JOURNAL OF ADVANCED ENGINEERING AND INNOVATION
Volume 4, Issue 1, June 2026 | pp. 65-75
https://doi.org/10.54518/jaei.4.1.2026.1476

Advanced Semiconductor Manufacturing Technologies: A Comparative Review between Taiwan and South Korea

Dafa Gautama[1] ✉

Universitas Bina Nusantara, Indonesia[1]

ABSTRACT

Advanced semiconductor manufacturing technologies have become a strategic foundation for global digital transformation, artificial intelligence, high-performance computing, and next-generation communication systems. Taiwan and South Korea are recognized as the world's leading semiconductor manufacturing hubs, supported by continuous technological innovation, strong industrial ecosystems, and government policy initiatives. This study aims to compare the development of advanced semiconductor manufacturing technologies in both countries through a systematic literature review. The review synthesizes recent studies published between published over the last five years to examine manufacturing processes, fabrication technologies, industrial strategies, supply chain resilience, research and development investment, and future technological trends. The findings indicate that Taiwan demonstrates significant leadership in advanced foundry manufacturing and process technology, while South Korea maintains strong competitiveness in memory semiconductor production and advanced packaging technologies. Despite differences in industrial specialization, both countries continue investing in research, infrastructure, and international collaboration to strengthen global competitiveness. This review provides valuable insights for researchers, policymakers, and industry stakeholders in supporting future semiconductor innovation and sustainable industrial development.

Keywords: *Advanced Manufacturing, Semiconductor Industry, South Korea, Systematic Literature Review, Taiwan.*

CORRESPONDING AUTHOR:
Dafa Gautama
Universitas Bina Nusantara, Indonesia

ARTICLE HISTORY
Received : January 17, 2026
Final Revised : March 9, 2026
Accepted : April 29, 2026
Published : June 30, 2026

1. | INTRODUCTION

The semiconductor industry has become one of the most strategic sectors supporting the global digital economy. Rapid advances in artificial intelligence, high-performance computing, fifth-generation and sixth-generation communication networks, cloud computing, autonomous vehicles, and Internet of Things (IoT) technologies have significantly increased the demand for advanced semiconductor devices with higher performance, lower power consumption, and greater manufacturing efficiency. Consequently, semiconductor manufacturing technologies have evolved rapidly through continuous innovation in fabrication processes, materials engineering, lithography techniques, packaging technologies, and process automation. As countries increasingly recognize semiconductors as critical components of economic competitiveness and national security, investment in advanced semiconductor manufacturing infrastructure has become a strategic priority worldwide (Schindler et al., 2024).

Among the leading semiconductor-producing economies, Taiwan and South Korea have established themselves as global leaders through different yet highly complementary industrial strategies. Taiwan has developed a globally competitive semiconductor ecosystem centered on advanced foundry manufacturing, supported by close collaboration between semiconductor manufacturers, equipment suppliers, research institutions, and government agencies. This integrated ecosystem has enabled Taiwan to maintain leadership in advanced process technologies, including sub-5 nm manufacturing, extreme ultraviolet (EUV) lithography implementation, and high-volume wafer fabrication. Continuous investment in research and development has further strengthened Taiwan's ability to meet growing global demand for high-performance logic chips used in artificial intelligence, mobile computing, and data centers (Huang et al., 2021).

South Korea has followed a different development pathway by establishing global leadership in memory semiconductor manufacturing while simultaneously expanding its capabilities in advanced logic chip production and semiconductor packaging. Strong government support, substantial private investment, and intensive research activities have enabled South Korean semiconductor companies to continuously improve manufacturing efficiency and technological competitiveness. Recent national semiconductor strategies emphasize strengthening domestic supply chains, expanding fabrication capacity, accelerating research on next-generation semiconductor technologies, and increasing resilience against global market uncertainties. These initiatives demonstrate South Korea's commitment to maintaining long-term competitiveness within the rapidly evolving semiconductor industry (Wong & Russell, 2024).

