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Rupesh Kharbanda,
Senior Director,
Moglix



In an era marked by the relentless march of technology, semiconductor innovation stands as the unsung hero powering high-tech manufacturing and the automotive industry. This Cover Story explores how semiconductors are shaping the future of these sectors, from IoT to AI, and why staying ahead in the semiconductor race is vital for businesses. Discover the trends and supply chain implications that will define the future of semiconductors.

The automotive and manufacturing sectors are experiencing a remarkable acceleration of innovations, primarily attributed to the advent of Industry 4.0. This fourth industrial revolution is founded on cutting-edge technologies such as the Internet of Things (IoT), Artificial Intelligence (AI) and smart manufacturing practices. Semiconductors are (literally) the heart of this revolution. Hence, be it a fitness watch or a self-driving car, micro-processors are the brain of every intelligent system.

Innovation in semiconductor technology has played an instrumental role in revolutionising high-tech manufacturing in the automotive and industrial manufacturing sectors. The automotive semiconductor market alone is predicted to grow at a steady rate of 7%, and is expected to be worth ~\$58,770.1 million in 2023, rising to \$115,609.68 million by 2033.

Regarding supply chain management, semiconductor technology has transformed the industry by enabling greater visibility and transparency. Semiconductor sensors have revolutionised logistics and production processes, allowing organisations to track inventory and monitor product quality in real time. The integration of semiconductor technology in supply chain management has led to significant cost savings and increased efficiency in operations, ultimately driving business growth.

With a rising demand for smart devices, companies are scrambling to integrate semiconductors into their products to stay ahead of the competition. The semiconductor industry works on a 'winner takes it all' principle. Companies with leading-edge capabilities capture an outsized portion of industry revenue. This makes it vital for organisations to maintain a commitment to innovation and stay ahead of the curve regarding cutting-edge semiconductor technology.

Understanding semiconductor innovation

As the demand for semiconductors continues to rise, the chip-making industry is facing significant challenges in terms of sustainability and cost-effectiveness. To address these issues, the industry is actively pursuing innovative approaches to chip-making that are both environmentally friendly and financially feasible. Some top global semiconductor trends and innovations are:

- **Internet of things:** As the demands for smaller-sized, diverse connectivity technologies and lower power consumption increase in IoT devices, semiconductor manufacturers focus on sensor and integrated circuit development. For example, IMOSTAR, a Taiwanese start-up, offers multi-band IoT chips. It collects sensor data and previous usage patterns to enable predictive maintenance.

- **AI and algorithmic chips:** Hardware-based accelerations are being introduced via algorithmic-specific chips to keep up with the rising volume of data that AI systems process. For instance, Rebellions, a South Korean start-up, offers domain-specific AI processors, while Gauss Labs, a US-based start-up, provides AI-based semiconductor manufacturing solutions.

- **Advanced materials:** Semiconductor start-ups are focusing on shrinking the structures' size and exploring novel materials like silicon carbide and gallium nitride. Start-ups like EPINOVATECH and QustomDot make GaN chips for transistor devices and create colour-changing nanoparticles for semiconductors, respectively. These offer cost-effective, robust solutions within restricted chip sizes.

- **RISC-V:** RISC-V is poised to revolutionise the industry and topple established players like CISC and RISC, the most popular ISAs. The implications of RISC-V's success are significant, as it will disrupt the traditional computing landscape and may lead to more open and collaborative development practices.

- **Novel architectures:** In the race for faster processing speeds, chip industry players are turning to non-volatile memory chips, 3D-enabled designs and nanotechnology-enabled processors. Efforts are also being made towards simpler instructions for parallel computing. YSEMI, a Chinese start-up, has created an ARM-based cloud processor for high-performance computing.

- **5G:** Organisations are designing technology-driven solutions for 5G to ensure low latency and reliable indoor and outdoor networks. Falcomm, a US-based start-up, is developing 5G power amplifiers for wireless communication to improve semiconductor manufacturing floor connectivity.

