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A—3—5 Diffusion Length Measurement Using Dynamic MOS RAM

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It is important to know the behavior of electrons which are injected from the peripheral circuit of the dynamic RAM to the substrate.

This paper presents a new method for the diffusion length measurement using the conventional 64K dynamic RAM. A large P-N junction is placed in parallel to the memory cell array of 64K dynamic RAM as shown in Fig.1. This junction acts as an electron injector to the substrate by forward biasing. When the injected electrons reach to the memory cell by diffusion, they drop into the potential well of the cells which store "H" level charge. Though the decrease of the "H" level charge is little in only one memory cycle, the disturb refresh mode, which performs a multiple-read operation to the memory cells except for these "H" stored cells, converts the "H" level charge to "L" level. So, the fail bit area of the memory array increases with the disturb time as shown in Fig.2. The distribution of minority carrier is expressed following equation,

$$n_p(x) = n_{p0} + [n_p(0) - n_{p0}]\exp(-x/L_n) \qquad ---(1),$$

where x is the distance from the edge of the injector, $n_p(0)$ is the concentration at the edge, n_{p0} is the minority carrier concentration in the equilibrium state of the P-type substrate, and L_n is the diffusion length of electrons. Assuming the condition $n_p(0) \geq n_p(x) \gg n_{p0}$, n_{p0} in the equation (1) is neglected. The charge decrease Q of the "H" level by the N times disturb at a distance x, is

$$Q = AqNn_p(x) \qquad ---(2)$$

, where q is electronic charge and A is a constant. When the distance to the boundary of the fail bit area is x_1 at N_1 disturb refresh times and x_2 at N_2, Q_1 and Q_2 are obtained using equation (2) respectively. Since the sensitivity of the identical sense amplifier is same,

$$Q_1 = Q_2 \qquad ---(3)$$

From eqs. (1)-(3), the diffusion length L_n is obtained as follows,

$$L_n = (x_1 - x_2)/\ln(N_1/N_2) \qquad ---(4)$$

Fig.3 shows the disturb times N_D vs. the distance from the edge of the memory cell array X_D as a parameter of the forward bias level V_F, which shows good agreement with the equation (4), and the measured diffusion length is not affected by the injection levels.

Fig.4 shows N_D vs. X_D as a parameter of the ambient temperature T_a. The data hold time of measured sample without injection exceeds 4 sec. at 60°C and 540 sec. at -20 °C and relates with n_{p0} in equation (1). On the other hand, 500K (1K = 1024) disturb refresh times take only 180 msec. at t_{cycle} = 320 nsec. So, these data are under the condition $n_p(0) \geq n_p(x) \gg n_{p0}$.

The good relationship between $\log(N_1/N_2)$ and $(x_1 - x_2)$ in wide temperature range is obtained and this suggests the validity of this method.

Fig.5 shows the temperature dependence of diffusion length L_n. The value of L_n increases according to the temperature, which suggests that the carrier trapping is dominant in the diffusion process.

A new method for diffusion length measurement has been proposed using the conventional dynamic RAM. This method shows the good agreement with the experimental results and useful techniques for the dynamic RAM analysis.

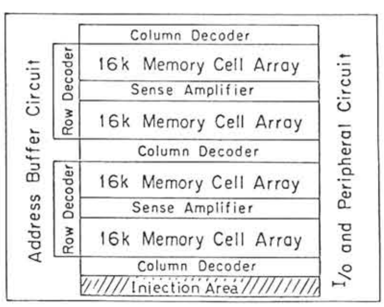

Fig.1 Layout of injector in 64K dynamic RAM

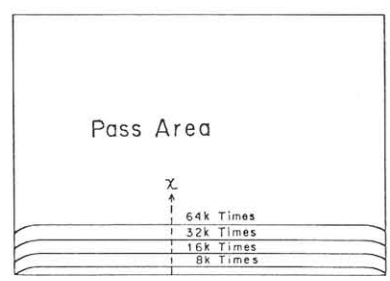

Fig.2 Failed bits map for varying disturb times

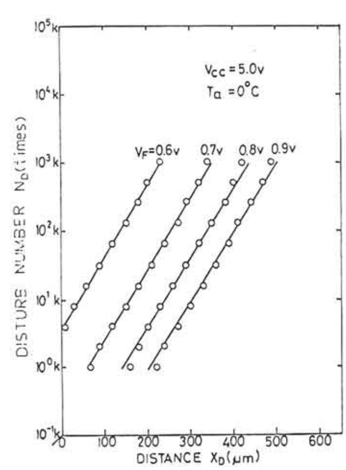

Fig.3 Disturb times N_D vs X_D, as V_F parameter

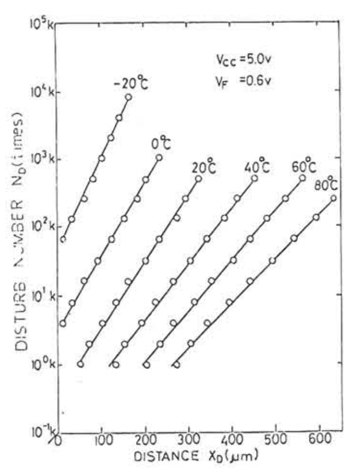

Fig.4 Disturb timed N_D vs X_D, as T_a parameter

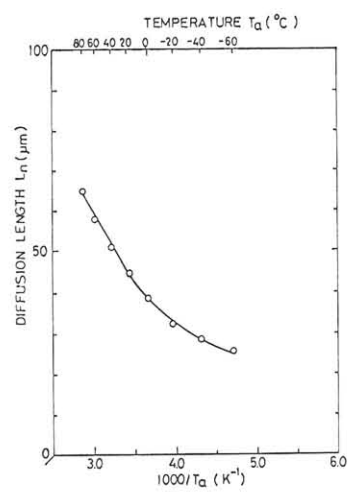

Fig.5 Temperature dependence of diffusion length of electron L_n