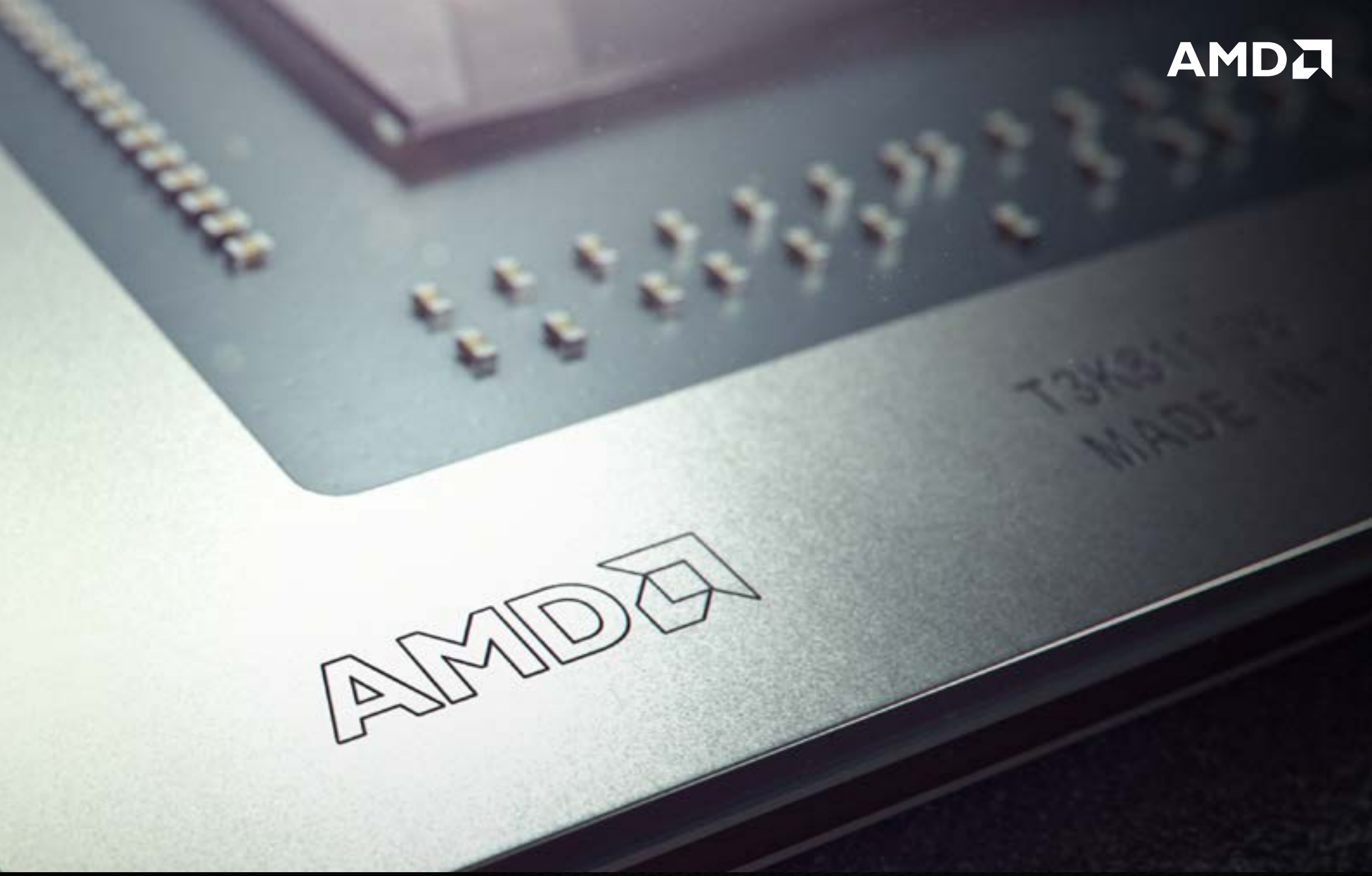


INTRODUCTION TO SEMICONDUCTORS

SEMICONDUCTORS: THE BRAINS OF MODERN ELECTRONICS

When we click, swipe, type or speak to an electronic device, we expect an instant response correct to our instructions. But what is searching, quantifying, optimizing and delivering our desired results? In most cases, it's a semiconductor.

