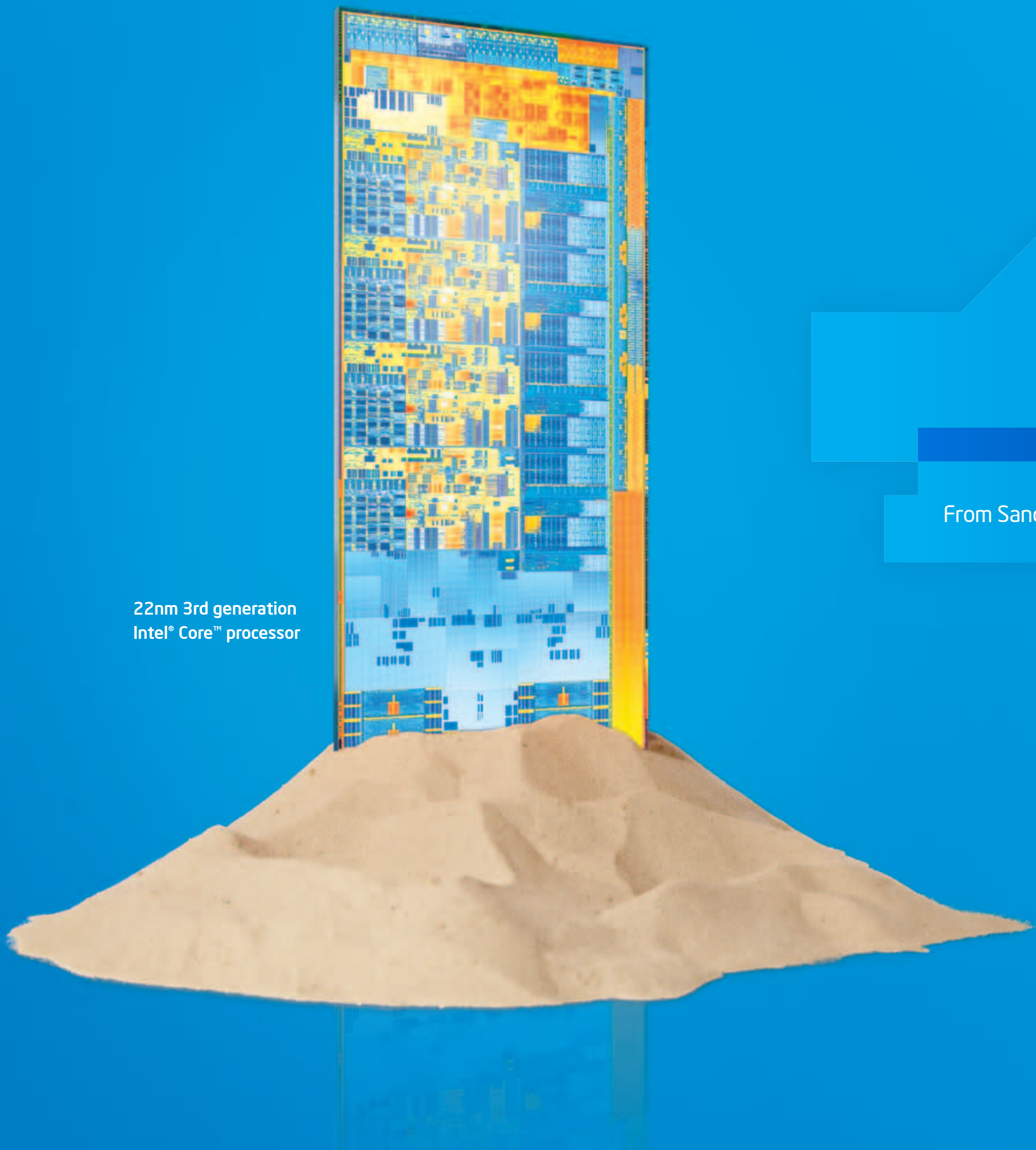
Transistors to Transformations

From Sand to Circuits — How Intel Makes Chips



22nm 3rd generation Intel® Core™ processor

“For years we have see
transistors can get. Th
structure is a **truly rev**
and one that should all
the historic pace of inn

-Gordon E. Moore, Co-founder, Intel Corporation, commenting on Intel’s radical reinvention of the transistor — the creation of the 22nm 3-D Tri-Gate transistor

n limits to how small
is change in the basic
olutionary approach,
ow Moore's Law and
ovation to continue."

A Smart World

REVOLUTIONARY

For decades, Intel's research and development, advanced ***silicon*** chips, and manufacturing have brought together the best of computing, communications, and consumer electronics to enable valuable benefits from technology.

Intel continues to introduce new process technologies that deliver more energy-efficient, secure, and higher-performance products, which are then designed into your increasingly connected, smarter devices.

MOORE'S LAW

According to ***Moore's Law,*** the number of ***transistors*** on a ***chip*** roughly doubles every couple of years. As a result, the transistor scale gets smaller and smaller. As the transistor count climbs, so does the ability to integrate more capabilities onto a chip and increase device complexity.

The cumulative impact of these spiraling increases in capabilities enables today's mobile devices, fuels the increasingly Internet-connected and information-rich digital experiences we seek, and powers industries and our global economy.

Delivering Moore's Law requires numerous innovations. Intel's world-first, advanced transistor design introductions include ***strained silicon*** (2003), 45nm with high-k/metal gate silicon technology (2007), followed by the 32nm 2nd generation high-k/metal gate silicon technology (2009). Recently, Intel introduced another radical design change—***22nm 3-D Tri-Gate transistors*** (2011), which entered high-volume production in 2012.

