# Intel (A): Dominance in Microprocessors



Paul Otellini gazed out the window of his new office at Intel's headquarters and was struck by how much Silicon Valley, Intel Corporation, and he had changed. San Jose and the surrounding communities were no longer the sleepy towns of orchards they had been when he began at Intel in 1974. Intel had evolved from a cutting-edge memory company into a dominant player in the computer industry value chain. Otellini also had moved from a functional staff position in finance through a number of operating and marketing roles to become the first nonengineer to serve as Intel's CEO. His tenure included roles as the general manager of Intel's Architecture Group and Microprocessor Products Group, where he led the introduction of the Pentium chip that redefined the company in the early 1990s.[1] As Otellini pondered those significant changes since 1974, he wondered what Intel would need to make to maintain its position of industry leadership in Microprocessors and how should he respond.

## Intel: The Early Days

The beginning of Intel Corporation (NASDAQ symbol: INTC), arguably one of Silicon Valley's dominant and most successful companies in the mid-2000s, differed from the mythical founding of Hewlett Packard in a garage or the youthful exuberance of Apple's Steve Jobs and Steve Wozniak. When Robert Noyce and Gordon Moore formed Intel, they were already in middle age, were considered experts in their field, and raised over $2 million in start-up capital in one afternoon.[2] Noyce had been one of the inventors of the integrated circuit, and Moore was a talented, visionary engineer and problem solver. It was Moore who noted in 1965 that every 18-24 months the number of transistors placed on an integrated circuit would double. Dubbed "Moore's law, "this prediction had driven competition and strategy in the industry since its inception. In fact, experts predicted the rate of doubling would continue well into the 2020s.[3]

Intel was not the first entrepreneurial venture for Noyce or Moore; the two had helped found Schockley Labs in 1956, and they had bolted Shockley a year later as members of the "traitorous eight" that founded Fairchild Semiconductors. Fairchild had operated for over a decade as a subsidiary of the Fairchild Camera and Instrument Corporation, an East Coast manufacturing company. The corporate parent never truly understood the semiconductor business, and corporate policies meant that emerging and lucrative technological advances, often designed by Moore and his team, were not exploited. Noyce and Moore founded Intel with two goals: to work with and commercialize high quality, exciting new technologies and to make money. On Moore's office wall hung a plaque that said, "this is a profit making organization. That's the way we intended it . . . and that's the way it is."[4]

Intel's culture, operating policies, and competitive position built on Moore and Noyce's fascination with great semiconductor technology. However, their first hire, Andy Grove, would have equal, if not greater, influence on Intel's culture and capabilities. Grove was born in Hungary as

András Gróf, but he Americanized his name shortly after arriving in the United States in 1957. He earned a PhD in Chemical Engineering from UC Berkley in 1963 and worked with Noyce and Moore at Fairchild. Grove joined the company as Director of Operations; he became the COO shortly thereafter and CEO upon Moore's retirement in 1987. Grove's fanatical attention to detail, his penchant for disciplined, data driven action and conduct, and his style of constructive conformation soon permeated the company, its operations, and processes. Despite the company's technological prowess in engineering and innovation, Grove worked tirelessly to make Intel a world class *manufacturing* organization, often combining a new product generation with a new fabrication process.[5]

Intel's first product was a memory chip that integrated existing memory cell technology with the rest of an integrated circuit. The result was a more powerful and useful chip that improved performance for users. The company pursued three equally promising technological platforms to create memory chips—Silicon Gate MOS, Multichip Memory modules, and the Schottky Bipolar Process. The founders would commercialize whichever technology could be mass-produced, thereby driving the cost per chip to its minimum. The Silicon Gate process won out, and the process created another win for Intel. The company's technology strategy revolved around hiring the brightest engineers they could find, promising them stock options, and putting them to work at the basic tasks, often using competing teams and platforms to enhance the development process.

