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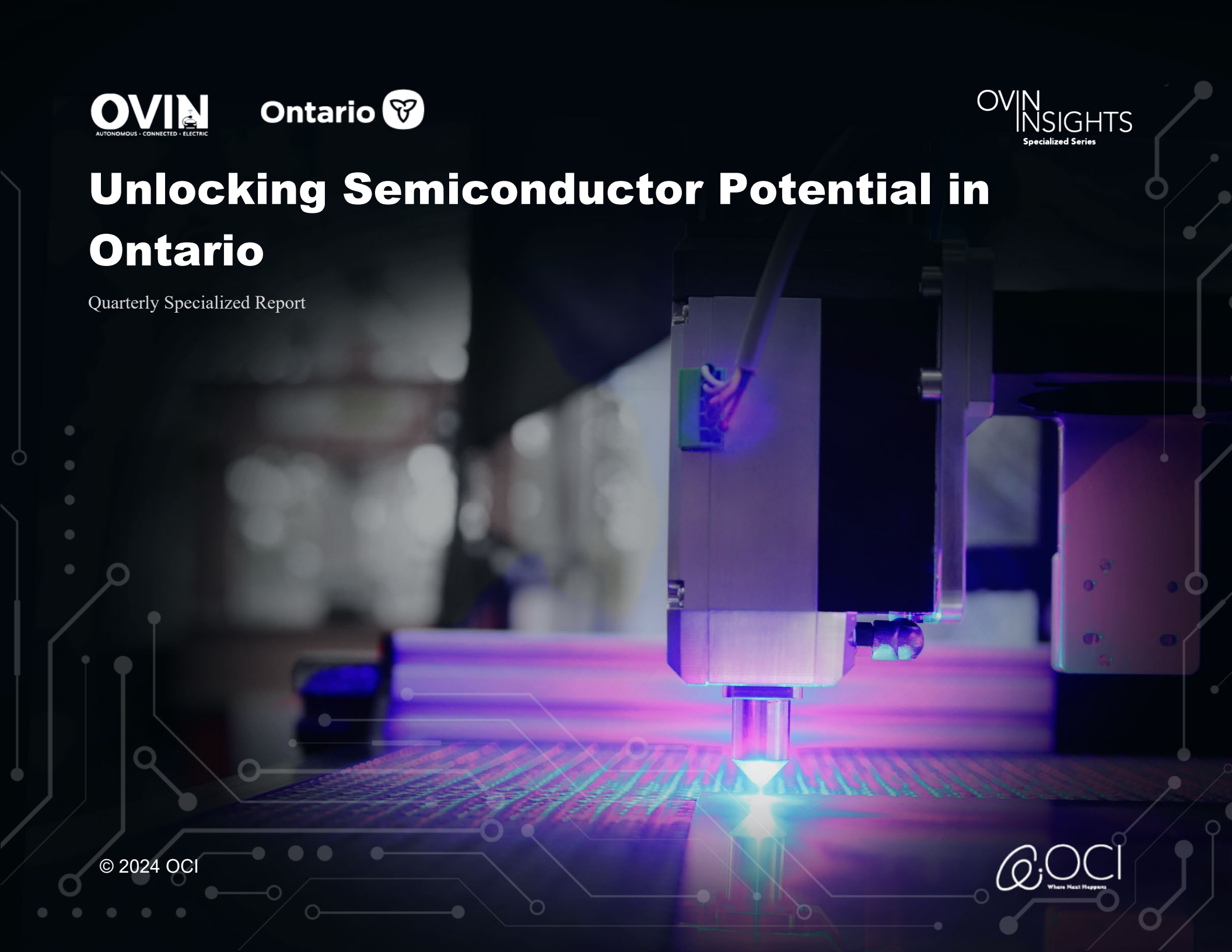
Ontario

OVIN INSIGHTS
Specialized Series

Unlocking Semiconductor Potential in Ontario

Quarterly Specialized Report



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Note: Throughout this document the graphs reference the North American Industry Classification System (NAICS) codes. Details of these codes can be found at census.gov/naics

1. Executive Summary

Semiconductors are the foundation of modern technology, powering a wide range of devices from smartphones to cutting-edge medical equipment, and fueling innovation across nearly every industry. In November 2023, the Semiconductor Industry Association (SIA) reported global semiconductor sales of $48B, reflecting a 5.3% increase from the previous year and a 2.9% rise from October 2023.[1] Forecasts indicate that the global semiconductor market will grow from approximately $825B in 2024 to $970B in 2027, with a compound annual growth rate (CAGR) of 5.6%.[2] The industry is projected to surpass US$1T in value by 2030.[3] Within this context, Canada's semiconductor market is expected to experience a 5% CAGR, growing from over $7B in 2024 to nearly $9B by 2027.[4] This rate surpasses that of the United States, which is projected to grow at around 3%, and aligns with the growth expected in Europe.[5]

The demand for semiconductors is rapidly increasing. A major factor is the automotive industry's shift towards electric and autonomous vehicles, which is projected to triple semiconductor demand in this sector, reaching US$150B globally by 2030.[6] Additionally, the push towards net-zero emissions is fueling semiconductor use in clean energy systems, such as solar, wind, and hydropower, with the renewable energy market expected to grow at a CAGR of 8-10% through to 2027.[7]

Automotive semiconductors, integral to systems like Electronic Control Units (ECUs) and Battery Management Systems (BMS), are vital for both internal combustion engine (ICE) vehicles and electric vehicles (EVs). By 2030, the automotive sector is projected to account for approximately 13% of the total global semiconductor market.[8] In this context, semiconductors for BMS in EVs and active safety technologies such as advanced driver-assistance systems (ADAS) are poised for significant growth. Notably, the demand for semiconductors in automotive safety and ADAS is anticipated to grow at a CAGR of 29% over the next decade, highlighting the critical role of semiconductors in enhancing vehicle safety and functionality.[9]

Ontario, as a central hub in the semiconductor landscape, is uniquely positioned to leverage this growth. Ontario stands poised to cement its leadership in the burgeoning semiconductor industry, particularly within the automotive sector. In 2020, the Canadian semiconductor sector generated $28.8B in total output, with Ontario accounting for 62.8% of this value,[10] and by 2022, Ontario's semiconductor industry had generated over $3.3B in revenue, representing 60% of Canada's total revenue in the sector.[11] Moreover, Ontario hosts 49% of Canada's semiconductor organizations,[12] and 56% of semiconductor related jobs.[13]

The province leads in research and development (R&D) within the sector, accounting for two-thirds of the in-house R&D expenditures in Canada and employing 7,384 R&D personnel. With a focus on advanced semiconductor applications, especially in the automotive sector, Ontario's dominance is further underscored by its substantial contributions to high-performance computing and autonomous vehicle technologies.

Ontario's semiconductor sector benefits from robust federal support mechanisms, including the Strategic Innovation Fund and the FABrIC initiative, and provincial mechanisms such as the Ontario Vehicle Innovation Network's (OVIN) R&D Partnership Fund, which aim to strengthen R&D and manufacturing capabilities.[14] The Canadian Photonics Fabrication Centre (CPFC) also plays a key role, enhancing research and innovation in

semiconductor technologies.[15] These initiatives align with the broader national strategy to develop a resilient semiconductor supply chain and reduce reliance on foreign sources.

Furthermore, Ontario's clean energy profile – boasting an electricity system that is 90% emissions-free – makes it an attractive location for sustainable semiconductor manufacturing.[16] The province's favorable business environment is reinforced by its Site Readiness Program, which supports the development of new semiconductor manufacturing facilities.[17] Additionally, a new bilateral manufacturing corridor with the United States and access to numerous free trade agreements further strengthens Ontario's position as a key player in the semiconductor industry, offering substantial opportunities for businesses in R&D and manufacturing.[18]

Ontario's prominence is also strengthened by federal initiatives such as the $250M investment to enhance domestic semiconductor capabilities,[19] and the $150M Semiconductor Challenge Callout.[20] Additionally, ventureLAB's Hardware Catalyst Initiative, which is one of OVIN's Regional Technology Development Sites (RTDS), has facilitated investments totaling more than $340M in Canadian technology companies.[21] These investments have enabled the semiconductor ecosystem in Ontario to continue expanding, enhancing supply chain capabilities across the board, and unlocking opportunities for direct links to the province's thriving automotive industry. In this context, Ontario can leverage its automotive industry success to establish itself as a leader in the semiconductor sector by adopting a similar strategic model. Key opportunities include scaling up semiconductor manufacturing, diversifying production, continuing to support small businesses, and implementing tax credits to drive growth. Additionally, exploring opportunities to expand next-generation power semiconductors and growing assembly and testing facilities will be crucial. By improving the supply chain connections between foundries and original equipment manufacturers (OEMs) and expanding critical mineral exploration, Ontario can solidify its position in the semiconductor industry, ensuring sustained economic growth and technological leadership.

Ontario's strategic position as a leading centre for semiconductor research, design, and manufacturing, coupled with its significant contributions to the automotive industry, underscore its potential to drive future growth in this critical sector. The province's ongoing investments in technology and innovation, along with its commitment to sustainability and skilled talent development, position Ontario as a key player in shaping the future of the global semiconductor industry.

This report provides an overview of the semiconductor industry in Ontario, focusing on its current status in R&D, design, and manufacturing, and its integration within the automotive sector. It includes an analysis of the economic impact of Ontario's semiconductor industry, identifies key players in research, design, and manufacturing within the ecosystem, and highlights Ontario's competitive advantages. Additionally, the report explores opportunities for expanding the semiconductor industry in Ontario to position it as a leader in the global supply chain.

2. Semiconductor Insights and Trends

This chapter provides an overview of the semiconductor industry, beginning with an explanation of different types of semiconductors.* Following this introduction, the chapter outlines the semiconductor lifecycle, detailing the key stages of research, design, and manufacturing. This high-level breakdown offers insight into the processes involved in bringing semiconductor technologies from concept to market.

The discussion then shifts to the specific application of semiconductors in the automotive industry, aligning with the focus of this report. The chapter highlights how semiconductors are integral to modern automotive technologies, including ADAS, EVs, and autonomous driving.

To contextualize Canada's role in the global semiconductor landscape, the chapter provides an overview of Canada's semiconductor market share. This analysis helps to provide understanding of Canada’s position within the industry and its contributions to semiconductor advancements.

Finally, the chapter examines critical factors influencing the semiconductor industry. It addresses issues such as increasing demand for semiconductor products, the complexities of global supply chains, and other economic and technological drivers shaping the industry’s future.

* For a more detailed overview of semiconductors refer to the OVIN Insights report Ontario’s Unique Position: Hardware Electronics and Semiconductors and Their Role in the Automotive and Mobility Sector

2.1 Semiconductor 101

Semiconductors are vital elements in all electronics, enabling the processing, storage, and transmission of data. They are the lifeblood of the automotive and mobility sector, powering every essential function in vehicles. Semiconductors provide a multitude of functions, such as driver assistance, electrification, communication, and entertainment.

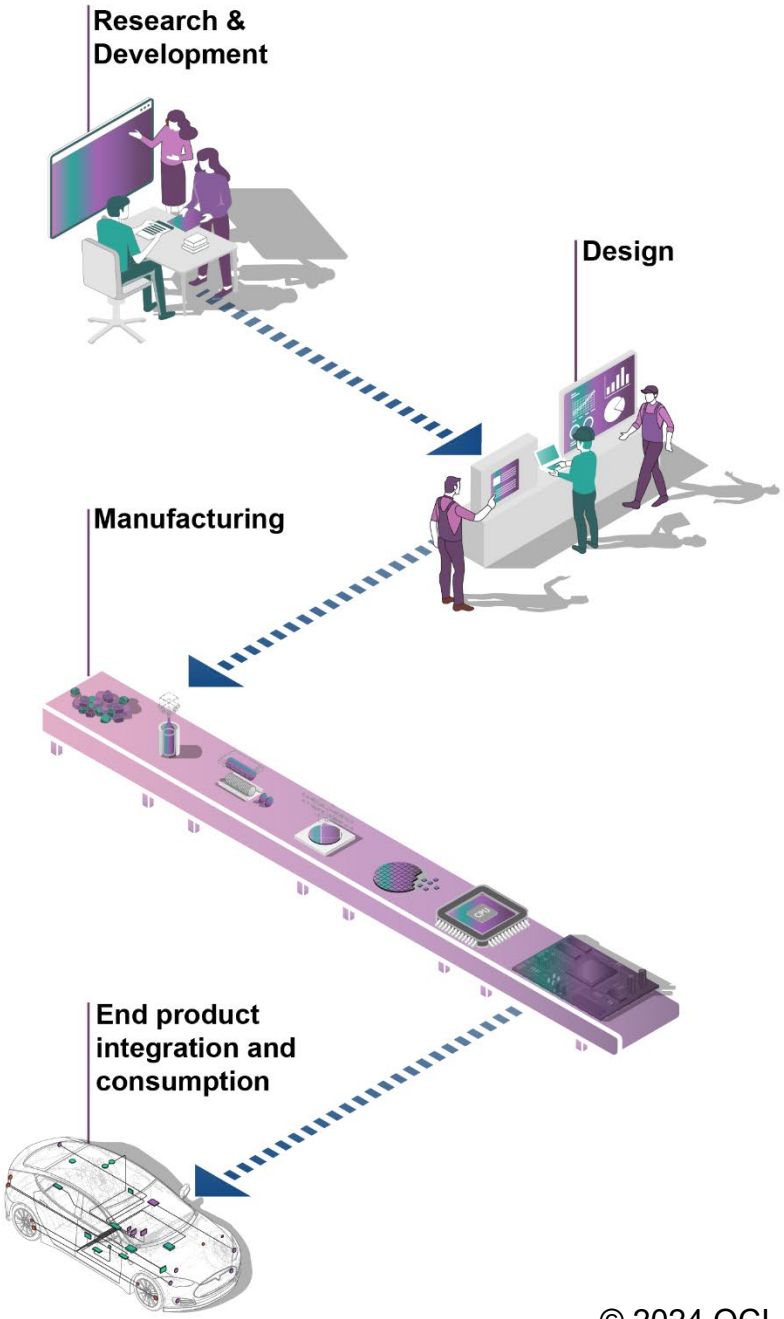
There are a number of different types of semiconductors. A selection of these is presented below.