YOUR WORLD CONNECTED

"Our vision is very simple: if it consumes electricity, it's going to end up computing, and if it's computing, it will be connected to the Internet," stated Kirk B. Skaugen, Intel Vice President and General Manager of the PC Client Group. He was describing server cloud computing capabilities and connected device growth expected within the next decade at the Web 2.0 Summit in November 2011.

Forecasts call for 15 billion connected devices[1] and over three billion connected users[2] by 2015. The growth of global data through 2015 is expected to surpass 4.8 ***zettabytes*** per year.[3] At these levels, each connected user will generate more than four ***GB*** of data traffic every day. That's the equivalent of a 4-hour HD movie.

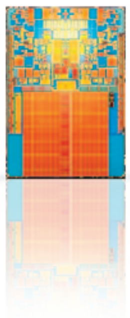
THE POWER TO TRANSFORM

From ***Ultrabook***™ devices, data centers, and high performance computing, to applications, security, and Intel-powered smartphones and tablets, the only thing more amazing than Intel's technology is what you do with it.

Find definitions of italicized words in the "Terminology" section at the end of this brochure.

2008*

Intel® Core™2 Duo processor die
(45nm high-k/metal gate silicon technology)

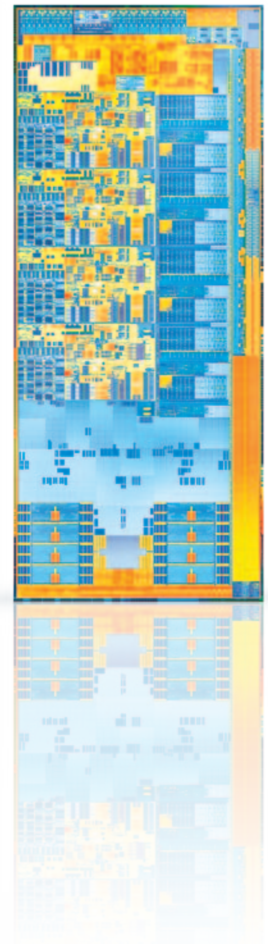


2010*

2nd generation Intel® Core™ processor die
(32nm process technology)

2012*

3rd generation Intel® Core™ processor die
(manufactured on industry-leading 22nm process technology with 3-D Tri-Gate transistors)



Die not shown to scale.

**Date of high volume production*

ADVANCED DESIGN

Intel creates industry-leading and world-first silicon products that introduce more capabilities, are smaller, more powerful, and use less energy. While advancing technology, Intel incorporates environmental principles into each step of the product life cycle. And by anticipating the needs for the next generation, Intel's success at advanced chip design has helped drive other innovations in almost all industries.

WHAT IS A CHIP?

A chip, also known as a ***die*** or processor, is a microelectronic device that can process information in the form of electrical current traveling along a ***circuit***. Although they look flat, today's chips may have more than 30 layers of complex circuitry compared to five layers on the 4004, Intel's first processor, introduced in 1971.

HOW CHIPS WORK

The way a chip works is a result of how a chip's transistors and ***gates*** are designed and the use of the chip. A chip can contain millions or billions of transistors interconnected in a certain manner. These transistors act as switches, either preventing or allowing electrical current to pass through. A gate turns the transistors on and off, allowing electrical currents to send, receive, and process digital data (1s and 0s) as instructions and information. Chips today can have multiple cores.

THE ULTIMATE PUZZLE

How would you organize something with 1,000,000,000 pieces, and then create a plan so it can be put together correctly and on time? Worldwide teamwork is critical. Precision counts. Rules matter. Many types of engineers work closely together to design chips and translate circuit schematics into ***mask*** layers for manufacturing.

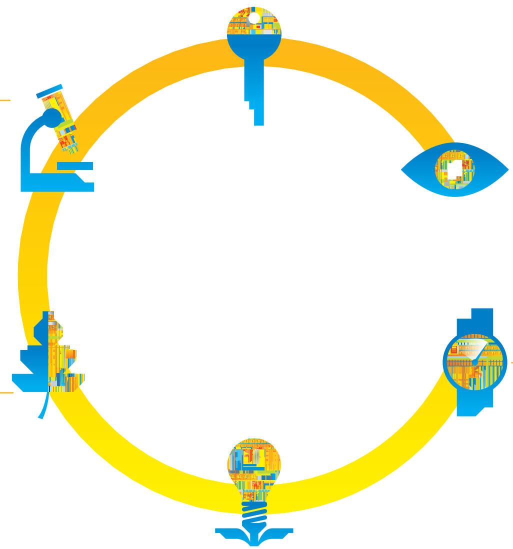
Before Intel makes chips, engineers ensure the accuracy of the specification. They begin with a design or blueprint and consider many factors: What type of chip is needed and why? How many transistors can be built on the chip? What is the optimal chip size? What technology will be available to create the chip? When does the chip need to be ready? Where will it be manufactured and tested? To answer these questions, Intel teams work with customers, software companies, and Intel's marketing, manufacturing, and testing staff. The design teams take this input and begin the monumental task of defining a chip's features and design.

When the specifications for the chip are ready, Intel creates a logic design, an abstract representation of the hundreds of millions of transistors and interconnections that control the flow of electricity through a chip. After this phase is complete, designers prepare physical representations of each layer of the chip and its transistors. They then develop stencil-like patterns, or ***masks,*** for each layer of the chip that are used with ultraviolet (UV) light during a ***fabrication*** process called ***photolithography.***

To complete the design, testing, and simulation of a chip, Intel uses ***computer-aided design (CAD)*** tools. CAD helps designers create very complex designs that meet functional, performance, and power goals. After extensive modeling, simulation, and verification, the chip is ready for fabrication. It can take hundreds of engineers working multiple years to design, test, and ready a new chip design for fabrication.

