

A-4-3

High Speed Bipolar ECL Devices Using
Vertically Isolated Self-aligned Transistor

T. Fujita, H. Sakai, K. Kawakita, T. Takemoto

Semiconductor Research Laboratory, Matsushita Electric Industrial Co., Ltd.

3-15 Yagumo-Nakamachi, Moriguchi-Shi, Osaka 570, Japan.

We have fabricated ECL devices to evaluate the performance of vertically isolated self-aligned transistor which is named VIST.¹⁾ This paper describes the characteristics of 2.5 GHz ECL divider and ring oscillators using VIST.

Figure 1 shows the cross-sections of VIST used in ECL devices. The minimum pattern size is 1.5 μm for high speed operation. A-type transistor has a single line base structure. By contrast, B-type transistor has a double line base structure, and the base area increase only 25% as compared with that of A-type in same emitter size.

The features of VIST are as follows.

- (1) Bird's beak free oxide isolation is formed,²⁾ which is suitable for high packing density.
- (2) All the side walls of emitter, base and collector are covered with oxide film. Accordingly, transistor capacitances are small.
- (3) An inactive base of high impurity concentration is formed extremely near the emitter region with a self-aligned method.³⁾ As a result, base resistance is low. Further, cut-off frequency (f_T) is high due to the flat bottom emitter.³⁾

We have fabricated a high speed 1/16 ECL divider using VIST. The transistor is walled emitter structure with emitter size of $1.5 \times 5.5 \mu\text{m}^2$ as shown in Table 1. This divider consists of a bias circuit and 4-stage master-slave Flip-Flops, each of which is identical configuration and current consumption. It operated at frequency up to 2.25 GHz at a power dissipation of 12.5 mW per one stage. Moreover, the divider with increased power dissipation was operable up to 2.5 GHz, and its output wave form is shown in Fig.2. The 2.5 GHz operating frequency is maximum value in that of all the silicon dividers which have been reported to date. Figure 3 shows a photograph of the 1/16 ECL divider. Using A-type VIST and B-type VIST, 17-stage ring oscillators with ECL gates have been fabricated as shown in Fig.4. The propagation delay time of A-type VIST was 176 psec/gate at a power dissipation of 3.7 mW. The current consumption corresponds to that of 2.25 GHz divider. Further, the power delay product of B-type VIST is 0.11 pJ/gate at low current regions. The emitter size of B-type VIST is $1.5 \times 2.5 \mu\text{m}^2$ as shown in Table 1.

As described so far, VIST is applicable for high speed and low power dissi-

pation bipolar LSI.

References

- 1) T. Takemoto et al., IEDM, p.708, 1981
- 2) K. Kawakita et al., Autumn Meeting of Japan Appl. Phys. Soc., p.541, 1981
- 3) T. Fujita et al., Proc. 12th Conf. on Solid State Devices, p.149, 1980

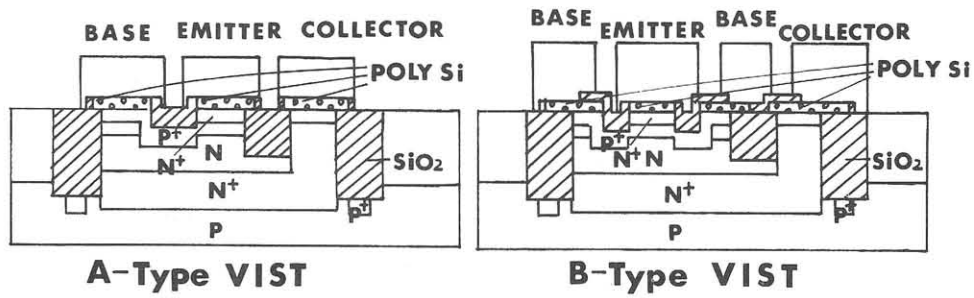


Fig.1. Schematic cross-sections of VIST

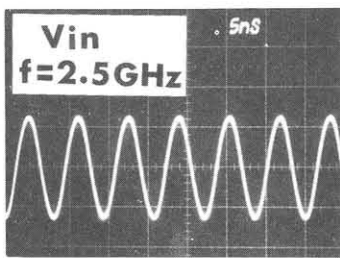


Fig.2. Output waveform of 1/16 ECL divider

Table 1. Characteristics of A-type and B-type VIST used in ECL devices

Type	A-VIST	B-VIST
Emitter size	1.5×5.5 μm ²	1.5×2.5 μm ²
C _{TE}	22 fF	10 fF
C _{TC}	19 fF	11 fF
C _{TS}	52 fF	38 fF
f _T	6 GHz	6 GHz
BV _{CEO}	5 ~ 6.5V	5 ~ 6.5V
BV _{EBO}	4.5V	4.5V
BV _{CSO}	30V	30V
Base structure	Single	Double

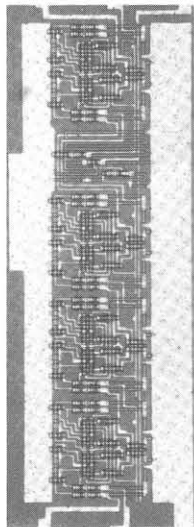


Fig.3. Photograph of 1/16 ECL divider

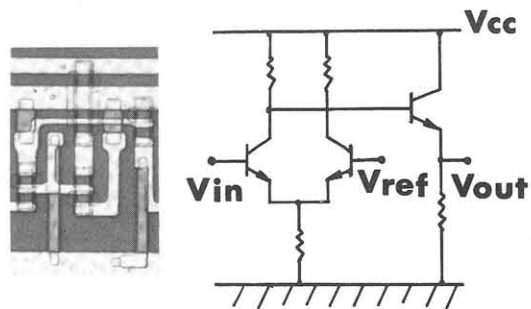


Fig.4. ECL gate used in 17-stage ring oscillator