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Revitalizing Ontario's Microelectronics Industry

A review of our current strengths and future potential for building a globally competitive microelectronics industry in Ontario

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The Information Technology Association of Canada (ITAC) is the voice of the Canadian information and communications technologies (ICT) industry in all sectors including telecommunications and Internet services, ICT consulting services, hardware, microelectronics, software and electronic content. ITAC's network of companies accounts for more than 70 per cent of the 589,000 jobs, $137.6 billion in revenue, $5.2 billion in R&D investment, $22.6 billion in exports and $11.5 billion in capital expenditures that the industry contributes annually to the Canadian economy.

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Executive Summary

The Canadian microelectronics industry has propelled the growth of Canada's knowledge-based economy for more than three decades. By enabling technological innovation in other sectors, notably information technology, communications, and manufacturing, its impact has been both profound and enduring. But, with the bursting of the telecom market bubble in 2000-01, the industry has changed dramatically. Competition is global and increasingly fierce. Several new business models and market niches have emerged. Manufacturing, research and development costs have skyrocketed and industry consolidation is underway worldwide.

Many industry thought leaders are anxious about the future of the microelectronics business in our country and particularly in Ontario, home to Canada's nucleus of microelectronic companies. They wonder if the Canadian industry can continue to compete in a global industry that is increasingly complex, competitive and both cost-intensive and cost-sensitive. With the recent acquisition of several Canadian companies by foreign interests, many are concerned about building truly global Canadian semiconductor companies to ensure a healthy mix of both domestic and foreign owned entities.

According to the almost 40 stakeholders from both the corporate and not-for-profit sectors interviewed for this review, the microelectronics industry in Ontario is at a crossroads. Although Ontario is home to a core of important microelectronic companies and research labs, it must better exploit its microelectronic research and business expertise to commercialize its innovations in lucrative global markets.

Fundamentally, these stakeholders agree that Ontario needs a new strategy to drive the future growth of its microelectronics industry. To build an industry with global clout, this strategy should:

- Leverage the existing strengths of Ontario's existing microelectronic clusters in the National Capital and Golden Triangle regions by creating new centres of excellence focused on building "critical mass" in the fields of broadband and video-processing technologies.
- Create new hybrid clusters to capitalize on emerging market opportunities by bringing together the expertise of Ontario microelectronic interests with new and evolving end markets for microelectronics products, such as health care technology, automotive manufacturing, and the consumer electronics products resulting from the convergence of PCs, handheld devices and televisions.
- Breed an industrial culture that concentrates on commercializing new technologies for the global market, and not only on pure research. Here, areas such as low power design and system-on-a-chip design are key examples. In addition to building awareness and fostering more partnership opportunities among academic, government and business interests, this requires a serious overhaul of the current tax and incentive regime for technological development in Ontario. We need to ensure that Ontario is attitudinally geared for the creation of strong enterprises and has a policy infrastructure to foster business growth.

Introduction

This review captures the opinions, perspectives and ideas of senior executives, not-for-profit representatives and other industry leaders (See Appendix A for the list of interviewees) on the future of Ontario's microelectronics industry.

These stakeholders, who collectively represent more than 30 companies operating in Ontario, shared their insights on the evolving global marketplace for microelectronics, how the industry is changing worldwide and what it means for companies in Ontario. They were asked for their views on current government programs and on the existing relationships among the public sector, post-secondary institutions, and business interests. They also shared their input on how the industry, academia and government could work together more effectively to stimulate industry growth and create more jobs (see Appendix B for the interview questions).

In addition to encapsulating the development of the microelectronics industry in Canada, its current challenges and future potential, this review outlines the recommendations of these stakeholders for building a microelectronics industry in Ontario that can deliver high value in terms of innovation, job and wealth creation.

An Historical Perspective

The microelectronic industry in Canada was born in Ottawa with the founding of Microsystems International Ltd. (MIL) in 1969. This joint venture between Northern Electric (now Nortel Networks) and the Federal Government attracted highly qualified microelectronics experts from all around the world, notably the United Kingdom.

Fired by the entrepreneurial fervour that subsequently seized Ottawa in the 1970s and 1980s, these industry leaders spun off several companies to capitalize on the then burgeoning market for telecommunications equipment. As a result, a vibrant cluster of telecom microelectronics companies emerged in the National Capital Region. It has since secured considerable expertise in photonics, wireless, encryption, and reverse engineering technologies as well as in Semiconductor Intellectual Property (SIP) licensing.

Meanwhile in the late 1970s and early 1980s, new microelectronics ventures surfaced in Toronto and southern Ontario. Fuelled by focussed investment from the Government of Ontario and the research capabilities of the University of Toronto, another microelectronics cluster developed here based on video-processing technologies. It produced world leading companies, such as ATI and Genesis.

By the 1990s, Ontario was a significant player in the global silicon chip business, largely based in California. It had established several world-leading centres of excellence in the industry. Having enjoyed a generation of strong growth, it could anticipate a future that appeared full of promise. But there were problems on the horizon, notably a stunning decline in the demand for telecom equipment and an acute shortage of highly qualified people – especially university graduates in engineering, material science and related disciplines.

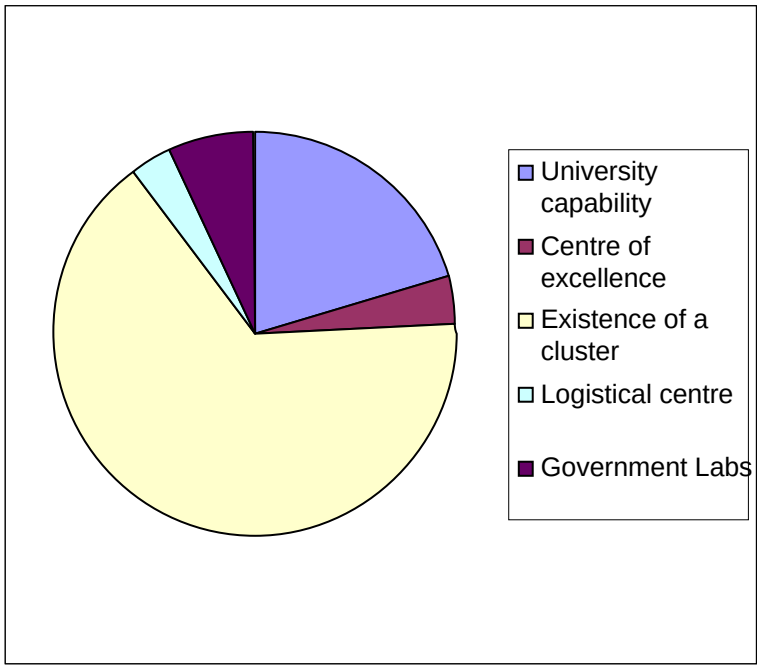
In 1999, the Strategic Microelectronics Consortium presented a strategic direction for the national industry[1], launching an industry-wide funding campaign. Its goal was to increase academic resources and enrolments in the disciplines of microelectronics, optoelectronics, wireless technology and related embedded software (see Appendix D for the Executive Summary).

