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The Evolution of Integrated Circuits and the Applications They Serve

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Abstract

A monolithic integrated circuit is a collection of electrical circuits located on a single, flat, compact piece of semiconductor material, often silicon. A little chip has a large number of tiny MOSFETs (metal–oxide– semiconductor field–effect transistors). As a result, discrete electrical component circuits are orders of magnitude quicker, less expensive, and more compact. Because of its mass manufacturing capability, durability, and building-block manner of integrated circuit design, integrated circuits have swiftly supplanted discrete transistor designs. ICs have revolutionised the area of electronics by being employed in practically every electronic product. Integrated circuits (ICs), such as current computer processors and microcontrollers, have become intrinsically tied to the foundation of modern civilizations, including computers, smartphones, and other digital household appliances, due to their small design and low cost.

Keywords: *MOSFET, IC, Transistor, Modern Computer Processors, Microcontrollers*

INTRODUCTION

Technological advances in metal-oxide-silicon (MOS) semiconductor device technology enabled the manufacturing of integrated circuits. Chips have expanded dramatically in size, speed, and capacity since their introduction in the 1960s, thanks to technical advances that allow more MOS transistors to be packed onto smaller chips. In an area the size of a

human fingernail, a contemporary chip may contain several billion MOS transistors. According to Moore's law, current computer processors are thousands of times quicker and have millions of times the capacity of their predecessors.

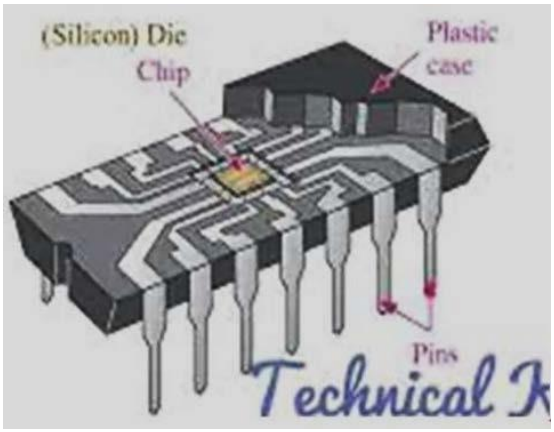


Fig.1: An Integrated Circuit.

Cost and performance are the two primary advantages of adopting integrated circuits over discrete circuits. The cost is incredibly low because the chips are printed as a whole, complete with all of their pieces, rather than being produced one transistor at a time via photolithography. Discrete circuits consume significantly more material than packaged integrated circuits. Because of their tiny size and close closeness, the IC's components flip fast and consume relatively little power.

The fundamental disadvantage of integrated circuits is the expensive expense of developing and producing the photo masks necessary. Because of their high initial cost, integrated circuits are only financially viable when large volumes of manufacturing are planned. Integrated circuits were the first to be invented. Small ceramic substrates, or "micro modules," containing a single shrunken component, were a forerunner idea to the IC. The components can then be joined in a tridimensional or dimensionally compact grid. In 1957, Jack Kilby offered this proposal to the US Army, which resulted in the creation of the short-lived Micro Module Program (akin to Project Tinker Toy from 1951). However, as the research progressed, Kilby came up with a novel, ground-breaking design: the IC.

Integrated Circuits (TTL)

TTL (transistor-transistor logic) was invented by James L. Buie in the early 1960s at TRW Inc. TTL became the dominant integrated circuit technology in the 1970s and early 1980s. Mainframe and minicomputer processors, as is common, were built using a significant number of TTL integrated circuits.

Bipolar integrated circuits, either in TTL or the faster emitter-coupled logic, were utilised in computers such as the IBM 360

mainframes, PDP-11 minicomputers, and the desktop Datapoint 2200. (ECL).

Integrated Circuits with MOS Transistors

Almost all modern integrated circuits (ICs) are metal-oxide-semiconductor (MOS) integrated circuits made up of MOSFETs (metal-oxide-silicon field-effect transistors). The MOSFET (also known as the MOS transistor), invented by Mohamed M. Atalla and Dawon K. at Bell Labs in 1959, paved the way for the development of high-density integrated circuits. MOSFETs allowed the P-N junctions of transistors on a chip to be swiftly separated from one another, as compared to bipolar transistors, which required many steps. DawonKahng introduced its advantage for integrated circuits in 1961. Kilby built the first integrated circuit in 1958, after the launch of Hoerni's planar technique and Noyce's planar IC in 1959 and Atalla and Kahng's MOSFET in 1960.

Moore's law asserts that the number of MOS transistors in an integrated circuit doubles every two years as IC technology progresses, especially with smaller features and bigger chips. Moore first claimed that it would double every year, but in 1975 he revised his prediction to every two years. This additional capacity was put to good use by cutting expenses and enhancing functionality. Almost every element of an integrated circuit's operation improves as feature size decreases. As memory capacity and speed rise, the cost per transistor and switching power consumption per transistor fall due to the Dennard scaling equations (MOSFET scaling). Manufacturers are competing to adopt tighter geometries since the benefits in speed, capacity, and power consumption are obvious to the end user. The size of transistors has decreased from tens of microns in the early 1970s to ten nanometers in 2017, resulting in a million-fold increase in transistors per unit area.

