Highly Reliable B4-Flash Technology for High Density Embedded NVM Application

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***Abstract*—This paper reports 90nm embedded B4-Flash technology and its superior performance and reliability. Embedded B4-Flash has been implemented to certain 90nm CMOS process and fabricated its 16Mbit test array chip. B4-Flash superiority of high speed program and erase, high reliability has been confirmed by evaluating the 16Mbit test array chip and single bit test vehicle. Direct comparison of the retention reliability between B4-Flash and conventional NOR fabricated in the same silicon has been carried out, for the first time. Superiority of B4-Flash reliability to conventional NOR, which has been pointed out in the previous paper [4] has been confirmed, accordingly.**

Keywords-component; B4-Flash, embedded flash memory, program speed, scalability, high reliability

I. INTRODUCTION

We have previously reported novel NOR type flash memory "B4-Flash" and showed its excellent features of high speed programmability, good scalability and high reliability.[1]-[5] B4-Flash does not need special cell structure, and it can be applied to both conventional stacked gate cell[2] and MONOS cell[1]. So that B4-Flash, suitable to high performance, high reliability and low cost standalone memory, is also well suited to embedded nonvolatile memory technology, because of its simple structure and process.

We have implemented B4-Flash technology to certain 90nm CMOS process, and fabricated 16Mbit test array chip. By evaluating the fabricated test vehicle, B4-Flash excellent features have been confirmed. In addition to those, we have also confirmed superior reliability characteristics of B4-Flash by comparing that of conventional NOR test vehicle which is implemented on the same silicon.

II. B4-FLASH EMBEDDED CMOS PROCESS

B4-Flash technology has been implemented to certain 90nm CMOS process. Embedded B4-Flash memory cell physical structure is quite the same as conventional embedded NOR, except for Pch memory cell. So that no special process technologies are required compared to that of conventional embedded NOR, which consists of poly-Si layer for floating gate and high voltage transistors, in addition to existing logic CMOS process. In this work, B4-Flash has been implemented to 90nm conventional NOR Flash process, so that no additional process module development are necessary except memory cell well, source/drain implant process.

Features of B4-Flash embedded CMOS process are summarized in Table 1.

B4-Flash embedded CMOS Technology	
technology node	90nm
well	CMOS well + deep N-well + cell well
transistors	1.8V and high voltage
gate	2 poly-Si: 1st poly-Si: floating gate 2nd poly-Si: control gate/periphery(dual gate)
gate/diffusion	Co salicide
metal	6Cu + 1 Al, (3 metals for B4-Flash module)
Cell size	0.28um X 0.46um = 0.13um2 (15.9F2)
Cell Tr.	Pch assymmetrical source/drain L/W = 120nm/120nm

Table 1. B4-Flash embedded CMOS technology features.

Embedded B4-Flash cell size is 0.13um2 (15.9F2) and cell transistor L/W are 120nm/120nm respectively. Illustration of the memory cell cross sectional view and TEM micrograph are shown in Fig 1.

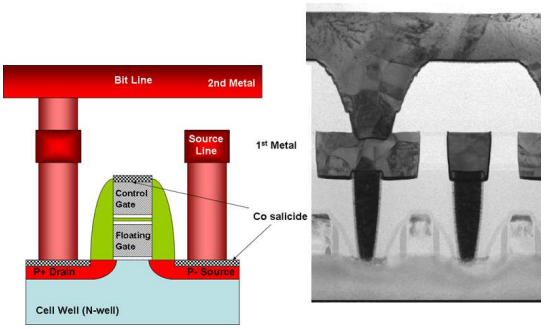

Fig. 1 Cross sectional illustration and TEM micrograph of the B4-Flash cell.

III. ELECTRICAL CHARACTERISTICS

A. *Single Cell Characteristics*

Fig. 2 shows that the single cell program, erase, drain disturb (DD) and gate disturb (GD) characteristics. Good performance of program time of less than 1usec and erase time of less than 10msec have been obtained. It should be also noted that sufficient operational margin of both drain and gate disturb of more than 10^7 have been achieved.

Single cell program and erase time are a little better than conventional NOR. However, B4-Flash has another advantage over conventional NOR in program and erase performance, due to following good reason.