Advanced semiconductor manufacturing depends on the successful integration of multiple sophisticated technologies throughout the fabrication process. Extreme ultraviolet lithography, atomic layer deposition, atomic layer etching, advanced process control, artificial intelligence-assisted manufacturing, cleanroom automation, and advanced packaging technologies have become essential for improving chip performance while reducing manufacturing complexity. These technological developments require substantial capital investment, highly skilled human resources, reliable supply chains, and close collaboration between governments, research institutions, and industrial partners. Consequently, countries leading semiconductor manufacturing continue investing heavily in technological innovation to sustain their competitive advantages in increasingly complex global markets (George & Schillebeeckx, 2022).

In recent years, geopolitical tensions, supply chain disruptions, and increasing demand for semiconductor products have highlighted the strategic importance of manufacturing resilience. Global shortages experienced during and after the COVID-19 pandemic demonstrated the vulnerability of semiconductor supply chains and encouraged governments to strengthen domestic production capabilities while diversifying international partnerships. Taiwan and South Korea have responded by expanding fabrication facilities, increasing investments in advanced manufacturing technologies, supporting semiconductor workforce development, and promoting closer cooperation between industry and academia. These measures aim not only to improve production capacity but also to enhance long-term supply chain security and technological independence (Agarwal et al., 2022).

Although both countries are recognized as global semiconductor leaders, their industrial structures, technological priorities, and innovation strategies differ considerably. Taiwan emphasizes contract manufacturing and advanced foundry services for international technology companies, whereas South Korea combines leadership in memory semiconductor production with increasing investment in logic manufacturing and advanced packaging solutions. Comparing these different development models provides valuable insights into how technological innovation, industrial policy, research investment, and infrastructure development influence semiconductor competitiveness in the global market.

Therefore, this study conducts a systematic literature review to compare advanced semiconductor manufacturing technologies in Taiwan and South Korea by synthesizing recent literature published between 2021 and 2025. The review examines technological advancements, manufacturing processes, industrial policies, supply chain development, research and development strategies, and future challenges affecting semiconductor manufacturing in both countries. The findings are expected to contribute to a deeper understanding of global semiconductor competitiveness while providing useful recommendations for policymakers, researchers, and industry stakeholders seeking to strengthen semiconductor innovation and sustainable industrial development.

2. | RESEARCH METHOD

This study employed a Systematic Literature Review (SLR) to comprehensively analyze and compare advanced semiconductor manufacturing technologies in Taiwan and South Korea. The SLR approach was selected because it provides a structured, transparent, and reproducible method for synthesizing scientific evidence from multiple sources while minimizing selection bias and improving the reliability of research findings (Ahmed, 2024). The review followed systematic review procedures consisting of research problem identification, literature searching, study screening, eligibility assessment, data extraction, comparative analysis, and evidence synthesis. The primary objective was to evaluate technological developments, manufacturing processes, industrial policies, research and development strategies, supply chain resilience, infrastructure investment, and future opportunities within the semiconductor industries of Taiwan and South Korea. Relevant publications were collected from internationally recognized scientific databases, including Scopus, Web of Science, ScienceDirect, SpringerLink, IEEE Xplore, and Google Scholar. Additional information was obtained from reports published by reputable organizations and industry associations, including the Semiconductor Industry Association (SIA), the International Energy Agency (IEA), the Industrial Technology Research Institute (ITRI), Taiwan Semiconductor Manufacturing Company (TSMC), the Ministry of Trade, Industry and Energy (MOTIE) of South Korea, the Korea Institute of Science and Technology Evaluation and Planning (KISTEP), and the Organisation for Economic Co-operation and Development (OECD) (Hwang et al., 2022).