By 2001-02, the industry had also diversified from its telecom roots into fields such as PC graphics, video processing, medical devices, consumer electronics and computer peripherals. In spite of this nascent diversification, however, the global downturn in demand for telecommunications equipment and the closure of Nortel's semiconductor factory in Ottawa dramatically stalled the growth of Ontario's microelectronics industry. The aftermath of these developments lingers today.

[1] *Strategy for Microelectronics in Canada, 1999*

Nevertheless, Ontario remains home to important microelectronic clusters. This success is due largely to early and ongoing investments by governments, academia and the private sector in research and development and to their continuing cooperation. In reviewing the reason most frequently cited by our respondents why today's companies exist in Ontario, by far the most significant was the existence of a cluster which had been formed through these collaborations, with interactions with universities being the next most significant as shown in Figure 1.

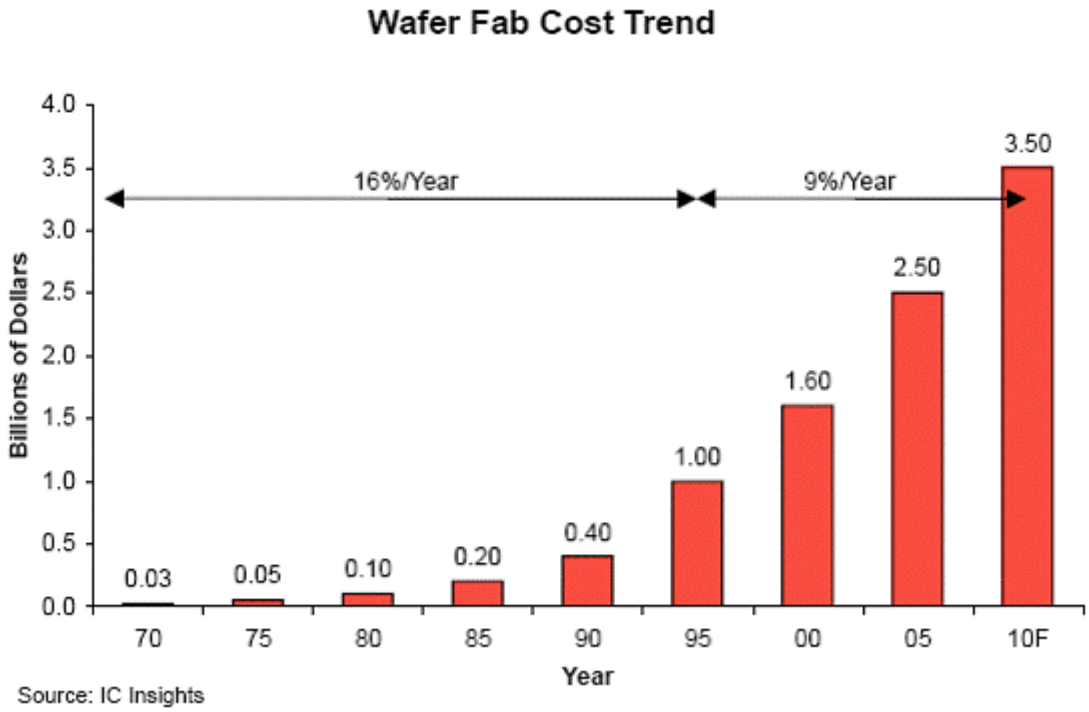
Figure 1. Why Microelectronics Companies Invest in Ontario



The Global Microelectronics Industry Today

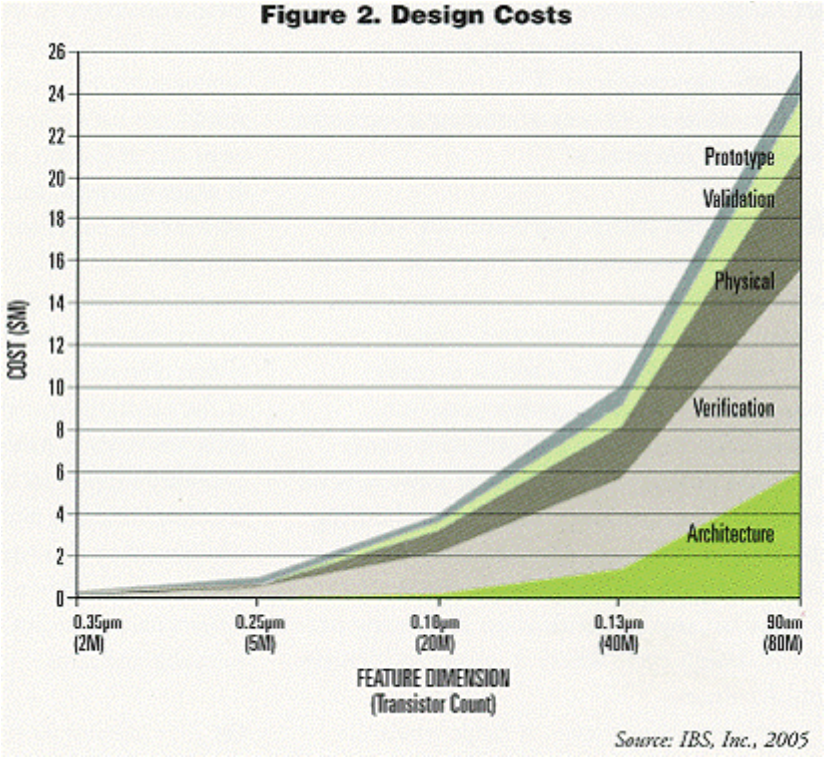
Over the past decade, escalating costs and remarkable technological advancement have dramatically reshaped the microelectronic industry worldwide. For example, the investment required for a next-generation semiconductor manufacturing plant is approaching $3 billion[2] as shown in Figure 3. Meanwhile, the average cost of developing a state-of-the-art System-on-a-Chip (SoC) now ranges from $20 to $50 million as shown in Figure 2 (see also Appendix F).

Figure 3



[2] Intel confirms $2.5 billion fab in China by Mike Clendenin, EE Times 03/26/2007

Figure 2. Design Costs



Source: IBS, Inc., 2005

At the same time, the 1965 prediction by Intel co-founder, Gordon Moore that "the number of transistors on a chip doubles about every two years" has proved true. Moore's Law has also meant that as silicon-based components and platform ingredients gain in performance, they become exponentially cheaper to produce. So, not only has the microelectronics industry become more cost-intensive, it has become more cost-sensitive as well.

