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BACKGROUNDER

60 YEARS OF CONTINUED TRANSISTOR SHRINKAGE, INNOVATION

Intel 45 Nanometer Technology Gives the Transistor Dramatic Make-Over

SANTA CLARA, Calif., Jan. 29, 2007 – Since the invention of the first transistor in 1947, technology has progressed swiftly, paving the way for more advanced and powerful, yet more cost-effective and energy-efficient products. Despite these advances, transistor heat and electric current leakage remain critical barriers to making transistors smaller and perpetuating Moore's Law. It is not surprising that some of the materials used to make transistors in the last 40 years need to be replaced.

Intel has developed breakthrough materials for its 45 nanometer (nm) transistors that, when combined, produce a transistor with very low current leakage and record high performance. With the first working processor – part of the "Penryn" family of next-generation Intel® Core™ 2 and Xeon® families of processors – developed using its 45nm manufacturing process technology, Intel has successfully addressed these difficult barriers to drive the progression of Moore's Law. Removing these roadblocks will ultimately deliver energy-efficient, low-cost, high-performance computing products from laptops and mobile devices to desktop PCs and servers.

On this 60th anniversary of the transistor, take a look back at its history and several key milestones as Intel's 45nm innovation ushers in new semiconductor technology and Moore's Law well into the next decade.

- Dec. 16, 1947: William Shockley, John Bardeen and Walter Brattain successfully build the first transistor at Bell Labs.

- 1950: William Shockley develops the bipolar junction transistor, the device most commonly referred to as a transistor by today's standard.

- 1953: The first commercial device to make use of the transistor is put on the market – the hearing aid.

- Oct. 18, 1954: The first transistor radio, the Regency TR1, was put on the market and contained just four germanium transistors.

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- April 25, 1961: The first patent is awarded to Robert Noyce for an integrated circuit. Original transistors had been sufficient for use in radios and phones, but newer electronics required something smaller – the integrated circuit.

- 1965: Moore's Law is born when Intel's Gordon Moore predicts that the number of transistors on a chip will double roughly every year (a decade later, revised to every 2 years) in the future, as stated in an article in *Electronics Magazine.*

- July 1968: Robert Noyce and Gordon Moore resign from Fairchild Semiconductor, and start a new company named Intel, short for integrated electronics.

- 1969: Intel develops the first successful PMOS silicon gate transistor technology. These transistors continue to use a traditional silicon dioxide (SiO_2) gate dielectric, but introduce new polysilicon gate electrodes.

- 1971: Intel launches its first microprocessor – the 4004. The 4004 was 1/8 of an inch by 1/16 of an inch, contained just more than 2,000 transistors and was manufactured with Intel's 10micron PMOS technology.

- 1978: With 29,000 transistors, the 16-bit 8088 runs at 5MHz, 8MHz and 10MHz, A pivotal sale to IBM's new personal computer division in 1981 makes the Intel 8088 microprocessor the brains of IBM's new hit product--the IBM PC. The 8088's success propels Intel into the ranks of the Fortune 500, and Fortune magazine names the company one of the "Business Triumphs of the Seventies."

- 1982: The 286 microprocessor, also known as the 80286, is released and is a 16-bit processor from Intel that could run all the software written for its predecessor. The 286 processor utilizes 134,000 transistors and runs at 6MHz, 8MHz, 10MHz and 12.5MHz.

- 1985: The Intel386™ microprocessor is released, featuring 275,000 transistors – more than 100 times as many as the original 4004. It was a 32-bit chip and was multi tasking, meaning it could run multiple programs at the same time.

- 1993: Intel® Pentium® Processor is released with 3 million transistors and made with Intel's 0.8micron manufacturing process.

- Feb. 1999: Intel launches the Pentium® III processor – a 1x1 silicon square containing more than 9.5 million transistors manufactured with Intel's 0.25 micron manufacturing process technology.

- Jan. 2002: The latest version of the Intel Pentium 4 processor is introduced at 2.2 billion cycles per second for high-performance desktop PCs. It is manufactured using Intel's 0.13 micron process technology and has 55 million transistors.

- Aug. 13, 2002: Intel unveils several technology breakthroughs in its forthcoming 90nm process technology, including higher-performance, lower-power transistors, strained

silicon, high-speed copper interconnects and a new low-k dielectric material. This will be the first process in the industry to implement strained silicon in production.

- March 12, 2003: The Intel® Centrino® mobile technology platform is born for laptops and includes Intel's latest mobile processor, the Intel Pentium M processor. This processor, based on a new mobile-optimized microarchitecture, is manufactured using Intel's 0.13 micron process technology and consists of 77 million transistors.

- May 26, 2005: Intel's first mainstream dual-core processor -- the Intel Pentium D processor – debuts with 230 million transistors and manufactured with Intel's leading 90nm process technology.

- July 18, 2006: The Dual-Core Intel® Itanium® 2 processor launches with the world's most intricate product design to date, utilizing more than 1.72 billion transistors. The processors are manufactured with Intel's 90nm process technology.

- July 27, 2006 – The world's best processor – Intel® Core™ 2 Duo – makes its debut. These processors have more than 290 million transistors and are built in several of the world's most advanced labs using Intel's 65nm process technology.

- Sept. 26, 2006 – Intel announces that more than 15 products based on 45nm are in development across desktop, mobile, and enterprise segments based on "Penryn," a derivative of the Intel® Core™ microarchitecture.

- Jan. 8, 2007: Expanding quad-core PC sales to mainstream buyers, Intel launches its 65nm Intel® Core™2 Quad processor for desktop PCs, as well as two additional quad-core server processors. The Intel Core 2 Quad processor boasts more than 580 million transistors.

- Jan. 29, 2007: Intel reveals breakthrough transistor materials – high-k and metal gate – that it is using to build the insulating wall and switching gate on the hundreds of millions of microscopic 45nm transistors – or switches – inside the next generation Intel® Core™ 2 Duo, Intel Core 2 Quad and Xeon® families of multi-core processors – codenamed Penryn. Working 45nm microprocessors have already been made with these advanced transistors.

Intel, the world leader in silicon innovation, develops technologies, products and initiatives to continually advance how people work and live. Additional information about Intel is available at www.intel.com/pressroom.

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