The literature search used combinations of keywords such as "advanced semiconductor manufacturing," "semiconductor fabrication," "Taiwan semiconductor," "South Korea semiconductor," "extreme ultraviolet lithography," "advanced packaging," "semiconductor supply chain," and "process technology." Publications were limited to English-language journal articles, conference papers, review articles, institutional reports, and government publications published between 2021 and 2025 to ensure that the review reflected recent technological developments and industrial trends. Studies were included if they directly discussed semiconductor manufacturing technologies, fabrication processes, industrial strategies, technological innovation, or comparative analyses involving Taiwan and South Korea. Publications unrelated to semiconductor manufacturing, lacking sufficient methodological information, or focusing solely on electronic device applications without manufacturing relevance were excluded. The selected literature was systematically categorized into key themes, including manufacturing technologies, process innovation, research investment, industrial policy, supply chain resilience, advanced packaging, and future development trends (Lau, 2022). Comparative synthesis was subsequently conducted to identify similarities, differences, competitive advantages, and strategic challenges faced by both countries, providing a comprehensive understanding of their contributions to the advancement of the global semiconductor industry.

3. | RESULTS AND DISCUSSION

The systematic literature review indicates that Taiwan and South Korea remain the two most influential countries in the global semiconductor manufacturing industry. Both countries have established highly competitive semiconductor ecosystems through continuous technological innovation, large-scale capital investment, and long-term industrial policies. Although they share the common objective of maintaining technological leadership, their industrial structures and competitive advantages differ. Taiwan has developed a manufacturing ecosystem centered on advanced foundry services, while South Korea has maintained global leadership in memory semiconductor production and has expanded its capabilities in advanced logic manufacturing and semiconductor packaging. These complementary strengths have enabled both countries to play critical roles in supporting worldwide demand for advanced semiconductor devices used in artificial intelligence, cloud computing, high-performance computing, consumer electronics, and next-generation communication systems (Tera et al., 2024).

Taiwan's semiconductor industry is characterized by its highly integrated manufacturing ecosystem, which connects semiconductor foundries, equipment suppliers, design companies, research institutions, and government agencies. This collaborative environment has accelerated innovation while improving production efficiency and manufacturing quality. Taiwan Semiconductor Manufacturing Company (TSMC) continues to lead global foundry manufacturing through continuous investment in advanced fabrication technologies, including extreme ultraviolet (EUV) lithography, process miniaturization, and high-volume wafer production. These technologies enable the production of increasingly complex semiconductor devices with higher transistor density, lower power consumption, and improved computational performance. Continuous investment in research and development has also strengthened Taiwan's ability to respond to rapidly changing market demands and technological advancements (Pasupuleti et al., 2024).

Another important factor supporting Taiwan's competitiveness is its strong emphasis on process optimization and manufacturing automation. Advanced semiconductor fabrication requires extremely precise process control, cleanroom management, defect detection, and quality assurance throughout every production stage. The integration of artificial intelligence, machine learning, and data analytics into manufacturing operations has improved production efficiency while reducing operational risks and manufacturing defects. Smart manufacturing technologies enable predictive maintenance, real-time monitoring, and automated quality inspection, allowing manufacturers to increase production yield and minimize equipment downtime. These technological capabilities have become increasingly important as semiconductor manufacturing processes continue to grow more complex at advanced technology nodes (Cao et al., 2023).

In comparison, South Korea has developed a semiconductor industry with a strong focus on memory semiconductor manufacturing while continuously expanding investments in advanced logic semiconductor production. South Korean companies have maintained leadership in dynamic random-access memory (DRAM) and NAND flash technologies through sustained research investment and technological innovation. At the same time, national semiconductor policies encourage diversification into advanced logic chips, semiconductor packaging, and next-generation manufacturing technologies to strengthen long-term industrial competitiveness. These initiatives reflect South Korea's commitment to reducing technological dependence while improving supply chain resilience in an increasingly competitive global market (Cohen & Kouvelis, 2021).