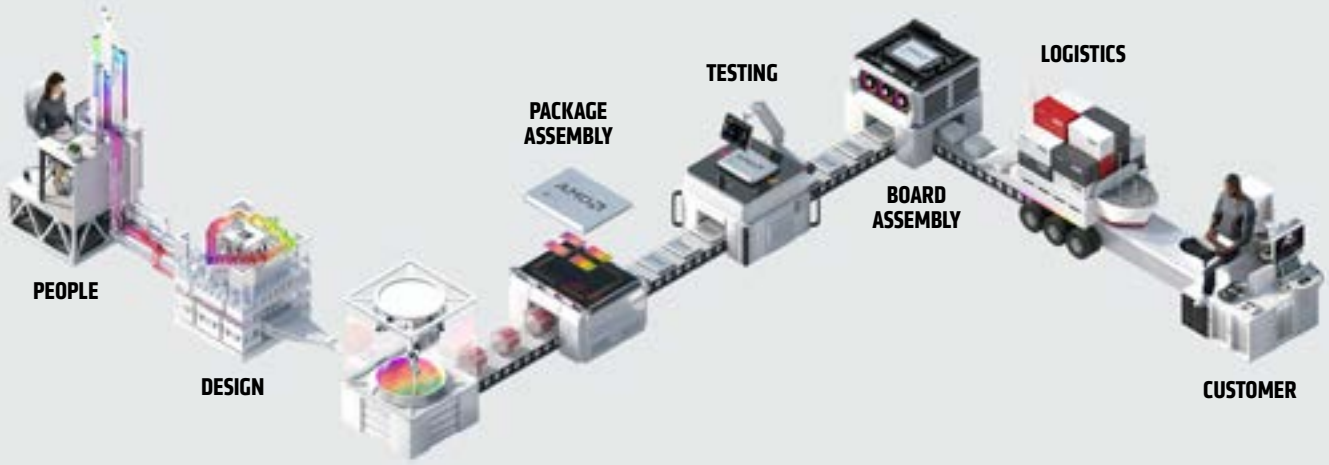
The term "semiconductor" refers to a critical component of millions of electronic devices used in education, research, communications, healthcare, transportation, energy and other industries. Today's personal computers, smartphones, cars, data center servers and gaming consoles rely on semiconductors for both core operations and advanced capabilities. For example, when we use our laptops to book a vacation, find a restaurant recommendation, stream a movie or access email, the laptop's semiconductor-based central processing unit (CPU) and graphics processing unit (GPU) implement computing functions that instantly turn questions into answers.

WHAT IS A SEMICONDUCTOR?

Integrated circuits (ICs) made from a semiconductor material (such as silicon) are essential parts of modern electronic devices across commercial and consumer industries. These circuits must have the ability to behave as an electrically controlled on/off switch (transistor) to perform the foundational logical computations in a computer. To achieve this near instantaneous switching ability, the circuits need to be constructed from a semiconductor material—a substance with electrical resistance between that of a conductor and an insulator.

The manufacturing process for semiconductor devices requires multiple steps performed in specialized facilities known as foundries or fabs. It takes years of industry experience and research to develop, design, produce, release and service a single semiconductor product family. A typical semiconductor company must concurrently work on multiple product families at different stages of the lifecycle. Once released, some customer contracts may require that the vendor continue to supply that product for a period up to about ten years.

FROM CHIP DESIGN TO CONSUMER PRODUCT



Semiconductor production is a highly complex process with long lead times necessary to deliver the capabilities we expect from the devices we rely on every day. Semiconductor production times can vary depending on complexity, but on average it can take from three to five years to go from initial research to final product.

SMART JARGON:
UNDERSTANDING SEMICONDUCTORS

- **CENTRAL PROCESSING UNIT (CPU):** The main control circuit of a computer that carries out arithmetic, logic, control and input/output (I/O) operations
- **CHIPLET:** An integrated circuit (IC) that contains a subset of the functional blocks typically required for a full System on Chip (SOC)
- **DIE:** A small block of semiconducting material on which a specific functional IC is made
- **FABLESS BUSINESS MODEL:** A leading business model in the semiconductor industry allowing companies to direct more profits toward research and development and growth strategies
- **GRAPHICS PROCESSING UNIT (GPU):** Circuits that perform simultaneous operations of large amounts of data for creation of images on a display or non-graphic computations such as machine learning analyses
- **INTEGRATED CIRCUIT (IC):** A set of electronic circuits designed onto one small area of a semiconductor material (such as silicon)
- **NANOMETER (NM):** Unit of measure (one billionth of a meter); used in reference to a process technology's minimum feature size (e.g., "7nm process technology")
- **ORIGINAL EQUIPMENT MANUFACTURER (OEM):** Company that assembles or produces final end-user devices to be marketed or sold by it or by others
- **PACKAGE:** A metal, plastic, glass, or ceramic casing containing one or more discrete ICs
- **PROCESS TECHNOLOGY:** The specific design rules and manufacturing process for a semiconductor; also known as technology node, process node, or just node
- **SYSTEM-ON-CHIP (SOC):** An IC that combines many components of a computer or other electronic system on the same chip
- **TRANSISTOR:** A component that regulates the flow of electrical current, and is a building block for ICs
- **WAFER:** A thin slice of silicon used for the fabrication of multiple ICs

Global semiconductor sales decreased 12% to US$412 billion in 2019, down from the industry's **highest-ever annual total of US $468 billion in 2018.**[1]

