NEC and NEC Electronics Develop Novel Channel-Engineering Technology for Advanced CMOS Transistors
Enabled by visualization of ultra-shallow junctions based on electron beam holography

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Tokyo, December 13, 2007 - NEC Corporation and NEC Electronics Corporation have successfully developed design technology to realize optimum channel structure in CMOS transistors for advanced LSIs in the 32nm generation and beyond. This achievement relies on visualization of impurity distributions in transistors based on electron beam holography technology with world-leading high spatial resolution.

Features of the new technology

(1) Pn-junctions with low resistance and very steep impurity profiles were realized by a combination of two state-of-the-art process technologies - cluster-ion implantation that suppresses the so-called channeling effect [(1)] for implanted impurity atoms and diffusion-less high-temperature millisecond annealing for impurity activation. These properties are both desirable for ultra-small CMOS transistors. In addition, improvement in actual device performance was confirmed.

(2) A novel metrology technique for visualizing cross-sectional potential distributions in nanometer-scale transistors was established by applying electron beam holography technology [(2)] with world-leading spatial resolution. This enabled highly accurate calibration of TCAD (process simulation) results, thereby allowing optimization of fabrication processes.

The functionality of electronic equipment, such as mobile phones, digital consumer electronics, mobile audio players, and car navigation systems, is becoming increasingly diverse with advances in IT network accessibility. This has generated strong demand for improvements in performance, power consumption and manufacturing costs of modern LSI devices, which in turn drives expectation for the realization of technologies to further miniaturize LSIs.

The major technical challenge with modern advanced CMOS devices is how to suppress the trend of increasing leakage current, which arises from the miniaturization of device structures. To overcome this problem, it is necessary to form ultra-shallow junctions in the channel regions of transistors; however, ultra-shallow junctions may potentially cause degradation in device performance due to increased parasitic resistance. Therefore, it is necessary to carefully optimize the junction structures (profiles) to meet the requirements for both performance enhancement and suppressed leakage current.

To achieve these requirements, optimum shapes for the ultra-shallow junctions based on TCAD (process simulations), whose results yield optimum process conditions to realize ideal junction structures, need to be designed. As the actual junction structure is known to be very sensitive to the parameters for fabrication processes, there is a demand for a highly accurate nanometer-scale metrology technique that allows tuning of the process parameters through observation of junction structures built in the actual devices.

From the point of view of process technology, an ion-implantation technique capable of introducing impurity atoms only into the very shallow region from the surface of silicon crystals is required. Furthermore, an annealing technique with a minimal thermal budget is needed to achieve electrical activation of impurities without inducing their notable redistribution through thermal diffusion.

NEC and NEC Electronics' research achievement meets these expectations and realizes shape control of the ultra-shallow junctions, as well as optimization of the fabrication processes. The research result demonstrated that planar-bulk-type CMOS devices can be miniaturized down to the 30nm generation, while maintaining good performance and suppressed leakage current.

NEC and NEC Electronics will continue this research toward delivery of system LSIs with improved performance and quality, indispensable to the realization of a ubiquitous-networked society.

This research was presented on December 10 at the International Electron Device Meeting (IEDM) being held in Washington DC.

About NEC Corporation

NEC Corporation is one of the world's leading providers of Internet, broadband network and enterprise business solutions dedicated to meeting the specialized needs of its diverse and global base of customers. NEC delivers tailored solutions in the key fields of computer, networking and electron devices, by integrating its technical strengths in IT and Networks, and by providing advanced semiconductor solutions through NEC Electronics Corporation. The NEC Group employs more than 150,000 people worldwide. For additional information, please visit the NEC home page at: http://www.nec.com

About NEC Electronics

NEC Electronics Corporation (TSE: 6723) specializes in semiconductor products encompassing advanced technology solutions for the high-end computing and broadband networking markets, system solutions for the mobile handset, PC peripherals, automotive and digital consumer markets, and platform solutions for a wide range of customer applications. NEC Electronics Corporation has 25 subsidiaries worldwide including NEC Electronics America, Inc. (www.am.necel.com) and NEC Electronics (Europe) GmbH (www.eu.necel.com). For additional information about NEC Electronics worldwide, visit www.necel.com.

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Notes

(1)

Electron beam holography is a technology that detects a slight perturbation in the wavelength of electrons, which takes place as a result of traversing through silicon crystal with different electrostatic potentials (e.g. n-type vs. p-type silicon). Therefore, a nanometer-scale mapping of pn-junctions is obtained.

(2)

Channeling: In the fabrication process of ion-implantation, impurity atoms are accelerated and implanted into crystalline silicon. As the crystalline lattice of silicon has a regularly ordered atomic structure, implanted atoms tend to penetrate through the ordered spacing of the lattice and reach the deeper region. This effect is called channeling. The effect is more abundant for lighter mass impurities. If the crystalline structure is no longer preserved, as in amorphous solid, the channeling effect is suppressed.

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