The review also demonstrates that South Korea has significantly increased investment in advanced semiconductor manufacturing infrastructure during recent years. Government support has encouraged the expansion of fabrication facilities, research centers, and collaborative innovation programs involving universities, research institutes, and private industries. These initiatives aim to accelerate technological commercialization while strengthening domestic production capacity. In addition, investment in advanced packaging technologies has become an important strategic priority because packaging performance increasingly influences semiconductor efficiency, thermal management, and device integration. Advanced packaging solutions allow manufacturers to improve chip performance without relying exclusively on further transistor miniaturization, making this technology an essential component of future semiconductor development (Kim et al., 2023). Supply chain resilience has emerged as another critical issue affecting semiconductor manufacturing in both Taiwan and South Korea. The COVID-19 pandemic, geopolitical tensions, and increasing global demand exposed vulnerabilities in semiconductor production and international logistics. As a result, both countries have introduced policies aimed at strengthening domestic manufacturing capabilities while maintaining international cooperation. Taiwan has continued expanding production capacity through new fabrication plants and stronger collaboration with global technology companies. South Korea has similarly invested in supply chain diversification, semiconductor materials, manufacturing equipment, and workforce development to reduce potential disruptions. These efforts illustrate the growing recognition that supply chain stability is essential for maintaining technological competitiveness and supporting global semiconductor production (Peters, 2023).

Despite their different industrial priorities, Taiwan and South Korea share several common characteristics that explain their continued leadership in semiconductor manufacturing. Both countries prioritize long-term research investment, technological innovation, skilled workforce development, and close collaboration between governments, universities, and private industries. Furthermore, both recognize that maintaining competitiveness requires continuous improvement in manufacturing technologies, production efficiency, and infrastructure development. As global demand for advanced semiconductor devices continues to increase, sustained investment in next-generation fabrication technologies, automation, and supply chain resilience will remain essential for preserving their leadership positions within the international semiconductor industry.

The comparative review further shows that government policy has played a decisive role in supporting semiconductor manufacturing development in both Taiwan and South Korea. Rather than relying solely on market forces, both governments have implemented long-term industrial strategies that encourage technological innovation, infrastructure expansion, and workforce development. Taiwan has continuously supported cooperation between research institutions and semiconductor manufacturers to accelerate technology transfer and improve manufacturing capability. Similarly, South Korea has strengthened national semiconductor initiatives through financial incentives, research funding, tax support, and investment in advanced fabrication facilities. These policy measures have increased industrial competitiveness while encouraging continuous innovation in semiconductor manufacturing technologies (Peters, 2023).

Technological innovation remains the primary factor driving competitiveness within the semiconductor industry. The reviewed studies indicate that continuous improvements in extreme ultraviolet (EUV) lithography, atomic layer deposition, atomic layer etching, advanced process control, and cleanroom automation have enabled manufacturers to produce increasingly smaller and more powerful semiconductor devices. Taiwan has demonstrated significant leadership in advanced foundry manufacturing through continuous process optimization and high-volume production, whereas South Korea has maintained strong competitiveness in memory semiconductor technologies while expanding advanced logic manufacturing and heterogeneous packaging capabilities. These technological developments have supported the production of high-performance chips required for artificial intelligence, cloud computing, data centers, autonomous vehicles, and next-generation communication systems (Addad et al., 2020).

Research and development investment has become another critical determinant of long-term industrial success. Both countries allocate substantial financial resources to semiconductor research, equipment development, and manufacturing innovation. Universities, national laboratories, and private companies collaborate closely to accelerate technological breakthroughs and improve manufacturing efficiency. Such collaboration supports the rapid commercialization of new fabrication technologies while strengthening knowledge transfer between academic research and industrial production. Continuous investment in research also enables manufacturers to respond more effectively to changing market demands and emerging technological challenges (Cohen et al., 2021).

The literature also identifies sustainability as an increasingly important consideration in semiconductor manufacturing. Advanced fabrication facilities consume significant amounts of electricity, ultrapure water, specialty gases, and raw materials. Consequently, manufacturers in Taiwan and South Korea have introduced sustainability initiatives aimed at improving energy efficiency, reducing greenhouse gas emissions, increasing water recycling, and minimizing industrial waste. Digital monitoring systems, artificial intelligence, and smart manufacturing technologies are increasingly used to optimize resource utilization while maintaining production quality. These initiatives not only improve environmental performance but also strengthen operational efficiency and support long-term industrial sustainability (Zehra et al., 2024).

