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RECENT DEVELOPMENT OF GUNN EFFECT LOGIC DEVICES

Toyosaku ISOBE, Shintaro YANAGISAWA and Tetsuo NAKAMURA

FUJITSU LABORATORIES LTD.

Kawasaki, Japan

The trend in fields such as PCM transmission systems and digital computers is towards a higher bit rate and a faster signal processing. Application of Gunn devices, especially the Schottky Barrier Gate-Gunn Effect Digital Device (SBG-GEDD)[1], to those fields has been considered extremely attractive. This is so because of the following properties; 1) high switching speed of 50 ps inherent to the domain formation, 2) simple device structure with various signal processing functions, for example, pulse regenerator, dual gate logic element and so on, 3) availability of the monolithic integration with a semi-insulating GaAs substrate.

Although planar Gunn devices are still in the laboratory stage and many works remain to be done in understanding the details of device behaviour and GaAs material, the potential of Gunn effect devices for high speed logic is expected to be great. To demonstrate the feasibility of the system application, two kinds of the integrated Gunn devices which have been developed in our laboratory will be described; a dynamic shift register for GHz clock rate and a high speed adder with a picosecond carry generator.

Figure 1 shows a monolithic chip of a 2-bit shift register composed of dual Schottky gate devices.[2] Unit device serves as AND function for two inputs[3]; one is clock pulse and the other is domain pulse from the proceeding stage device. Improving high bit rate performance under DC bias condition, we introduced the following processes: The first is a gate notch structure in which the active layer thickness is reduced under the Schottky gate. The second is a new isolation technique utilizing the orientation dependence on chemical etching. Adapting this process to the connection between the devices, the fine gate of 2 μ length was obtained for the device with 35 μ spacing between anode and cathode electrodes. Reducing the spacing to 20 μ, 5 GHz operation can be realized. The present shift register will find their extensive applications in various pulse processing, for example PCM multiplexer.

Another example is a Gunn effect carry generator used for a binary adder.[4] Experimental 4-bit carry generator (as shown in Fig. 2) is composed of four SBG-GEDD's with a common cathode. An important feature of this device is to utilize the lateral spreading domain whose velocity is very fast; 1-4x10^8 cm/s was obtained

experimentally. The lateral spreading domain which corresponds to the carry signal can be controlled by changing the potential distribution in the active area. Therefore this device may be called a functional device.

If we can integrate the 64-bit adder consisting of this carry generator, Gunn effect AND, and EXCLUSIVE OR gates on one chip, the total number of gates will be about 200 and the addition time will be within 1 ns.

On the other hand, the present day's algorithm introduces a parallel circuit design (e.g., carry look-ahead adder) to increase the operation speed at the expense of more than 3000 logic IC gates for 64-bit addition.

Thus, utilizing the function of the Gunn domains, the complex circuits can be made to be simple and fast.

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References

1) T. Sugeta, M. Tanimoto, T. Ikoma and H. Yanai, IEEE Trans., 1974,ED-21,p.504.
2) S.Yanagisawa, O. Wada and H. Takanashi, IEDM, 1975, 14.4.
3) S. Kataoka, N. Hashizume, M. Kawashima and Y. Komamiya, 4th Cornell Conference, 1972, p. 225.
4) T. Nakamura, S. Hasuo, G. Goto, K. Kazetani and T. Isobe, ISSCC, 1975, p. 166.

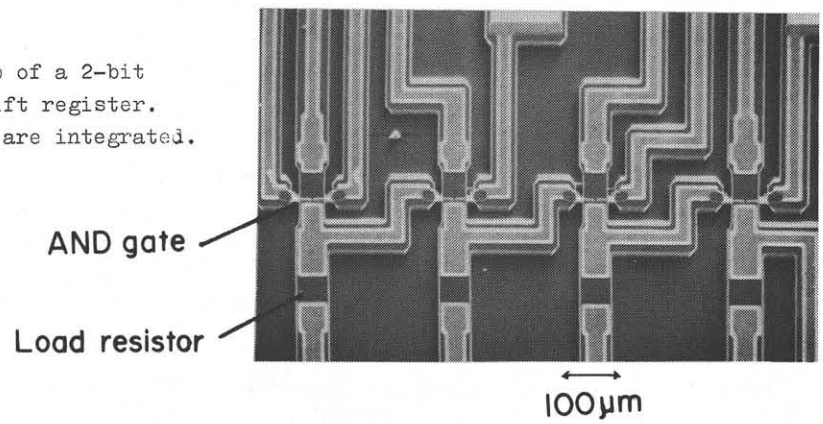

Fig. 1
Monolithic chip of a 2-bit Gunn effect shift register. Four AND gates are integrated.

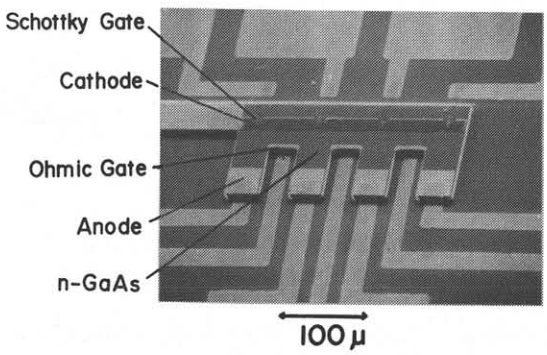

Fig. 2
Integrated 4-bit carry generator composed of four SBG-GEDD's with a common cathode.