Semiconductor innovation in high-tech manufacturing

The realm of high-tech manufacturing has been profoundly impacted by remarkable advancements in semiconductor technology. These innovations, characterised by continuous improvement and component miniaturisation, have empowered the development of exceptionally powerful and efficient electronic devices. From smartphones to AI and IoT applications, semiconductors have been the driving force behind the rapid growth and transformation of diverse industries. The world of smartphones and mobile devices has witnessed a remarkable transformation, as semiconductors power high-performance processors and memory chips. This has led to faster and more efficient smartphones, capable of handling advanced applications and delivering seamless user experiences.

One area where semiconductors are having a significant impact is in the world of IoT applications. IoT technology devices rely heavily on integrated circuits, sensors and other semiconductor chips to function. This has paved the way for smart homes, wearables and industrial IoT applications. For instance, smart thermostats like Nest, empowered by semiconductor technology, have transformed energy efficiency in homes by intelligently regulating heating and cooling systems.

Another area where semiconductors are becoming increasingly important is in the field of AI. As AI technology becomes more prevalent in fields such as military, retail, healthcare and research, the demand for specialised sensors, memory and fast processors to run and maintain these

systems is skyrocketing. In fact, the worldwide AI market is predicted to grow to \$390.9 billion by 2025.

Semiconductor chips are also playing an essential role in the medical field. Devices such as Magnetic Resonance Imaging (MRI) machines, pacemakers, blood pressure monitors and patient monitors rely on semiconductors for improved accuracy and functionality. For example, wearable fitness trackers like Fitbit utilise semiconductor technology to monitor vital signs and track health metrics.

In the renewable energy sector, semiconductors have a crucial role in optimising power conversion, energy storage systems and monitoring equipment. Solar inverters, which convert DC power from solar panels into AC power for use in homes and businesses, rely on semiconductor devices to ensure maximum energy efficiency and reliability.

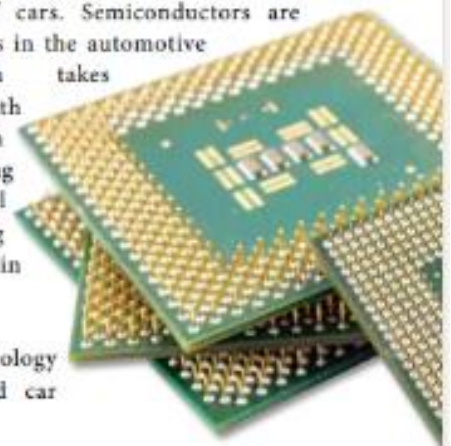
Semiconductors in the automotive industry

In 2019, sales of automotive semiconductors hit \$40 billion. By 2040, sales of automotive semiconductors might reach \$200 billion. Automotive semiconductors are one of the fastest-growing markets for the global semiconductor industry. They are crucial to innovating better engines known as ICEs (Internal Computing engines). Moreover, there will be no electric vehicles without semiconductors. Some of the key trends in automotive semiconductor innovation are:

- **Better connectivity:** Users are accustomed to features like route planning and road closure warnings utilising the internet-connected GPS in our cars, red light alerts, parking assistance and many other critical services that you require while operating a vehicle. The semiconductor processes and senses crucial data on the computing systems of the car, enabling precise, dependable and timely operation of the vehicle.

- **Vehicle electrification:** Mechanical systems are currently being replaced by electric ones for some of the features and functions of cars. Semiconductors are essential to accomplish this in the automotive industry. Electrification takes things up a notch with battery management in hybrid vehicles, improving the efficiency of fuel combustion and recovering energy from brakes in electric vehicles.

- **Increased safety:** Technology has significantly improved car



brakes over the past ten years and revolutionised other automotive industries. Semiconductors also significantly enabled better safety systems in automobiles, particularly in Autonomous Vehicles (AV), which improved the braking system. Today's vehicle owners can save lives by using features like blind-spot detection systems, cruise control, parking camera assistance, emergency braking systems, collision avoidance sensors and more.

