

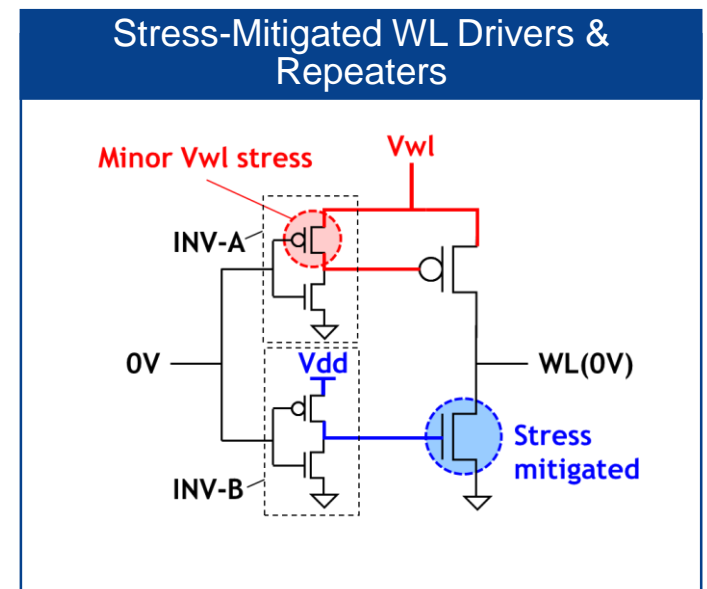
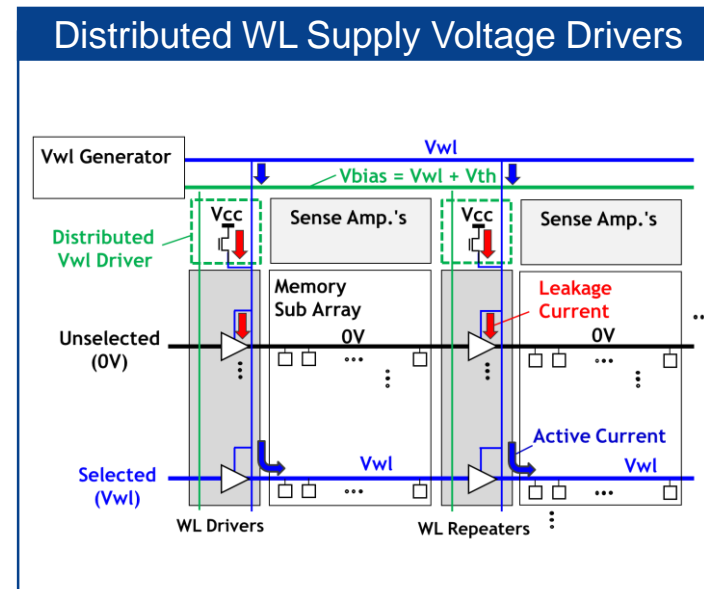
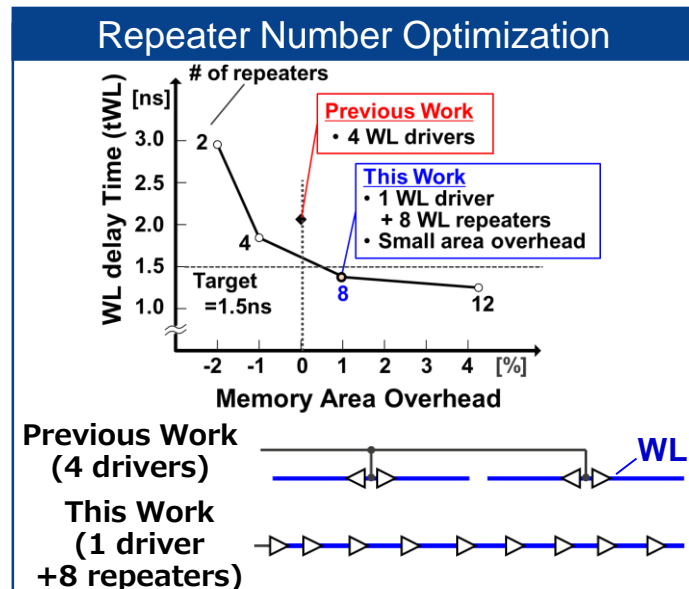
# **Presentation Highlights: “A 24MB Embedded Flash System Based on 28nm SG-MONOS” – 2019 Symposia on VLSI Technology and Circuits**

## **New Technology Achieves Industry's Largest Capacity of Embedded Flash Memory (24 MB) and Industry's Fastest Random Access Operation (240 MHz)**

- **Reliable, high-speed SG-MONOS Flash memory is added to high-performance 28nm High-k Metal Gate (HKMG) CMOS process. Renesas achieved more than 15-percent reduction in memory cell size compared with previous-generation MCUs, enabling large flash memory capacity with high-performance logic circuits.**
- **Renesas also developed the following circuit techniques for high-speed read, low-noise and advanced OTA:**
  - **Word line driver configuration for high-speed access and high reliability**
  - **Low noise program for OTA**
  - **Flash memory system for high-speed and robust software switching**