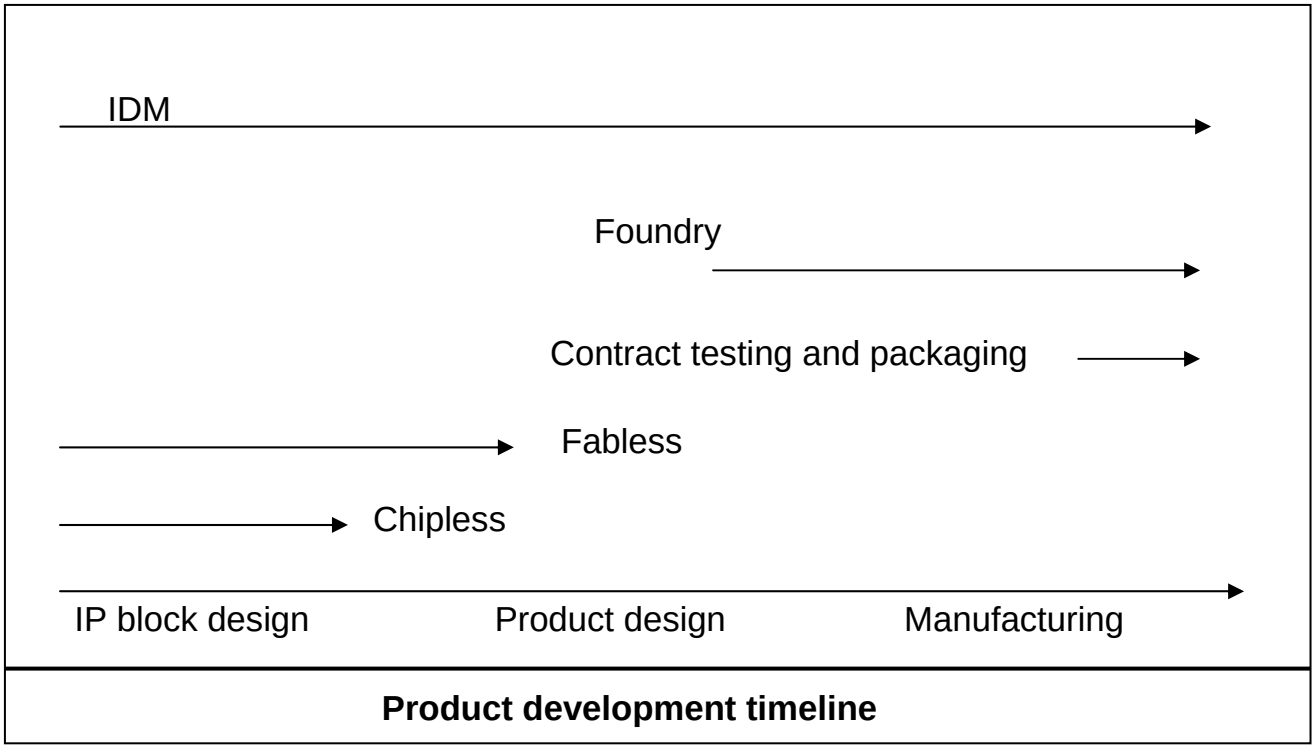
These trends have fundamentally changed the way microelectronics companies compete and operate. Originally, most microelectronic companies were integrated device manufacturers (IDM) or companies that performed all the design and manufacturing functions required to produce a typical semiconductor product. But today, there are now several different business models in the semiconductor industry supply chain (as illustrated in Figure 4). These include:

- Companies devoted solely to developing Semiconductor Intellectual Property (SIP), known as the "Chipless" business model;
- Companies that concentrate only on product design, referred to as the "Fabless" business model;
- Companies that offer contract semiconductor manufacturing to other companies, known as the Foundry business model ; and
- Companies that perform testing and packaging for other companies on a contract basis.

There are also variations of each of these business models. For example, IDMs, that outsource a significant portion of their manufacturing, are known as "Fab-light". Other companies focus only on creating and licensing Intellectual Property (IP) but while no single business model has an inherent economic advantage over the other business models, there is a trend for most companies to increasingly specialize in a particular technological market. For example, Cambridge, England's ARM is a world leading "chipless" company in the embedded systems market. ATI of Markham, Ontario (now acquired by AMD) is a "fabless" world leader in computer graphics and multi-media processing with more $2 billion in revenue and over 2500 employees. And Intel, the world's largest semiconductor company, remains an Integrated Device Manufacturer or IDM, concentrating for the most part on PC technology.

In effect, the global microelectronics industry is no longer the preserve of a handful of global design and manufacturing giants. Instead, most microelectronics companies now serve a particular function in the industry's value chain and increasingly companies compete in distinct markets. As such, the degree of collaboration and cooperation among companies is growing on a global scale. Countries and regions seeking to compete in this fast moving and increasingly competitive industry must not only invest in research and development, they must also concentrate on attracting and building companies across as much of the value chain as possible (while acknowledging that the most capital intensive activity of building semiconductor manufacturing plants, as described above, will increasingly become centralised in just a few, key locations worldwide).

Figure 4. Semiconductor Supply Chain



Ontario's Potential in the Global Microelectronics Industry

According to the participants in this review, Ontario microelectronic companies have much to gain from competing and cooperating in global markets. For example, partnerships with U.S. based interests offer the opportunity to improve product marketing and sales. China offers both a vast market and lower cost manufacturing. India offers access to lower cost Research and Development (R&D).[3]

In Ontario, most new start-ups are following the "chipless" and patent licensing business models. This is not surprising since the capital available to Canadian companies is typically less than ten percent of the capital available to U.S.-based companies. While there is great value in creating semiconductor intellectual property, this is only one aspect of a successful cluster. There are other opportunities in emerging areas such as nano-technology. If we can capitalise on the growing need for microelectronics in other sectors, we can fund more companies across the value chain. The growing proliferation of microelectronics in other sectors, such as health care, automotive as well as forestry, mining and agriculture, also present important opportunities.

Above all, with the proliferation of microelectronics into a variety of other technologies, the industry is an enabling one, generating revenues and jobs throughout Ontario's economy. Underlying microelectronics capabilities can also extend into nanotechnology and MEMS activities. If Ontario had a microelectronic industry growth strategy more closely integrated with other sectoral growth strategies, the microelectronics sector could play an important part in securing their success.

However, given the changing dynamics of the industry worldwide, there are several key possibilities for growth strategies. These include:

- Building microelectronic clusters around the existing capabilities of Ontario's market-leading microelectronics companies in their supply chains and engaging the university research to help build the "critical mass" necessary to attract and retain the people, companies and investment necessary to be value-delivering and sustainable.

- Exploiting the opportunities to develop and commercialize microelectronic technologies for sectors where microelectronic technologies are driving innovation and creating new markets. For example, the convergence of the capabilities and technologies found in PCs,handheld devices and TVs into new consumer devices presents an excellent opportunity for companies such as RIM and AMD to work with universities and other, smaller companies to help develop the technologies for these devices of the future.

- Accelerating the development of world-class IP-based solutions by microelectronics operations in Ontario by enabling the private sector to own and take advantage of the Intellectual Property (IP) it develops in partnership with government, public institutions and universities.

These issues are discussed in more detail on the following pages.

[3] see also Appendix E: Countries of choice for Canadian Companies to invest

Building clusters with "critical mass"

To generate economic advantage now and for successive generations of products and technologies, Ontario must build "clusters with critical mass" or clusters capable of attracting and retaining the highly skilled people, valuable intellectual property and robust companies that will ensure Ontario's microelectronics industry becomes significant on a global scale.

