doped semiconductor;

one or more doped epitaxy regions made of a highly doped semiconductor; and

one or more resistors,

wherein the intrinsic base, the doped epitaxy region, and the resistors are stacked upon one another in a channel between the emitter layer and the collector.

2. The VBJT, as in Claim 1, where doped epitaxy regions have a doping concentration of between $4x10^{20}$ cm^{-3} and $2.5x10^{21}$.

3. The VBJT, as in Claim 1, where the emitter semiconductor is doped with an n-type dopant with an emitter dopant concentration between $4x10^{20}$ cm^{-3} and $2.5x10^{21}$ cm^{-3}.

4. The VBJT, as in Claim 1, where an extrinsic base made of an extrinsic base semiconductor and surrounds the intrinsic base.

5. The VBJT, as in Claim 1, further comprising one or more metal contact layers each metal contact layer encompassing one or more of the doped epitaxy regions and one or more of the metal contact layers being connected to an external connection.

6. The VBJT, as in Claim 1, where a resistor dielectric thickness of the resistor determines a resistor length of the respective resistor.

7. The VBJT, as in Claim 6, where the resistor length is between 5 nanometers (nm) and 100 nm.

8. The VBJT, as in Claim 1, where the resistor has resistor dopant with a resistor dopant concentration between $1x10^{17}$ cm^{-3} and $1x10^{19}$ cm^{-3} and is made of one of the following materials: a type IV semiconductor, silicon, germanium, silicon-germanium, and a type III semiconductor.

9. The VBJT, as in Claim 8, where resistor dopant type is the same dopant type used in the emitter layer and collector.

10. The VBJT, as in Claim 8, where the resistor has a carbon doping in addition.

11. The VBJT, as in Claim 9, where the carbon doping has a carbon doping concentration between $1x10^{17}$ and $8x10^{20}$ cm^{-3}.

12. The VBJT, as in Claim 1, where the doped epitaxy region is bottom doped epitaxy region and the resistor is a emitter resistor and the emitter resistor is disposed on the emitter layer, the emitter bottom doped epitaxy region is disposed on the emitter resistor, and the intrinsic base is disposed on the emitter resistor to form a common-collector VBJT circuit.

13. The VBJT, as in Claim 1, where the doped epitaxy region is a top doped epitaxy region and the resistor is a collector resistor and the intrinsic base is disposed on the emitter layer, the top doped epitaxy region is disposed on the intrinsic base, and the collector resistor is disposed on the top doped epitaxy region to form a common-emitter VBJT circuit.

14. The VBJT, as in Claim 1, where the one or more doped epitaxy regions comprise a bottom doped epitaxy region and a top doped epitaxy region and the one or more resistor that comprise an emitter resistor and a collector resistor and the emitter resistor disposed on the emitter layer, the bottom doped epitaxy region is disposed on the emitter resistor dielectric, the intrinsic base is disposed on the bottom doped epitaxy region, the top doped epitaxy region is disposed on the intrinsic base, and the collector resistor is disposed on the top doped epitaxy region to form a emitter-degenerate circuit VBJT circuit.

15. A vertical bipolar junction transistor (VBJT) emitter-degenerate circuit comprising:

an emitter substructure, the emitter substructure having an emitter layer made from an emitter semiconductor;

an emitter resistor disposed on the emitter layer;

a bottom doped epitaxy region disposed on the emitter resistor;

an intrinsic base disposed on the bottom doped epitaxy region, the intrinsic base made of one of an undoped semiconductor or a lightly doped semiconductor;

a top doped epitaxy region disposed on the intrinsic base

a collector resistor disposed on the top doped epitaxy region; and

a collector made of a collector semiconductor, disposed on the collector resistor,

wherein the emitter resistor, the bottom doped epitaxy region, the intrinsic base, the top doped epitaxy region, and the collector resistor are stacked in a channel between the emitter layer and the collector.

16. The VBJT emitter-degenerate circuit, as in Claim 15, wherein the emitter resistor, the bottom doped epitaxy region, the top doped epitaxy region, the collector resistor, and the collector are all doped with the same dopant type.

~~17. A method of making a vertical bipolar junction transistor (VBJT) circuit comprising the steps of:~~

~~creating an interim multi-layer stack by creating an emitter substructure, the emitter substructure having an emitter layer and depositing on the emitter layer the following layers: one or more interim resistor substructures, a dummy contact layer, and a tri-layer dummy stack;~~

~~etching a trench in the interim multi-layer stack;~~

~~epitaxially growing in the channel the following:~~

~~one or more resistors, each resistor surrounded by a resistor dielectric layer of one of the respective interim resistor substructures;~~

~~a doped epitaxy region surrounded by the dummy contact layer; and~~

~~an intrinsic base surrounded by a dummy layer in the tri-layer dummy stack;~~

~~removing the dummy contact layer and replacing the dummy contact layer by depositing a metal contact layer;~~

~~removing the dummy layer and replacing the dummy layer with an epitaxially grown an extrinsic base layer; and~~

~~depositing a collector on the intrinsic base.~~

~~18. The method, as in Claim 17, where the layers deposited on the emitter layer in the following order:~~

~~the interim resistor substructure, being an emitter resistor substructure;~~

~~the dummy contact layer; and~~

~~the tri-layer dummy stack.~~

~~19. The method, as in Claim 17, where the layers deposited on the emitter layer in the following order:~~

~~the tri-layer dummy stack;~~

~~the dummy contact layer; and~~

~~the interim resistor substructure, being a collector resistor substructure.~~

~~20. The method, as in Claim 17, where the layers deposited on the emitter layer in the following order:~~

~~one of the interim resistor substructures, being a first, emitter resistor substructure;~~

~~the tri-layer dummy stack;~~

~~the dummy contact layer; and~~

~~one of the interim resistor substructures, being a second, collector resistor substructure.~~

17. A vertical bipolar junction transistor (VBJT) comprising:

an emitter substructure, the emitter substructure having an emitter layer made from an emitter semiconductor;

a collector made of a collector semiconductor;

an intrinsic base, the intrinsic base made of one of a lightly doped or moderately doped semiconductor, and the intrinsic base being between the emitter and the collector; and

one or more of the following: (a) a top doped epitaxy region and a collector resistor, the top doped epitaxy region being in contact with the intrinsic base and the collector resistor and being between the intrinsic base and the collector resistor and (b) a bottom doped epitaxy region

and an emitter resistor, the bottom doped epitaxy region being in contact with the intrinsic base and the emitter resistor and being between the intrinsic base and the emitter resistor.

18. The vertical bipolar junction transistor (VBJT), as in claim 17, where an extrinsic base made of an extrinsic base semiconductor and surrounds the intrinsic base.

19. The vertical bipolar junction transistor (VBJT), as in claim 18, where the extrinsic base and the intrinsic base are doped with the same dopant type.

20. The vertical bipolar junction transistor (VBJT), as in claim 17, where the intrinsic base is made of a material having a lower bandgap than the material of which the top doped epitaxy region and the bottom doped epitaxy region are made.