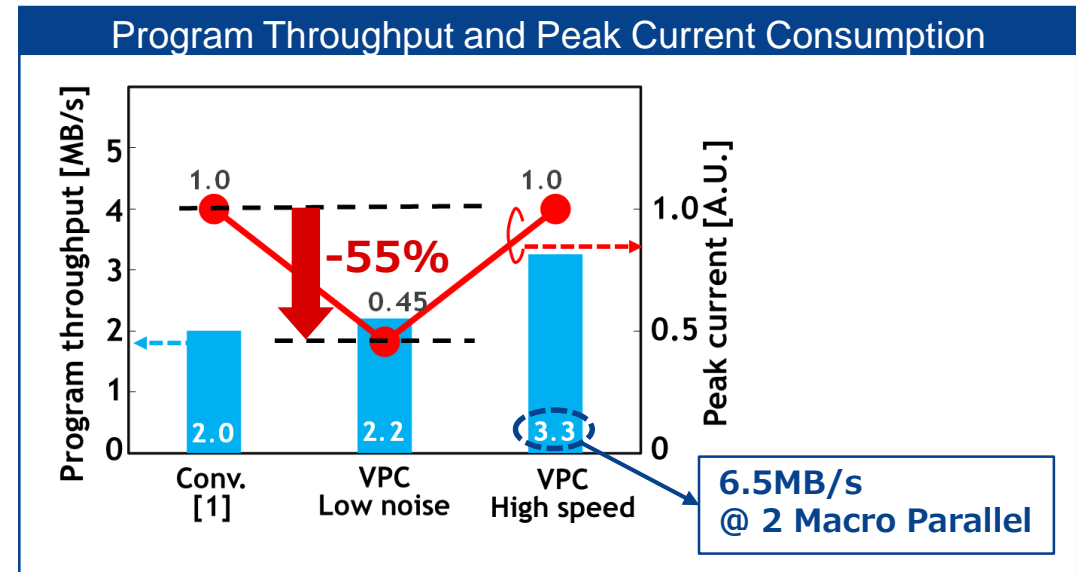
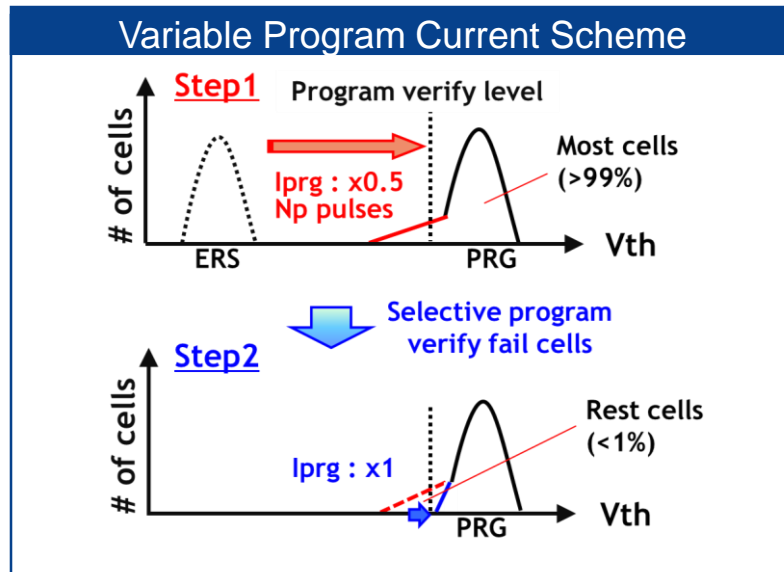
# Circuit Technique: Word Line Driver Configuration for High-Speed Read and High Reliability

- Long word line (WL) delay time caused by heavy parasitic load can be shortened by WL division.
- The number of inserted repeaters is optimized to achieve 240MHz access with a small area penalty of less than 1%.
- In accordance with insertion of repeaters, there is a risk of WL supply voltage ( $V_{wl}$ ) drop due to leakage current and reliability degradation caused by increased gate insulator film area.
- A distributed WL supply voltage driver and novel stress-mitigated WL repeater & driver resolved these issues to achieve both high-speed read and high reliability.