- **Sensors and actuators** – semiconductor devices which are made for measuring physical, chemical, and biological properties, such as temperature, pressure, and acceleration. This category also includes gyroscope sensors and micro-electromechanical system (MEMS) devices which convert electrical signals into physical actions.[22]
- **Discrete** – assembled using a single semiconductor device and used to perform a simple electronic operation. Examples include diodes, transistors, resistors, capacitors, and inductors.[23]
- **Optoelectronic** – semiconductor devices used for light sensing and emitting functions. Examples include displays, light emitting diodes (LED), and optical switches.[24]
- **Analog Integrated Circuits** – integrated circuits (IC) which accept analog input or provide analog output. They are largely used to process analog signals.[25]
- **Logic Integrated Circuits** – ICs which are designed for digital logic functions. Examples include digital bipolar devices, metal-oxide-semiconductor (MOS) logic devices, and programmable logic devices.[26]
- **Memory Integrated Circuits** – ICs which are designed for memory functions. These are manufactured using either a single or combination of MOS technologies.[27]
- **Micro Integrated Circuits** – ICs which are constructed using MOS or bipolar MOS technologies. They are designed for digital logic functionalities and examples include microprocessors, microcontrollers, and digital signal processors.[28]

2.2 Semiconductor Lifecycle

The semiconductor lifecycle at a high-level can be presented in four phases. It begins with research and design phases, followed by the manufacturing of silicon wafers which are then packaged ready for integration into the final product. An outline of the steps in the lifecycle is as follows:

1. **Research** – R&D is undertaken to ensure technological innovation and maintain competitiveness.
2. **Design** – highly sophisticated equipment is used to design chips for either specific or general product usage. It involves various stages, such as conceptualization, architectural design, circuit design, layout, verification, and testing.
3. **Manufacturing**† – silicon wafers are produced from purified materials, such as sand. These wafers are printed with highly intricate circuit designs and cut into tiny individual semiconductors called dies.[29] The dies are then packaged to provide electrical connections, mechanical protection, and thermal management, forming a chip. Multiple components integrated into a single package form a power module.[30]
4. **End product integration and consumption** – chips and power modules are then integrated into finished goods by OEMs and Electronics Manufacturing Service (EMS) companies and shipped worldwide to companies, retailers, and consumers.[31]



† For a more detailed overview of the manufacturing process refer to the OVIN Insights report Ontario's Unique Position: Hardware Electronics and Semiconductors and Their Role in the Automotive and Mobility Sector

2.3 Semiconductor Application in the Automotive Industry

The automotive semiconductor market is poised for growth. The global market is expected to expand from US$60B in 2022 to US$140B in 2032.[32] With a CAGR of 10% the automotive semiconductor market exceeds growth for all other industries, including data storage and wireless industries.[33] Automotive is estimated to have a 13% share of the total global semiconductor market by 2030.[34] This growth is driven by three major trends: autonomy, electrification, and connected mobility. These trends are key to enhancing vehicle capabilities and are expected to significantly boost the demand for automotive electronic components and semiconductors.[35]

Semiconductors are required for devices in ICE vehicles and EVs such as ECUs and BMS. ECUs control the major systems of all vehicles, such as powertrain, infotainment, connectivity, and comfort, with some high-end vehicles containing hundreds of ECUs.[36] In 2023, powertrain held a global automotive semiconductor market share of 17%, with a value of US$16B, while infotainment held a 32% market share, valued at US$31B.[37] Powertrain is expected to have a CAGR of -3% to 2030, with the decline associated with the expansion of centralized compute units for next generation vehicles, whereas infotainment has an estimated CAGR of 6%, reaching a US$46B market share by 2030.[38] Semiconductors used for vehicle electrification are also expected to increase their market share over the next 10 years, by around two thirds, as the demand for EVs grows.[39]

In EVs, semiconductors are key to the operation of BMS. BMS functionality includes monitoring the battery, providing battery protection, estimating the battery's operational state, continually optimizing battery performance, and reporting operational status to external devices.[40] There are two main types of semiconductors within BMS; a master controller and numerous battery monitoring and balancing ICs.[41] BMS contributes to approximately one-third of the demand for silicon in electric powertrains.[42]

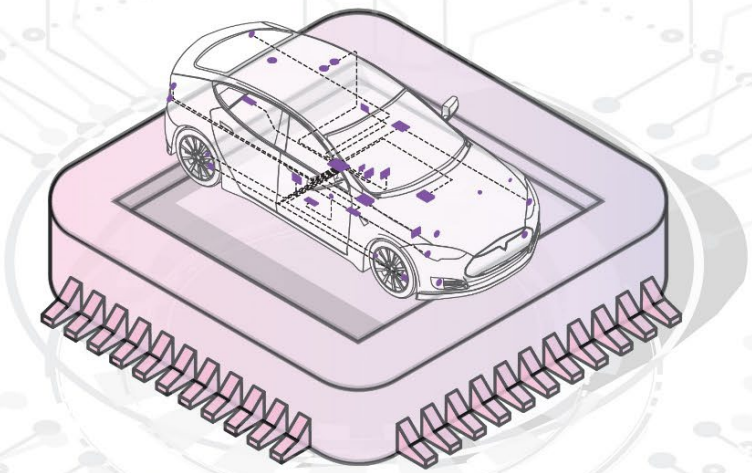
In addition to operational functionality, the World Health Organization reports approximately 1.24M casualties annually from road traffic accidents, highlighting the urgent need for improved safety measures.[43] This has led to a heightened focus on active safety technologies, such as automatic emergency braking systems and ADAS. These features, which are becoming standard in many new vehicles, rely on sensors that incorporate semiconductor technology to monitor and respond to vehicle behavior. Consequently, the increasing integration of vehicle safety systems is expected to drive substantial growth in the automotive semiconductor market over the coming years.[44] Revenue for semiconductor applications related to ADAS and connected and autonomous vehicles (CAVs) is expected to grow at a CAGR of 29% over the next 10 years.[45] Safety and ADAS had a global automotive semiconductor market share of 9% in 2023, with a value of US$9B.[46] Semiconductor application for safety and ADAS within the global automotive semiconductor market is expected to have a CAGR of 22% to 2030, reaching a value of US$37B.[47]

These factors underscore that as the automotive industry evolves and incorporates more complex electronic systems, the essential role of semiconductors will not only spur market expansion but also intensify efforts to optimize supply chains to meet rising demand.

Semiconductor Applications in the Automotive Industry

Infotainment
- Audio/video
- Driver display
- Navigation

Safety
- Airbag controls
- Collision avoidance
- Parking assistance system
- Power locks
- Braking assistance system
- Tire pressure monitoring
- Traction control system



Powertrain
- Engine control
- Fuel injection system
- Hybrid electric control
- Transmission control

Connectivity
- Controller Area Network (CAN)
- Broadband, Wifi,
- Bluetooth
- Over-the-air soft-ware updates

Comfort
- Window/mirror controls
- Seat controls
- Climate control

Electrical
- Starter
- Lighting system
- Vehicle diagnostics

2.4 Semiconductor Market Share in Canada

This section presents a brief overview of the semiconductor market share in Canada, to provide an understanding of the current state of the Canadian semiconductor industry, and potential areas of growth.

In 2023, ICs held the dominant market share globally, with over 81.3%.[48] In 2024, ICs are projected to have a market value in Canada of $7.12B with a CAGR of 10.04% to 2029.[49] This significant market share can be ascribed to widespread integration of ICs in a multitude of technological applications, including automotive systems, telecommunications, industrial machinery, and consumer electronics.[50]

The largest proportion of the IC market in Canada is made up of logic ICs. They are projected to contribute $2.59B in 2024 with a CAGR of 12.46% to 2029, largely due to the growing demand for EVs, medical devices, and 5G-enabled smartphones.[51] Logic ICs are closely followed by memory ICs, which are projected to reach a revenue in Canada of around $2.49B in 2024, with a CAGR of 8.76% to 2029.[52] The growth of the memory IC market is largely due to increased demand for autonomous vehicles, data centre and cloud applications, and Internet of Things (IoT).[53]

Next is analog ICs, which are projected to reach a market value in the Canadian market of $1.45B in 2024, with a CAGR of 9.47% to 2029.[54] Growth in this market is expected to be due to increased demand for general-purpose and application-specific analog devices in communications and smartphone applications.[55] Finally is the micro IC market, which is projected to reach $0.6B in 2024, with a CAGR of 4.56% to 2029.[56] The expansion of this market is anticipated to be due to increased demand and technological advancements of microprocessors and microcontrollers in a range of automotive, telecommunication, healthcare, and cloud computing applications. A key area of growth for micro ICs in automotive is expected to be the increase in demand for advanced and efficient microcontrollers in ADAS.[57]

In addition, the sensors and actuators market in Canada is projected to have a value of $100.3M in 2024 with a CAGR of 10.33% to 2029.[58] This growth is due in part to the increased demand for MEMS in ADAS.[59] MEMS are essential to automotive systems for precise sensing and actuation and play a critical role with ADAS, autonomous vehicle technologies, accelerometers, airbags, tire pressure, stability control and fuel injection systems. Their integration with power electronics enhances decision-making and power management.[60]

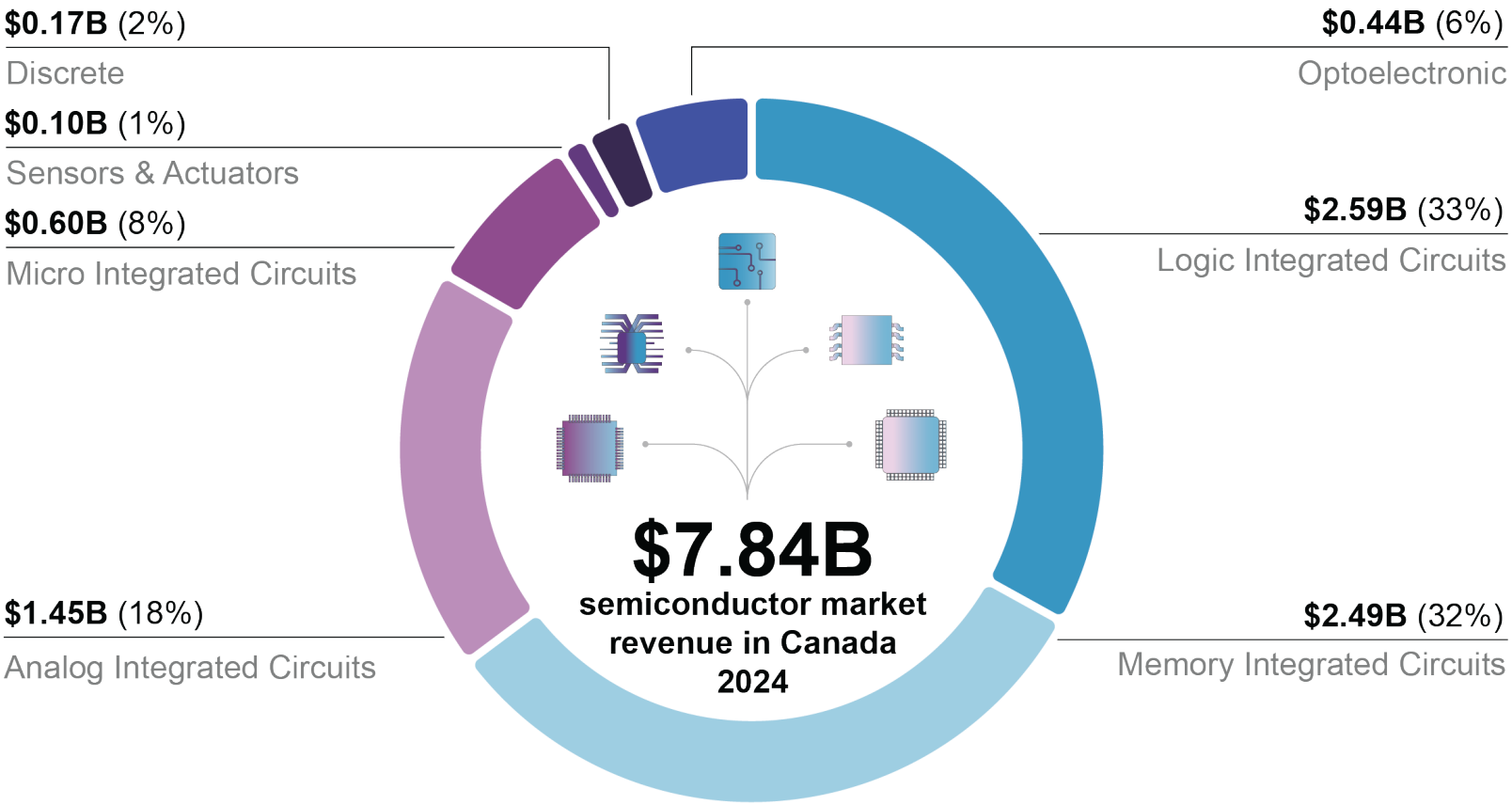
Furthermore, discrete semiconductors are projected to reach a revenue of $170.2M in Canada in 2024, with a CAGR of 8.46% to 2029.[61] Growth in this market is being driven by an increased demand for power efficiency and high-energy devices used in automotive, wireless, and portable electronics.[62]

Lastly, optoelectronic semiconductors are projected to reach a market value in Canada of $0.44B in 2024, with a CAGR of 3% to 2029.[63] This expansion is mostly due to an increase in demand and technological advancements in consumer electronics and healthcare but is also down to the demand for technological advances and efficient optoelectronics in the automotive industry.[64]

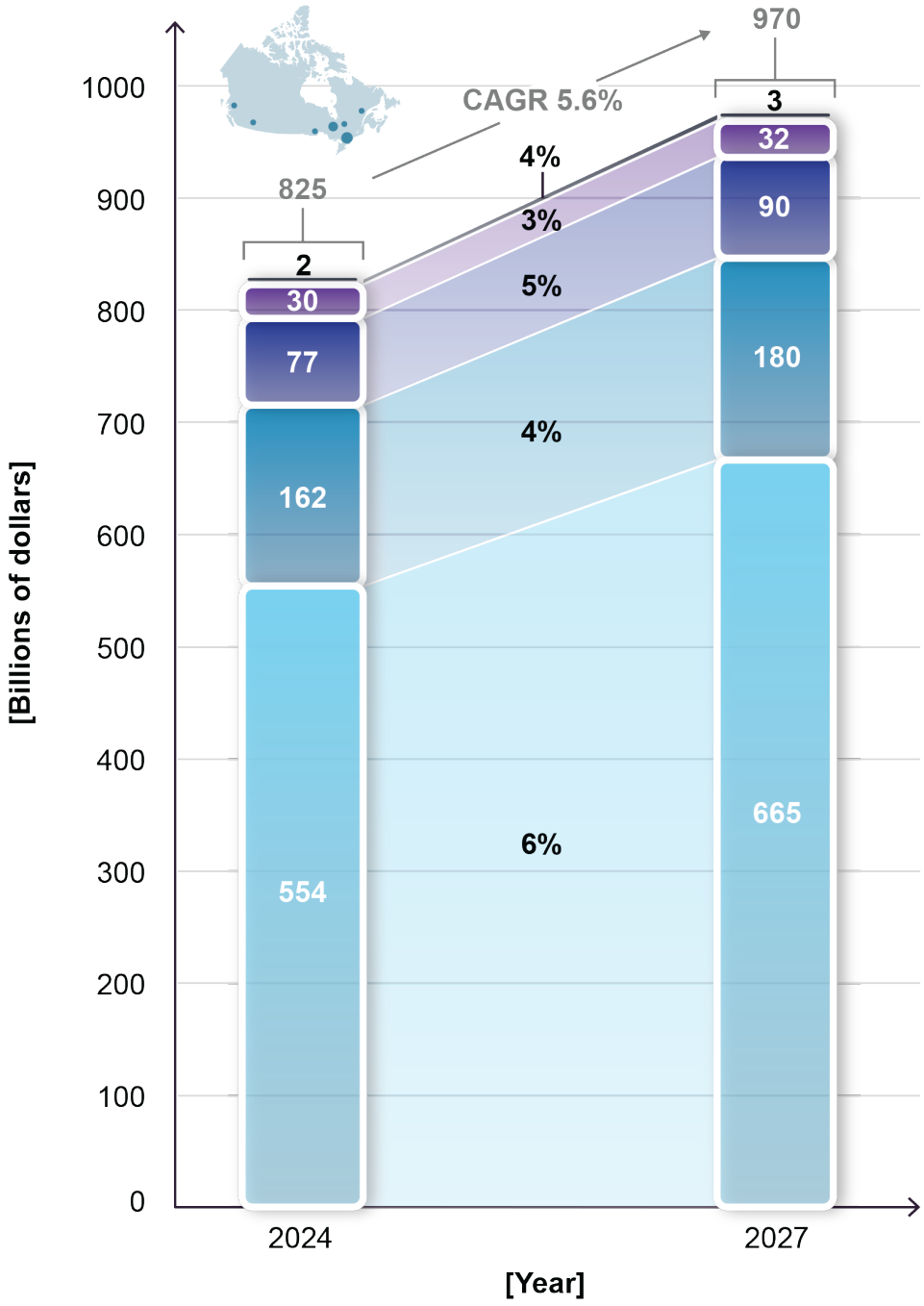
The Canadian semiconductor market is poised for robust growth across various segments, driven by the increasing integration of advanced technologies in multiple sectors. ICs are set to maintain

their dominant position, fueled by burgeoning applications in automotive, telecommunications, and consumer electronics. Within the IC category, logic ICs and memory ICs are expected to lead the charge, reflecting their critical roles in emerging technologies like EVs, 5G, and data centres. Analog ICs, micro ICs, and sensors and actuators also show promising growth trajectories, underscoring the broad and expanding scope of semiconductor applications. While discrete and optoelectronic semiconductors are projected to grow at a slower pace, their contributions remain vital to innovations in power efficiency and consumer electronics.

