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E-1-4 # Consideration on Bubble Memory as Practical Device

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I Introduction

The most important matter of the memory is reliability which is strongly related to the operating margin. The purpose of this paper is to describe the basic operating margin of the bubble memory from the viewpoints of (1) the film media, (2) the memory chip and (3) the memory system.

II The bubble existing range

The film is requested to provide such properties that the bias field range for the magnetic circular domain to exist (the bubble existing range)is sufficiently wide and stable against the change of ambient temperature. The bubble existing range is given by Thiele's formula. The calculated results of the bubble existing range is 26% which is the ratio of the range (0.11 x $4\pi Ms$) to the center value of the bias field if the film thickness (h) is 8 times of the characteristic length (ℓ).

The operating margin of the bubble memory is different from the bubble existing range, since many other conditions affect the operating margin. However it seems that the bubble existing range gives some idea to the operating margin.

III The operating margin of the chip

The operating margin of the chip is mainly determined by the following items.
(1) The interaction between the magnetic bubble and permalloy pattern of the bubble circuits (2) The driving speed (3) The irregular motion in the bubble circuits (4) The degradation effect due to long term operation (5) The quality of the sensing signal
The most important problem among those is the first item. It is not difficult to obtain very close operating margin to the bubble existing range in the linear propagation circuit, although the operating margin shifts to stronger field side than the bubble existing range. But it is not easy to obtain the same wide operating margin in the transfer gate and splitter circuits as in the linear propagation circuit. The reason for this is mainly caused by complexity of interaction between the bubble and those permalloy patterns. The difficulty is to make the same operating bias field of all bubble circuits such as the minor loop, the transfer gate, and the splitter etc.

The speed of the bubble can be expected to reach to about 10 MHz level in near future, but the driving field is inclined to increase as the driving frequency becomes high.

It is very difficult to find out each sources of statistic errors during long term operation. But it is considered that anomalous motion from magnetic gradient direction, inertia motion, frequent start and stop motion and nonuniform speed in one period circuit are the important sources for errors. Some degradation of the operating margin is found during long term operation, but this is not serious problem if one adds about one Oe to the initial operating margin for taking into

account of degradation.

It is not easy to obtain a high level sensing signal and a good signal to noise ration as the bubble diameter becomes small. However about 3 mV of the sensing signal and 5 of the signal to noise ratio can be expected at 3μ bubble diameter using a high sensitive permalloy detector and adopting a technique of noise cancellation between the detector terminals and the amplifier terminals. Many chips are inserted into a drive coil with the permanent magnets. It is very important to obtain the identical operating bias field among chips. This problem will be solved only by improvement of the production technology.

IV The operating margin of memory system

The operating margin as the memory system is mainly determined by temperature change, packaging conditions, aging characteristics of the components and external disturbance field. Temperature of chip in the drive coil rises due to the heat from the coil, and as a result the operating bias field related to collapse field changes at rate of about 0.2%/°C～0.3%/°C. This rate can be reduced to below 0.06%/°C, because the temperature coefficients of chips can be compensated by that of the bias magnet. If the operating temperature range of the memory system is 50°C, 3% of the operating margin is needed since the operating bias field changes by 3%.

The operating margin needed for the packaging condition is estimated to be about 3% of the operating bias field. This value contains the margins for adjusting accuracy of the operating bias field, local difference of the bias field, excess bias field from the driving field and inclined installation of the chip to the bias field. The operating bias field of each module changes due to leackage of magnetic flux from adjacent packages. The operating margin for this is estimated to be 0.5% of the bias field when a moderate magnetic shield is performed. The operating margin needed for the change of the components characteristics caused by long term stress is estimated to be about 2.5% of the bias field.

V Conclusion

Our experience indicates that the amount of 9% operating margin is necessary for memory system design. Consequently, chips must provide that value as the common operating margin for one package. This will be realizable, even if it is not easy, because the bubble existing range which is supplier of the operating margin is 26%.