A New Investigation on Erase $V_T$ Variation of NOR Flash fabricated with 90 nm Technology


Advanced Technology Development Team, Semiconductor R&D Center, Memory Business, Samsung Electronics Co., Ltd.
San #24, Nongseo-Ri, Kiheung-Eup, Yongin-City, Kyungki-Do, Korea, 449-711
Phone: +82-31-209-2660 E-mail: t-yong.kim@samsung.com

1. Introduction
As the NOR flash enters into sub-100 nm technology node, there appeared to be several issues to seriously limit NOR flash scaling. Among those restrictions, the large fluctuation of $V_T$ in erase states seems to be one of the most difficult tasks to solve, especially for flash memories with multi-level cells (MLC). Many efforts have been devoted to tightening the $V_T$ distribution by the process optimization. However, as the design rule is scaled down to nm-scale regime, some unexpected factors, for instance, the parasitic capacitance coupling between adjacent floating gates (FGs) in NAND[1], could appear to make the $V_T$ distribution worse. Among these, in this paper, we report for the first time the effect of a parasitic capacitance originated from the misalignment of the bit-line (B/L) contact on the $V_T$ shift of the erased state.

2. Experiments
The layout of cell array is shown in Fig. 1 and cell has a channel width/length of 90/150 nm. The space for BL contact between FGs is 260 nm where the contact size is 100 nm. The NOR flash cells are fabricated with a 90 nm technology with self-aligned shallow trench (SA-STI) and self-aligned source (SAS) structure. The key features of 90 nm NOR Flash technology was reported elsewhere [2].

3. Results and Discussions
In Fig. 2, we have calculated the erased $V_T$ with the key process parameters that could give rises to the $V_T$ distribution. The key process parameters are illustrated with their notations. It should be noted that the effect of the misalignment of B/L contact on the erased $V_T$ has been considered to be negligible down to 120 nm NOR Flash technology compared to other key parameters such as tunnel oxide thickness, active width, and ONO thickness, etc. However that is no longer true in nm-technology. As the NOR flash enters into sub-100 nm technology, the variation of $V_T$ becomes more sensitive to $S_{	ext{mc}}$. Thus, it is essential to precisely control the misalignment of B/L contact in nm technology.

4. Conclusions
We have investigated an additional factor influencing the erase $V_T$ distribution in 90-nm technology. The misalignment of B/L contact is no longer negligible due to the parasitic capacitance between FG and B/L contact. When the misalignment of B/L contact is increased, the curve of the erase $V_T$ distribution is splitted to two curves, which could result in the poor distribution of the erase $V_T$.

References
Fig. 1 Schematic layout of NOR flash cell array. W and L are the active width (90nm) and channel length (150nm), respectively. The size of B/L contact and space are 100nm and 260nm.

Fig. 2 The simulated results for erased $V_T$ sensitivity with respect to the key process parameters which are the thickness of tunnel oxide ($T_{tunnel}$), the width of channel ($W_{act}$), the thickness of ONO ($T_{ono}$), the space of B/L contact to the gate ($S_{mc}$), the thickness of floating gate ($T_{fp}$), the width of floating gate ($W_{fp}$), and the length of ONO ($L_{ono}$).

Fig. 3 The $V_T$ variations with the process parameters, where the $S_{mc}$ parameter seems to be the most important factor in 90-nm technology.

Fig. 4 SEM image of misaligned cell, where a bitline contact is shifted to the odd cell, touching the SiN layer. $C_{ONO} = \text{capacitance between FG and control gate}$, $C_f = \text{capacitance between FG and source}$, $C_{CH} = \text{capacitance between FG and channel}$, $C_D = \text{capacitance between FG and drain}$, and $C_{CNT} = \text{capacitance between FG and B/L contact}$.

Fig. 5 The erase $V_T$ distribution for (a) perfectly aligned and (b) 22nm-misaligned cells. For the case (b), the distribution curve is clearly splitted into two curves.

Fig. 6 The simulated data of the contribution of $S_{mc}$ to the variation of erase $V_T$. In the 90-nm technology corresponding to 80-nm space of MC to gate, the dramatic change is observed.

Fig. 7 The difference of erase $V_T$ between the odd and even W/L is plotted vs. the amount of the misalignment.