Projected Semiconductor Market Revenue in Canada by Semiconductor Type, 2024[65]



Forecast Growth of the Semiconductor Industry Worldwide, 2024-2027[66]



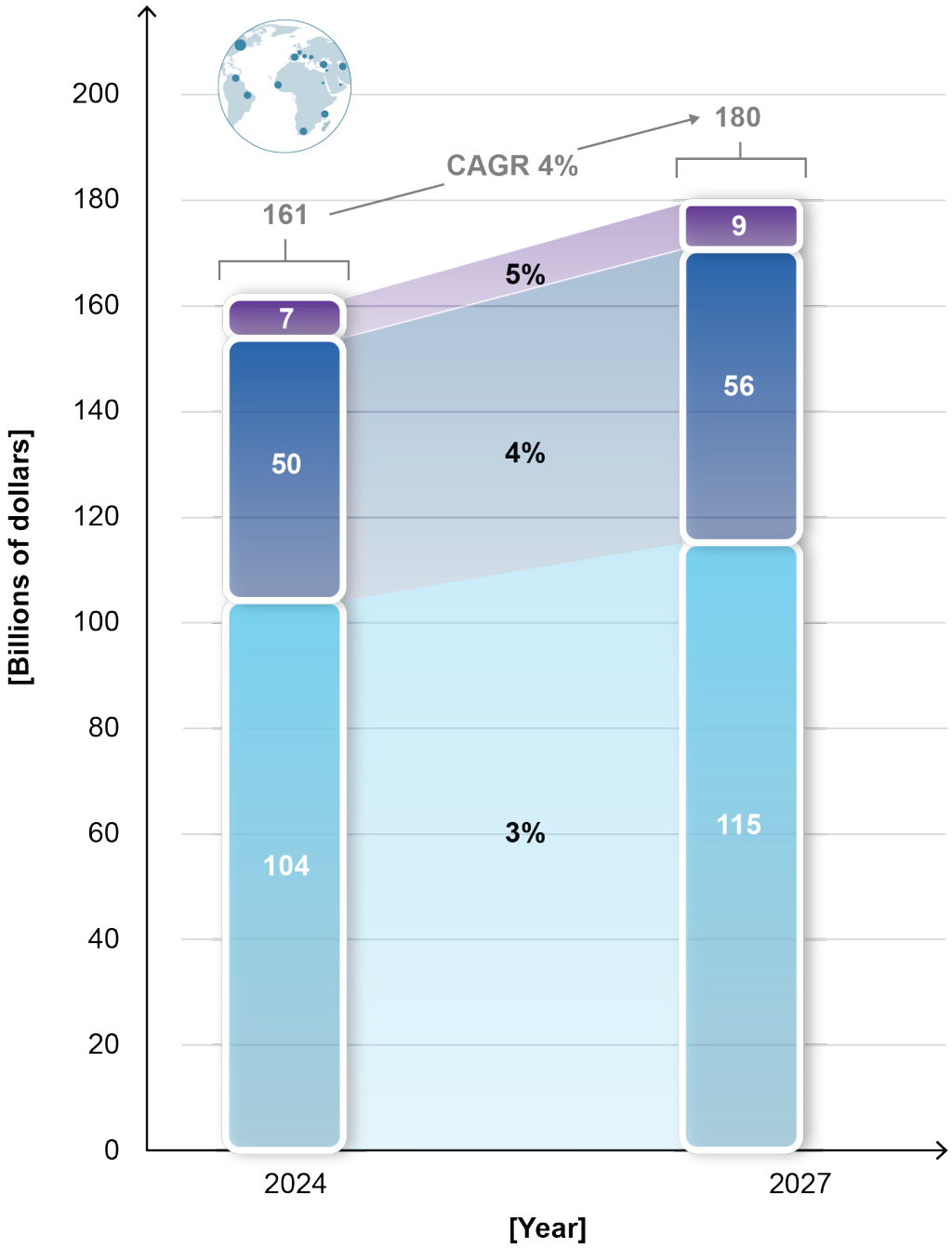
2.5 Semiconductor Market Growth Forecast

In November 2023, the SIA reported that global semiconductor sales reached $48B.[67] This figure represents a 5.3% increase from November 2022, which saw sales of $45.6B, and is 2.9% higher than the $46.6B reported in October 2023.[68] Additionally, the semiconductor industry is expected to be worth over US$1T by 2030.[69]

2.5.1 Forecast growth worldwide

Globally, the semiconductor industry is forecast to grow from a market value of $825B in 2024 to $970B in 2027, with a CAGR of 5.6%.[70] Asia is expected to have a CAGR of 6%, with the market there predicted to grow from $554B in 2024 to $665B in 2027.[71] North America is anticipated to have a 4% CAGR, growing from $162B in 2024 to $180B in 2027.[72] Europe is predicted to have a 5% CAGR, expanding from $77B in 2024 to $90B in 2027.[73] Australia and Oceania are expected to have a slightly smaller CAGR, at 4%,[74] along with South America, at 3%.[75]

Forecast Growth of the Semiconductor Industry in North America, 2024-2027[76]



2.5.2 Forecast growth in North America

The semiconductor industry is forecast to expand across North America over the next three years from a market value of $161B in 2024 to $180B in 2027.[77] Over this time, the Canadian market is predicted to grow by a CAGR of 5%, expanding from over $7B in 2024 to nearly $9B in 2027.[78]

The market is predicted to increase by a CAGR of 4% in Mexico, from nearly $50B in 2024 to just under $56B in 2027.[79] The United States is expected to see a slightly slower CAGR than Canada, at 3%. The market in the United States is predicted to grow from just over $104B in 2024 to just over $115B in 2027.[80]

2.6 Factors Influencing the Semiconductor Industry

There are a number of factors influencing the growth and direction of the global and domestic semiconductor industry. Outlined below are a selection of these.

2.6.1 Increasing demand across multiple sectors

There are several advanced technologies driving demand for semiconductors around the world. These include technologies such as quantum computing, data storage, and future telecommunications, with prototype chips currently under development for 6G and 7G communications technology.[81] The emergence of new technologies, such as AI, IoT, and machine learning (ML), of which the advancement of semiconductors is integral, are also providing new opportunities for market development.[82]

The automotive industry is a major catalyst for increased semiconductor demand; as the demand for EVs and CAVs rises, so does the need for semiconductors.[83] Globally, there is expected to be a tripling in demand for semiconductors within the automotive sector, reaching a US$150B market value by 2030.[84] Advancements in semiconductor technologies will enable the development of smaller, lighter, and more energy efficient vehicles.[85]

Another driver for demand is the push towards net-zero. Jurisdictions around the world are setting targets for the transition to a low-emission economy. Key to this is the use of semiconductors in clean and smart energy systems. The use of semiconductors in the global renewable energy market is expected to grow with a CAGR of 8-10% through to 2027.[86]

2.6.2 Increasing global investments

Countries around the world are investing large amounts to strengthen their domestic semiconductor industries. In 2022, the United States federal government announced an investment of US$280B to introduce the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act, to strengthen domestic semiconductor manufacturing, design, and research.[87] In the same year, the European Union announced an investment of over US$46B with the launch of the European Chips Act.[88] Additionally, the Chinese government has committed to invest over US$150B between 2014 and 2030 in its commercial semiconductor industry.[89]

2.6.3 Dependency on critical minerals supply

Critical minerals are essential to the production of semiconductors. At least 300 materials are required throughout the manufacturing process.[90] In order for the semiconductor supply chain to operate efficiently, the continuous supply of critical minerals is of vital importance to the industry.[91] Currently, the critical minerals market is dominated by China and East Asia, making disruptions to the global supply chain more likely due to reliance on a single geography, and market and geopolitical risks.[92]

2.6.4 Dependency on complex supply chain

The semiconductor supply chain is highly complex, involving multiple stages across a multitude of geographic regions. The components of a chip can travel over 40K kilometres before it is even integrated into the final product and can cross international borders 70 or more times before reaching the end consumer, due to different specialities throughout the production lifecycle being located within different regions and companies.[93] It can take up to 26 weeks for a customer to receive the final product after placing an order.[94] This complexity presents numerous pinch points with the potential to cause disruption to the supply chain.

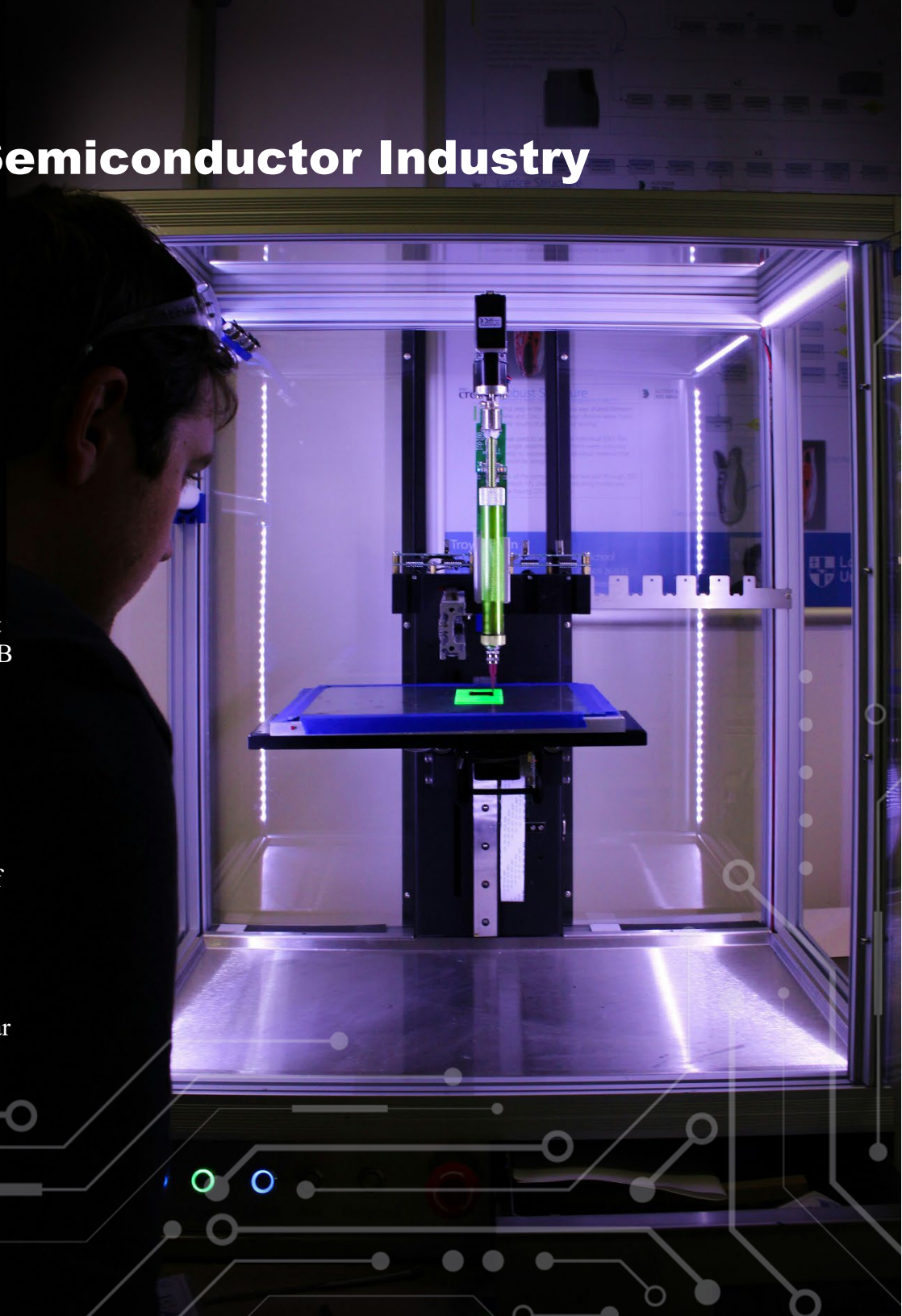
2.6.5 Increasing supply chain diversification

Activity related to semiconductors is currently highly concentrated in a few countries and companies, from the sourcing of critical minerals to R&D and manufacturing. This concentration constrains access and reduces resilience of the sector, highlighting the need for greater diversification within the supply chain. Without diversification, the semiconductor industry is vulnerable to localized events, resulting in wider impacts on the sectors reliant on it, such as automotive. This was demonstrated by the 2020-2022 chip shortage, whereby the automotive industry was forced to delay production plans.[95]

"The growing global hardware sector presents an exciting opportunity for Canadian innovators to step forward with their world-class products and add value to global supply chains. Our government is committed to ensuring growth and competitiveness in this vital sector by supporting Canadian businesses to seize the opportunities before us as we work towards a strong, inclusive, and digital economic recovery from COVID-19."[96]

- The Honourable Mary Ng, Minister of Export Promotion, International Trade and Economic Development and Member of Parliament for Markham–Thornhill

3. Snapshot of Ontario's Semiconductor Industry



Ontario is a strategic hub for the semiconductor industry, powering our modern world. Several types of semiconductors are designed and manufactured in facilities across Ontario, with a broad range of applications for use. A key market for semiconductors in the province is the automotive and mobility industry.

In 2020, the Canadian semiconductor industry alone generated $28.8B in total output, with $16.3B representing value added directly by the sector.[97] Ontario stands out as the central hub of this sector, contributing an impressive 62.8% of the total value added ($10.2B) and 65.5% of value via direct impacts.[98] By comparison, Quebec, British Columbia, and Alberta collectively contributed $5.2B – significantly less than Ontario's direct impact alone.[99] Considering that Ontario has contributed more than $800B in Canada's GDP in 2020 (accounting for approximately two-fifth of total Canada's GDP),[100] the high concentration of the semiconductor industry's economic impact in Ontario become more evident when comparing this to its Gross Value Added (GVA).[101]

The semiconductor industry is a major job provider in Canada, supporting 123,694 full-time equivalent (FTE) jobs in 2020.[102] Of these, over half (69,494 FTE) were directly employed within the sector.[103] Ontario alone accounted for 56% of the sector's jobs in 2023.[104] Canada's Semiconductor Council estimates that employment in the Canadian electronics sector will continue to grow year on year, with an expected growth rate of 0.26% per year up to 2030 for the semiconductor component manufacturing sector.[105]

In terms of R&D, Ontario is a dominant player, with two-thirds of Canada's in-house semiconductor R&D expenditures ($1.2B) taking place in the province.[106] The Canadian semiconductor industry supported 11,530 FTE R&D personnel in 2020, with a significant portion (7,384 FTE) based in Ontario.[107] Notably, R&D personnel in the Canadian semiconductor sector earned an average salary of over $117K, compared to the national average for R&D personnel across all sectors of $91K.[108] Ontario's role in the IT sector underscores its vital contribution to both the Canadian economy and its technological advancement.

The province also benefits from the presence of leading research facilities within the semiconductor sphere. These include ventureLAB's Hardware Catalyst Initiative, which is an OVIN RTDS, the Vector Institute, and the National Research Council (NRC) Advanced Electronics and Photonics Research Centre. Additionally, Ontario's universities grant employers with access to a substantial pool of highly-skilled talent. The University of Waterloo, University of Toronto, McMaster University, and Carleton University have all been included in the list of top ten universities across Canada in terms of electronics R&D funding.[109]

In March 2023, the United States and Canada announced plans to establish a bilateral semiconductor manufacturing corridor. This decision came as International Business Machines (IBM) expressed its intention to expand operations in Canada. During United States President Joe Biden's visit to Canada, he and Canadian Prime Minister Justin Trudeau issued a joint commitment to counter authoritarian regimes by reducing reliance on foreign sources for critical minerals and semiconductors. As part of this initiative, the Canadian government pledged $250M to enhance its domestic semiconductor industry, focusing on research, development, and manufacturing.[110]

More broadly, Ontario benefits from Canada's regulatory and policy framework. Ontario has access to 15 free trade agreements with 51 countries and is a tariff-free zone for manufacturers.[111] Also, in 2022, the federal government announced a $150M fund, referred to as the Semiconductor Challenge Callout, to boost R&D, build on manufacturing strength, and position Canada as a critical global supplier of semiconductors.[112]

These factors highlight that businesses in the semiconductor sector can thrive in Ontario by leveraging the province's strengths in R&D, cutting-edge manufacturing capabilities, and substantial market opportunities.

