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A NOVEL AND HIGH PERFORMANCE BIPOLAR DEVICE OF LOW EMITTER IMPURITY CONCENTRATION STRUCTURE

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Abstract : A novel, high performance, passivated bipolar device is reported. The structure of this device, called here a "LEC structure", is characterized by low-emitter-impurity-concentration and electrical barrier in the emitter, which causes superior device performance and productivity. The principle of this device, its technology and versatility will be discussed.

The general design of the bipolar device to get high emitter efficiency is to provide a much higher emitter impurity concentration than the base concentration to keep the value of the injected minority carrier current from the base into the emitter as low as possible.

However, the LEC device uses emitter impurity concentration of about $10^{15}/cm^3$, and $\alpha > 0.9999$ is easily obtained. The answer to this paradox is that the LEC uses the electrical barrier in the emitter to reflect the minority carrier injected from the base. The current from the emitter into the base (majority carrier current in the emitter) is supplied from the electrical barrier, which is ohmic to the majority carrier.

There are some kinds of barriers suitable for the LEC in the sense of reflecting the injected carrier :

* L-H junction (n^+n or p^+p junction) barrier
* p-n junction barrier
* MIS barrier
* Heterojunction barrier

The L-H barrier LEC device and the p-n barrier LEC device will mainly be discussed. An L-H barrier LEC transistor structure is shown in Fig. 1, and a photograph of angle lapped cross section of the L-H barrier LEC transistor is shown in Fig. 2. The LEC device structure is a passivated type and the fabrication process of the LEC uses the present Si technology and is reproducible and very controllable. Double diffused transistor structure is widely accepted because of its high performance, productivity, and designability. But it has an uncertainty about the effective base doping profile, which is affected by the emitter diffusion condition. On the other hand, the base profile of the LEC device, independent of the emitter diffusion profile, can be exactly determined. The total number

of base doping charges of the LEC device is not affected by the emitter diffusion condition and can be completely monitored if the ion implantation process is used for the base. The impurity profile of the L-H barrier LEC transistor, and that of the double diffused transistor are shown in Fig.3 and Fig.4. In addition, this LEC has an insensitive surface structure and can be designed to prevent the lateral current flow which makes device design difficult sometimes. V-I characteristics of the LEC transistor of the very high amplification factor (hFE>10,000) are shown in Fig.5, which suggests the superiority of the LEC structure.

Some kinds of new high performance devices using multiple barriers in the emitter will be also discussed.

References

1) A.S. Grove Physics and Technology of Semiconductor Devices (for example)

2) J.B. Gunn J. Electron Control (1958), 4,17

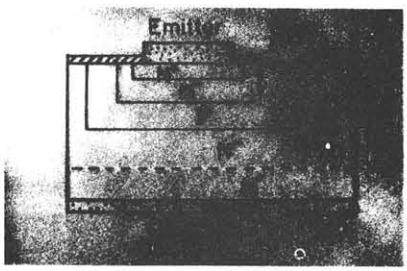

Fig 1
An L-H barrier LEC transistor structure

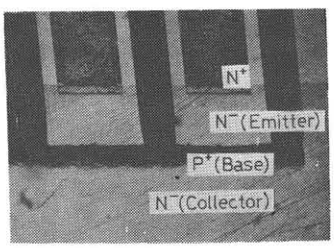

Fig 2
A photograph of angle lapped cross section of the L-H barrier LEC transistor

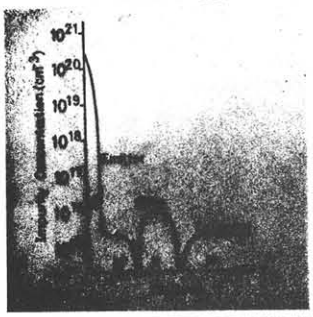

Fig 3
The impurity profile of the L-H barrier LEC transistor

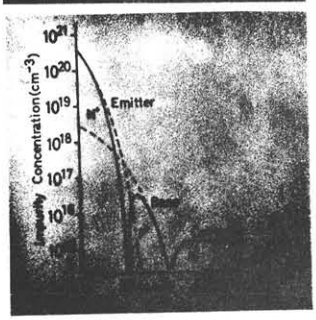

Fig 4
The impurity profile of the double diffused transistor

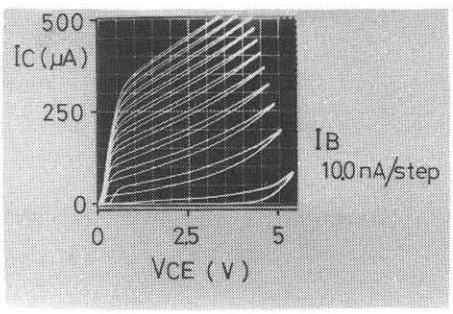

Fig 5
V-I characteristics of the LEC transistor of the very high hFE