NEC Develops Novel Silicon Nanophotonics Technology for Optical Interconnections

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NEC Corporation today announced the successful development of fundamental silicon nanophotonics technology that facilitates optical data transmission in large-scale integration (LSI) chips by eliminating data transmission bottlenecks, aiming to realize higher performance in electronic devices.

This development will be presented on February 8 at ISSCC (International Solid-State Circuits Conference) 2006 in San Francisco, California, from February 5 to 9.

Features of the new technology:

-- Reduction of the footprint area for the opto-electronic signal transfer function down to ten microns square, small enough to set onto an LSI chip, is achieved by combining an ultra-small amplifier with an existing Si nano-photodiode.
-- Application to an optical wavelength division multiplexing system enables transmission of a significantly larger amount of data compared to conventional copper wiring through an optical wire with a width of less than one micron.

Both of these developments have significantly increased the possibility of realizing optical data transmission and high-frequency optical clock distribution on LSI chips.

In a networked society, where large amounts of information are

exchanged, devices need to operate at higher speeds to be able to process tremendous volumes of data. Conventionally, the operating speed of an LSI chip has been accelerated by increasing the clock rate through miniaturization of transistors. Recently, however, LSI manufacturers have found it difficult to increase clock speed without simultaneously increasing power consumption due to the growing leakage current of transistors as miniaturization advances. To overcome this problem, NEC developed a multicore technology that enables the suppression of clock speed in an LSI chip through parallel processing. This technology already has been commercialized by NEC as an application processor, MP211, for mobile handsets. However, by 2015, the data transfer rate for a microprocessor (MPU) is expected to exceed one terabit per second, ten times higher than current rates, and cause difficulty in conventional electrical wiring in high-performance information and network systems. Thus, there is a great need for novel data transfer technology that employs light (optical wiring technology).

Important factors in developing optical wiring technology include reduction of size, increase in speed and reduction in power of the opto-electronic component, which consists of an opto-electronic device and a high-speed amplifier. NEC has developed a nano-photodiode made of Si as a high-performance, ultra-small opto-electronic device, which has a high-speed response of more than 50 gigahertz with a footprint of less than ten microns square. However, a structure such as this with a high-speed amplifier is very complicated and thus requires a footprint of several tens of microns square, resulting in an unrealistic layout for placement within an LSI chip with an opto-electronic component using conventional technology.

In response to this, NEC leveraged the small electrical capacitance of nano-photodiode (junction capacitance of about ten aF) to reduce the footprint of the high-speed amplifier by approximately two orders of magnitude. In addition, a high-speed opto-electrical signal transfer was

carried out with little power consumption by combining the circuit and nano-photodiode.

Moreover, NEC has been striving to develop fundamental items vital to the realization of optical-wavelength division-multiplexing technology, which dramatically increases the amount of data that can be transmitted by sending multiple optical signals with different wavelengths in an optical wire. These items include:

-- Technology for realizing ultra-small optical multiplexers/demultiplexers with a size of about 100 microns square, about one hundredth the size of conventional devices, with an ultra-fine optical waveguide

-- Development of ceramic electro-optic film fabrication by an aerosol deposition method for reducing the size of optical modulators, which change electric signals into optical signals, to 100 microns, about one tenth the size of conventional devices
These developments are aimed at simplification of the LSI structure, which is now becoming progressively complex. These technologies greatly increase the possibility of incorporating into LSI chips optical wires that can realize data transfers 100 times greater than current copper wires with low power and high speed.

NEC believes that its elemental Si nanophotonics technology and new circuit technology will contribute substantially to the sophistication of computers and servers, in addition to the miniaturization of network devices and the development of network components with high endurance for electro-magnetic noise.

Source: NEC