3.1 Ontario's Semiconductor Industry Economic Impact

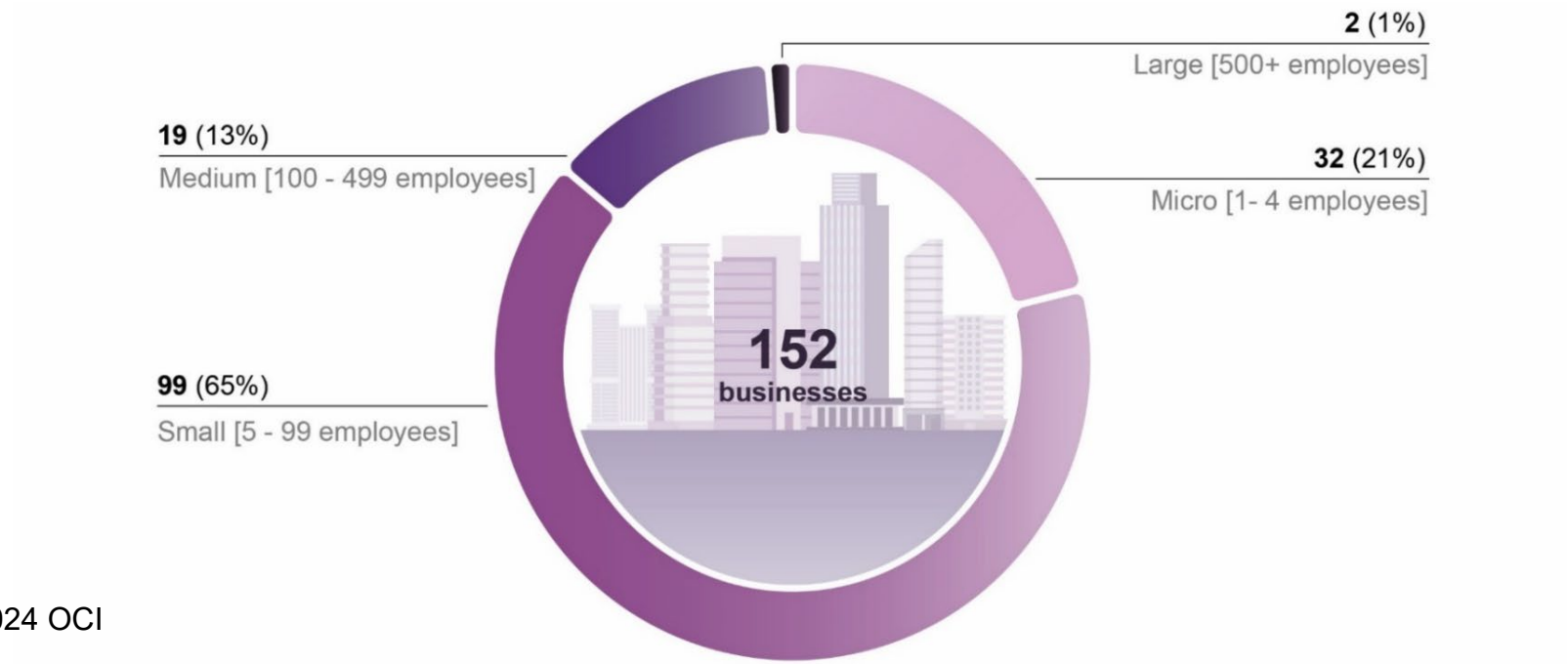
The following section presents an overview of the scale and economic impact of Ontario's semiconductor industry.

3.1.1 Size of semiconductor businesses in Ontario

In 2023, there were 152 organizations operating in Ontario within the semiconductor industry.[113] An impressive 49% of all semiconductor businesses in Canada are located in Ontario.[114] Of the organizations in Ontario, 32 were micro-organizations, with a headcount of 1-4, making up 44% of Canada's micro semiconductor businesses, and 99 were small enterprises, with between 5 and 99 employees, making up 51% of Canada's small semiconductor businesses.[115] 19 semiconductor organizations in the province were medium-sized enterprises, with between 100 and 499 employees, making up 45% of Canada's medium semiconductor businesses, and two were large companies, with over 500 employees, making up 67% of Canada's large semiconductor businesses.[116]

The high number of semiconductor businesses in Ontario, which form a significant proportion of Canada's total semiconductor businesses, demonstrates the dominant role Ontario plays in the global semiconductor supply chain, and the strength of the ecosystem in the province, attracting investment and highly skilled workers from around the world.

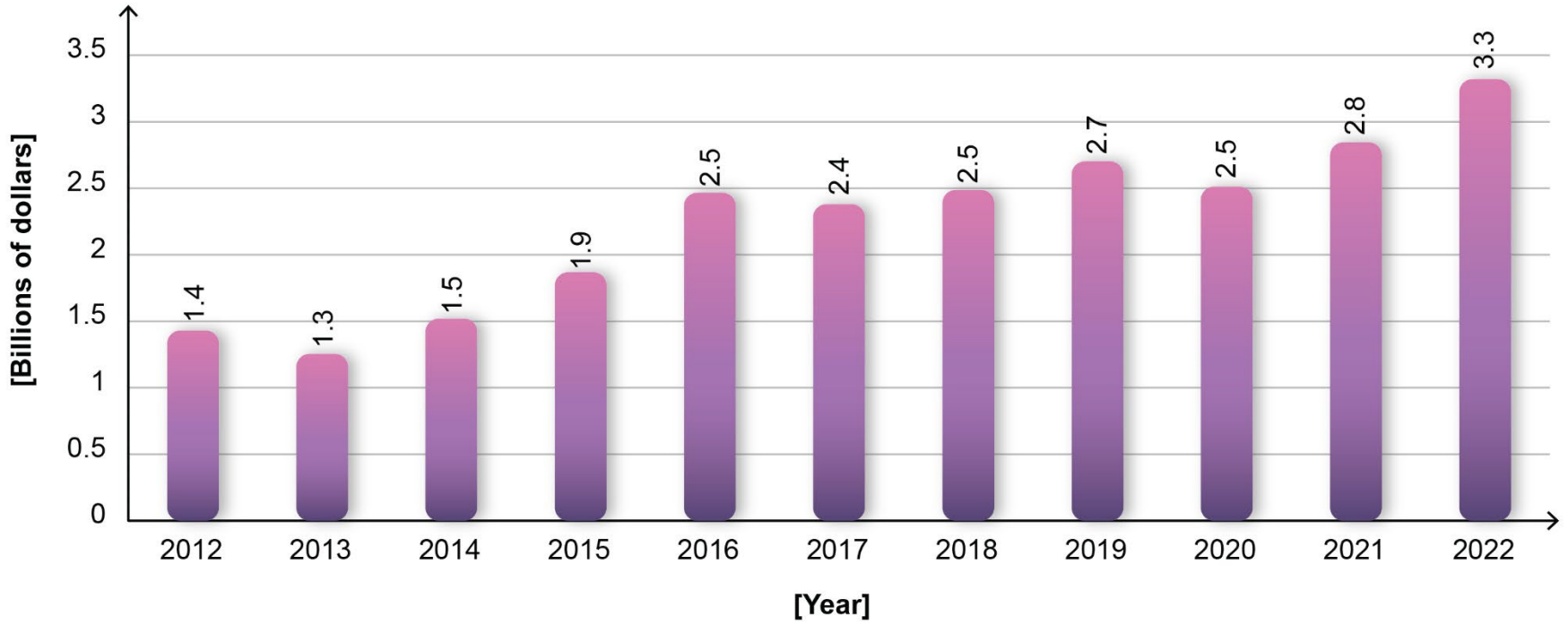
Size and Number of Semiconductor and Other Electronic Component Manufacturing Businesses in Ontario [NAICS 3344], 2023[117]



3.1.2 Total semiconductor revenue in Ontario

The semiconductor and other electronic component manufacturing industry in Ontario has steadily grown since 2012. Total revenue for the industry reached over $3.3B in 2022, expanding from just over $1.4B in 2012.[118] The revenue generated in Ontario alone made up 60% of the total revenue generated in the semiconductor industry across Canada ($5.5B) in 2022.[119] Ontario's contribution has grown from 49% in 2012, highlighting the growing strength of the semiconductor industry in the province.[120] The Canadian semiconductor market overall is forecast to grow with a CAGR of 6.52% to $8.96B by 2027.[121]

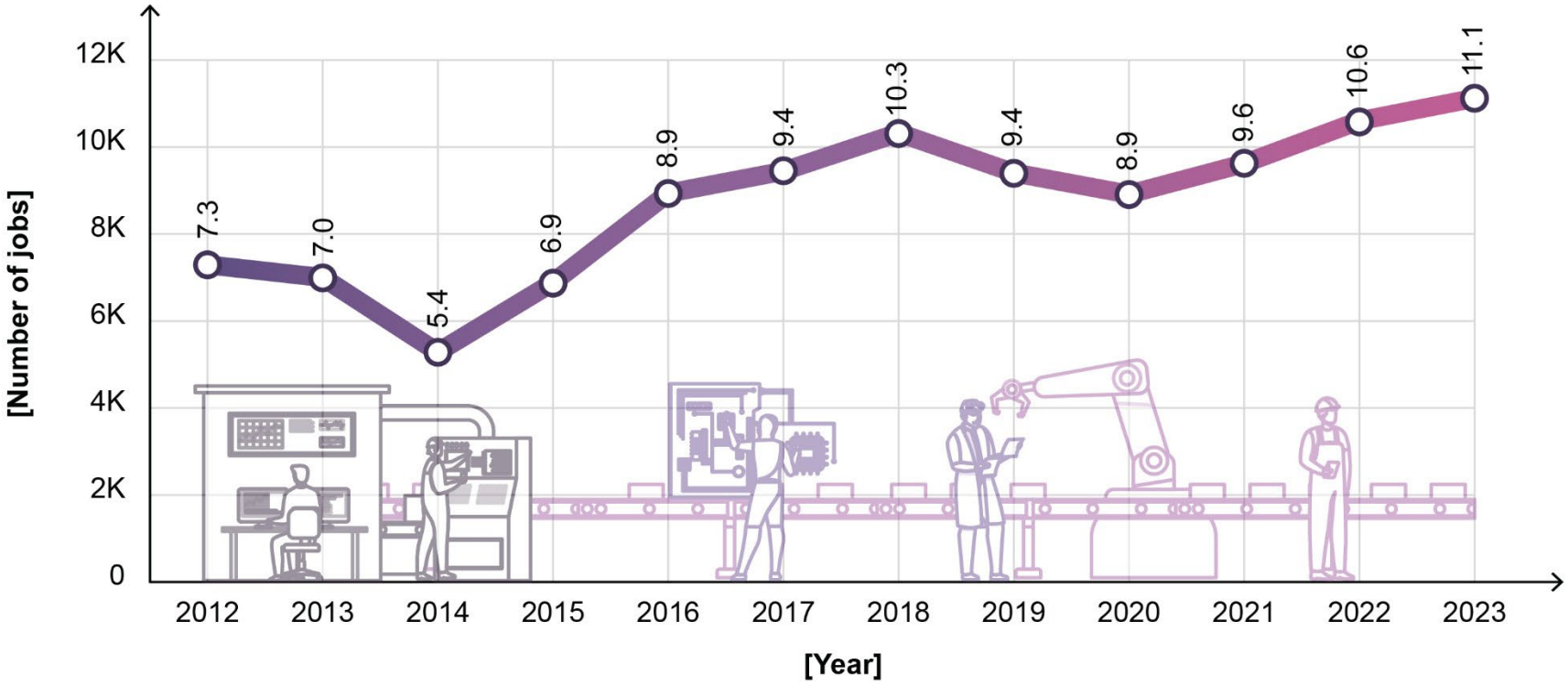
Total Annual Revenue for the Semiconductor and Other Electronic Component Manufacturing Industry in Ontario [NAICS 3344], 2012-2022[122]



3.1.3 Number of semiconductor jobs in Ontario

The number of jobs in Ontario's semiconductor industry has grown over time. In 2023 there were 11.1K jobs in the industry, compared with 7.2K in 2012.[123] Across Canada there were 19.7K jobs in the semiconductor industry in 2023, with roles in Ontario making up 56%.[124] In comparison, semiconductor jobs in Ontario made up 49% of roles in the industry across Canada in 2012, showing a 7% growth.[125] This highlights that not only is the semiconductor job market growing in Ontario, but its contribution to the national market is also expanding.

Number of jobs in the Semiconductor and Other Electronic Component Manufacturing Industry in Ontario [NAICS 3344], 2012-2023[126]



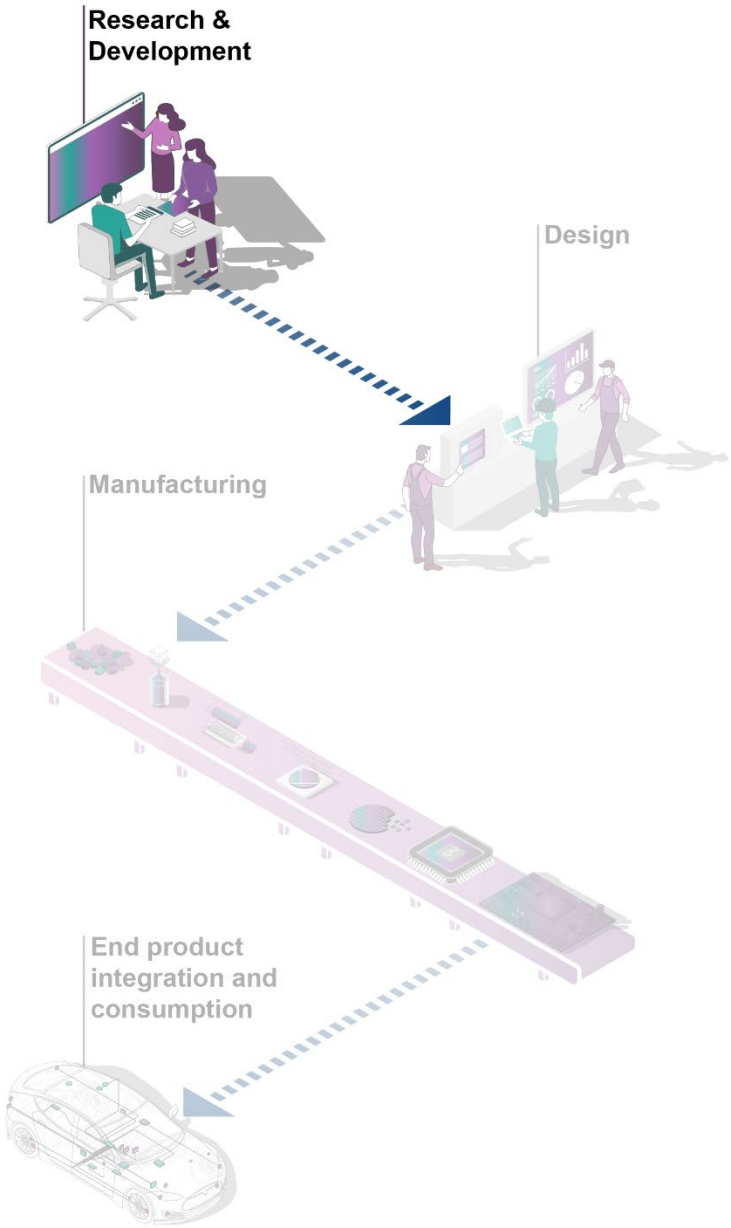
3.2 Semiconductor Research and Development in Ontario

Semiconductor R&D is vital for Ontario's booming tech ecosystem, serving as a cornerstone in the perpetual cycle of innovation that powers the province's semiconductor industry. Within Ontario's R&D framework, governments, academic institutions, and private enterprises collectively contribute to financing and conducting research activities that propel valuable commercial innovations.

The majority of semiconductor industry R&D activity in Canada is concentrated in Ontario, with $1.2B being spent in the province in 2020, or two-thirds of Canada's in-house expenditures.[127]

Research in the semiconductor industry in Ontario is crucial for advancing technological innovation and maintaining competitiveness in the global market. Through leading edge research facilities, such as ventureLAB, and specialist programs at a number of research institutions, such as the University of Toronto and the University of Waterloo, among others, Ontario fosters the development of cutting-edge semiconductor materials, processes, and devices, driving economic growth and creating high-value jobs in the region. Additionally, research in this field contributes to enabling breakthroughs in various sectors such as automotive, healthcare, communications, and renewable energy.

The following section gives an overview of the semiconductor research landscape in Ontario.