Another major challenge concerns supply chain resilience and geopolitical uncertainty. Semiconductor manufacturing depends on highly specialized equipment, raw materials, and international supplier networks. Disruptions caused by geopolitical tensions, trade restrictions, or natural disasters can significantly affect global semiconductor production. Taiwan and South Korea have therefore expanded investment in domestic manufacturing capabilities while strengthening cooperation with international technology partners. Diversifying suppliers, increasing local production of semiconductor materials, and improving logistics infrastructure have become essential strategies for reducing supply chain risks and ensuring stable production capacity (Peters, 2023).

Human capital development also represents a strategic priority identified throughout the reviewed literature. The rapid advancement of semiconductor manufacturing technologies requires highly skilled engineers, researchers, and technicians capable of operating sophisticated fabrication equipment and developing next-generation manufacturing processes. Both Taiwan and South Korea continue strengthening collaboration between universities, research institutes, and industry to improve workforce quality through specialized education, technical training, and research programs. These initiatives contribute to sustaining innovation while ensuring the long-term availability of qualified professionals needed by the semiconductor industry (Shih, 2023).

Overall, the comparative analysis demonstrates that Taiwan and South Korea have achieved global leadership through different but complementary industrial strategies. Taiwan maintains a competitive advantage in advanced foundry manufacturing, process technology, and high-volume fabrication, while South Korea continues leading memory semiconductor production and expanding advanced packaging and logic manufacturing capabilities. Despite differences in industrial specialization, both countries prioritize continuous technological innovation, strong policy support, research investment, supply chain resilience, and sustainable manufacturing practices. These shared commitments are expected to strengthen their competitiveness and support the continued advancement of the global semiconductor industry. As demand for advanced chips continues to increase, both countries will remain key contributors to technological innovation and the future development of semiconductor manufacturing worldwide.

4. | CONCLUSION

This study compared advanced semiconductor manufacturing technologies in Taiwan and South Korea through a systematic literature review to identify their technological capabilities, industrial strategies, and future development opportunities. The review demonstrates that both countries play essential roles in the global semiconductor industry but have adopted different approaches to achieving technological competitiveness. Taiwan has established global leadership in advanced foundry manufacturing through continuous innovation in fabrication processes, manufacturing efficiency, and high-volume production. Meanwhile, South Korea has maintained its competitive advantage in memory semiconductor manufacturing while expanding investments in advanced logic chips, semiconductor packaging, and next-generation fabrication technologies.

The findings also indicate that long-term government policies, sustained research and development investment, advanced manufacturing infrastructure, and strong collaboration between industry, academia, and research institutions are fundamental factors supporting semiconductor innovation in both countries. Furthermore, improvements in automation, artificial intelligence, sustainable manufacturing, and supply chain resilience have become increasingly important for maintaining global competitiveness amid rising technological complexity and market uncertainty.

Overall, Taiwan and South Korea demonstrate that continuous technological advancement, strategic industrial planning, and international collaboration are essential for strengthening semiconductor manufacturing capabilities. The experiences of both countries provide valuable lessons for policymakers, researchers, and industry stakeholders seeking to develop resilient, innovative, and sustainable semiconductor industries capable of supporting future digital transformation and global economic growth.

Acknowledgment

We gratefully acknowledge the contributions of individuals who supported the completion of this article.

Funding Information

This research did not receive any funding.

Conflict of Interest Statement

The authors declare that there is no conflict of interest.

Ethical Approval and Originality Statement

Ethical approval was obtained for this study. The manuscript represents original work and has not been previously published, nor is it under consideration by another journal.