Due to the foresight of both government and industry leaders, Ontario has already established important microelectronics clusters in Ottawa, Toronto and southern Ontario. These clusters exist today because the government invested in university faculty and the creation of Centres of Excellence in the late 1970s and early 1980s, like the Canadian Microelectronics Corporation (now CMC Microsystems), and MicroNet. Serving as a focal point for collaboration among both private and public interests, these centres enable participating companies to provide a global business context for the work of university researchers and government laboratories. They also allow industry, government and academia to work together in setting meaningful short-term and long-term goals for technology innovation and development.

Ontario's microelectronics clusters provide employment and a strong source of innovative capacity for the province. But in comparison with other major microelectronics centres they are relatively small and relatively weak. Smart customers are at the heart of any cluster. An emerging company, such as Galazar for example, benefits from its access to a large customer such as Alcatel-Lucent in the Ottawa cluster. Sometimes these anchors are obvious. RIM and AMD, for example, play a central role in southern Ontario. But sometimes they are not. There is, for example, no major medical services or equipment vendor based in the province. But the province itself controls a large investment in healthcare delivery. The automotive industry is, with a few exceptions, composed of few large firms. However, their concentration in Ontario suggests that this activity might be aggregated to anchor a cluster.

A second area of concern lies in the degree of interaction among industry stakeholders. At the 12th Executive Forum on Microelectronics, held in Toronto on November 29 and 30, 2006, industry leaders recognised that the geographical scope of a cluster has a direct bearing on the extent of the multilevel collaborations that take place within the cluster. For example, when a cluster is located within a geographically small area, interactions are usually common at the working levels. However, when a cluster's member organizations are spread over a geographically large area, then the interactions are invariably limited to senior management. Consequently, working level interactions must be more carefully orchestrated to be successful. For example, the time and distance between AMD in Toronto and universities beyond the Toronto/Waterloo area has been cited as a significant barrier to interaction. Therefore, as the participants in this study pointed out, it only makes common sense to build on the strengths of Ontario's existing clusters in Ottawa, Toronto and southern Ontario and to think carefully about new cluster possibilities.

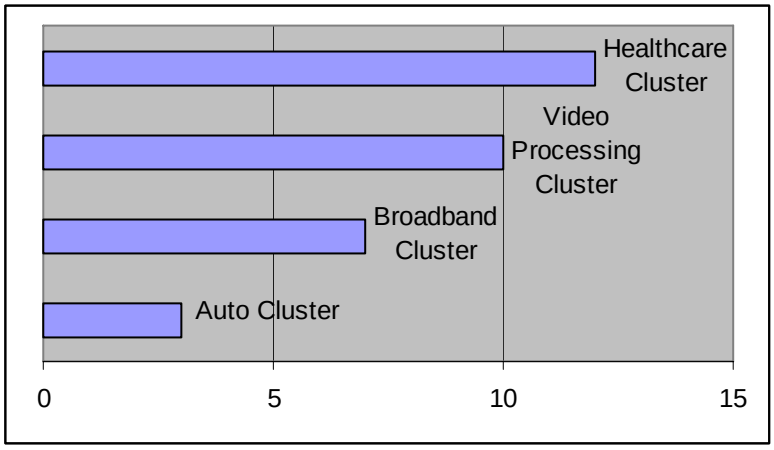
However, another potential opportunity exists in Kingston, where Canadian Microsystems Corporation (CMC) is based. It provides infrastructure to the university community across Canada. In recent years, it has also broadened its scope from being a supplier of design and prototyping capability in semiconductor and microelectronics technologies to a supplier for MEMS (micro-electro-mechanical systems). Although the bulk of Canadian MEMS research and development is now taking place outside of Ontario, Ontario could build on its existing capacity and thereby reap the rewards of already significant investments of between $500 million to $1 billion. However, the gap to the creation of a sustainable cluster is greater in Kingston than in Ottawa or GTA.

Exploiting new and emerging opportunities with other sectors

Microelectronics technologies have emerged as a crucial part of the technological foundations of many different industries. In other words, microelectronic components are no longer just general purpose, but often designed and built for a specific purpose in a distinct market. They have evolved from standard products or building blocks into full system-on-chip products, which are application-specific.

With this evolution, new opportunities to exploit microelectronics are rapidly growing. The participants in this review believe that Ontario is home to other important clusters, which are ripe for greater microelectronic innovation. These sectors are identified in Figure 5, within the context of overall support for formalising existing, emerging clusters where the horizontal axis shows number of stakeholders "voting" for greater interaction with each sector.

Figure 5. Potential Thematic Clusters



The sectors providing the most notable opportunities for microelectronic development in Ontario include the healthcare sector and the automotive sector. It should be noted that this Figure captures the feedback of a "straw poll" of the participants in this process. More detailed economic analysis of their potential is clearly required.

Intensifying the focus on world-class commercialization

The overriding opinion of the participants questioned for this review is that the current model under which governments, academia and companies collaborate to conduct R&D has not "got the job done" in terms of creating profitable businesses.

One of the key issues is that Intellectual Property (IP) is shared or owned outright by the university or government agency involved in the technology development project. This inhibits corporate growth since the companies involved cannot commercially exploit the IP they helped to develop. The Ontario Ministry of Research and Innovation raised this issue in its December 2006 Strategic Plan and committed to address it:

> Going forward, the Ministry will require that publicly sponsored research organizations manage intellectual property in ways that support Ontario's long term innovation goals. Institutions will need to show clearly how they plan to make IP more readily available to the commercial sector; provide incentives to inventors to identify, protect and commercialize IP; ensure very low barriers to rapid exploitation of IP; and provide access for companies that develop IP in Ontario.[4]

ITAC has expressed its support for this approach. There are "best practice" models for IP management already existent in Ontario. If we can use them to guide us as we follow through on MRI's ambition, then we can create an IP regime in the province that competitively differentiates it and makes the province a more attractive location for R&D collaboration and investment.

Many participants also expressed deep concern about the general lack of desire to excel among the players, both public and private, in Ontario's microelectronics industry. It's not clear who has responsibility for the formation of a strong culture of commerce and innovation. Industry clearly must create models to emulate. But governments too have a role to play in leading the celebration of business achievements. Programs, such as the Premier's Catalyst Awards, all contribute toward a higher appreciation of innovation-driven enterprises. For example, many experienced research and business people are leaving the industry, retiring or bootstrapping their own ventures. But few are creating new venture-capital funded companies.

Overall, the participants felt that the emphasis on investing in research, as recommended in the 1999 Strategy document, is no longer appropriate given the rapidly changing nature of the microelectronics industry and the new opportunities on the horizon. Rather, the emphasis should now be placed on "development", with governments and companies concentrating on the successful identification and exploitation of viable business opportunities.