3.2.1 Ontario's ecosystem in semiconductor research and development

Several organizations and facilities located in Ontario are contributing to advancing Canada's semiconductor sector through R&D. A number of these entities are presented in this section. The remit of some of these organizations goes beyond R&D but they have been included in this section due to R&D being their core function.

CMC Microsystems

Founded in 1984, CMC Microsystems is a nonprofit organization headquartered in Kingston which is driving research and innovation in advanced technologies like microelectronics, photonics, MEMS, IoT, AI, and quantum computing hardware and software. It facilitates technology adoption by providing access to research facilities which enable developments in design, manufacturing, and testing capabilities, and enables the training of highly qualified personnel (HQP), supporting over 10K researchers and 1.2K companies globally. In 2022-2023, CMC processed over 480 semiconductor prototypes and launched a pioneering quantum device fabrication service in collaboration with VTT Technical Research Centre. It also achieved record prototype production and excelled in photonics, fabricating 178 designs that reinforced Canada's global leadership in the field. CMC expanded internationally through partnerships like Australia's Semiconductor Sector Service Bureau and increased its presence in the United States and Mexico, while its Virtual Incubator Environment Program supported 28 Canadian start-ups, highlighting its role in fostering national innovation and entrepreneurship.[128]

In August 2024, the organization announced that it would be partnering with McMaster University to advance R&D in relation to developing new processes and training programs for semiconductors and photonics.[129]

In 2021, CMC Microsystems became the industrial partner for the OpenHW Accelerate research project, which optimizes RISC-V vector processors for ML, sensor data processing, and acceleration of Edge application.[130] This partnership was enabled via the Mitacs Accelerate research internship program, which fosters connections between companies and more than 50 research-based universities.[131]

ventureLAB

ventureLAB is a prominent technology research hub that has collaborated with more than 2K tech ventures since 2011. Funded by OVIN, Ontario's Ministry of Economic Development, Job Creation and Trade (MEDJCT), Fed Dev Ontario and York Region, it offers comprehensive support and facilitates direct connections for founders to secure capital, attract and retain talent, and effectively commercialize technology and intellectual property (IP).[132]

In Ontario, the semiconductor-oriented laboratory and incubator is found within ventureLAB's Hardware Catalyst Initiative. ventureLAB serves as one of OVIN's RTDS, which are strategically positioned across Ontario. The RTDS facilities empower small and medium enterprises (SMEs) to innovate, test, and prototype their cutting-edge automotive technologies and intelligent mobility solutions. They also provide invaluable

guidance, expertise, and insights in crucial areas relevant to the automotive and mobility sector.[133]

ventureLAB expedites the market-entry process for technology firms, facilitating local growth and scalability for Canadian hardware and semiconductor companies. Moreover, it equips them to effectively compete on a global scale.[134] The Hardware Catalyst Initiative has facilitated investments totaling more than $340M in Canadian technology companies.[135]

In April 2024, ventureLAB and CMC Microsystems signed a Memorandum of Understanding (MOU) to formalize their relationship and advance the advanced technology ecosystem in Canada.[136] This agreement facilitates mutual support between the two organizations to advance their complementary programs.

Research institutions

A number of universities in Ontario have leading electronics-related research programs. These include the Giga-to-Nanoelectronics Centre at the University of Waterloo,[137] the Institute for Quantum Computing at the University of Waterloo,[138] the Nano and Micro Systems Lab at the University of Waterloo,[139] and the Toronto Nanofabrication Centre at the University of Toronto.[140] In addition, the University of Ottawa has a NanoFab facility,[141] and a Micro and Nano Systems Lab.[142] Carleton University is also active in semiconductor research, with a focus on device design and novel device structures, and semiconductor sensors.[143] The institution also has a Microfabrication Facility.[144] York University houses a Microfabrication Facility at its Keele campus, providing an opportunity for micro-nano device prototyping.[145] Also, McMaster University is home to the Centre for Emerging Device Technologies,[146] and has a research focus on microelectronic, nanoelectronic, and optoelectronic components and systems, as well as exploring low-cost manufacturing technologies for sensors and integrated sensor systems.[147]

“Canada has the talent, capability, and tools to grow and expand in the hardware and semiconductor space. The benefits of growing this vital sector are numerous and include creating good jobs, boosting the economy, and standing out in the global market.”[148]

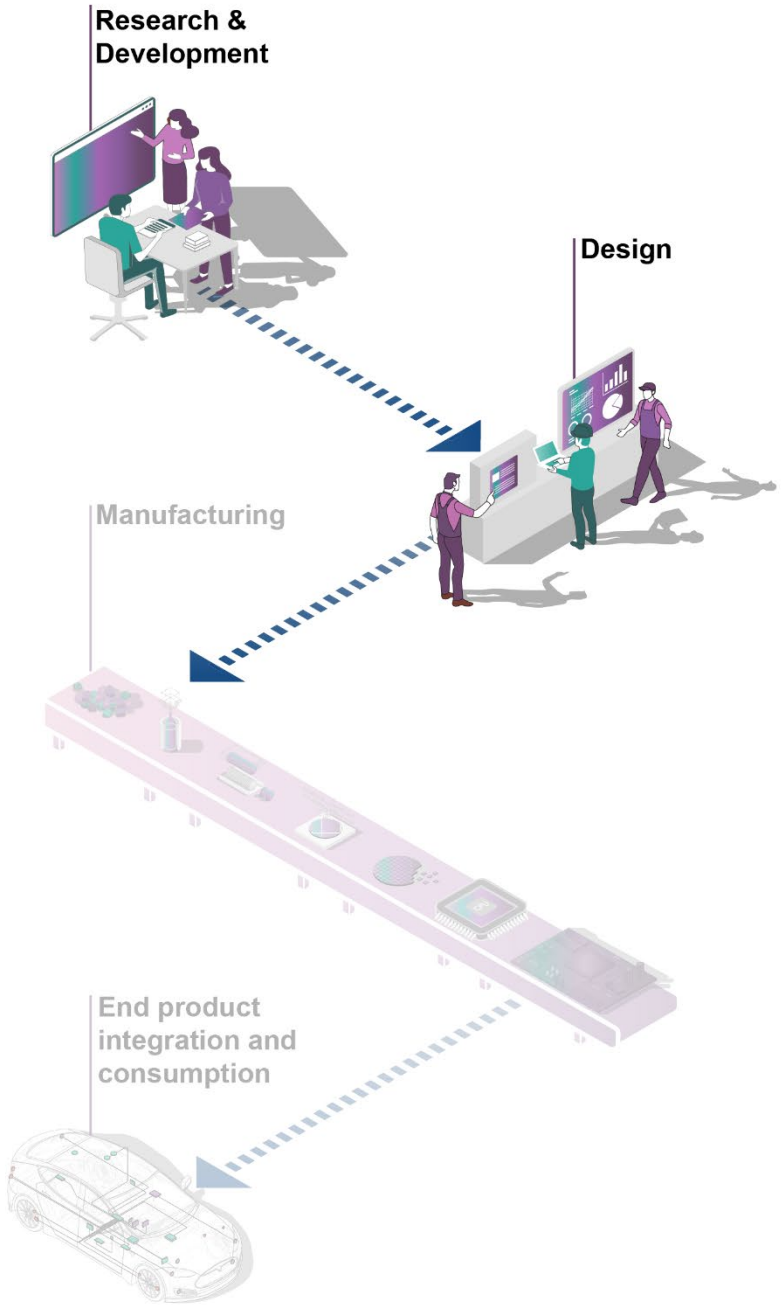
– The Honourable Mélanie Joly, Minister of Foreign Affairs

3.3 Semiconductor Design in Ontario

Semiconductor design plays a pivotal role in developing a wide range of electronic devices, from smartphones and computers to medical devices and automotive systems, driving innovation and technological advancements across industries. Semiconductor design involves the intricate process of creating electronic circuits and systems at the microscopic level, typically using materials like silicon. It encompasses various stages, including conceptualization, architectural design, circuit design, layout, verification, and testing. Engineers meticulously craft these designs to meet specific performance, power consumption, and cost targets.

Semiconductor design in Ontario thrives within a vibrant ecosystem of research institutions, technology companies, and academic centres. The province hosts several world-class semiconductor design firms, along with notable research organizations like ventureLAB and CMC Microsystems which support semiconductor design startups and provide access to cutting-edge design tools and fabrication facilities. Additionally, collaborations between industry and academia, supported by government initiatives, foster innovation and talent development, positioning Ontario as a hub for semiconductor design excellence.

The following section provides an overview of Ontario's semiconductor design landscape.



3.3.1 Ontario's ecosystem in semiconductor design

There is a broad range of fabless semiconductor organizations located in Ontario, focusing on the design of advanced technologies. An assortment of these companies is described below. For some of these organizations their remit goes beyond design, but they have been included here due to this being their core function.

TSMC Design Centre

Ontario is home to Taiwan Semiconductor Manufacturing Company's (TSMC) Design Centre. TSMC is the world's largest chipmaker. It works with innovators in the semiconductor sector, helping them transform their designs into functioning products – which can be manufactured at volume – by providing independent design and processing capability.[149] The main focus of the facility is to deliver state-of-the-art products in automotive, AI, computing, IoT, and mobile.[150]

Alphawave Semi

Alphawave Semi is a semiconductor fabless with corporate headquarters located in Toronto.[151] The organization specializes in designing semiconductors for wired connectivity solutions, enabling data to travel faster and facilitate the development of autonomous vehicles, AI, and next generation services in data centres, amongst other things.[152] Alphawave Semi offers silicon IP, chiplets, custom silicon, and connectivity solutions.[153] Alphawave Semi provides its customers with the option of licensing its high-performance silicon IP or buying a completed custom silicon semiconductor designed to meet their requirements.[154]

In 2023, the company announced that it would be expanding its presence in Ontario with the opening of an office in Ottawa.[155] This new office contains lab space to allow its engineers to test next-generation connectivity technologies.[156]

AMD

AMD is a fabless semiconductor design company with a focus on data centre and cloud, gaming, and AI markets.[157] The organization has its Canadian headquarters in Markham, and concentrates its efforts on research and advanced development, specifically related to AI. It states that its mission related to R&D is inventing and discovering new technologies, evaluating technology opportunities, and encouraging collaborative innovation.[158]

AMD's products include processors, accelerators, graphics, adaptive System-on-Chips (SOCs) and field programmable gate arrays (FPGAs), System-on-Modules (SOMs), and software, tools and apps.[159] Industries targeted by the company include automotive, aerospace and defence, industrial and vision, robotics, and supercomputing and research, amongst others.[160]

In 2022, AMD acquired Xilinx, an American semiconductor company. The acquisition enables AMD to offer a portfolio of high-performance and adaptive computing products, strengthening its technical capabilities in advanced technology development, including die stacking and packaging technology, chiplet and interconnect technology, AI and domain-specific architectures, and software platforms.[161] Additionally, in August 2024, AMD announced that it would be acquiring ZT Systems, a server maker, to expand its portfolio of AI chips and hardware.[162]

Astera Labs

Astera Labs established itself in Ontario with a vision to innovate within the semiconductor industry, particularly in enhancing connectivity solutions for data centres and hyperscalers. Its presence in Ontario underscores the region's role as a hub for technology innovation, leveraging local talent and infrastructure to drive advancements in semiconductor technology. Astera Labs is a fabless organization which specializes in purpose-built connectivity solutions for AI and cloud infrastructure.[163]

Blumind

Blumind is a Canadian start-up company founded in Ontario in 2020. The organization has developed a patented all-analog semiconductor architecture to process neural networks,[164] which it claims consumes 100 to 1K times lower energy than digital approaches.[165] Blumind is a member of ventureLAB and in February 2024 was recognized by global investors as one of Canada's most innovative technology companies after being awarded the CIX Top 20 Early Award.[166]

Infineon Technologies AG

Infineon Technologies AG completed the acquisition of Ottawa-based GaN Systems Inc., in October 2023.[167] GaN Systems is known for its advanced gallium nitride (GaN) power conversion solutions and expertise. The acquisition accelerates Infineon's GaN development and reinforces its leadership in power semiconductor technology which is crucial for developing more energy-efficient and CO_2-reducing solutions. Infineon now boasts 450 GaN experts and over 350 GaN patents, enhancing its position and speeding up market delivery.[168]

The acquisition, valued at US$830M, was funded through Infineon's existing resources. Infineon continues to lead in power systems and IoT, with around 56.2K employees and a 2022 revenue of approximately €14.2B.[169]

Intel

Intel is a global computing organization which opened an engineering lab in Toronto in 2018.[170] The lab specializes in designing graphics processing units (GPUs) and is the organization's main engineering and design facility for its new GPUs.[171] Intel was already a leader in the central processing unit (CPU) market, with the opening of this lab positioning the organization strategically in the GPU market.

Marvell

In Ontario, Marvell is actively involved in developing critical technologies and solutions for semiconductor end markets – including cloud, 5G, and automotive – contributing to the province's thriving technology ecosystem.[172] Through its collaboration with local partners, academic institutions, and government agencies, Marvell spearheads initiatives aimed at advancing semiconductor technologies in key areas such as networking, data storage, and connectivity.[173] In relation to automotive, Marvell designs technologies such as automotive ethernet, custom and accelerated compute, and data storage.[174]

Nvidia

Nvidia is a fabless semiconductor design company specializing in AI and accelerated computing solutions. The organization serves industries such as automotive, gaming, energy, healthcare, manufacturing, supercomputing, and telecommunications, among others.[175] In 2018, Nvidia launched its Toronto AI Lab, which has a focus on computer vision, ML, and computer graphics.[176]

NXP

NXP produces purpose-built, rigorously tested technologies which allow devices to sense and connect.[177] NXP's Ottawa Technology Centre focuses on two main areas: developing software and silicon IP for dataplane processing and advancing image cognition technologies for autonomous vehicles and ADAS. Following its acquisition of Cognivue, NXP is enhancing its capabilities in image cognition to support next-generation automotive vision solutions.[178]

Peraso

Peraso is a fabless semiconductor company with its Canadian headquarters located in Toronto. The organization specializes in developing millimeter wave solutions, with technical expertise in radio frequency (RF) circuits, phased array antenna systems, advanced packaging, high speed analog mixed signal, and advanced wireless design.[179] Key markets targeted by Peraso include tactical communications, fixed wireless broadband, augmented and virtual reality, private fiber networks, and consumer and enterprise cable-free electronics.[180] The company was founded in 2009, originating from research conducted at the University of Toronto.[181]

Qualcomm

Qualcomm is an American organization which designs semiconductors and wireless telecommunications products. The organization has had a presence in Markham since 2009, with a focus on device displays, audio technology, ML, and high-performance, low-power CPUs.[182] Qualcomm selected Markham as its global centre of excellence for ML due to the area's substantial AI and ML ecosystem.[183]

Ranovus

Ranovus is an Ottawa-based fabless organization which specializes in next-generation technology for internal communication networks of data centres. In 2018, the organization was granted a $20M investment via the federal government's Strategic Innovation Fund.[184] This investment enabled the development and construction of next-generation data infrastructure centres, allowing the organization to conduct advanced manufacturing in Canada.[185] More recently, in 2023, Ranovus was granted $36M via the Strategic Innovation Fund, to further advance the production and manufacturing of semiconductor products and services in Ottawa.[186] This latest investment is expected to increase Ranovus' Canadian workforce to 200 full-time employees.[187]

StarIC

StarIC is a provider of analog/mixed-signal semiconductor IP and tailored-design solutions. With vast design expertise and validated IP across various technology nodes and applications, StarIC collaborates with clients in diverse fields such as wireline, optical/photonics, sensors, IoT, automotive, telecom, ML hardware, consumer electronics, biomedical, and aerospace. StarIC has unveiled a strategic partnership with GlobalFoundries to advance silicon photonics innovation, unveiling a revolutionary library of high-speed silicon photonics.[188] The organization also counts battery monitoring amongst its many design specialities.[189]

Synopsys

Synopsys is an electronic design and automation solutions and services organization with several locations across Ontario.[190] The company offers solutions for a broad range of industries, including automotive, aerospace and government, IoT, medical, manufacturing, photonic, and optical.[191] For the automotive industry specifically, Synopsys offers design and verification,

prototyping, automotive-grade IP, and software security solutions related to SOCs and multi-die systems.[192]

Synopsys also offers a training and education program, enabling users to learn industry best practice. As part of this, it has developed the Purple Certification Program which provides training in physical design, design verification, register transfer level synthesis, design for test, and analog mixed signal circuit and layout design.[193]

Tenstorrent

Tenstorrent is a Toronto-based start-up specializing in computer architecture, application-specific IC (ASIC) design, advanced systems, and neural network compilers.[194] The organization has offices across North America and Asia.[195] In 2023 Tenstorrent announced that it would be partnering with the South Korean firm LG Electronics to build semiconductors which power automotive products, data centres, and smart TVs.[196]

The Six Semiconductor Inc

The Six Semiconductor Inc (TSS), a Canadian technology firm located in Markham, specializes in developing advanced solutions optimized for a broad spectrum of applications such as AI/ML, high-performance computing, mobile devices, and automotive sectors.[197]

TSS is actively expanding its internship program, drawing students from prestigious Canadian universities like the University of Toronto, Queen's University, McMaster, and Toronto Metropolitan University, aiming to address industry imbalances favoring software careers over hardware.[198]

Untether AI

Untether AI is a chip start-up founded in 2018, with its headquarters located in Toronto.[199] The organization specializes in delivering energy-centric AI inference acceleration from the edge to the cloud, helping to support neural network models.[200] Its products include AI inference accelerator cards and ICs. In August 2024 the firm was recognized as being a leader in its field after receiving verification from the MLPerf Inference benchmarks – a peer-reviewed AI performance and power benchmark.[201]

Xanadu

Xanadu is a Toronto-based organization which was founded in 2016.[202] It is a quantum computing company which has quickly grown to become one of the leading quantum hardware and software companies in the world.[203] The organization offers hardware and software products and services, such as its X-Series cloud-accessible integrated quantum nanophotonic device (a world first),[204] and its PennyLane tool for programming quantum computers.[205] In February 2024, Xanadu received $3.75M from the federal government to advance and commercialize its quantum software product, PennyLane.[206] The funding is expected to create 22 new quantum jobs in Ontario.[207] Additionally, in May 2024, the company announced that it would be partnering with the University of Toronto and Toronto Metropolitan University, along with a number of industry partners, to advance research into quantum technologies, cybersecurity, deep learning, and smart grids.[208] The research project is expected to address gaps in training and education related to the quantum landscape in Canada.

