# Moore’s law: Beyond sub nanometer

Since commencing my studies in Electronics in 2008, my curiosity has revolved around the mechanisms driving the continual reduction in size of computer components by manufacturing companies. It wasn't until 2011 that I encountered Moore's Law, a conceptual framework dating back to 1975 that seemingly governs this downsizing process. Initially misconstrued as a binding regulation, Moore's Law, coined by Dr. Gordon Moore, posits that the number of transistors on an integrated circuit should double approximately every two years. Over time, it became evident that Moore's Law functioned more as a predictive guideline than a steadfast rule.

Dr. Gordon Moore's initial prediction in 1965 suggested a doubling of transistor count on integrated circuits annually, which he later amended in 1975 to a biennial doubling, acknowledging the complexity of maintaining such rapid progress [3].

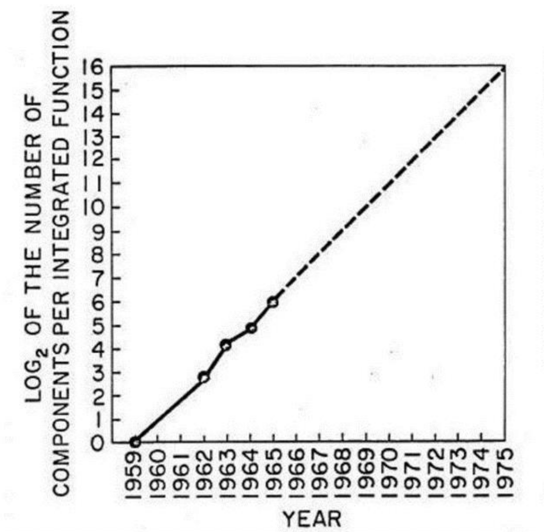


Fig. 1. Moore’s law (1965)

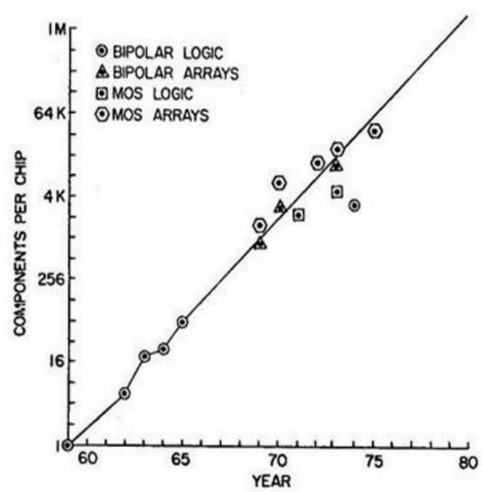


Fig.2. Moore’s Law (1975)

The realization of Moore's Law owes much to advancements in fabrication processes. Notably, the construction of a new TSMC manufacturing FAB now demands an investment of around $33 billion, illustrating the escalating costs associated with this progress [1]. Moore's initial prediction pertained to planar and wire-based transistors with only 75 transistors on a chip in 1965. Despite various declarations over the decades that adhering to Moore's Law was implausible, the consistent introduction of new cell phones and computers powered by chips following the law has contradicted such skepticism.

Advancements in transistor technology, from planar to FinFET and GAA (gate-all-around) transistors, have played a pivotal role in sustaining Moore's Law. Transistors, fundamental to computing, are projected to maintain their core operating principles, potentially reaching critical dimensions of 1 nanometer or less, resulting in device densities of 10 trillion transistors per square centimeter. This evolution may lead to a greater diversity of transistor types catering to specific functions, with experts emphasizing the enduring significance of transistors in computing.

Looking ahead to the future, projections suggest that by 2047, transistor architectures may have undergone significant innovations, potentially incorporating material advancements and entirely new architectures. While silicon is expected to remain central, there is speculation about the use of currently exotic semiconducting materials.

The omnipresence of transistors is anticipated to impact various facets of modern life, influencing computing power, sensing, communication, data processing, human interaction, and virtual or mixed reality environments. Over time, transistors have undergone remarkable miniaturization, shrinking from several microns to as small as 2 nanometers. Technological breakthroughs in lithography, particularly extreme ultraviolet (EUV) systems, and innovations in transistor design such as FinFETs and GAA transistors, have been instrumental in achieving this scale of miniaturization. These advancements have facilitated the continuous doubling of transistor densities, a cornerstone of Moore's Law.

The evolution of semiconductor technology and the sustained adherence to Moore's Law have paved the way for powerful CPUs, exemplified by the latest CPUs with over 10 billion transistors, each using a "5 nm process." This progress underscores the critical role played by advancements in lithography and transistor design in pushing the boundaries of semiconductor technology.