To encourage companies to invest in product definition and the development of new products, the current tax incentive system must change. For example, the federal government's Scientific Research and Experimental Development (SR&ED) Program should advance successful commercialisation by supporting related "market development" activities, all the way from the research and development phases through to "mass production".

We also need to recognize the importance of maintaining headquarters operations in Canada. The only new HQ's we'll get are the ones of companies that start here. The broader business decisions which control the destiny of business units and their related engineering teams are made at the

[4] Ministry of Research and Innovation, Strategic Plan, December 2006, pages 11-12.

headquarters level. This develops a vital cadre of talented executives skilled in all dimensions of the management of an innovation driven enterprise. This talent pool is particularly thin in Canada and this is often cited as a limit to the growth potential of technology companies here. Quite simply, we need to ensure a robust innovation ecosystem (including a broad array of financing options) to encourage companies to grow in Canada.

There are a number of other structured issues in our innovation ecosystem that require adjustment to foster the growth of microelectronics and the tech sector generally. A key issue is ensuring that Ontario continues to be a competitive jurisdiction for investment for the performance of R&D. The SR&ED credit program needs reform (and is currently the subject of a federal review process) in order to ensure that all R&D investors have access to their credits. U.S. dollar parity is imposing new pressures on R&D activities by making Canada one of the highest cost jurisdictions for the conduct of R&D in the world. This puts our ability to retain and grow foreign investment in jeopardy. It also prompts domestic R&D performers to consider lower cost jurisdictions themselves (see Appendix E for most targeted countries). Ontario needs to be alert to these pressures and agile enough to design long and short term remedies (such as a temporary enhancement of its own research and development credit) in order to ensure that we retain Ontario's strong R&D base. Research and development is a highly mobile activity. Once it leaves a jurisdiction, it's very hard to get it back.

One felicitous arrival in Ontario's innovation ecosystem is an emerging capacity for effective collaboration to produce commercial outcomes through microelectronics institutions like CMC and the former Micronet. Other new centres of excellence in other knowledge-based endeavours show considerable promise. They should be examined closely for best practices and emulated to help anchor new clusters of activity. We have an excellent base but a new effort is required to catalyse growth in the sector.

Recommendations

The discussions upon which this paper is based were wide ranging, reflecting the diverse experiences and market orientation of a group of highly opinionated industry leaders. Nevertheless, some key common threads linked many of the discussions. These key themes included a general recognition of the importance of cluster formation/intensification and the need to build Canadian microelectronics companies to achieve critical mass and global, commercial leadership.

Based on the foregoing issues and opportunities, the following are the broad recommendations that emerged from discussions with the participants in this review.

1. Establish a Broadband centre of excellence in Ottawa

At the 2006 Executive Forum on Microelectronics, it became clear that the time was right for a major new initiative in Ottawa's telecom cluster – a Broadband centre of excellence focused on wired and wireless broadband technology. This centre would bring together the assets of Ottawa's microelectronic companies, the Communications Research Centre's Broadband Applications Laboratory, the National Research Centre Laboratories and OCRI.

Significant interest already exists in building this centre of excellence. For example, a major U.S.-based manufacturer, seeking to capitalize on the expertise of Ottawa's microelectronic scientists and companies, is exploring the establishment of a major new analogue design centre in the National Capital Region.

Another important correlative opportunity lies in the potential creation of an "Ottawa Security Centre". This would recognize the vital role trust and security plays in the expansion of the broadband market and take advantage of the growing worldwide market in encryption and data security technologies. Although significant effort would be required to reach critical mass in this emerging market, several fundamental cluster attributes already exist in Ottawa. These include world-class encryption expertise, a related government department, and a core group of start-up companies.

2. Establish a Multi-Media Processing centre of excellence with a focus on converged consumer devices in Ontario's Golden Triangle

Ontario's Golden Triangle Region has become home to a vibrant core of microelectronic companies specializing in advanced video and multi-media processing technologies. The anchor of much of this activity is the phenomenal rise of ATI. With its roots tracing back to the Ontario Centre of Microelectronics established by the Electrical Engineering faculty at the University of Toronto in the early 1980s, ATI became a world class computer graphics company. ATI also achieved leadership in the market for multi-media processors for cell phones and other handheld devices as well as for DTV chips and for the graphics chips in the burgeoning world of game consoles. This leadership propelled ATI into the rare position of growing from start-up to multi-billion dollar global centerpiece in a relatively short expanse of time.

In addition, Ontario's Golden Triangle Region is home to Dalsa, based in Waterloo, and Gennum Corp, based in Burlington, two well-established video processing technology companies. Now that ATI has been acquired by AMD, Ontario not only has world leading capability in graphics design for personal and mobile computing platforms, it is also now tied to one of the two largest computer chip companies in the world. The result is significant opportunities to attract design activities for next

generation devices integrating the graphics, microprocessor and core-logic functions of the computer. In addition to this core, the Golden Triangle also benefits from access to a central feature in cluster building – the presence of a smart customer. The Toronto area is the undisputed focal point for Canada's media (both 'old' and 'new') industry. As such, it is home to major broadcasting technology R&D centres which can drive innovation and excellence in their supply chains. Canadian microelectronics companies in the area already produce Emmy-award winning products for the media industry. Public investment to give this activity additional leverage and focus would be timely.

As a result, we believe there is a huge opportunity to establish a Centre of Excellence in Video and Multi-Media Processing in Ontario's Golden Triangle, which would invest in:

- Research at the University of Toronto, the University of Waterloo and McMaster University;
- Low-power design and testing facilities and resources;
- Shared facilities for research, product design and Design for Manufacture (DFM) testing (similar to the CMC shared testing facilities in Toronto and the opto-electronics facilities in Kingston);
- A hardware investment in a shared facility for sub-micron fault analysis which would ensure ready, local access to an important, time critical capability.

A significant opportunity also exists for these companies to partner with system-level developers such as RIM in the innovation related to the converged consumer devices of the future, which will combine the functions of PCs, handheld devices and TVs.

Many established and emerging companies in the area would benefit from this investment and focus. Besides those already mentioned, these include Christie Displays, IMAX, Harris, Evertz, Silicon Optics, VIXS, Genesis and Fresco. Combined efforts of industry, academia and Government to strengthen this cluster would likely also attract investments from other leaders in video processing into the area.

3. Build an Automotive centre of excellence (including Microelectronics)

Several of the participants in this study felt that Ontario's wealth of activity in the automotive industry should present opportunities for Ontario microelectronics companies, but so far these opportunities have not emerged. Yet microelectronics plays a huge role in the creation of the 21st century automobile. The value of microelectronics in the modern car already surpasses that of its steel. The importance of microelectronics is expected to continue to grow as new innovations, such as active collision avoidance systems, proliferate.

Government leadership in the creation of a focal point for an automotive centre of excellence might play a useful role in breaking down the silos between the two industries to the benefit of both. This might initially take the form of a sponsored dialogue between microelectronics and automotive. This might lead to an array of possible collaborations from a formal centre of excellence in automotive electronics to more "viral" bilateral collaborations.