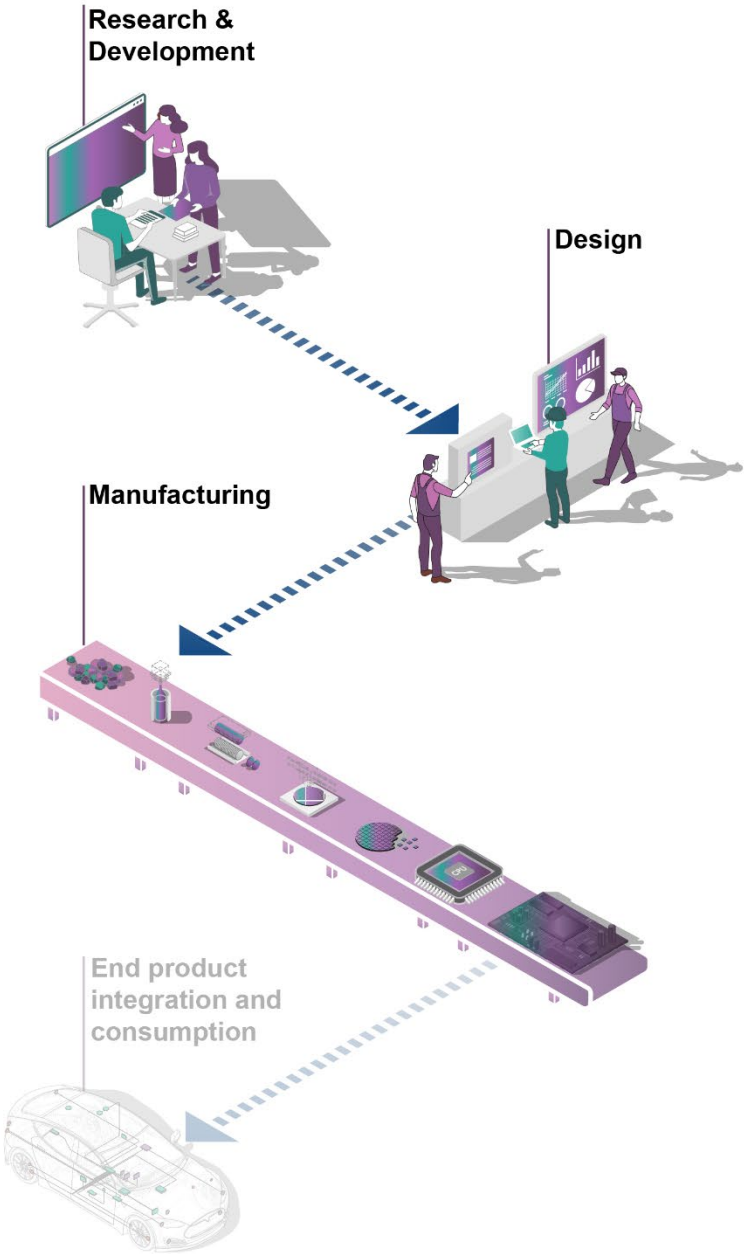
3.4 Semiconductor Manufacturing and Integration in Ontario

Semiconductor manufacturing is an increasingly growing market around the world. It is a highly complex process involving thousands of steps, with chips built in fabrication plants using leading-edge equipment to manufacture microscopic elements.[209] The manufacturing process is constantly being reviewed and updated, with advancements taking years of experimentation.[210] Recent developments include the integration of different chips and chip components into a single package, known as multi-chip modules (MCM).[211]

Ontario's semiconductor manufacturing and integration sector supports a broad range of industries across the province, and further afield, including automotive, AI, communications, healthcare, aerospace and defense, computing, and smart energy, amongst many others.

A number of organizations at the forefront of semiconductor production are located in Ontario, building on the research and design strength in the province to establish a sustainable and prosperous industry.

The following section presents Ontario's semiconductor manufacturing landscape.



3.4.1 Ontario's ecosystem in semiconductor manufacturing

Several global semiconductor manufacturers have identified Ontario as a strategic choice to locate their Canadian business, along with a number of Canadian-founded organizations calling the province home. A selection of these corporations is presented below. Some of the organizations included here have a remit which goes beyond manufacturing, but they have been included in this section due to this being their core function.

Celestica

Celestica is a design, manufacturing, and supply chain solutions company with its headquarters in Toronto. The organization has an Electronics Testing Lab and Microelectronics Lab in Newmarket, Ontario.[212] Celestica provides solutions for a range of markets, including communications, enterprise, aerospace and defense, smart energy, healthcare technology, industrial, and capital equipment.[213]

Celestica has also secured a place for itself in the market with its smart supply chain solution for the entire product lifecycle. The organization provides support to its customers for design and engineering, hardware platform solutions, manufacturing services, precision machining, logistics, product licensing, and after-market services.[214] In support of the automotive industry supply chain, Celestica's key offerings include integrated inverters, ADAS, light detection and ranging (LiDAR), BMS, and power converters, all tailored to meet the demands of modern vehicle electrification.[215]

Onsemi

Onsemi is a semiconductor manufacturer which specializes in automotive solutions and industrial end-markets. The organization has a manufacturing facility in Burlington, Ontario, and design engineering in multiple locations in Ontario.[216] It produces miniaturized System-in-Packages (SiPs), Hybrids and MCMs using 3D Chip Stacking at its Burlington assembly and test facility.[217] The organization provides solutions for powertrain, safety and security, vehicle electrification, body electronics and LED lighting, and ADAS.[218] It is supporting the acceleration of change in vehicle electrification and safety, sustainable energy grids, industrial automation, and 5G and cloud infrastructure.[219]

Sanmina

Sanmina is a technology company which specializes in end-to-end design, manufacturing, and logistics solutions. The key sectors it supplies include industrial, medical, defense and aerospace, automotive, communications networks, and cloud solutions.[220] The organization has an Optical Microelectronics facility in Ottawa, where it manufactures state-of-the-art optical and RF microwave products.[221] At this facility it also provides product design and development, test and process engineering, and new product introduction support for component, module and system-level applications.[222]

Teledyne DALSA

Teledyne DALSA is a manufacturing company which specializes in IC and electronics technology, software, highly engineered semiconductor wafer processing, and machine vision for automotive manufacturing. The organization has its headquarters in Waterloo, with sales offices located in the United States, Europe, and Asia.[223] Its machine vision products provide automotive manufacturers with the ability to guide robots during the assembly process, verify the correct orientation and installation of parts, and perform critical dimension measurements, amongst many other things.[224]

3.5 Ontario's Competitive Advantage

Ontario boasts a competitive advantage in semiconductor research, design, and manufacturing due to its robust ecosystem of top-tier research institutions, innovative technology companies, and strong government support. The province's world-class universities and research centres foster cutting-edge advancements in semiconductor technologies, while a skilled workforce and flourishing tech community drive rapid innovation and development. Additionally, Ontario's strategic location and well-established infrastructure enhance its manufacturing capabilities, positioning it as a leading hub for semiconductor excellence in North America.

Ontario is also home to a prosperous automotive sector, being the only province in which all five OEMs in Canada (Ford, GM, Stellantis, Honda, and Toyota) operate. With demand for EVs expected to grow – the International Energy Agency has predicted that there could be up to 240M EVs on roads globally by 2030 – Ontario is very well positioned to respond to the needs of the automotive industry in the electric transformation through its growing semiconductor industry.[225] The automotive corridor in Ontario is concentrated in the south of the province, in close proximity to the Northeast Semiconductor Manufacturing Corridor spanning Ontario, Quebec, and New York. As Ontario's automotive industry continues to expand as a result of innovations in next-generation vehicles, its semiconductor industry is well-placed to exploit this opportunity.

A selection of further competitive advantages in Ontario is presented below.

Ontario's skilled workforce

Ontario's existing skilled workforce and future pipeline of talent, make the province a prime location for semiconductor businesses looking to build new facilities in close proximity to labour.

Ontario has a large skilled workforce, thanks to its network of high calibre post-secondary institutions. Ontario is the best educated jurisdiction of Organization for Economic Co-operation and Development (OECD) countries,[226] with 74% of working age adults possessing a post-secondary degree.[227] The province has a large and growing number of workers trained in science, technology, engineering, and math (STEM) programs; 70K students graduate from a STEM program every year.[228] Moreover, four Ontario universities are ranked in the world's top 100 for graduate employability.[229]

Universities across Ontario have committed to work together, through the Council of Ontario Universities' Partnering to Develop a Highly Skilled Workforce plan, to ensure that Ontario has highly skilled talent ready to join the workforce in high-growth areas, such as software engineering and design.[230]

Ontario is also working to ensure a strong future pipeline of skilled workers by supporting STEM programs for students in primary and secondary school. Specific programs, such as OVIN's Regional Future Workforce – Empowering Equity in STEM Pilot Program, are contributing to this effort by providing funding for educational summer programs in STEM fields. The program works to bridge the gap between equity-deserving and underrepresented students and the future automotive and mobility

labour force by providing students with skills, training, and engagement opportunities.[231]

Ontario also makes it easy to tap into global talent markets. The province's Global Skills Strategy immigration program provides a 10-business day window to process work permits, enabling access to a wider pool of skilled workers.[232]

Supportive policies

Ontario is a tariff-free zone for manufacturers and has access to free trade agreements with 51 countries.[233] Specifically, Ontario has free trade access to a number of leading semiconductor jurisdictions, such as South Korea and Japan – via the Canada-Korea Free Trade Agreement[234] and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership, respectively.[235]

Additionally, Ontario's Site Readiness Program can help businesses locate sites that can be used for new semiconductor manufacturing facilities. This program is a funding initiative which helps make industrial sites investment-ready.[236] The program has enabled investment in, and construction of, large-scale manufacturing facilities across the province.

Clean energy

Ontario has an electricity system that is 90% emissions free, making it one of the cleanest in the world.[237] Semiconductors assembled in Ontario can therefore have lower carbon footprints than those assembled in jurisdictions with fossil fuel-powered energy systems, making the province an attractive location for investors who prioritize sustainable manufacturing. Additionally, Ontario provides support for manufacturing companies located in the province, by providing electricity at reduced costs through the Northern Energy Advantage Program (NEAP)[238] and the Comprehensive Electricity Plan.[239]

Canadian Photonics Fabrication Centre

The CPFC, funded by Canada's NRC and located in Ottawa, offers a comprehensive array of essential processes and supporting services to recommend optimal wafer configurations and fabrication techniques, ensuring devices meet the exact performance criteria for their intended applications.[240]

The NRC of Canada is undertaking a significant upgrade of CPFC to enhance its research, innovation, and commercialization capabilities, with $90M of funding provided by the Government of Canada.[241] The expansion aims to strengthen the centre's capacity as Canada's primary compound semiconductor foundry. Construction, which began in September 2023, involves adding a new 7.5K square-foot building with a state-of-the-art clean room, gowning room, and advanced wastewater collection system to minimize environmental impact. These upgrades will support increased demand and upgrade outdated equipment to strengthen the telecommunications supply chain.[242] It stands out as North America's only pure-play compound semiconductor foundry and plays a vital role in Canada's quantum strategy, with NRC researchers leading in quantum publication outputs over the past decade.

The CPFC's expertise is reinforced by strong academic and research collaboration with institutions like the University of Ottawa, Carleton University, and Algonquin College. Notable research centres such as the University of Ottawa's Centre for Research in Photonics and the Max Planck uOttawa Centre for Extreme and Quantum Photonics engage in advanced photonic and semiconductor research. These efforts are complemented by partnerships with key industry players like Ciena, Nokia, Ranovus, and Marvell.[243]

TechInsights

TechInsights provides an information platform for the semiconductor industry. The organization is headquartered in Ottawa, providing more than 650 companies globally with the biggest database of semiconductor and technology analysis in the world.[244] The platform provides information and analysis related to semiconductors with a core theme being the automotive industry. The analysis is focused on executive insights, market opportunity, module and semiconductor innovation, procurement, and supply chain.[245] The firm has in-house state-of-the-art laboratories through which it conducts its world-leading analysis.[246] The Ontario-founded organization has expanded to have offices all over the world, including the United States, United Kingdom, Japan, Taiwan, Poland, and South Korea.[247] TechInsights is considered to be the most trusted source of semiconductor related actionable, in-depth intelligence, providing decision makers and professionals with accurate information to make informed business, design, and product decisions with greater confidence.[248]

3.6 Federal Initiatives

Ontario also benefits from a number of federal initiatives, including national funds and tax incentive programs which promote innovation and R&D, and programs dedicated to expanding Canada's semiconductor ecosystem. A selection of these is described below.

Strategic Innovation Fund

The Strategic Innovation Fund is an initiative delivered by the federal government which provides major investments in innovative projects.[249] The program provides funding for two types of projects: business innovation and growth projects, and collaborations and network projects.[250] The core objectives of the program are to encourage businesses across Canada to invest in R&D activities, to accelerate growth and expansion of innovative businesses, to attract and retain large-scale investment in Canada, and to advance collaboration networks between the private sector, research institutions, and non-profit organizations in key emerging technology sectors.[251]

Accelerated Investment Incentive

The Accelerated Investment Incentive is a program delivered by the federal government which allows organizations to write off a large share of the cost of newly acquired capital assets.[252] This includes immediately writing off the full cost of machinery and equipment which is used for manufacturing or processing goods, as well as equipment related to clean energy.[253]

Scientific Research and Experimental Development

The Scientific Research and Experimental Development tax incentives program is a federal initiative which aims to encourage organizations to conduct R&D in Canada.[254] The program allows businesses engaged in R&D to earn tax incentives such as claiming a deduction against income, or earning an investment tax credit which can be applied against income tax payable.[255] To be eligible, work must be undertaken in Canada, conducted for the advancement of scientific knowledge or for the purpose of achieving a technological advancement, and it needs to be a systematic investigation which is carried out in a field of science or technology through experiment or analysis.[256] The initiative is Canada's largest R&D program, offering $3B in tax incentives annually.[257]

FABrIC

FABrIC is a $220M five-year project being delivered by CMC Microsystems, aimed at securing Canada's position in the semiconductor industry.[258] The purpose of the project is to

strengthen the Canadian semiconductor industry through the creation of a highly qualified pool of talent, fostering innovation in the manufacturing process, and providing access to foundries for Canadian businesses.