INTEL ENVIRONMENTAL, HEALTH, & SAFETY PRODUCT LIFE CYCLE

From initial research to the end of a product's life, Intel integrates environmental principles and health and safety practices into each stage.



01 RESEARCH & DEVELOPMENT

Benign semiconductor materials

Design for the Environment Principles

Nanotech research

02 MATERIALS & EQUIPMENT SELECTION

Process equipment safety

Restriction of Hazardous Substances (RoHS) compliance

Electronic Industry Citizenship Coalition

Material screening tool

Product specs

03 CHEMICAL USE APPROVAL

Toxicity screening

Hazard classification

Risk evaluation

Substitution alternatives

Control mechanism

Personal protective equipment

04 INTEL OPERATIONS

Resource conservation

International Organization for Standardization (ISO) 14001

Climate-change footprint

Employee safety and wellness

Waste reduction and recycling

05 INTEL PRODUCTS

Energy efficiency

RoHS compliance

Product packaging reduction

Energy Star*

Halogen-free[4]

Lead-free[5]

Power-supply energy specifications

Power management software

06 END OF LIFE

Community recycling events

Environmental Protection Agency (EPA) Plug-In to eCycling

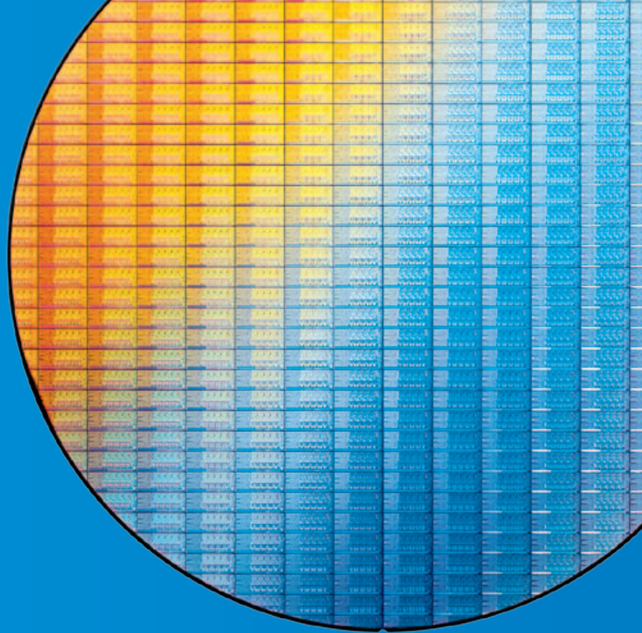
Electronic Product Environmental Assessment Tool (EPEAT)

Environmental education

Waste Electrical and Electronic Equipment (WEEE) Directive

Global. Connected. Mission Critical.

Intel's manufacturing leadership includes a global network of high-volume, technically advanced wafer fabrication facilities, or fabs, that run 24 hours a day, 7 days a week, 365 days a year.



FABRICATION

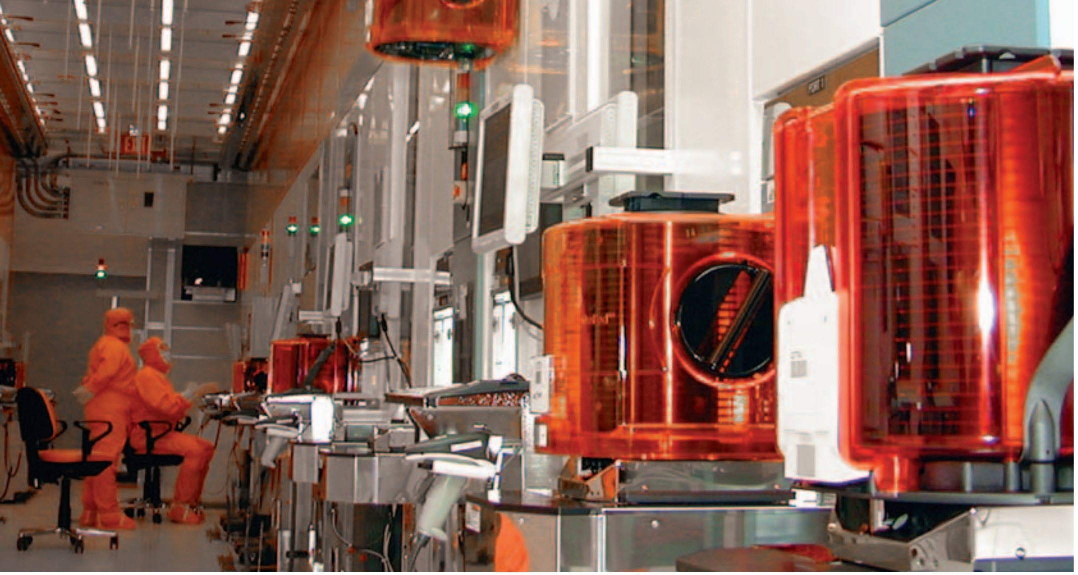
The process of making chips is called fabrication. Inside Intel's ultra-clean ***fabs***, the world's most complex, tiniest machines — processors and other silicon chips — are built in a sustainable manner. Intel fabs are among the most technically advanced manufacturing facilities in the world. Within these sophisticated fabs, Intel makes chips in a special area called a ***cleanroom.***