The resulting partnerships could spur the creation of a new growth industry in Ontario. The Centre could also ultimately attract additional car manufacturing companies and encourage existing companies to locate technology centres in Ontario.

4. Build a Healthcare Technology centre of excellence (including Microelectronics)

There are a plethora of new and exciting innovations that a Healthcare Technology Centre of Excellence based in Ontario could develop to speed the introduction of new applications that both reduce costs and improve patient care in the healthcare sector.

For example, the cost of today's diagnostic technology could be significantly reduced with a new generation of smaller and less expensive machines, based on microelectronic technology. With its existing expertise in encryption and security technologies, Ontario could also spearhead the development of centralized electronic health records and new biometric-based identification tools. There are many Ontario-based companies that would welcome the opportunity to collaborate in a microelectronics-for-health venture. These include Zarlink and Gennum. There are also many potential customers including Abbott Labs, G.E. Medical and Siemens who are active participants in Ontario's innovation ecosystem and could benefit from this opportunity.

In the same way that the Canadian telecom industry defined world standards (which were consistent with those developed in Canada and, more importantly from a commercial standpoint with those in the United States), many participants in this review also felt that Ontario faces a similar opportunity with respect to defining world standards for health care technology such that products developed for the whole market could also be sold on a global basis.

The Ontario Government already plays a central role in healthcare delivery. It can additionally play a much larger role in driving innovation in all dimensions of the development of healthcare technology. By fostering research collaborations (whether through a formal Centre of Excellence or other means), Ontario has the potential to create new economic activity that will serve a national and global market. It will also, as the principal investor in healthcare delivery, benefit from the economies and efficiencies that new innovations will drive.

5. Create additional opportunities for intra-industry collaboration and promotion

To ensure the cross-pollination of ideas and ongoing cooperation among the different stakeholders in the microelectronics industry and other sectors, the participants in this review felt that the industry needs more events and conferences that bring government, academic and corporate representatives together. It is particularly important for companies to learn about the new technological frontiers being explored by government and university labs. These events should also make it easier for companies to understand how to access available technology and provide opportunities to discuss public/private partnerships.

In addition to these networking and education events, it is essential to promote the achievements of all the players in Ontario's microelectronics clusters to the broader public and government. The successes of the individual research organizations and companies also deserve more recognition and awareness.

6. Promote and provide resources for entrepreneurialism and corporate growth

In addition to encouraging research and development and promoting careers in the scientific and engineering fields, many participants felt that Ontario lacks professionals with strong business development skills. In fact, one of the CEOs interviewed for this review stated that his company

would only expand its marketing and business development functions outside of Ontario, due to the lack of highly qualified people in this area.

Overall, some participants reported that there is a crisis emerging in Ontario with respect to developing or recruiting senior people with a strong entrepreneurial bent due to Ontario's high income tax rates. While many Ontario business people accept the current regime, it is virtually impossible to attract new entrepreneurs and business developers.

ITAC's annual survey of compensation levels in the IT industry shows that employees, such as those who perform integrated circuit design engineering, earn an average of $150,000 Canadian. Salaries of this nature are commonplace in our industry and in many other knowledge-based sectors. Without a small army of employees with this level of skill, there would simply be no microelectronics or ICT industry in Canada and certainly no capacity for innovation.

Canada's highest marginal tax rate is currently applied on income over $120,879. In short, it applies to a large contingent of the engineers, business developers, marketers and scientists necessary to the viability of our industry. In California and Texas (two jurisdictions of highest interest for the ICT industry) the highest marginal rate only becomes applicable at $319,000.

The effect of this high tax rate is to impose a burden on knowledge-based employers who must increase base salaries significantly to make up the tax differential. This severely impairs their ability to attract and retain high value knowledge workers for their research and development activities. It also makes their ability to recruit highly qualified professional managers skilled in the operations of technology ventures problematic.

Provincial governments have the ability to address this problem. For example, in Quebec, returning business people are offered a two-year tax holiday. Ontario should also consider such a program for individuals with demonstrated business skills. In addition, immigrants with such skills should be fast-tracked and provided incentives to pursue their careers in Ontario.

Many of the participants in this report also feel that more can be done to support not only the research and development of new innovations, but also their commercialization. Many microelectronics companies and other technology firms have called for the expansion of SR&ED credits to cover expenses that fall outside the current definitions of R&D but are nevertheless essential to a successful product launch. These expenses include market research and cost associated with work with initial pre-market customers. Ontario has the latitude if it chooses to extend this kind of support with or without the cooperation of its federal partner in the SR&ED program.

All in all, a pro-business environment must be fostered within Ontario through more competitive tax rules and incentives.

7. Enable companies to own and exploit the IP they help to create

The corporate interests interviewed for this study all pointed to the vital need for a new approach to IP creation and ownership to further drive the commercialization and market success of new technological innovations.

Traditionally in academic or government R&D partnerships with companies in Canada, the IP is owned by the university or government lab or by the researchers and students. Moving forward, the participants in this review would like to explore a new model for industry/university or lab

partnerships. In this new model, companies would work together with university and government researchers to prioritize the research areas to be explored based on a proven market need. Then, all the IP generated within the program would be owned by the company for commercial exploitation. In this way, the university and government researchers would benefit by working in areas deemed important by industry. Furthermore, personal relationships would develop to facilitate future research and ease the transition of graduate students from academia into industry.

In the hugely competitive global knowledge-based economy, all jurisdictions seek key competitive differentiators that will attract investment. Arguably, the calibre of Ontario's workforce is one such differentiator. Another could be its progressive approach to intellectual property. Ontario already has several "best practice" examples of IP management (the University of Waterloo is one). Jurisdiction-wide emulation of these practices could give the province a key competitive asset. This would also address the aspirations for intellectual property management excellence that the Ministry of Research and Innovation strategy aspires to.

8. Encourage multinational organizations to invest in Ontario

While much of the Ontario microelectronics sector is "home grown", the acquisition of ATI by AMD suggests it can also provide attractive opportunities for multinational investment. The quality of Ontario's labour pool, its universities and research institutions, its stability and easy access to the United States have all made it attractive for other major technology players in telecommunications, software and other dimensions of technology. But if Ontario is to be fully competitive in attracting this investment, it must be cognizant of several impediments.

A big issue for foreign-owned multi-national organizations and even smaller companies that take U.S.-financing (MNOs) operating in Ontario and Canada is the current SR&ED program. Companies doing research in Ontario can earn these tax credits. Companies that are relatively small, Canadian-owned and private can earn a fully refundable tax credit of 35 per cent up to the first $2 million of their R&D expenses. Larger publicly traded Canadian companies qualify for a non-refundable investment tax credit of 20 per cent which takes the form of a deduction from corporate income taxes. For profitable Canadian subsidiaries of multinationals, the non-refundable tax credit is available, but, depending on the tax treaty involved, it produces no direct incentive to maintain or expand R&D activity in Canada. These credits reduce taxes payable in Canada but increase taxes payable by the parent company in its headquarters' jurisdiction, particularly the United States. This effectively produces a flow of tax credits from the Canadian fiscal system into the U.S. Treasury without producing any incentive at all.