In July 2024, the federal government announced that it would be investing $120M through the Strategic Innovation Fund to support the FABrIC initiative in developing a pan-Canadian network of stakeholders from across a variety of fields, including the design, manufacturing, and commercialization of semiconductors.[259]

Over the next five years, FABrIC aims to cultivate a resilient and sustainable semiconductor ecosystem, enabling Canadian companies to develop over 10 new process manufacturing technologies, commercialize 85 products and services, and create 750 new or improved product offerings.[260] Additionally, it anticipates the inception of 75 new companies and the development of skills critically needed by the industry in 25K HQP.[261] FABrIC will also create nearly 325 highly skilled jobs, and will maintain approximately 440 jobs throughout the duration of the project.[262] The resulting advanced sensor and computer technologies will incorporate quantum technologies, AI, photonics, semiconductors, and MEMS, across industries such as EVs, green technology, healthcare, and agriculture.[263]

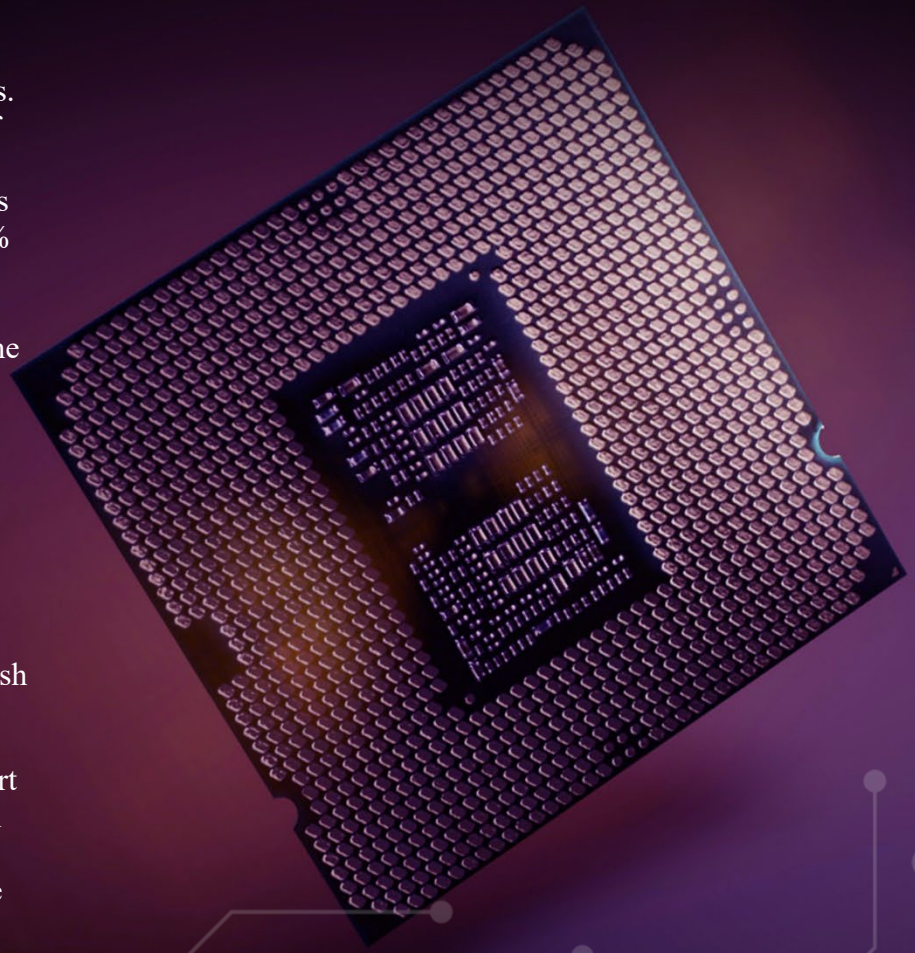
Canada Semiconductor Council

The Canada Semiconductor Council (CSC) is a national organization that represents a diverse range of companies and institutions involved in the development and manufacturing of semiconductor components. CSC is committed to advancing Canada's semiconductor sector by enhancing domestic supply chain resilience and positioning the country as a leader in semiconductor R&D, design, and manufacturing. CSC's primary objectives include fostering consensus on a national strategy to drive sustained growth in the semiconductor industry, promoting its role as a catalyst for Canadian economic expansion, and supporting its integration into other key sectors. Additionally, CSC facilitates networking opportunities to encourage informal knowledge exchange and collaboration among its members.[264]

Automotive Microchips Working Group

In March 2024, CSC launched the Automotive Microchips Working Group. The group is made up of senior executives from the semiconductor and automotive sectors, federal and provincial policy experts, and representatives from the investment community.[265] The core objective of the group is to explore practical strategies for boosting Canada's semiconductor supply chain within the automotive industry.[266] Areas the group will explore include design centres, semiconductor manufacturing, and packaging and assembly strategies.[267]

4. Opportunities for Ontario to Lead in the Semiconductor Industry



The semiconductor market is emerging as a crucial sector with immense potential for both economic and technological progress. The increasing demand for advanced chips, driven by the rise of AI, next-generation vehicles, and smart devices, underscores a significant growth opportunity. Notably, the automotive sector is expanding rapidly within this market, projected to capture a 13% share of the global semiconductor market by 2030,[268] with semiconductor demand in the automotive industry expected to triple, reaching a market value of $150B by the same year.[269] The evolving landscape of the automotive semiconductor market highlights the critical role of the supply chain, impacting aftermarket services and semiconductor manufacturing.

Ontario is well-positioned to seize this opportunity, given its strong automotive industry and technological prowess. By integrating its advanced automotive capabilities with semiconductor innovation, Ontario can harness this decisive moment to drive industry growth, attract investment, and establish itself as a key player in the global semiconductor landscape.

This section explores various opportunities for Ontario to support semiconductor industry growth, drawing inspiration from global initiatives. It focuses on research, design, and manufacturing, offering potential strategies for Ontario to enhance its role in the expanding semiconductor sector.

4.1.1 Emulating Ontario's automotive industry success in semiconductor component manufacturing

Canada aims to position itself strategically within the semiconductor industry, mirroring its approach in the North American automotive sector by focusing on component production rather than direct competition with major players like the United States. Experts suggest that Canada should adopt a collaborative approach, specializing in areas like sensor technologies and photonic semiconductors, which are expanding areas within the semiconductor market where Ontario already has expertise and capability, that require less investment, and can complement rather than compete with United States advancements.[270] Additionally, experts have identified that power electronics and compound semiconductors, which are the key drivers enabling the shift towards EVs, are core strengths within Ontario's ecosystem.[271] Power electronics is seen as a key area, not only due to the direct feed into automotive (EV, Hybrid) and transportation supply chains (aerospace, marine, rail), but also due to its requirement in green technologies such as batteries, solar and wind power, and grid energy storage. It is also important to industrial automation and robotics, industrial motors, satellites, data centres (power management, cooling systems), telecommunications, industrial grid management power and utilities.[272]

Ontario, as a key player, can capitalize on this strategy and its strategic location, by investing in niche semiconductor sectors, particularly those that align with its existing technological expertise and infrastructure, like that of automotive and the growing CAV market. The province may prioritize focusing on developing specialized semiconductor technologies, such as compound semiconductors, power electronics and sensors for EVs and CAVs, and photonic chips for telecommunications, leveraging its strengths in design and packaging. This collaborative and targeted approach could help Ontario integrate effectively into the semiconductor ecosystem and potentially surpass the economic impact of its role in the auto industry.[273]

4.1.2 Expand next-generation power semiconductors

The automotive industry has seen a dramatic rise in semiconductor use due to advancements in vehicle technology and capabilities. Modern cars now feature sophisticated electronics for systems such as automatic parking and early braking, driving a surge in demand for automotive semiconductors. This growth is largely attributed to the increasing complexity of onboard electronics, including microcontrollers, intelligent sensors, and advanced power systems. The automotive semiconductor market has outpaced growth in both the broader automotive and semiconductor sectors, reflecting the critical role these components play in enhancing vehicle performance and safety.[274] Moreover, the automotive semiconductor market exceeds growth for all other industries, including data storage and wireless industries, with a CAGR of 10%.[275]

Key trends in automotive semiconductors include the rapid adoption of wide band-gap materials like Silicon Carbide (SiC) and GaN, also known as compound semiconductors, which offer superior performance in high-voltage applications compared to traditional silicon semiconductors. These materials are crucial for the electrification of drivetrains in hybrid and EVs, where they help manage power more efficiently and improve overall system performance. Additionally, there is a growing focus on faster innovation cycles to keep pace with evolving vehicle technologies, particularly in areas like power management, driving dynamics, and infotainment systems, where centralized compute units are

expected to be an emerging field. This trend highlights the need for continuous advancements in semiconductor technology to meet the demands of next-generation vehicles.[276]

Further analysis has identified opportunities for Ontario to boost its automotive semiconductor supply chain in terms of critical R&D and manufacturing for compound semiconductors (silicon carbide, gallium nitride) and power electronics. Key opportunities include power modules, battery management ICs (BMIC), battery electronic printed circuit boards (PCB), GaN and SiC MOSFETs (switch to control electronic signals), Insulated Gate Bipolar Transistor (IGBT: switch to control high power levels in EVs) and wafer testing (quality control).[277]

Furthermore, advancements in photonic semiconductors are required to meet future demand for next-generation communications technology, with prototype chips currently under development for 6G and 7G communications technology in the United Kingdom.[278]

The FABrIC proposal highlights Canada's strategic strengths in semiconductor manufacturing and outlines key opportunities for scaling up investment. Key areas of focus include compound semiconductors, exemplified by companies like GaN Systems in Ottawa, recently acquired by Infineon Technologies. These technologies intersect with critical sectors such as healthcare and automotive and offer substantial potential for commercialization in IoT devices.[279] Ontario can promote expansion of compound semiconductor manufacturing and packaging facilities.

Ontario can capitalize on the booming automotive sector by exploring opportunities to expand on semiconductor technologies, especially those tailored for EVs and hybrid drivetrains. The province could support R&D in cutting-edge power semiconductors, such as SiC and GaN, which are crucial for enhancing EV performance and efficiency. By fostering innovation in high-performance electronic components and facilitating partnerships between automotive and tech companies, Ontario can establish itself as a leader in the rapidly growing automotive semiconductor market. This strategic investment not only promises economic growth but also positions Ontario at the forefront of the next generation of automotive technology.

4.1.3 Establish direct-to-source model between foundry and OEM

Ontario is the only province in which all five OEMs in Canada (Ford, GM, Stellantis, Honda, and Toyota) operate, but the provincial semiconductor industry does not currently directly supply these automakers. Usually, semiconductor manufacturers produce general purpose chips which are then incorporated into ECUs by subsystem makers. The supply chain can be streamlined, establishing a direct-to-source model which enables foundries to connect directly with OEMs, providing them with semiconductors which are made specifically for their products.[280]

This is a significant opportunity for Ontario to develop a resilient domestic supply chain, benefitting from the presence of the OEMs in the province. By developing a direct-to-source model, the automotive semiconductor supply chain can be more efficient, reliable, and eliminate supply/demand competition.[281] It also enables OEMs to dictate their requirements and collaborate with foundries to innovate for next generation vehicles.

4.1.4 Expand advanced packaging, assembly and testing, and AI / ML capabilities

In the semiconductor industry, Asia dominates both front-end (wafer fabrication) and back-end (assembly and testing) processes,

with over 75% of fab capacity and 90% of assembly and testing market share concentrated in the region, particularly in China and Taiwan. Despite efforts by the United States and Europe to boost domestic fabrication capabilities, nearly all assembly and testing work remains in Asia, largely outsourced to third-party or Outsourced Semiconductor Assembly and Test (OSAT) vendors. The distinction between front-end and back-end manufacturing is blurring as companies seek to integrate these processes more closely to capture greater value across the supply chain. Advanced packaging has emerged as a critical component for high-performance chips, driving demand for capabilities that are currently experiencing shortages.[282]

In this context, to strengthen back-end manufacturing capabilities, reduce supply chain complexities, and avoid delays, expansion in advanced packaging technologies and increasing nearshore assembly and testing capacities are growing. Experts have identified an opportunity in Ontario for a mobility and automotive power electronics development centre including advanced packaging research centre, to ensure market-leading industrial research and innovation, which supports continued investment and growth within Ontario's automotive and industrial supply chains.[283] Integrating AI and ML into operations will also be crucial for OSAT facilities to enhance efficiency, improve demand forecasting, optimize inventory management, and enable advanced testing methodologies such as dynamic and AI-driven testing.[284]

Ontario could focus on expanding advanced packaging technologies and fostering capabilities in nearshore assembly and testing facilities to reduce supply chain complexities and ensure timely delivery of high-performance chips. Moreover, Ontario could prioritize integrating AI and ML into semiconductor operations to enhance and enable advanced testing.

4.1.5 Expand critical mineral exploration

Critical minerals are essential to the production of semiconductors, with at least 300 materials identified as being required throughout the manufacturing process.[285] Ontario maintains a list of critical minerals via its Critical Mineral Strategy. These critical minerals have exploration or development potential, strategic economic importance, application in technologies that support a low-carbon economy, or global market demand.[286] Included in the list are materials essential to the production of semiconductors: gallium and germanium.[287] China is currently the leading producer of both materials; 60% of the world's germanium[288] and 80% of gallium.[289] In 2023, China began restricting exports of these materials which may in the shorter-term affect production levels of semiconductors, but in the longer term presents an opportunity for Canada – and Ontario in particular – to explore mining potential with a view towards establishing itself as a key producer.[290]

Ontario has exploration potential for both materials.[291] The province already has a thriving mining industry, with 35 active mining operations producing $13.5B worth of materials in 2022,[292] and its mining industry continues to expand, with $989M spent on exploration in 2022.[293] There is a significant opportunity to concentrate research and exploration on the potential of Ontario as a source for gallium and germanium. Further expansion of programmes such as the Ontario Junior Exploration Program (OJEP), which supports junior mining companies in financing early exploration projects,[294] will help boost exploration and establish Ontario's domestic supply chain for semiconductor manufacturing.

4.1.6 Foster supportive regulatory environment

In recent years, United States policymakers and several other countries have imposed export controls on semiconductors and semiconductor manufacturing technologies destined for China, citing potential military applications. The semiconductor industry anticipates grappling with the implications of these regulations, alongside potential further restrictions and retaliatory measures. Companies are navigating a complex landscape where they must balance compliance with evolving regulations while strategically planning for future restrictions and advancements in domestic semiconductor capabilities. Anticipation and adaptation to these regulatory shifts will be critical for industry players navigating geopolitical dynamics impacting global semiconductor trade.[295]

Amidst current geopolitical challenges impacting semiconductor trade, Ontario can strategically support its local industry by fostering an innovative environment and ensuring regulatory compliance. The province should explore opportunities to expand R&D to advance semiconductor technologies, focusing on areas less affected by stringent export controls. Collaborative efforts among industry, academia, and government can strengthen Ontario's capability to develop and manufacture chips domestically.

A collaborative approach can be further developed via the United States federal government's CHIPS and Science Act 2022, a key output of which is the building of integrated supply chains across North America, with Canada and the United States pledging to create a Northeast Semiconductor Manufacturing Corridor.[296] Ontario benefits from being strategically located on the United States-Canada border, bridging the tech industries of both nations. By aligning proactively with international trade regulations and anticipating future shifts, Ontario has the opportunity to establish itself as a stable and attractive hub for semiconductor firms navigating global trade complexities. This approach ensures sustained growth and competitiveness in Ontario's semiconductor sector over the long term.

