C－4－1 (Invited)

SQUIDs as Potential Elements in Josephson Computers

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1. Introduction

The interferometer type Josephson devices, i.e., SQUIDs, are noted as potential elements for high speed computers. This paper describes the potentiality of the SQUID in Josephson computers.

2. Basic characteristics of SQUIDs

Figure 1 shows a two-junction SQUID and its threshold characteristic (control current dependence of the critical current), and Fig.2 shows a three-junction SQUID and its threshold characteristic. It can be noticed from these figures the difference of the threshold characteristics between two- and three-junction SQUIDs. Three-junction SQUIDs are especially suitable for logic applications, while two-junction SQUIDs are applied to both memory circuits [1] and logic circuits[2]. Detailed characteristics will be discussed.

3. Application of SQUIDs to digital circuits

Digital circuits using SQUIDs have been investigated so far. Some examples, such as an SFQ memory circuit [3], a cascade logic chain [1], a full adder circuit [2] will be introduced. One of them, a 4-bit full adder circuit using two-junction SQUIDs, is shown in Fig.3.

4. New type SQUIDs

Various kinds of SQUIDs have been introduced in order to obtain higher performances as compared with the conventional magnetically coupled SQUIDs. They are the CIL (Current Injection Logic) [1], the direct coupled four-junction gate [4], the CCL (Counter-electrode Coupled Logic) [5], and so on. As an example of the new gates, the CCL is shown in Fig.4. Figure 4(a) shows the structure of the CCL type two-junction SQUID, and 4(b) shows a fabricated CCL. This device has no specific control line as is provided in the conventional magnetically coupled logic device, but input signals couple to the junction magnetically by using the counter-electrode instead of the control line.

5. Toward the Josephson computer

Finally, Josephson computers in future will be discussed.

REFERENCES

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[2] S.Hasuo et al., Proc. Conf. SSD 1979, Suppl. JJAP, vol.19, pp.595-599, 1980
[3] A.Ishida et al., Spring Meeting of J. Appl. Phy. Soc., p.455, 1980
[4] S.Takada et al., Proc. Conf. SSD 1979, Suppl. JJAP, vol.19, pp.607-611, 1980
[5] H.Suzuki et al., IECE (Japan), ED79-131, 1980

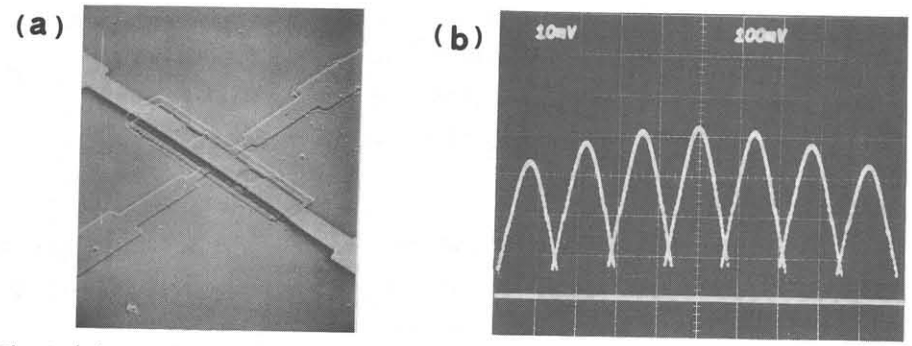


Fig.1 (a) Photograph of a two-junction interferometer, whose junction area is 5x5 μm^2. (b) Its threshold characteristic. (V,H)=(0.2,2.0)mA/div.

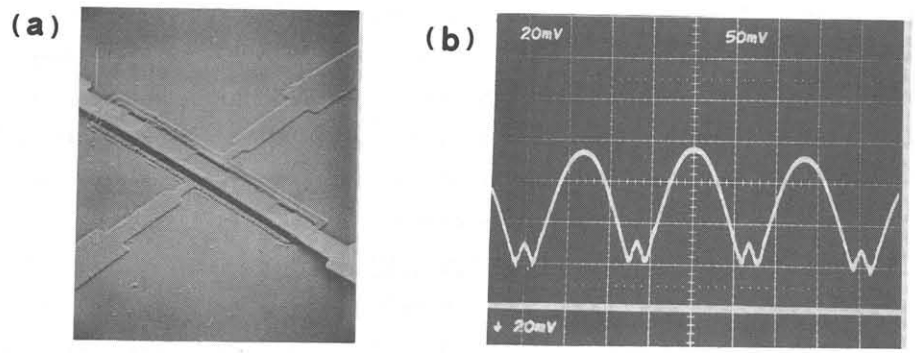


Fig.2 (a) Photograph of a three-junction interferometer, whose smaller junction area is 5x5 μm^2 and the larger one is 5x10 μm^2. (b) Its threshold characteristic. (V,H)=(0.4,1.0)mA/div.

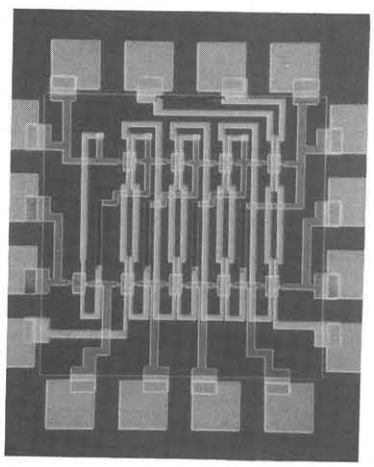
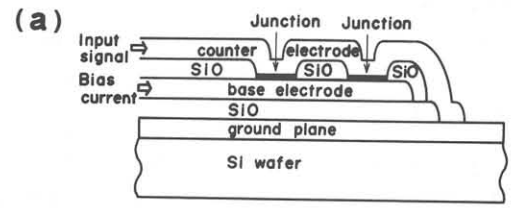


Fig.3(up) Photograph of a 4-bit parallel full adder circuit, which consists of four carry generators and five sum generators.



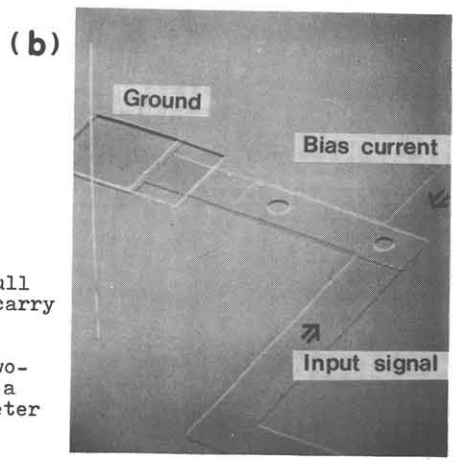


Fig.4(right) (a) Structure of a CCL type two-junction SQUID, and (b) SEM picture of a fabricated device, whose junction diameter is 10 μm.