The participants interviewed for this review believe that the R&D spending by foreign owned companies is just as important as that of domestic companies. Therefore, foreign owned companies should be equitably rewarded for their R&D investments in Ontario. If SR&ED could be reformed to deliver better value, these companies would have a greater incentive to expand their existing investment or to set up new operations in our province. Ontario's advocacy on reform of the federal SR&ED Program is vital. But in addition the province can re-examine its own credit program to help ensure our strong R&D base is protected.

Furthermore, the Canadian Bill 198, with it's different emphasis to the Sarbanes Oxley Act in the US, restricts the ability of smaller companies to compete. First, it makes Canadian directors personally liable, thus putting them at a disadvantage compared to US directors. Second, because of the additional costs associated with complying with these regulations, a company must be larger to access public funding. This makes it more attractive for a small company to seek acquisition rather than to seek an initial public offering. As a result, there seems to be a trend where small companies

are being bought, usually by larger foreign (mostly US) companies and their headquarters (with the related strategic control of all operations) do not remain in Ontario.

To attract more foreign owned companies to locate in Ontario, some observers in this review believe that:

- The Ontario government should more aggressively promote Ontario as less expensive than California, yet an equally high quality place to conduct research and to do business;
- There should be additional financial incentives to retain corporate headquarters in Ontario as well as policies that ease corporate acquisitions; and
- The Ontario government should promote the microelectronics industry to the financial community because Canadian high-tech companies remain significantly undervalued compared to their US counterparts. This could increase the Canadian stock price index and provide valuable investment opportunities for Canadian public companies to grow their businesses.

9. Encourage growth of early stage companies

The Ontario microelectronics ecosystem contains many early stage companies who, like the larger firms, must contend with the challenging economics of the modern microelectronics marketplace coping with the growing pains of any emerging technology venture.

Venture capital is a particular challenge for early stage companies. The loss of the LSIP program in Ontario left a large hole in early stage funding. As was noted in the Ministry of Research and Innovation's Strategic Plan "Ontario needs a dynamic and responsive capital market that can take a company from the early seed stage through to the formation of a large, globally competitive late stage company." With escalating costs, the reality in microelectronics of this imperative is particularly acute. The province must address the capital issue as it indicated it would in the MRI Strategic Plan if these emerging companies can enjoy any reasonable expectation of growth. Additionally any barriers to investment in Ontario-based companies by U.S.-based venture capitalists should be identified and eliminated.

Other measures may be adopted to foster the vigour of early stage companies. The SR&ED tax credit system is the single largest incentive for doing business in Ontario (and Canada). But for start-up companies, it is even more important because it provides cash refunds. Several of the start-up executives interviewed, reported that SR&ED cash refunds from Ontario were received many weeks later than those from the Federal Government. This delay is causing difficulties in terms of cash flow. It should be investigated. This seems like a relatively small administrative issue but improvement here could ensure the sustainability of an emerging company.

To be more competitive, the Ontario government should also adopt a system similar to Quebec where SR&ED tax rebates to start–up companies from the province and from the Federal government are treated separately and are cumulative.

The current emphasis on earlier stage "research" rather than later stage "development" has also caused problems for many Ontario start-ups. Many would like to see an extension of the current R&D credits to cover costs further down the pathway to commercialization. These may take the form of an expanded SR&ED program or an alternate Ontario specific program.

Generally, many participants noted that it is now imperative to align corporate and government priorities to create more start-up companies, which will produce the next generation's success stories.

Conclusion

Clearly, the visionary investments of governments in microelectronic R&D labs thirty years ago have proved to be very successful for the Ontario economy. Today, Ontario is home to a core of global microelectronic companies, which have generated jobs and wealth for the province. That same calibre of decisive foresight is required today to revitalize Ontario's microelectronics industry and bring it into its next stage of growth.

The industry is proud of its track record and of the high level of collaboration it has enjoyed with the Province of Ontario. We look forward to continuing this collaboration to create new opportunities for a new generation of researchers, entrepreneurs and companies in Ontario.

Appendix A: Corporate Participation

Company Name	Contact Name	Meeting date/status
Advanced Micro Devices, Inc.	Richard Brait	29th March
Cadence Design Systems Inc.	Nick Deeble	28th March
Chipworks Inc.	Terry Ludlow	5th April
DALSA Inc.	Brian Doody	10th April
Elliptic Semiconductor	Rick White Gord Harling	19th March By email
Freescale Semiconductor Inc.	Dino DiBernardo	3rd April
Fresco Microchip Inc.	Lance Greggain	3rd April
Galazar Networks Inc.	Richard DeBoer	13th April
Genesis Microchip Inc.	Paul Russo	n/a
Gennum Corporation	David Lynch	8th May
IDT Canada	Sab Ventola	30th March
MOSAID Technologies Inc.	George Cwynar	27th March
Semiconductor Insights Inc.	Edward Keyes	13th April
Sidense Corporation	Xerxes Wania	23rd March
Synopsys, Inc	Mario Dorio	10th April
Tundra Semiconductor Corporation	Daniel Hoste Adam Chowaniec	7th May 5th April
ViXS Systems Inc.	Sally Daub	3rd April
Zarlink Semiconductor Inc.	Kirk Mandy	22nd March

Not for Profit and prominent individuals:

Organization/Name	Contact Name	Meeting date/status
CMC Microsystems	Jim Roche	13th April
	Doug Barber	3rd April
	Tony Stansby	28th March
	Dick Foss	28th March
	Brian Barge	30th March

Appendix B: Interview Guide

Census Data

Name of company
Name of company CEO
Headquarters address
Number of years operating in Ontario
Company description (semiconductor company serving which markets)
Current size (employees, revenue)
Five year growth
Growth projection
Private, TEX, TSX or other listing

1. Why did your firm establish its operations in Ontario?
2. Does your company currently take advantage of any Ontario programs to encourage research and development activity, employment or foreign investment in the province?
3. Is your company working with any Ontario university or college in any research and development capacity?
4. Is your company working in collaboration with any Ontario Centre of Excellence?
5. How would you rate the publicly funded research (university, college and OEC) infrastructure in Ontario?
6. How would you rate the calibre of graduates Ontario academic institutions produce?
7. Is the supply of highly qualified people a problem for your company and, if it is a problem, can you suggest possible remedies?
8. Is your company currently employing personnel outside the province? If so, where and in what capacity? Why?
9. Is capital formation a problem for Ontario-based companies and how would you rate your company's ability to attract capital?
10. Is the current corporate tax structure in the province an impediment to growth?
11. Do the current personal income tax rates present a challenge to the recruitment and retention of highly qualified people?
12. Are SR&ED tax credits a competitive incentive for location R&D activities in Ontario?
13. Do you think the microelectronics industry in Ontario will shrink or grow over the next decade and in what industrial markets do you anticipate growth?
14. What can the Ontario Government do to stimulate growth in the microelectronics sector?