4.1.7 Tax credits in support of the semiconductor industry

Tax credits are crucial to fostering the creation of start-ups in Canada, enabling them to thrive and innovate in the semiconductor sector. Canada's lower cost structure compared to Silicon Valley enhances its attractiveness for growing design capabilities in semiconductor technologies.[297] Vietnam has unveiled plans including tax incentives and grants aimed at attracting semiconductor firms like Nvidia and Samsung to expand their operations within the country.[298] Similarly, Taiwan has introduced the Industrial Innovation Act, akin to the United States CHIPS and Science Act, aimed at bolstering its semiconductor sector. Under this legislation, semiconductor firms can qualify for significant tax incentives, including a 25% deduction on R&D expenses and a 5% deduction on costs for new machinery used in advanced manufacturing processes.[299]

In addition, Malaysia and Singapore announced at the beginning of 2024 that they had signed an MOU to work on a Johor-Singapore Special Economic Zone (SEZ).[300] The purpose of the SEZ is to increase cross-border trade and investments and to create a stronger economic connection between the two jurisdictions.[301]

To strengthen Ontario's semiconductor industry, the province could draw inspiration from Vietnam's proactive measures by introducing targeted tax incentives and grants designed to attract

major semiconductor players to establish or expand their operations in Ontario, along with exploring the opportunity for developing SEZs. Ontario already offers businesses fast write-offs of the cost of capital investments such as new machinery and equipment.[302] Ontario could expand this program to include tax deductions on R&D expenses as Taiwan has. Clear eligibility criteria focusing on substantial R&D commitments and investments in cutting-edge manufacturing technology would create a conducive environment for semiconductor innovation and growth within Ontario.

4.1.8 Steer Canada's semiconductor strategy

Canada is reshaping its semiconductor industry strategy and actively negotiating with the United States and Mexico governments to forge a new trade pact focused on integrating a cohesive North American semiconductor supply chain. Additionally, efforts are underway to formalize a northeast semiconductor corridor spanning Ontario, Quebec, and New York State. This corridor, akin to the symbiotic relationship between Windsor, Ontario, and Detroit in the automotive industry, aims to integrate key players. Toronto, a centre for AI-related design and development, complements Bromont, home to IBM, Teledyne, and CM2I. Expansion plans envision extending this corridor into a triangle incorporating Waterloo, Ontario, and Ohio.[303]

Experts note that the semiconductor sector requires long term, sustained effort provincially, federally, and with bilateral partners such as the United States and Mexico, in terms of coordinated investments and support.[304]

Furthermore, Ontario can actively engage with the Northeast Microelectronics Coalition Hub in the United States and leverage the opportunities under the CHIPS and Science Act to strengthen its position as a key player in the North American semiconductor industry ecosystem. This approach not only enhances Ontario's economic prospects but also contributes to regional and international semiconductor innovation and collaboration.[305]

4.1.9 AI-driven chip design and manufacturing

In 2023, the semiconductor industry faced challenges from weak demand for traditional chips like those used in smartphones and computers, compounded by low memory prices. However, the emergence of chips designed to accelerate the training and inference of generative AI models provided a notable growth area. The market for generative AI chips is anticipated to have sales exceeding US$50B in 2024.[306] This represents approximately 8.5% of the total value of all chips expected to be sold globally during the year. Longer-term forecasts suggest that AI chips, particularly those tailored for generative AI applications, could reach sales of US$400B by 2027.[307]

These tools are expected to significantly enhance manufacturing, operations, and maintenance processes by enabling predictive maintenance, smart diagnostics, and troubleshooting. Additionally, there is a growing emphasis on improving the sustainability and efficiency of semiconductor fabs. Companies are exploring both upgrading existing facilities and constructing new, environmentally friendly plants.[308]

Having established itself as a leader in AI, Ontario can strategically expand its semiconductor industry by focusing on AI-driven chip design through dedicated R&D centres and partnerships with universities and tech firms. Exploring opportunities to expand facilities for AI model training will empower engineers in generative AI applications for chip design

and simulation. Initiatives to attract AI talent, enhance data security measures, and promote AI-specific chip manufacturing with incentives and infrastructure support are crucial. Establishing centres for AI chip testing and collaborating globally with industry leaders will further solidify Ontario's role in AI-driven semiconductor innovation, fostering economic growth and technological leadership in the sector.

Additionally, fostering partnerships between Ontario's tech sector and global leaders in AI and semiconductor manufacturing would accelerate knowledge transfer and technological adoption, positioning Ontario as a hub for advanced semiconductor manufacturing with a strong focus on AI-driven smart manufacturing solutions.

4.1.10 Addressing the cybersecurity risks

The semiconductor industry is confronting heightened cybersecurity risks, distinct from other sectors, due to its possession of valuable and restricted IP. These companies are prime targets for profit-seeking ransomware attacks and state-backed cyber threats seeking to exploit geopolitical tensions. The potential escalation of these tensions could lead to further IP and material restrictions, exacerbating cyberattacks and disrupting production. Threat actors are increasingly targeting not only core semiconductor companies but also their extended supply chain partners. This cyber battle necessitates semiconductor firms to urgently enhance their cyber defense capabilities and fortify digital infrastructure across their supply chains to mitigate these evolving threats.[309]

Ontario can play a crucial role in supporting the semiconductor industry by focusing on enhancing cybersecurity measures. Given the industry's vulnerability to sophisticated cyber threats targeting valuable IP and disrupting production, Ontario can invest in initiatives that strengthen cyber defense capabilities within semiconductor firms and their supply chains. This includes fostering collaboration between industry stakeholders, academia, and government agencies to develop robust cybersecurity frameworks, protocols, and technologies tailored to semiconductor manufacturing. Additionally, Ontario can incentivize R&D in advanced cybersecurity solutions specifically designed for the semiconductor sector, ensuring resilience against evolving cyber threats and safeguarding critical IP.

4.1.11 Workforce development

The semiconductor industry is experiencing a period of intense global competition driven by significant investments in new manufacturing facilities. Companies across several countries, including South Korea, Germany, and the United States, are committing nearly $1T from 2023 to 2030 to expand their production capacities. This surge in investment not only promises to reshape the industry landscape but also highlights the critical role of talent in sustaining this growth. Without a sufficient pool of skilled workers, these ambitious capital projects risk delays or operational inefficiencies. The sector faces a substantial talent shortfall exacerbated by an inadequate number of graduates, an aging workforce, and lingering perceptions that deter potential candidates from entering the field.[310] Experts note that there is a major gap between the supply of engineering talent and the demand on the R&D side.[311]

To address these challenges, semiconductor companies and the provincial and federal government must prioritize talent acquisition and retention as a strategic imperative. The industry's demand for qualified candidates, particularly in technical roles, has surged dramatically, with job postings increasing by over 75% annually in regions like the European Union and the United States

from 2018 to 2022. If current trends persist, the shortfall could reach staggering numbers: more than 100K engineers needed in both the United States and Europe, and over 200K in the Asia-Pacific region (excluding China). Addressing these gaps requires concerted efforts to enhance the industry's attractiveness, tap into underutilized labour pools, and leverage contingent labour effectively. Moreover, the talent challenge extends beyond semiconductor manufacturers to include companies throughout the industry's value chain, from equipment manufacturers to component suppliers, all struggling to fill critical technical roles necessary for sustained growth and innovation.[312]

OVIN is directly supporting development of the workforce through its Talent Development Internship/Fellowship Program, which offers opportunities for students and recent graduates to gain industry experience in relation to EVs, CAVs, and battery technologies.[313] In-demand technical skills include systems architectures (SoC, SiP, System-on-package (SoP), complex ASIC), data analysis, ML and AI, and skilled trades (electricians, pipefitters, welders etc.) as well as electrical, chemical, and materials engineering to develop appropriate materials and devices.

As production techniques become more advanced, semiconductor talent will be expected to have stronger skills in ML and AI as well as the ability to carry out more advanced manufacturing processes and quality control. Adaptability will also be key as technology evolves. Potential future skills gaps include advanced digital skills (AI, ML, data analytics, software programming), systems architectures, skilled trades, electrical and materials engineering skills, and cyber security.

Ontario can be an attractive place for companies to locate by offering a large number of skilled workers via its world-class universities and growing workforce trained in STEM programs. Several strategic actions can be undertaken, as highlighted below.

Enhancing policies to attract foreign expertise

Ontario could support its semiconductor industry by establishing partnerships between local universities and leading semiconductor firms. This collaboration would create specialized educational programs aligned with industry needs, ensuring a continuous supply of skilled professionals. An example of this is the collaboration between semiconductor firms and universities in Vietnam. The country aims to train 50K engineers by 2030, with universities collaborating closely with industry leaders like Samsung to introduce specialized semiconductor courses. The Vietnamese government is also integrating the semiconductor sector into two key national programs, focusing on research grants, product development, and export competitiveness.

Additionally, Ontario could improve its policies to attract foreign talent and promote technology transfer agreements with global chip-producing nations, fostering innovation and knowledge exchange within the sector. Furthermore, integrating the semiconductor industry into national R&D programs, such as the Semiconductor Challenge Callout, FABrIC, and partnerships between leading research institutions, could prioritize funding and support, enhancing Ontario's export competitiveness in this field.

Experts note that there is also an opportunity to leverage the preexisting immigration programs in Canada which make it easier to keep graduating talent in Ontario – more so than in the United States.[314]

Invest in new graduate programs

Taiwanese authorities and leading chipmakers plan to invest over US$300M in new graduate programs for the semiconductor industry over the next decade.[315] This initiative is intended to safeguard Taiwan's chip economy amidst efforts by the United States and China to develop domestic talent and relocate semiconductor production locally.[316]

Ontario could strengthen its semiconductor sector by exploring opportunities to expand new graduate programs and establishing a dedicated task force. This would involve developing specialized graduate programs in semiconductor technology at universities to cultivate a skilled workforce. Experts note that a key opportunity is to develop the skillsets required within the automotive semiconductor industry via Ontario's universities and colleges.[317] Collaboration between higher education providers would allow development of a funnel of talent with the ability to design specialized chips for cars.[318] Further collaborations with industry leaders and research institutions would ensure the curriculum meets industry standards. Additionally, forming a task force comprising government officials, industry leaders, and academics would enable the development of policies supporting semiconductor innovation.

Industry branding

Promoting industry awareness and branding is essential to attract talent. Campaigns highlighting career opportunities, the sector's impact on technological advancement, and the potential for meaningful work can improve perceptions and attract a diverse pool of candidates. Moreover, expanding the talent pool through diversity initiatives, including actively recruiting underrepresented groups like women and retirees, can bring valuable skills to the semiconductor workforce. Flexible work arrangements and tailored career development programs are vital to supporting their integration and retention within the industry. Additionally, investing in workforce retention strategies such as flexible work policies, technical career progression paths, and continuous learning opportunities will enhance job satisfaction and mitigate attrition rates, ensuring a stable and skilled workforce for the semiconductor sector.

Upskilling the existing workforce

Supporting skills development and reskilling programs is essential for Ontario to stay competitive in the evolving semiconductor landscape. Initiatives that upskill the existing workforce in emerging technologies and advanced manufacturing techniques, including the use of generative AI for targeted skills enhancement, will ensure the province maintains its edge. Establishing strong industry-government partnerships and aligning them with broader economic strategies will foster growth, innovation, and economic resilience within Ontario's semiconductor sector.

Enhancing education and training programs in collaboration with universities and technical institutions is also crucial. Updating curricula to focus on emerging technologies like AI, ML, and advanced materials relevant to semiconductor manufacturing will help align education with industry needs. This approach will ensure a skilled workforce capable of driving sector innovation.

Moreover, collaborative initiatives involving Ontario's universities, research institutions, and industry leaders should focus on developing cutting-edge semiconductor technologies and training through specialized programs and apprenticeships. Prioritizing partnerships with international semiconductor companies can drive innovation and expand market access. These strategies will position Ontario as a hub of excellence in semiconductors, fueling economic growth and generating high-tech job opportunities.

5. Glossary

ADAS	Advanced Driver-Assistance Systems
AI	Artificial Intelligence
AMC	Advanced Manufacturing Consortium
ASIC	Application-specific Integrated Circuit
BMS	Battery Management Systems
CAGR	Compound Annual Growth Rate
CAV	Connected and Autonomous Vehicle
CHIPS	Creating Helpful Incentives to Produce Semiconductors
CPFC	Canadian Photonics Fabrication Centre
CPU	Central Processing Unit
CSC	Canada Semiconductor Council
ECU	Electronic Control Unit
EMS	Electronics Manufacturing Service
EV	Electric Vehicle
FPGAs	Field Programmable Gate Arrays
FTE	Full-Time Equivalent
GaN	Gallium Nitride
GDP	Gross Domestic Product
GPU	Graphics Processing Unit
GVA	Gross Value Added
HQP	Highly Qualified Personnel
IBM	International Business Machines
IC	Integrated Circuits
ICE	Internal Combustion Engine
IoT	Internet of Things
IP	Intellectual Property
LED	Light Emitting Diodes
LiDAR	Light Detection and Ranging
MCM	Multi-Chip Modules
MEDJCT	Ministry of Economic Development, Job Creation and Trade
MEMS	Micro-electromechanical Systems
ML	Machine Learning
MOS	Metal-Oxide-Semiconductor
MOU	Memorandum of Understanding
NEAP	Northern Energy Advantage Program
OECD	Organization for Economic Co-operation and Development

OEM	Original Equipment Manufacturers
OSAT	Outsourced Semiconductor Assembly and Test
NRC	National Research Council
OJEP	Ontario Junior Exploration Program
OVIN	Ontario Vehicle Innovation Network
R&D	Research & Development
RF	Radio Frequency
RTDS	Regional Technology Development Site
SIA	Semiconductor Industry Association
SiC	Silicon Carbide
SiP	System-in-Package
SME	Small & Medium Enterprise
SOCs	System-on-Chips
SOMs	System-on-Modules
SoP	System-on-Package
SEZ	Special Economic Zone
SPS	Semiconductor Products Sector
STEM	Science, Technology, Engineering, and Math
TSMC	Taiwan Semiconductor Manufacturing Company
TSS	The Six Semiconductor Inc

6. About OVIN

The Ontario Vehicle Innovation Network (OVIN) is Ontario's flagship initiative for the automotive and mobility sector, with a mission to drive economic development and catalyze a future that builds safer, cleaner, and more efficient transportation.

Led by the Ontario Centre of Innovation (OCI) and supported by the Government of Ontario through the Ministry of Economic Development, Job Creation and Trade (MEDJCT), Ministry of Transportation (MTO), and Ministry of Labour, Immigration, Training and Skills Development (MLITSD), OVIN is driving the future of the sector by supporting the growth of Ontario-made automotive and mobility innovation, developing a highly skilled workforce, and reinforcing Ontario's role as the global automotive and mobility hub of the future.

OVIN supports Ontario-based automotive and mobility companies to accelerate the development and commercialization of transformative technologies and transportation systems through the following programs:

- Research and Development Partnership Fund
- Talent Development
- Regional Technology Development Sites
- Demonstration Zone
- Technology Pilot Zones
- Going Global

OVIN supports the development of a highly skilled, future-ready automotive and mobility workforce through a number of talent strategy and workforce planning initiatives:

- Strategies and frameworks, including the Talent Strategy & Roadmap, Critical Minerals Talent Strategy, and Reskilling Framework
- Pilots and programs, including the Regional Future Workforce and Content Partnerships
- The OVIN Learning Hub, comprised of the Skills and Career Navigator and Upskilling Platform
- DEI Advisory Committee

The OVIN Central Hub drives the province-wide coordination of activities and resources that reinforce Ontario's position as a leading automotive and mobility jurisdiction. The Central Hub is a focal point for all stakeholders across the province, fostering collaboration between industry, small- and medium-sized enterprises, post-secondary institutions, municipalities, government, and new entrants into Ontario's thriving automotive and mobility innovation ecosystem. Through the Central Hub, OVIN drives public education, research, analysis and thought leadership activities, with the goal of raising awareness around the potential of transformative technologies and growth opportunities for Ontario and its partners.

To find out the latest news, visit www.ovinhub.ca or follow OVIN on social media @OVINhub

7. OVIN Objectives

	Foster the development and commercialization of Ontario-made advanced automotive technologies and smart mobility solutions.
	Showcase the Province of Ontario as the leader in the development, testing, piloting and adoption of the latest transportation and infrastructure technologies
	Drive innovation and collaboration among the growing network of stakeholders at the convergence of automotive and technology
	Leverage and retain Ontario's highly skilled talent, and prepare Ontario's workforce for jobs of the future in the automotive and mobility sector
	Harness Ontario's regional strengths and capabilities, and support its clusters of automotive and technology

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9. Disclaimers

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