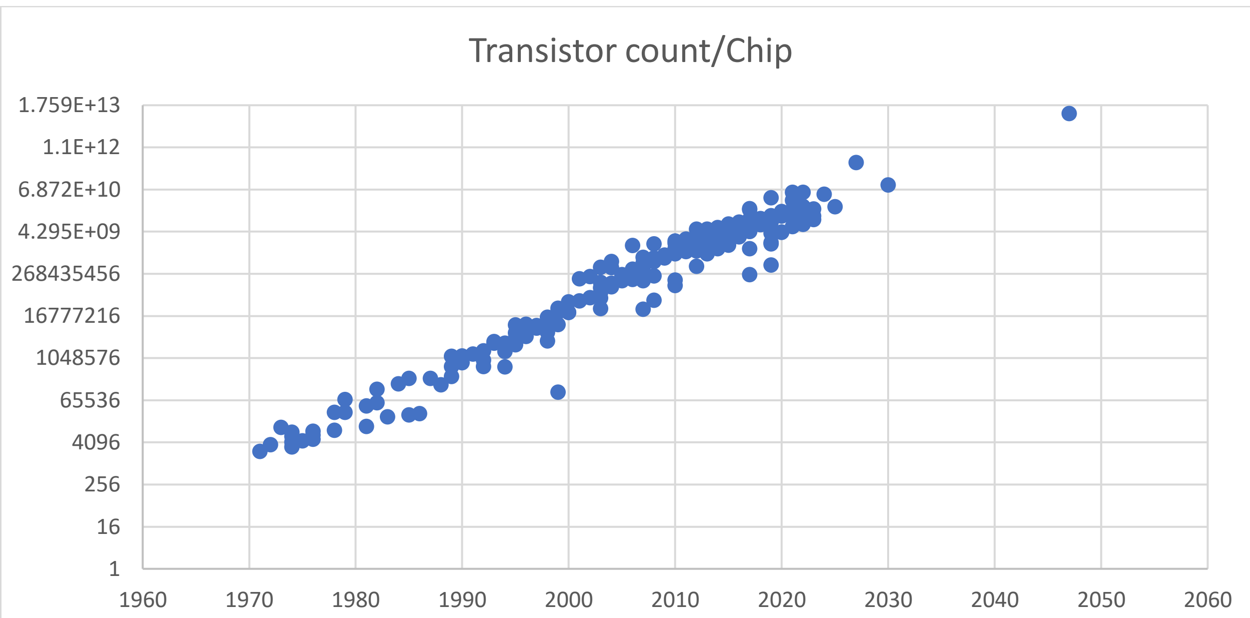


Fig .3. –No. of Transistor per Chip

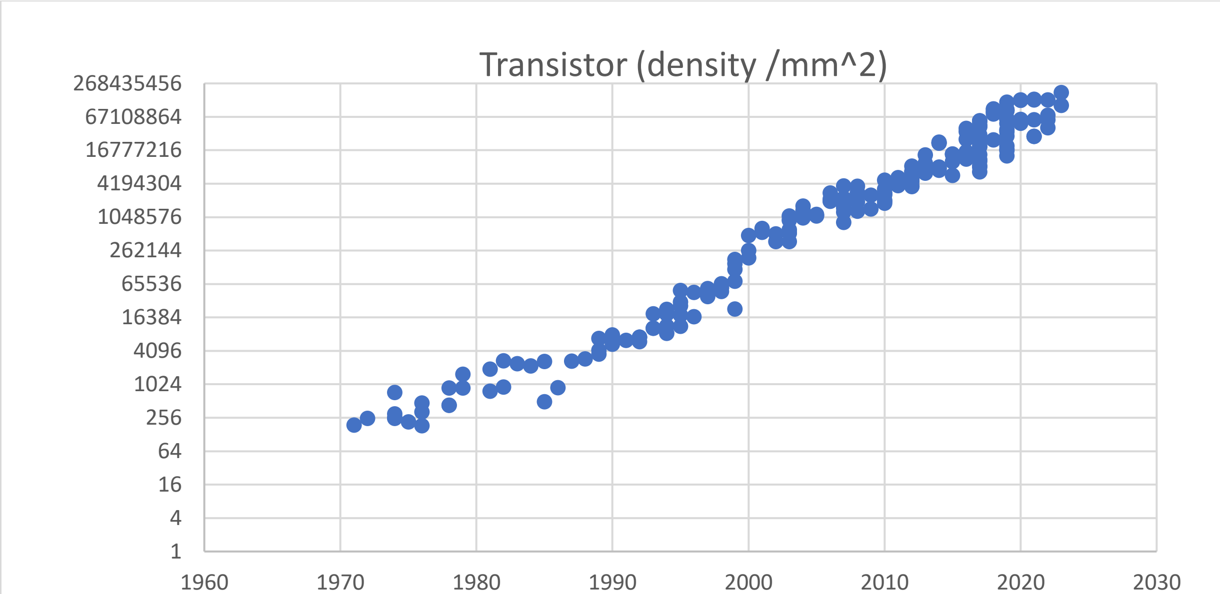


Fig .3. – density Transistor per Chip till Year 2023

In summary, the journey from Dr. Gordon Moore's initial prediction in 1965 to the present day has witnessed the transformative impact of Moore's Law on the electronics industry, driven by relentless advancements in fabrication processes, transistor technologies, and materials science. The future trajectory of transistors, with their continued miniaturization and diverse applications, remains a focal point of academic and industrial interest.

Following Excel Sheet I used to create the plot and data:

Microsoft Excel Chart


References:

[1] https://spectrum.ieee.org/gordon-moore-the-man-whose-name-means-progress

[2] https://www.fanaticalfuturist.com/2016/06/moores-law-gets-a-new-shot-in-the-arm/

[3] https://alwaysbecurious.substack.com/p/learn-about-the-tiniest-new-transistors?utm_source=%2Fsearch%2Ftransistors&utm_medium=reader2

[4] https://alwaysbecurious.substack.com/p/always-be-curious-188-apples-m3-triplets?utm_source=%2Fsearch%2Ftransistors&utm_medium=reader2

[5] https://alwaysbecurious.substack.com/p/what-will-transistors-be-like-25?utm_source=%2Fsearch%2Ftransistors&utm_medium=reader2

[6] https://ourworldindata.org/moores-law