# Hitachi and Renesas Technology Develop 1.5-V Low-Power, High-Speed Phase Change Memory Module for On-Chip Nonvolatile Memory Applications

## — Confirmation of 416-kbyte/sec Write Throughput and 20-Nanosecond Read Operations with a100-μA Write Current Memory Cell —

TOKYO, February 16, 2007— In addressing the need for next-generation high-density on-chip non-volatile memory technology, Hitachi, Ltd. and Renesas Technology Corp. today announced the development of a 512-kbyte (4-Mbit equivalent) phase change memory module operating at a 1.5-V power supply voltage, which achieves 416-kbyte/sec high-speed write and read speeds with a 20-nanosecond*[1] access time. Using the previously developed "low-power phase change memory cells" with a 100-μA (micro*[2]-ampere) write current, the two companies developed a peripheral circuit technology to enable the high-speed write and read operations.

Hitachi and Renesas Technology presented these results at the International Solid-State Circuits Conference (ISSCC) held in San Francisco, U.S.A from February 11, 2007.

In recent years, microcontrollers have become core components in various kinds of control and information devices ranging from industrial equipment to in-vehicle systems, home electronics, and mobile phones. As products become more sophisticated and versatile, the amount of information handled by these microcontrollers has been rapidly increasing. Therefore, these microcontrollers require higher levels of performance and density in on-chip nonvolatile memory for storing data and programs. At the same time, phase change memory is becoming a promising candidate for next-generation on-chip nonvolatile memory due to its high endurance of write cycles, simple structure, and ease of fabrication.

Phase change memory is a type of nonvolatile memory that exploits two-phase changes in electrical resistance of a film caused by Joule heat, which is generated by a current — an amorphous state*[3] (high resistance) and a crystalline state (low resistance). Using these differences in electrical resistance as "1" and "0" information, it performs storage and readout operations. Hitachi and Renesas Technology have previously developed a low-power-operation phase change memory that can be written with a 1.5-V power supply voltage and 100-μA current using tantalum pentoxide for the interfacial layer. As the write voltage can be lowered compared with conventional on-chip nonvolatile memory, this memory offers advantages such as eliminating a need for a power supply circuit that generates a high voltage within a chip, helping to reduce the module size, and achieving a high level of density. However, because the readout current is small, it is critical to have a memory array circuit technology that enables high-speed operation despite its small current.

Features of the newly developed circuit technology are as follows.

(1) Write circuit technology enabling high-speed writing with a small current

1) Data write scheme with two-step current control

High-speed writing is achieved by controlling the current flowing through the phase change film during writing in two steps, first at 100 μA and then at less than 100 μA, and generating Joule heat efficiently.

2) Serial write scheme

Normally, memory writing is performed simultaneously for multiple bits that need to be written. As the current necessary for writing is [cell write current × number of bits simultaneously written], the peak current during writing operation is large when many bits are written. A serial write scheme has now been developed whereby bits are written serially one at a time, and the peak current is suppressed by allowing only one bit to be written.

(2) High-speed read circuit supporting minute read current

Despite its advantage in realizing write operations with a small current, an earlier problem with phase change memory developed by Hitachi and Renesas Technology was its slow reading time, caused by the small readout current. Now, to solve this problem, a read circuit has been developed in which a two-stage sense amplifier (amplification circuit) is used, and a signal is amplified gradually, optimizing the operating voltage of each sense amplifier. Compared with the use of a single-stage sense amplifier, amplification can be performed in a shorter time, and a faster read time can be achieved while suppressing the sense amplifier current consumption to 280 μA.

(3) Circuit technology enabling measurement of minute currents on the order of nano-amperes

In order to test the quality of fabricated memory cells, it is important to accurately measure the readout current value before a signal is read. However, in normal operation, a minute readout current on the order of nano-amperes is obscured by a current leakage generated in the memory circuit, and it has been difficult to measure accurately. Thus, a new circuit technology has been developed that reduces current leakages to a minimum level by optimizing the memory circuit voltage, making it possible for the minute readout current of a memory cell to be measured with a high degree of accuracy. Feeding back measurement results to the manufacturing process makes it possible to contribute to improvements in memory cell quality.

An experimental 512-kbyte memory module was fabricated using a 130-nm CMOS process, employing the newly developed circuit technology for cells writable at 100 μA. Test results confirmed the possibility of 416-kbyte/sec write operations and 20-nanosecond read operations, and high-speed operation was achieved while maintaining the performance of low-power-operation phase change memory cells.

This technology is expected to promote the implementation of next-generation highly-integrated on-chip nonvolatile memory, and to support significant advances in the development of future microcontrollers for embedded systems.

**About Hitachi, Ltd.**
Hitachi, Ltd., (NYSE: HIT / TSE: 6501), headquartered in Tokyo, Japan, is a leading global electronics company with approximately 356,000 employees worldwide. Fiscal 2005 (ended March 31, 2006) consolidated sales totaled 9,464 billion yen ($80.9 billion). The company offers a wide range of systems, products and services in market sectors including information systems, electronic devices, power and industrial systems, consumer products, materials and financial services. For more information on Hitachi, please visit the company's website at http://www.hitachi.com.

**About Renesas Technology Corp.**
Renesas Technology Corp. is one of the world's leading semiconductor system solutions providers for mobile, automotive and PC/AV (Audio Visual) markets and the world's No.1 supplier of microcontrollers.

It is also a leading provider of LCD Driver ICs, Smart Card microcontrollers, RF-ICs, High Power Amplifiers, Mixed Signal ICs, System-on-Chip (SoC), System-in-Package (SiP) and more. Established in 2003 as a joint venture between Hitachi, Ltd. (TSE:6501, NYSE:HIT) and Mitsubishi Electric Corporation (TSE:6503), Renesas Technology achieved consolidated revenue of 906 billion JPY in FY2005 (end of March 2006). Renesas Technology is based in Tokyo, Japan and has a global network of manufacturing, design and sales operations in around 20 countries with about 26,200 employees worldwide. For further information, please visit http://www.renesas.com

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**<Terminology>**

*1 Nano: One billionth

*2 Micro: One millionth

*3 Amorphous state: A state in which atoms, molecules, and so forth making up a solid do not have a regular structure like that of a crystal. Also referred to as a noncrystalline state.