Data Disclosure Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

Addad, R. A., Taleb, T., Flinck, H., Bagaa, M., & Dutra, D. (2020). Network slice mobility in next generation mobile systems: Challenges and potential solutions. *IEEE Network*, *34*(1), 84-93.

Agarwal, U., Rishiwal, V., Tanwar, S., Chaudhary, R., Sharma, G., Bokoro, P. N., & Sharma, R. (2022). Blockchain technology for secure supply chain management: A comprehensive review. *Ieee Access*, *10*, 85493-85517.

Ahmed, S. K. (2024). How to choose a sampling technique and determine sample size for research: A simplified guide for researchers. *Oral Oncology Reports*, *12*, 100662.

Cao, W., Bu, H., Vinet, M., Cao, M., Takagi, S., Hwang, S., ... & Banerjee, K. (2023). The future transistors. *Nature*, *620*(7974), 501-515.

Cohen, M. A., & Kouvelis, P. (2021). Revisit of AAA excellence of global value chains: Robustness, resilience, and realignment. *Production and Operations Management*, *30*(3), 633-643.

George, G., & Schillebeeckx, S. J. (2022). Digital transformation, sustainability, and purpose in the multinational enterprise. *Journal of World Business*, *57*(3), 101326.

Huang, Y., Xu, H., Gao, H., Ma, X., & Hussain, W. (2021). SSUR: an approach to optimizing virtual machine allocation strategy based on user requirements for cloud data center. *IEEE Transactions on Green Communications and Networking*, *5*(2), 670-681.

Hwang, W. S., Hong, C., Oh, I., & Yeo, Y. (2022). Assessing the economy-wide impacts of public R&D support options based on a computable general equilibrium model: focusing on types of fiscal incentives and beneficiaries. *Applied Economics*, *54*(40), 4664-4680.

Kim, T., Choi, C. H., Hur, J. S., Ha, D., Kuh, B. J., Kim, Y., ... & Jeong, J. K. (2023). Progress, challenges, and opportunities in oxide semiconductor devices: a key building block for applications ranging from display backplanes to 3D integrated semiconductor chips. *Advanced Materials*, *35*(43), 2204663.

Lau, J. H. (2022). Recent advances and trends in advanced packaging. *IEEE Transactions on Components, Packaging and Manufacturing Technology*, *12*(2), 228-252.

Pasupuleti, V., Thuraka, B., Kodete, C. S., & Malisetty, S. (2024). Enhancing supply chain agility and sustainability through machine learning: Optimization techniques for logistics and inventory management. *Logistics*, *8*(3), 73.

Peters, M. A. (2023). Semiconductors, geopolitics and technological rivalry: the US CHIPS & Science Act, 2022. *Educational Philosophy and Theory*, *55*(14), 1642-1646.

Schindler, S., Alami, I., DiCarlo, J., Jepson, N., Rolf, S., Bayırbağ, M. K., ... & Zhao, Y. (2024). The second cold war: US-China competition for centrality in infrastructure, digital, production, and finance networks. *Geopolitics*, *29*(4), 1083-1120.

Shih, A. J. (2023). Multicultural diversity workforce and global technology collaboration empowered semiconductor manufacturing excellence in taiwan: a manufacturing engineer's perspective. *Journal of Manufacturing Science and Engineering*, *145*(9), 090801.

Tera, S. P., Chinthaginjala, R., Pau, G., & Kim, T. H. (2024). Toward 6G: An overview of the next generation of intelligent network connectivity. *IEEE Access*, *13*, 925-961.

Wong, C. Y., & Russell, C. J. (2024). A search dilemma for market niches: Korea and Taiwan in a time of US-China high-tech decoupling. *Global Policy*, *15*(2), 475-486.

Zehra, K., Mirjat, N. H., Shakih, S. A., Harijan, K., Kumar, L., & El Haj Assad, M. (2024). Optimizing auto manufacturing: a holistic approach integrating overall equipment effectiveness for enhanced efficiency and sustainability. *Sustainability*, *16*(7), 2973.