As of 2016, average chip areas ranged from a few square millimetres to 600 millimeters2, with up to 25 million transistors per millimeter2. ICs were once just electrical devices. Since the development of integrated circuits, new technologies have been included in an attempt to obtain the same benefits of compact size and low cost. Sensors, optics, and mechanical devices are examples of these technologies.

- Chips that are sensitive to light are known as charge-coupled devices, and they are closely related to active-pixel sensors. In scientific, medical, and

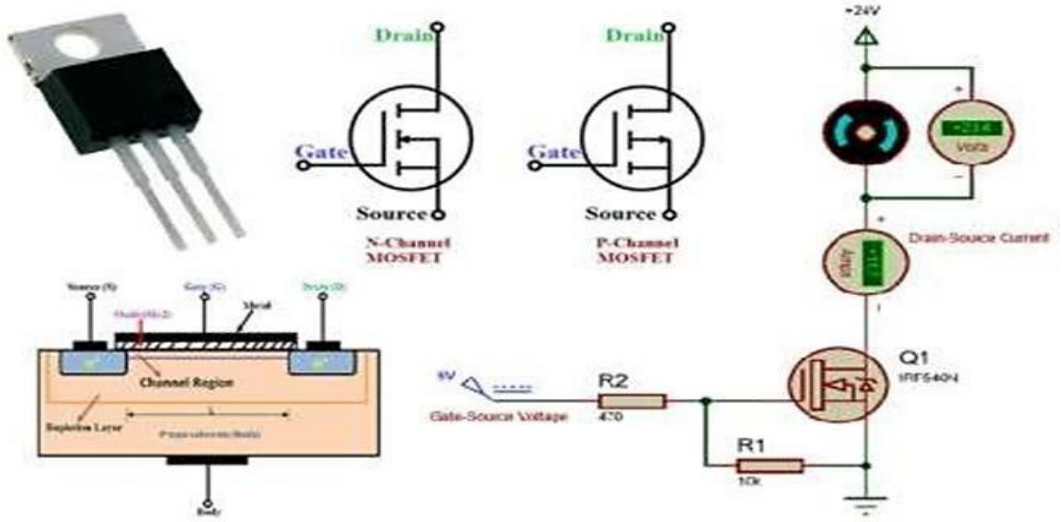
consumer uses, they have largely supplanted photographic film. Every year, billions of these devices are manufactured for uses such as telephones, tablets, and digital cameras. In 2009, this sub-field of ICs was awarded the Nobel Prize.

- Micro electromechanical systems are small mechanical devices that are powered by electricity and can be incorporated onto chips. These devices were created in the late 1980s and are now used in a wide range of commercial and military applications. DLP projectors, inkjet printers, and accelerometers and MEMS gyroscopes used in automotive airbag deployment are all examples.

- Since the early 2000s, academic research and industry have actively pursued the integration of optical functionality (optical computing) into silicon chips, resulting in the successful commercialization of silicon-based integrated optical transceivers combining optical devices (modulators, detectors, and routing)with CMOS-based electronics. Using the developing discipline of physics known as photonics, photonic integrated circuits that utilize light are also being created.

- Sensor applications in medical implants and other bioelectronics devices are also being developed using integrated circuits. In such biogenic conditions, special sealing procedures must be used to prevent corrosion or biodegradation of the exposed semiconductor components.

As of 2018, the vast majority of transistors are MOSFETs manufactured in a single layer on one side of a silicon device using a flat two-dimensional planar method. Through-silicon via, "monolithic 3D," stacked wire bonding, and other techniques for stacking multiple layers of transistors to create a three-dimensional integrated circuit have all been prototyped by researchers (3DIC). Examples of transistors made from various materials include graphene transistors, molybdenite transistors, carbon nanotube field-effect transistors, gallium nitride transistors, transistor-like nanowire electronic devices, organic field-effect transistors, and more. Transistors are made by covering the entire surface of a tiny silicon sphere with a substrate, typically to produce "flexible transistors" for a flexible display or other flexible electronics.



Businesses are turning to multi-chip modules, three-dimensional integrated circuits, package-on-package, high-bandwidth memory, and through-silicon vias with die stacking to boost performance while decreasing size.

These approaches are referred to as "advanced packaging. 2.5D and 3D packaging are the two primary types of advanced packaging. 2.5D refers to multi-chip modules, whereas 3D refers to die stacking techniques such as package on package and high-density packing. Each technique makes use of two or more dies that come in a set. Methods like as 3D NAND, on the other hand, stack many layers on a single component.

CONCLUSION

An indivisible circuit is one in which all or a portion of the circuit components are electrically linked inextricably for construction and commerce purposes. Thin-film transistors, thick-film transistors, and hybrid integrated circuits are examples of technology that may be employed to produce circuits that fit this need. In contrast, the phrase "integrated circuit" has evolved to refer to a monolithic integrated circuit, which is a single-piece circuit structure fabricated on a single piece of silicon.

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