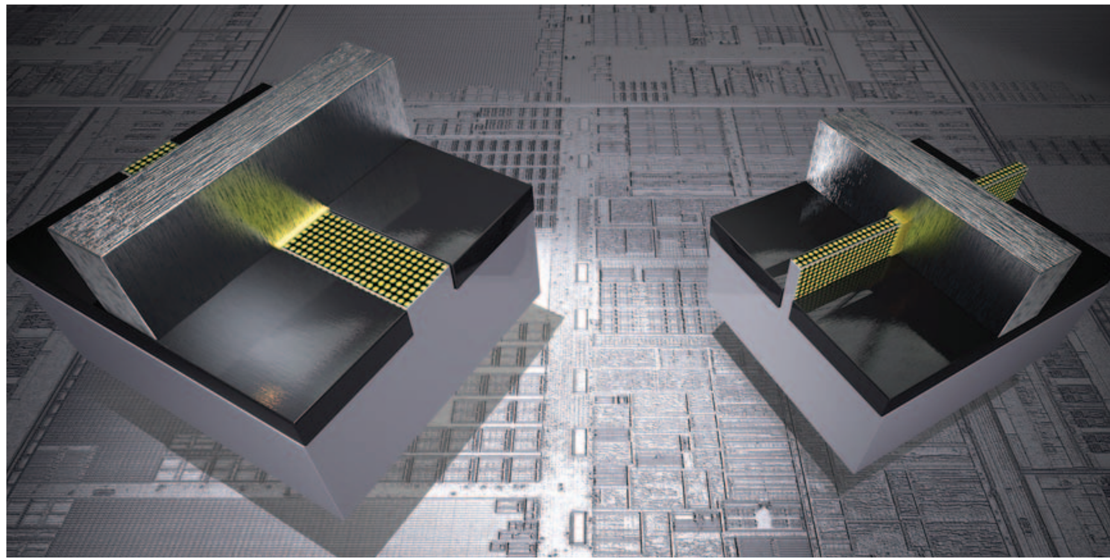
Because particles of dust can ruin the complex circuitry on a chip, cleanroom air must be ultra-clean. Purified air is constantly recirculated, entering through the ceiling and exiting through floor tiles. Technicians put on a special suit, commonly called a bunny suit, before they enter a cleanroom. This helps keep contaminants such as lint and hair off the ***wafers.***

In a cleanroom, a cubic foot of air contains less than one particle measuring about 0.5 micron (millionth of a meter) across. That's thousands of times cleaner than a hospital operating room.

Automation has a critical role in a fab. Batches of wafers are kept clean and are processed quickly and efficiently by traveling through the fab inside ***front-opening unified pods (FOUPs)*** on an overhead monorail. Each FOUP receives a barcode tag that identifies the recipe that will be used to make the chips inside. This labeling ensures the correct processing at each step of fabrication. Each FOUP contains up to 25 wafers and weighs more than 25 pounds. Production automation machinery allows for this FOUP weight, which is too heavy to be handled manually by technicians.

Above: 3rd generation Intel® Core™ wafer





Top left: Orange FOUPs carry 300mm wafers in an automated fab.
Top right: Highly-trained technicians monitor each phase of chip fabrication.
Bottom left: Purified air enters from the ceiling and exits through perforated floor tiles.

Bottom right: The 32nm planar transistor (on left) illustrates current (represented by yellow dots) flowing in a flat plane under the gate, while Intel's smaller 22nm 3-D Tri-Gate transistor (on right) illustrates increased current flow over three sides of a vertical fin.

How Intel Makes Chips

SAND TO INGOT

Sand
Sand has a high percentage of silicon—the starting material for computer chips. Silicon is a ***semiconductor***, meaning that it can be turned into an excellent conductor or insulator of electricity with minor amounts of impurities added.

Melted Silicon
Silicon is purified to less than one alien atom per billion. It is melted and cooled into a solid crystal lattice cylinder, called an ingot.

Monocrystalline Silicon Ingot
The ***silicon ingot*** has a diameter of 300 millimeters (mm) and weighs about 100 kilograms (kg).

INGOT TO WAFER

Slicing Ingots
The ingot is cut into individual silicon discs called wafers. Each wafer is about one mm thick.

Polishing Wafers
The wafers are polished to a flawless, mirror-smooth surface. Intel buys these manufacturing-ready wafers.

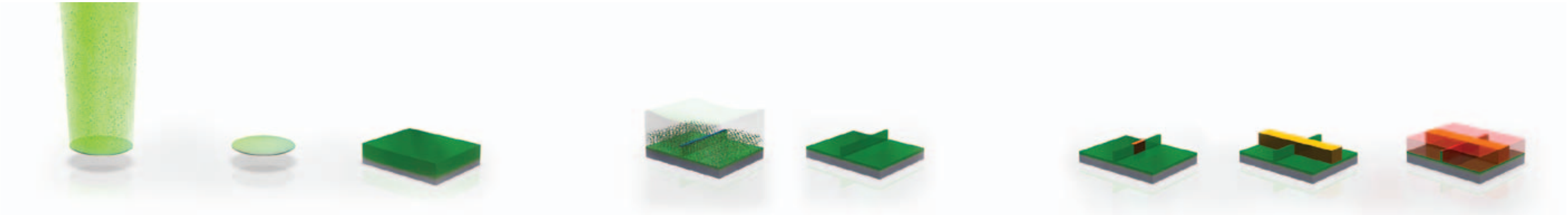
PHOTOLITHOGRAPHY

Applying Photoresist
Photolithography is a process that imprints a specific pattern on the wafer. It starts by applying a light-sensitive, etch-resistant material called ***photoresist*** onto the wafer surface.

Exposing Photoresist
The photoresist is hardened and parts of it are exposed to ultraviolet light, making it soluble. The light passes through a mask (similar to a stencil), and then through a lens to shrink and print circuit patterns on each layer of every chip on the ***wafer***.

Developing Resist
A chemical process removes the soluble photoresist, leaving a patterned photoresist image as determined by what was on the mask.