Appendix C: Strategy for Microelectronics in Canada Executive Summary (1999)

Microelectronics, comprising semiconductors, hybrids and modules, is a fundamental enabling technology for value creation across the global economy. The 30% annual reductions in costs of semiconductor integrated circuits (ICs), sustained for over twenty years, have made electronics a major engine of global wealth and job creation, fuelling an ever-expanding stream of affordable new products and applications from cell phones and camcorders to medical instruments and computers. This document presents a strategy for Canada to secure its full share of the economic benefits of electronic and microelectronic technology.

The goal for microelectronics is to grow from its current 0.4% of GDP to a level comparable to that of other advanced economies. The U.S. semiconductor sector, for example, is forecast to account for over 2% of U.S. GDP by 2005. For the Canadian sector this would translate to growing from $4 billion in 1998 to a 2005 level of $22 billion.

Of equal importance to the direct revenue contribution of microelectronics are the much larger revenues from the electronic products and systems that microelectronics enable. Depending on the degree of integration with other sectoral growth strategies, our microelectronics sector could underpin a domestic microelectronics-enabled industrial base in excess of $100 billion.

Over the past five years, the search for ever-smaller, cheaper and more capable semiconductor devices has profoundly changed the structure of the global microelectronics industry to Canada's advantage. Rapid growth of the fabless integrated circuit design business and the emergence of “Systems on a Chip” (SoC) technology both offer enormous potential for Canada to capitalize on its established strengths in microelectronics design. Canada's microelectronics capability already extends far beyond its early roots in telecommunications, and is now capable of facilitating growth in such diverse sectors as automotive, aerospace and medical instrumentation.

Three strategic thrusts, technology, finance and human resources, are key to achieving the enabling potential of microelectronics. In each, success depends on mobilizing broad-based support from a host of stakeholders in governments, the educational community and industry. Human resources, and the immediate need for faculty re-building, are the highest priority.

In technology, pressures of time-to-market and emerging SoC technology demand closer customer/supplier linkages, favouring co-location of the OEM user, the design team and the manufacturing facilities. Hence, there is a need for all elements of the value chain to exist in Canada. The lack of large-scale semiconductor manufacturing in Canada can best be addressed by attracting foreign manufacturing companies having the required technology. Historical weaknesses in advanced product manufacturing have been substantially reduced by the emergence of a multi-billion dollar world-class contract manufacturing industry. Other links of the value chain are well established.

In financing, our Canadian system must become more supportive of new start-ups. Also, effort must be made to maximize allowable use of our excellent R&D tax credit system, to take into account the differing situations of established companies and start-ups.

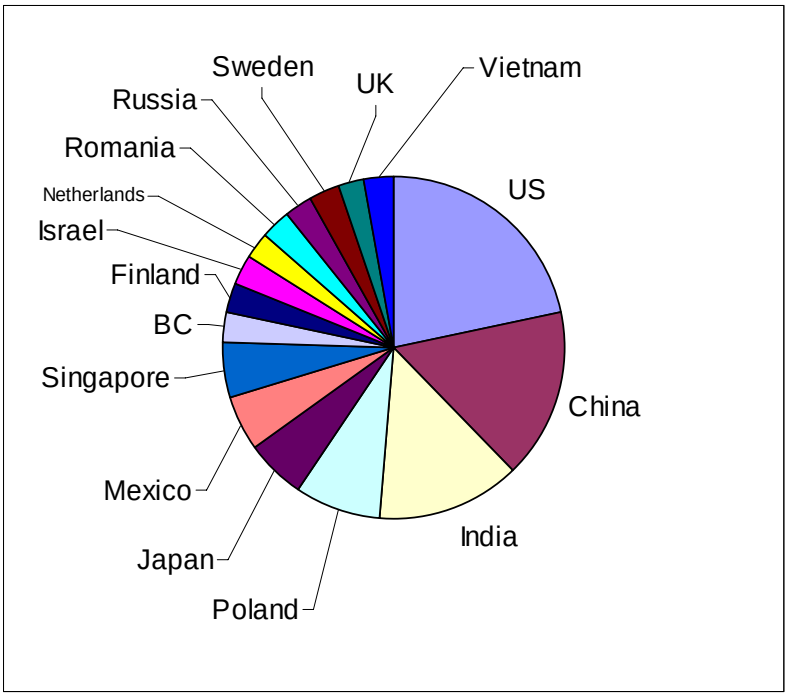
In human resources, lack of a sufficient and sustained supply of well-trained people is the most serious barrier to rapid growth. Our educational system currently supplies less than half the numbers needed for the microelectronics sector to realize its full growth potential, and more still are needed to increase microelectronics awareness in OEM sectors. Canada’s educational initiatives in

microelectronics must cover the waterfront, from high schools through to college, university and continuing education programs.

The other essential item in a sustainable growth strategy is the expansion of the national support infrastructure to keep pace with industry growth, to stimulate entrepreneurial activity both in microelectronics and applications sectors, and to attract foreign companies to broaden our existing industry base. Organizations like Micronet and the Canadian Microelectronics Corporation (CMC) in particular, play vital roles in linking industry's future knowledge directions and human resource needs to the educational and research communities.

In reviewing the success of the automobile industry in Ontario, it is clear that government incentives do matter, especially in the manufacturing sector. As such, there is a clear opportunity to repeat the past, much smaller (than the automotive sector) investments in telecom related microelectronics, but on a much more significant scale.

Appendix D: Countries of Choice for Canadian Companies to Invest



Appendix E: Design Costs

Source: IBS Inc as referenced in the FSA Forum March 2006 Quarterly report.

The associated table shows the size of the design teams required.

Table 2. Design Composition

	0.18µm (5M gates)			0.13µm (10M gates)			90nm (20M gates)			65nm* (40M gates)		
	Design engineering head count		EDA tool exp	Design engineering head count		EDA tool exp	Design engineering head count		EDA tool exp	Design engineering head count		EDA tool exp
	No.	%	%	No.	%	%	No.	%	%	No.	%	%
Architecture and Project Mgmt.	3	10.0	2.0	8	13.3	3.0	29	20.4	4.0	66	21.2	?
Specification to RTL	3	10.0	3.0	9	15.0	5.0	26	18.3	7.0	58	18.7	?
Functional Verification	13	43.3	52.0	22	36.7	50.0	42	29.6	47.0	88	28.4	?
Physical Design	9	30.0	42.0	16	26.7	39.0	28	19.7	36.0	58	18.5	?
Post-GDS II	2	6.7	1.0	5	8.3	3.0	17	12.0	6.0	41	13.2	?
Subtotal Hardware	30	100.0	100.0	60	100.0	100.0	142	100.0	100.0	311	100.0	?
Software	18	37.5		54	47.4		170	54.5		390	55.6	
TOTAL	48	100.0		114	100.0		312	100.0		701	100.0	

* Estimate

Source: IBS, Inc., 2005

NB. These numbers are for larger corporations. Smaller companies tend to manage designs at much lower costs and lower headcounts.