Intel's first chip, the 1101 static memory chip, appeared on the market in 1969, as did their first money-making product, the 3101 static random access (SRAM) memory chip. (see **Exhibit 1**). In 1970, Intel introduced the 1103, the first dynamic random access memory (DRAM)

**EXHIBIT 1** **Key Events for Intel**

| Year | Intel Key Products | Key Events |
|---|---|---|
| 1968 | | Intel founded |
| 1969 | 3101, first bipolar memory | |
| | 1101, first CMOS memory | |
| 1970 | 1103, first dynamic memory | |
| 1971 | 4004, first 4-bit microprocessor | |
| | 1702, first EPROM (erasable memory) | Intel went public |
| 1972 | 8808, first 8-bit microprocessor | |
| 1974 | 8080, first 8-bit microprocessor for computing | |
| 1976 | 8085, integrated 8-bit microprocessor | |
| 1978 | 8086, low-cost 16-bit microprocessor | |
| 1979 | 8088, low-cost 16-bit microprocessor | |
| 1981 | | IBM PC with 8088 processor and DOS |
| 1982 | 80286, 16-bit microprocessor with memory management | |
| 1985 | 386, 32-bit processor | Intel exited memory business to focus on microprocessors |
| 1986 | | Compaq announces first 386 PC |
| 1989 | 486, 32-bit microprocessor with integrated cache memory and floating point processor | |
| 1990 | | Microsoft announces Windows 3.0 |
| 1991 | | Intel launches "Intel Inside" campaign |
| 1993 | Pentium processor, superscalar technology | Microsoft announces Windows NT |
| 1995 | Pentium Pro processor, Dynamic Execution and Dual Independent Bus | Microsoft announces Windows 95 |

| Year | Intel Key Products | Key Events |
|---|---|---|
| 1996 | | 25th anniversary of the microprocessor |
| 1997 | Pentium processor with MMX technology | |
| | Pentium II processor: Dynamic Execution, Dual Independent Bus and MMX technology | |
| 1999 | Pentium III processor | |
| 2004 | Pentium 4 next generation processor | |
| 2001 | Itanium 64-bit processor | U. S. Recession causes 4.6% decline in PC sales |
| 2002 | Pentium M Processor: 90 nm process technology | |
| 2003 | Intel introduces the Centrino mobile chip | |
| 2005 | Pentium D Processor: 3.2 GHz clock speed | |

Source: Albert Yu, Creating the Digital Future (New York, Free Press, 1998) and Intel product release data.

chip. The 1103 offered customers a stable memory chip that met two key objectives for Intel: (1) the chip could be produced cheaply in mass quantities and (2) it offered the promise of technical improvements in future generations. With the 1103 chip, Intel would begin to conquer the memory market. Intel began producing its chips in a renovated factory the company had purchased from Union Carbide.

Intel was hungry for new revenue and in 1969 Gordon Moore accepted a development project for Busicom, a Japanese calculator company. Busicom wanted a custom chip for its programmable calculators. Moore wanted much more, however: generic chips that could be produced and sold in mass quantities.[6] Intel engineer Ted Hoff resolved the conflict when he proposed a four-chip set that performed multiple tasks. One chip would act as the CPU, another would be a memory chip for working with active data, one would be a ROM memory chip where the program would be stored, and one would handle the input/output (I/O) interface.

The product was the Intel 4004 chip, a 4-bit[l] chip that packed as much processing power as the first computer, the 1940s ENIAC machine that required a whole room of transistors.[7] In August of 1972, Intel introduced a second microprocessor, built on 8-bit technology, and named the 8008. Two Seattle teenage hackers, Bill Gates and Paul Allen, would later purchase an 8008 and try to build a machine for a local traffic consulting company.



# The Rise of the Microprocessor and Intel's Dominance

Throughout the 1970s, Intel continued its work in memory chips and produced a number of breakthrough products, including an erasable memory chip (EPROM) that significantly improved customer performance while lowering costs. The microprocessor business continued to grow slowly, and even though the 8008 was a technical marvel, it proved to be a slow and clunky device. Intel's third generation chip, the 8080, came to market in 1975. One 8080 customer, MITS, used the chip as the core of a new product, a truly personal computer. Bill Gates and Paul Allen bought one of these new machines, the Altair 800, and

[l]A "bit" is short for a binary digit. It is a spot on a silicon chip that can either hold an electric charge or not. Increasing the bits computer chips could string together led to increases in information storage and processing power.