CHIPS ARE THREE-DIMENSIONAL STRUCTURES built simultaneously on batches of wafers in a fab. Making chips is a complex process requiring hundreds of precisely controlled steps that result in patterned layers of various materials built one on top of another. These layers form the circuits, which include electrical pathways and transistors (switches). Follow some of the key steps illustrating Intel's chip manufacturing process for the 22nm 3rd generation Intel® Core™ processors.



ION IMPLANTATION

Implanting Ions
Ions (positively or negatively charged atoms) are embedded beneath the surface of the wafer in regions not covered by photoresist. This alters the conductive properties of the silicon in selected locations.

Removing Photoresist
After the ion implantation, the photoresist is removed, resulting in certain regions being doped with alien atoms (green in the image).

The Transistor
Although hundreds of chips are usually built on a single wafer, the next steps focus on a small piece of a chip—a transistor.

ETCHING

Etching
To create a fin for a tri-gate transistor, Intel applies a hard mask material (blue in the image) using photolithography. Then a chemical is applied to ***etch*** away unwanted silicon, leaving behind a fin with a layer of hard mask on top.

Removing Hard Mask
The hard mask is chemically removed, leaving a tall, thin silicon fin that will contain the ***channel*** of a transistor.

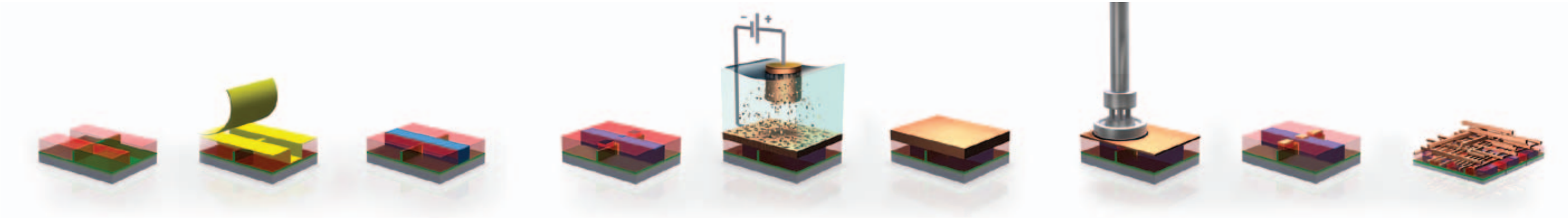
TEMPORARY GATE FORMATION

Creating a Gate Dielectric
Photoresist is applied to portions of the transistor, and a thin silicon dioxide layer (red in the image) is created by inserting the wafer in an oxygen-filled tube-furnace. This layer becomes a temporary ***gate dielectric.***

Creating a Gate Electrode
Using photolithography, a temporary layer of ***polycrystalline silicon*** (yellow in the image) is created. This becomes a temporary gate electrode.

Insulating the Transistor
In another oxidation step, a silicon dioxide layer is created over the entire wafer (transparent red in the image) to insulate the transistor from other elements.

How Intel Makes Chips



"GATE-LAST" HIGH-K/METAL GATE FORMATION

Removing the Temporary Gate
The temporary gate electrode and gate dielectric are etched away in preparation for forming the final gate. This procedure is called gate-last.

Applying High-k Dielectric Material
Multiple layers of ***high-k dielectric material*** (yellow in the image) are applied to the wafer surface using a method called atomic layer deposition. This material is etched away in some areas, such as the silicon dioxide layer.

Forming a Metal Gate
A metal gate electrode (blue in the image) is formed over the wafer and removed from regions other than the gate electrode. The combination of this and the high-k dielectric material improves performance and reduces leakage.

METAL DEPOSITION

Preparing to Connect the Transistor
Three holes are etched into the insulation layer (red in the image) above the transistor. The holes are filled with copper or another material that creates metal connections to other transistors.

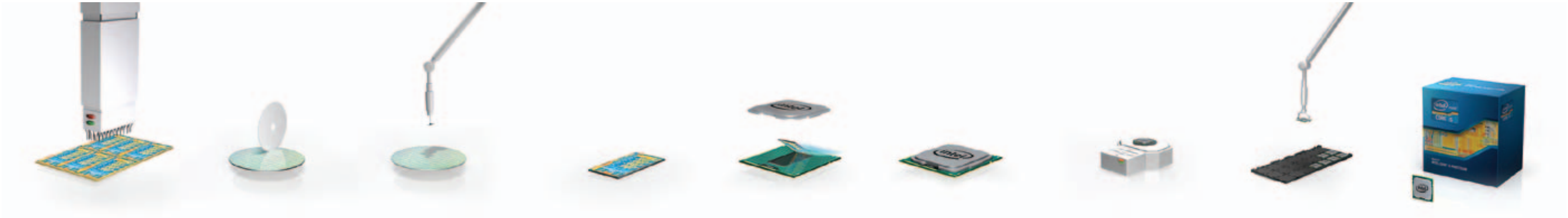
Electroplating
The wafers are put into a copper sulphate solution. Copper ions are deposited onto the transistor using a process called electroplating.

After Electroplating
Copper ions settle as a thin layer of copper on the transistor surface.

METAL LAYERS

Polishing
The excess material is polished off, revealing a specific pattern of copper.

Connecting with Metal Layers
Like a multi-level highway, metal layers interconnect the transistors in a chip (middle and right images). The design of the chip determines how the connections are made. Although chips look flat, they can have more than 30 layers of this complex circuitry.



WAFER SORT TEST AND SINGULATION

Sort Testing
After wafer processing is complete, each chip on a wafer is tested for its functionality.

Slicing Wafers
The wafer is cut into pieces called die.

Moving to Packaging
Based on the responses received in the ***wafer sort*** test, die are selected for packaging.

PACKAGING DIE

Individual Die
The silicon die shown here is a 3rd generation Intel® Core™ processor, Intel's first 22nm microprocessor using 3-D transistors.