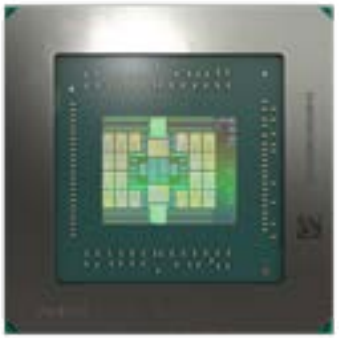
The market for artificial intelligence (AI)-related semiconductors is expected to grow from a current US$6 billion in revenues **to more than US $30 billion by 2022 – a predicted compound annual growth rate (CAGR) of almost 50%.**[2]

MOORE'S LAW AND CURRENT CHALLENGES

In 1965, engineer Gordon Moore observed that the number of components within an integrated circuit were doubling every year. He predicted that this trend would continue for at least another decade. In 1975 (when leading processors had a transistor count of about 4,000-5,000), he revised his predicted rate to a doubling every two years. This became known widely in the semiconductor industry as Moore's Law. By 2015, Moore forecast that the rate for increasing IC density would reach a point of saturation within the next decade or so—as transistor miniaturization reaches a fundamental barrier at the atomic level. The transistor count for AMD's 2nd generation EPYC™ server CPU launched in 2019 has reached nearly 40 billion.[3]

A single smartphone today has far more computing power than the computers used by NASA for the Apollo 11 moon landing in 1969.[4]

PROCESS TECHNOLOGY EVOLUTION*



1971 [10 µm]

2019 [5 nm]

Future [3 nm]

µm - micrometer nm - nanometer.

**Relative scale for illustrative purposes. Not actual size.*

NEWEST PROCESS TECHNOLOGIES: 7NM AND BEYOND

7nm process ICs represent the newest wave of chips in electronic devices and enable better performance per watt than previous generation ICs. Higher density designs pack more components into a smaller space for greater functionality (such as for artificial intelligence and machine learning applications) and can offer increased energy efficiency.

AMD is the first company to bring 7nm x86 CPUs and GPUs to market. These devices are already being used in data centers and consumer products (e.g., desktops and laptops) today. With extremely long lead times for new process technologies, AMD engineers are focused on innovations that may one day help deliver 5nm and 3nm process ICs.

THE RISE OF CHIPLETS

Another key approach to increased processor performance is the introduction of partitioned multi-die design, which allows a semiconductor company to interconnect many smaller and lower core dies together to make a CPU with a greater number of cores. For example, AMD's second generation EPYC™ server processor divides an architecturally monolithic 32-core server die into eight 7nm discrete "chiplets" combined in a multi-chip module and connected using high-speed signaling. As a single chip, manufacturing this EPYC™ processor would not have been possible within the constraints (reticle limit) of manufacturing equipment. A chiplet design may also increase the yield of acceptable products in manufacturing. AMD estimates that the multi-die approach reduces manufacturing costs by about forty percent.

THE POWER AND FREEDOM TO GO FURTHER

From accelerating drug discovery to completing an online purchase, semiconductor processors enable a wide variety of data-based decision-making. For over 50 years AMD has driven innovation in high-performance computing, graphics and visualization technologies.

WHAT WE MAKE—

AMD RADEON

GRAPHICS

AMD Radeon™ graphics combines breakthrough graphics architecture with cutting-edge software to build platforms that can handle the most challenging, important and graphics-intensive applications today – including gaming, creation, compute, AI, and virtual and augmented reality.

Gaming

Compute & AI

Virtual & Augmented Reality

AMD RYZEN

AMD EPYC

COMPUTE

AMD Ryzen™ and AMD EPYC™ high-performance microprocessors and chipsets deliver powerful, efficient performance for consumer and commercial devices like desktops, laptops and servers.

Client Systems

Infrastructure & Cloud

SOLUTIONS

AMD's leading high-performance graphics and compute design capabilities uniquely enable us to create differentiated solutions for customers and partners. From embedded products that power medical imaging devices and digital signage to semi-custom processors for leading game consoles and beyond, AMD technology is everywhere.

Semi-Custom

Vertical Platforms

Partnerships

FOR MORE INFORMATION ABOUT AMD SEMICONDUCTOR TECHNOLOGY, PRODUCTS AND SOLUTIONS, PLEASE VISIT:

AMD.COM

1. Worldwide Semiconductor Sales Decrease 12 Percent to $412 Billion in 2019," SIA, February 3, 2020
2. Opportunities for the global semiconductor market," PWC, April 3, 2019.
3. "AMD EPYC CPU with 39.5 billion transistors is a jaw-dropping sight under the microscope" TechRadar, accessed January 14, 2020.
4. "Building America's Innovation Economy," Semiconductor Industry Association (SIA), accessed September 16, 2019.

AMD