- **Expanding use of AVs:** AVs, also called driverless self-driving cars, are one of the key breakthroughs in the automotive industry. These automobiles employ "Autopilot Mode" with the aid of AI-based technologies. However, while creating these AVs, cutting-edge semiconductors are needed to fine-tune this extremely complex system.

- **Advanced driving assistance:** The software integration employed in the car is responsible for functions like cruise control, the Anti-braking System (ABS), voice-activated GPS, Over-The-Air (OTA) updates, active steering etc. AUTOSAR (Automotive Open System Architecture) controls all of these procedures. It is an open, standardised ECU software architecture that was created especially for the automotive sector. In all AUTOSAR-enabled vehicles, its main purpose is to build a bridge between vehicular operations and application software.

Supply chain implications of semiconductor innovation

Leading semiconductor manufacturers, including Intel in the US and Samsung in South Korea, play a pivotal role in global production. The top five producers comprise China, Japan, Taiwan, South Korea and the USA. The intricate semiconductor supply chain involves various stakeholders in design, manufacturing, testing, packaging and distribution, with intellectual property licensing and recycling also in the mix. Vulnerable to disruptions like the 2020 COVID-19 pandemic, the supply chain necessitates investments in capacity expansion and supplier diversification. Intel's \$20 billion investment in Arizona and MICRON's \$15 billion expansion in Boise, Idaho, are examples. However, a looming talent shortage requires new workforce strategies to meet growing industry demands by 2030, as cautioned by Deloitte.



Procurement strategies in the era of semiconductor innovation

The semiconductor industry experienced an average growth rate of 7.6% annually from 2015 to 2022. Amid macroeconomic challenges, the industry's revenues are expected to decline by 3%-4% in 2023. With shortages affecting manufacturers in automotive, consumer goods and technology sectors, some COOs are turning to AI-based solutions to boost supply chain resilience. McKinsey reports that 90% of the semiconductor shortage-driven demand is associated with mature technologies used in everyday applications, such as cars, electronics, home appliances and medical devices. Manufacturers must devise strategies to overcome these challenges:

Chip hunting to alleviate short-term bottlenecks

Progressive companies propose a two-pronged approach by combining short-term quick fixes with strategic focuses on medium- and long-term goals. A technical strategy to scour the markets for chip supply is necessary to remedy the issue immediately. This can be achieved through AI, enabling companies to find new supplier sources, even custom-made parts. The long-term strategy includes:

- Identifying vulnerable categories.
- Implementing inventory strategies to mitigate supply risks.
- Forging closer ties with IDMs and fabless players.
- Creating a digital twin of the supply chain.

It is essential to continually review and align supplier and OEM trajectories, while an actively managed technology roadmap can steer purchases towards areas of lower supply risk. To reduce dependence on older technologies, companies must make hard-headed decisions on products with chip availability in mind and limit EOL exposure by revisiting chip portfolios.

Future trends

Despite their diminutive size, semiconductors have become indispensable in managing our connected world. These tiny components have driven technological progress, enabling the digital infrastructure that underpins vital sectors such as healthcare, telecommunications and defence. As time marches on, the demand for top-tier semiconductors is only set to increase, spurred on by the growing capabilities of AI and the rise of IoT. Some of the key future trends could be:

- Optimism regarding revenue growth
- Automotive emerges as the key revenue driver
- Chip shortage to end soon

Final thoughts

As industries embrace digitalisation and automation, the demand for chips will grow significantly. Consequently, semiconductor companies must address the supply shortage promptly to support on-going innovation and drive productivity across various sectors. Despite the challenges, the semiconductor industry remains a driving force behind technological advancements shaping multiple industries' future. To sustain this progress, collaborative efforts, investment in research and development and efficient supply chain management will be essential to meet the growing demand for semiconductor chips and fuel continued growth and progress in the digital era. □