Packaging
The substrate, the die, and a heat spreader are put together to form a completed processor. The green substrate creates the electrical and mechanical connections so that the processor can interact with the system. The silver-colored heat spreader is a thermal interface that helps dissipate heat.

Completed Processor
A completed processor, such as the 3rd generation Intel Core processor, is one of the most complex manufactured products on Earth.

CLASS TESTING AND COMPLETED PROCESSOR

Package Testing
Processors undergo final testing for functionality, performance, and power.

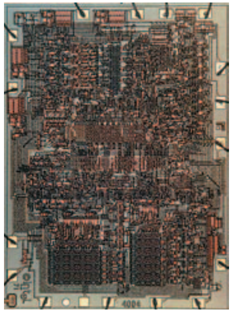
Binning
Based on final test results, processors with the same capabilities are grouped into transporting trays.

Retail Packaging
Intel® processors, such as the 3rd generation Intel Core processor shown here, are sent to system manufacturers in trays, or they are boxed for retail stores.

Intel Chips

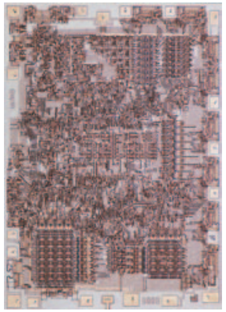
Throughout Intel's history, new and improved technologies have transformed the human experience.

1971



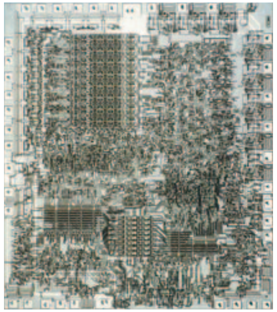
Intel® 4004 processor
Initial clock speed: 108KHz
Transistors: 2,300
Manufacturing technology:
10 micron

1972



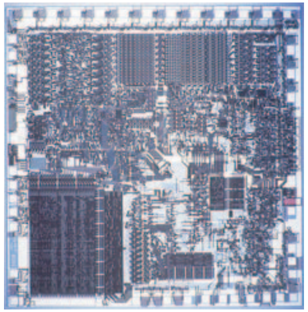
Intel® 8008 processor
Initial clock speed: 800KHz
Transistors: 3,500
Manufacturing technology:
10 micron

1974



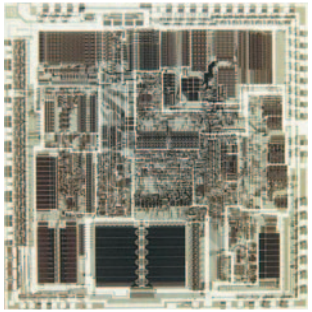
Intel® 8080 processor
Initial clock speed: 2MHz
Transistors: 4,500
Manufacturing technology:
6 micron

1978



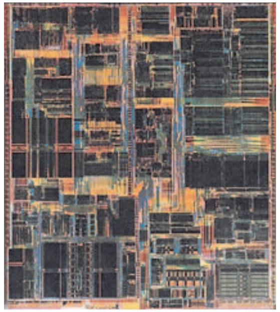
Intel® 8086 processor
Initial clock speed: 5MHz
Transistors: 29,000
Manufacturing technology:
3 micron

1982



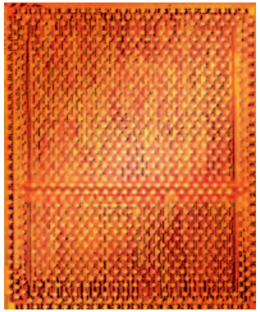
Intel® 286 processor
Initial clock speed: 6MHz
Transistors: 134,000
Manufacturing technology:
1.5 micron

1997



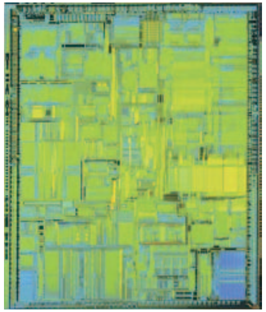
Intel® Pentium® II processor
Initial clock speed: 300MHz
Transistors: 7.5 million
Manufacturing technology:
0.25 micron

1998



Intel® Celeron® processor
Initial clock speed: 266MHz
Transistors: 7.5 million
Manufacturing technology:
0.25 micron

1999

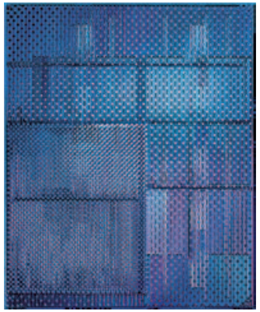


Intel® Pentium® III processor
Initial clock speed: 600MHz
Transistors: 9.5 million
Manufacturing technology:
0.25 micron

2000

Intel® Pentium® 4 processor
Initial clock speed: 1.5GHz
Transistors: 42 million
Manufacturing technology:
0.18 micron

2001

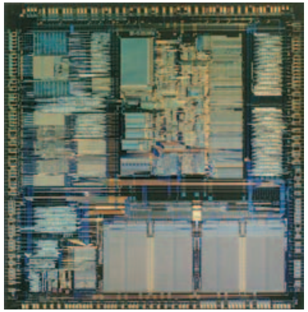


Intel® Xeon® processor
Initial clock speed: 1.7GHz
Transistors: 42 million
Manufacturing technology:
0.18 micron

Die not shown to scale.