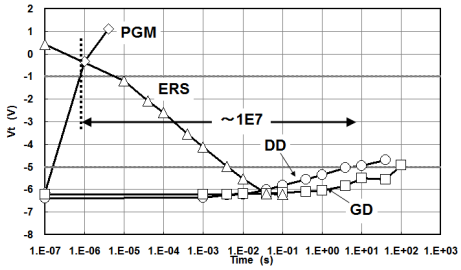

Fig. 2 Program, erase, drain and gate disturb characteristics.

Program current has been evaluated to be 10nA/bit which is three orders of magnitude less than that of conventional NOR. Thanks to this small program current feature, B4-Flash can utilize wide word simultaneous program scheme which achieves effective program speed much higher than that of conventional NOR.

For erase operation time, B4-Flash erase state has deeper Vt (negative high Vt) which is opposite to NOR, so that B4-Flash neither suffer over erasure issue at all. This B4-Flash erase state feature helps to reduce total erase operation time compared to that of conventional NOR.

Fig. 3 shows the single bit constant condition cycling endurance characteristics of the obtained test vehicle. No problematic degradation in program and erase Vt up to 10k cycles, can be seen.

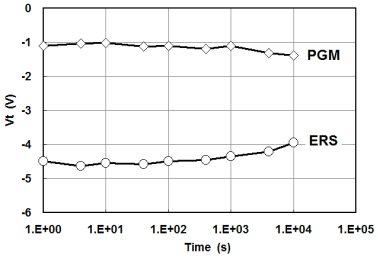

Fig. 3 Cycling endurance characteristics of B4-Flash.

B. B4-Flash Array Characteristics

16Mbit B4-Flash test array chip has been fabricated. Fig. 4 (a) shows the chip layout of the test array. 16Mbit array erase and checker program Vt distribution is shown in Fig. 5 (b).

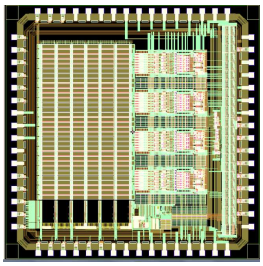

Fig. 4 (a)

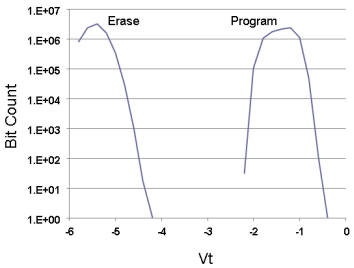

Fig. 4 (b)

Fig.4 (a) B4-Flash 16Mbit test array chip. (b) Checker board Vt distribution of B4-Flash 16Mbit test array chip.

IV. B4-FLASH SUPERIOR RELIABILITY

We have pointed out that B4-Flash realizes superior data retention reliability to conventional Nch NOR in the previous paper[4].

In this paper, we have confirmed this superiority by direct comparison between B4-Flash array and conventional Nch NOR array fabricated in the same silicon, same process and same fab., for the first time.

Fig. 5 shows B4-Flash and conventional NOR cell array retention characteristics after 10K erase write cycles and 150C 504 hours bake. Tunnel oxide thickness of both B4-Flash and conventional NOR is very thin as 6nm, for accelerated retention test. B4-Flash shows good retention characteristics regardless of 6nm thin tunnel oxide, while conventional Nch NOR shows deficient properties due to stress induced leakage of thin tunnel oxide.

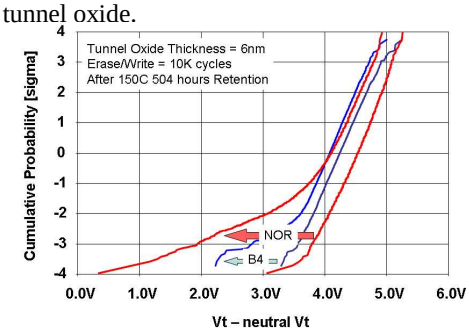

Fig. 5 Retention characteristics comparison between conventional NOR and B4-Flash.

CONCLUSIONS

Superiority of 90nm embedded B4-Flash technology has been confirmed. Embedded B4-Flash shows, high speed erase write performance, good scalability and high reliability compared with conventional embedded NOR technology. Embedded B4-Flash requires no special process module other than conventional stack gate embedded process. B4-Flash is one of the most promising candidates for non-volatile memory technology embedded to scaled CMOS below 90nm.

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