# Circuit Technique: Low Noise Program for OTA

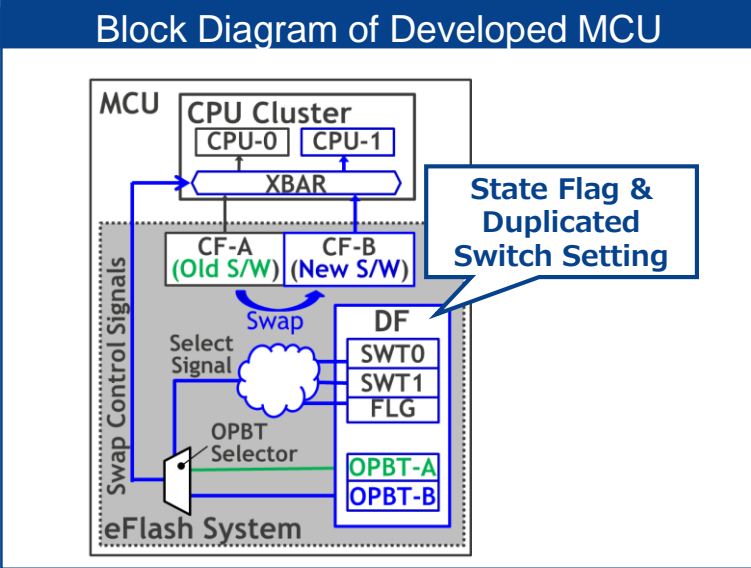
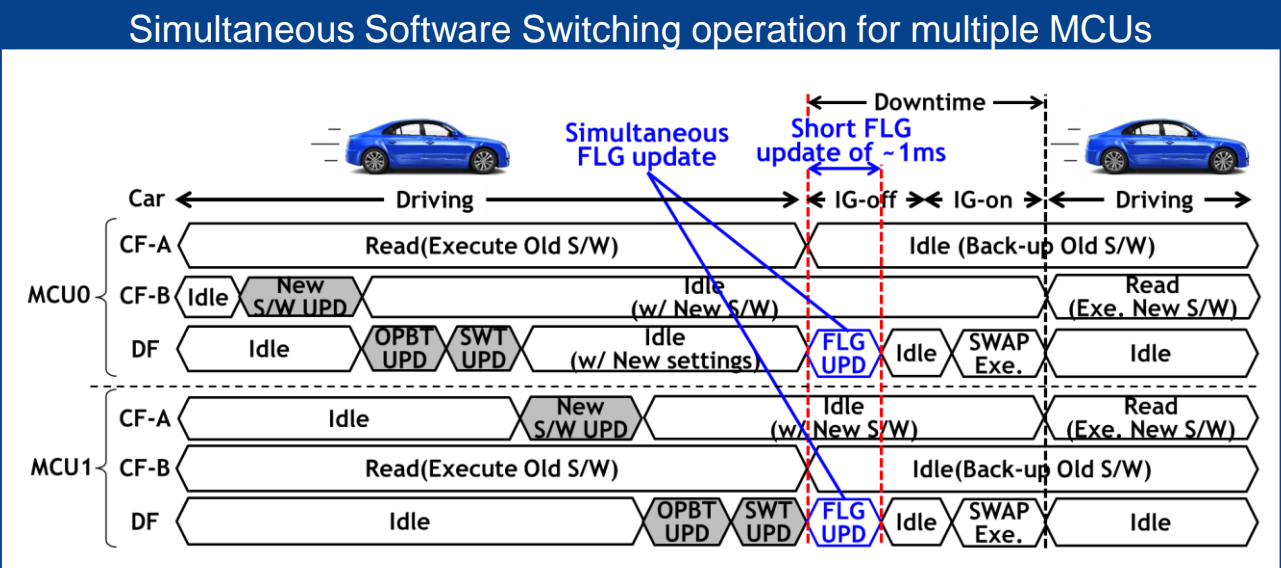
- The Flash memory macro's peak current consumption is reduced by 55% without program speed degradation by changing the write current per memory cell between initial and later operations.
- Applying the variable program current scheme, a high-speed program mode is also available in which the number of simultaneously programmed cells is increased under stable power supply such as in testing.
- Moreover, high-speed programming of 6.5MB/s is achieved with a 2 macro parallel program.



# Circuit Technique: Flash Memory System for Fast and Robust Software Switching

- The 24MB flash memory can store large-scale software even when it is divided into two areas for new and old software.
- Achieves fast software switching within 1ms after ignition off. The high-speed erase of SG-MONOS makes the imperceptibly short downtime possible.

- Moreover, duplicated switching settings and an additional flag prevent incorrect operation even after unintentional OTA termination.
- As a result, the technology realizes fast and robust software switching.



# Developed eFlash System Chip Features

## Chip Micrograph



## Flash Macro Features

	This Work
Technology	28nm HKMG CMOS Process SG-MONOS eFlash
Memory Capacity	Code Flash 24MB (4MB x 6) Data Flash 1MB (256KB x 4)
Memory Cell Size	<0.045 $\mu\text{m}^2$
Random Read Freq.	240MHz
Program Peak Current (vs. Conv. Circuit)	-55%
Program Throughput	Max.6.5MB/s
Operation Temp.(Tj (Note 1))	-40~170 $^{\circ}\text{C}$

(Note1) Junction Temperature