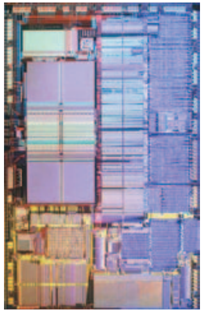
Decades of Intel chips, including the 22nm 3rd generation Intel® Core™ processor with its revolutionary 3-D Tri-Gate transistors, illustrate Intel's unwavering commitment to delivering technology and manufacturing leadership to the devices you use every day. As you advance through the chart, the benefits of Moore's Law, which states that the number of transistors roughly doubles every couple of years, are evident as Intel increases transistor density and innovates the architecture designs that deliver more complex, powerful, and energy-efficient chips that transform the way we work, live, and play.

1985



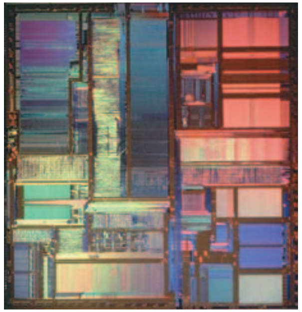
Intel386™ processor
Initial clock speed: 16MHz
Transistors: 275,000
Manufacturing technology:
1.5 micron

1989



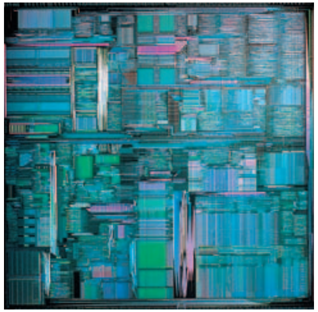
Intel486™ processor
Initial clock speed: 25MHz
Transistors: 1.2 million
Manufacturing technology:
1 micron

1993



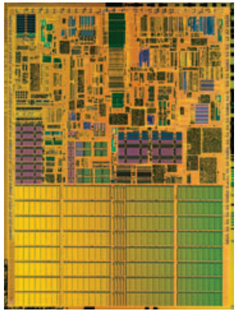
Intel® Pentium® processor
Initial clock speed: 66MHz
Transistors: 3.1 million
Manufacturing technology:
0.8 micron

1995



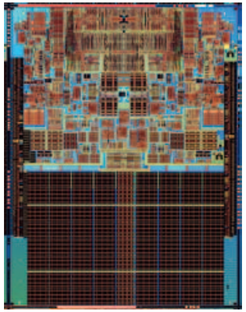
Intel® Pentium® Pro processor
Initial clock speed: 200MHz
Transistors: 5.5 million
Manufacturing technology:
0.35 micron

2003



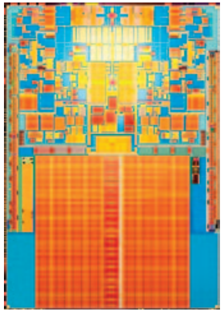
Intel® Pentium® M processor
Initial clock speed: 1.7GHz
Transistors: 55 million
Manufacturing technology:
90nm

2006



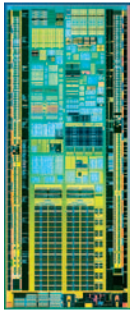
Intel® Core™2 Duo processor
Initial clock speed: 2.66GHz
Transistors: 291 million
Manufacturing technology:
65nm

2008



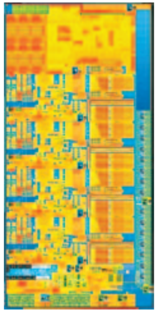
Intel® Core™2 Duo processor
Initial clock speed: 2.4GHz
Transistors: 410 million
Manufacturing technology:
45nm

2008



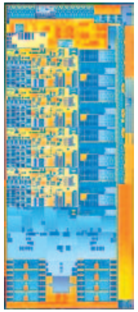
Intel® Atom™ processor
Initial clock speed: 1.86GHz
Transistors: 47 million
Manufacturing technology:
45nm

2010



2nd generation Intel® Core™ processor
Initial clock speed: 3.8GHz
Transistors: 1.16 billion
Manufacturing technology:
32nm

2012



3rd generation Intel® Core™ processor
Initial clock speed: 2.9GHz
Transistors: 1.4 billion
Manufacturing technology:
22nm

This Next Decade

Intel will create and extend computing technology to connect and enrich the lives of every person on Earth. We believe fundamentally that computing technology will have a positive impact on every individual, business, and community around the world.

NEW LEVELS OF SECURITY

The full benefits of technology can only be realized when the computing experience is secure—when individuals can be certain that personal information remains personal, and when businesses can ensure that data and systems integrity is never breached.

To enable this vision, Intel is delivering a new level of security that builds protection and safety into the heart of computing technology. From silicon, to software, to services, Intel is building security into everything we do.

One example is the Ultrabook, which delivers a safer experience with security technology features built into the chip. Intel® Anti-Theft[6] and Intel® Identity Protection[7] technologies, coupled with software and services, protect your identity and data for greater peace-of-mind.

THE ULTIMATE MOBILE DEVICE

Intel Capital is investing to help accelerate innovation and the adoption of new technology and services in the automotive industry. The funding is part of Intel's ongoing work with automakers and in-vehicle infotainment suppliers to help integrate advanced technologies into cars. Ultimately, the connected car will have the intelligence and context awareness to offer the right information, at the right time, and in the right way to keep drivers and passengers informed, entertained, and productive while maintaining optimal safety. A connected car could then communicate with the cloud, the transportation infrastructure, and even other vehicles to provide additional services such as advanced driver assistance and real-time traffic information to optimize the flow of traffic.

THE HEART OF INNOVATION

Throughout Intel's history, we have pushed the boundaries of what's possible. Our vision for the next decade is even more ambitious.

Intel believes that education, innovation, and entrepreneurship are the keys to driving economic growth and improving social conditions. Skills such as digital literacy, problem solving, critical thinking, and collaboration are best developed in active learning environments supported by technology to inspire the next generation.

At the heart of what is possible is innovation and imagination.

22nm 3-D Tri-Gate transistor
Intel's 3-D Tri-Gate transistor uses three gates wrapped around the silicon channel in a 3-D structure, enabling an unprecedented combination of performance and energy efficiency. Intel designed the new transistor to provide unique, ultra-low power benefits for use in handheld devices, like smartphones and tablets, while also delivering improved performance normally expected for high-end processors.

Channel
The region under the gate of a transistor where current flows when the transistor is in the "on" state.

Chip
A tiny, thin square or rectangle that contains integrated electronic circuitry. Die are built in batches on wafers of silicon. A chip is a packaged die. Chips are also called processors and microprocessors. Microprocessors are the brains of computers, servers, communications products, and other digital devices.

Circuit
A network of transistors interconnected by wires in a specific configuration to perform a function.

Cleanroom
The ultra-clean room where chips are fabricated. Cleanroom air is thousands of times cleaner than that in a typical hospital operating room.

Computer-aided design (CAD)
Computerized workstations and software used to design integrated circuits.

Die
Alternate name for a chip, usually before it is packaged. See also Chip.

Etching
The removal of selected portions of materials to define patterned layers on chips.

Fab
A shortened term for fabrication facility, where Intel manufactures silicon chips.

Fabrication
The process of making chips.

Front-opening unified pod (FOUP)
A container that holds and carries wafers as part of an automated system in a fab.

Gate
The input control region of a transistor where a negative or positive charge is applied to block or allow current to flow.

Gate dielectric
A thin layer underneath the gate that isolates the gate from the channel.

Gigabyte (GB)
One gigabyte is one billion (1,000,000,000) bytes. A byte is a unit of computing information that equals eight bits. A bit (binary digit) is the basic unit of information in computing.

High-k dielectric material
A material that can replace silicon dioxide as a gate dielectric. It has good insulating properties and creates a high field effect between the gate and channel. Both are desirable properties for high-performance transistors. Also, because high-k materials can be thicker than silicon dioxide while retaining the same desirable properties, they greatly reduce current leakage.

Mask
A stencil-like pattern used during fabrication to print layered circuit patterns on a wafer.

Moore's law
In 1965, Gordon Moore predicted that the number of transistors on a piece of silicon would double every year — an insight later dubbed Moore's Law. In 1975, Moore updated his prediction that the number of transistors that the industry would be able to place on a computer chip would double every couple of years. As the number of transistors goes up, the cost per transistor goes down.

Nanometer (nm)
One billionth of a meter.

Photolithography
The process of creating a specific pattern of material on a silicon wafer by using UV light and a mask to define the desired pattern.

Photoresist
A substance that becomes soluble when exposed to UV light. Analogous to photographic film, it is sensitive to UV light, but is also resistant to certain etching chemicals. Used to define circuit patterns during chip fabrication.

Polycrystalline silicon
Silicon made up of many crystals, also known as polysilicon. This conductive material is used as an interconnect layer on a chip.

Semiconductor
A material (such as silicon) that can be altered to conduct electrical current or block its passage.

Silicon
The principal ingredient in common beach sand and the element used to make the wafers upon which chips are fabricated. It is a natural semiconductor and is the most common element on Earth after oxygen.

Silicon ingot
A cylinder formed of 99.9999% pure silicon. Ingots are sliced into thin silicon discs called wafers.

Strained silicon
A layer of silicon that is stretched or compressed to alter the interatomic distance in the lattice. This reduces the atomic forces that restrict the movement of electrons through the transistors. It allows for better mobility, improved chip performance, and lower energy consumption.

Transistor
A type of switch that controls the flow of electricity. A chip can contain millions or billions of transistors.

Ultrabook™
Announced in June 2011 at Computex, the Ultrabook™ device specification and roadmap changes made to the Intel® Core™ processors are enabling this new breed of devices. Ultrabook systems marry thin and light with the best in performance, responsiveness, security, and battery life — filling the gap between desktop/laptop and tablet.

Wafer
A thin silicon disc sliced from a cylindrical ingot. Used as the base material for building integrated circuits.

Wafer sort
An electrical test procedure that identifies the chips on a wafer that are not fully functional.

Zettabyte (ZB)
A unit of computing information equal to one sextillion bytes. (That's one followed by 21 zeros — enough space to store 4.4. trillion HD movies.) See Gigabytes for other computing units.

FOOTNOTES

1 Source: *Worldwide Device Estimates Year 2020 - Intel One Smart Network Work* forecast.

2 Source: *Cisco® Global Cloud Index: Forecast and Methodology, 2010 – 2015.* http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns1175/Cloud_Index_White_Paper.html

3 *Ibid.*

4 Applies only to halogenated flame retardants and polyvinyl chloride (PVC) in components. Halogens are below 900 parts per million (PPM) bromine and 900 PPM chlorine.

5 Lead is below 1,000 PPM per European Union (EU) Restriction of Hazardous Substances (RoHS) Directive of July 2006 (2002/95/EC, Annex A). Some RoHS exemptions for lead may apply to other components used in the product packaging.

6 No system can provide absolute security under all conditions. Requires an enabled chipset, BIOS, firmware and software, and a subscription with a capable service provider. Consult your system manufacturer and service provider for availability and functionality. Intel assumes no liability for lost or stolen data and/or systems or any other damages resulting thereof. For more information, visit http://www.intel.com/go/anti-theft.

7 No system can provide absolute security under all conditions. Requires an Intel® Identity Protection Technology-enabled system, including a 2nd generation Intel® Core™ processor-enabled chipset, firmware and software, and participating website. Consult your system manufacturer. Intel assumes no liability for lost or stolen data and/or systems or any resulting damages. For more information, visit http://ipt.intel.com.

Terminology

It starts with more powerful processors.

Where it goes is up to you.

-Gordon Moore, Co-founder, Intel Corporation

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