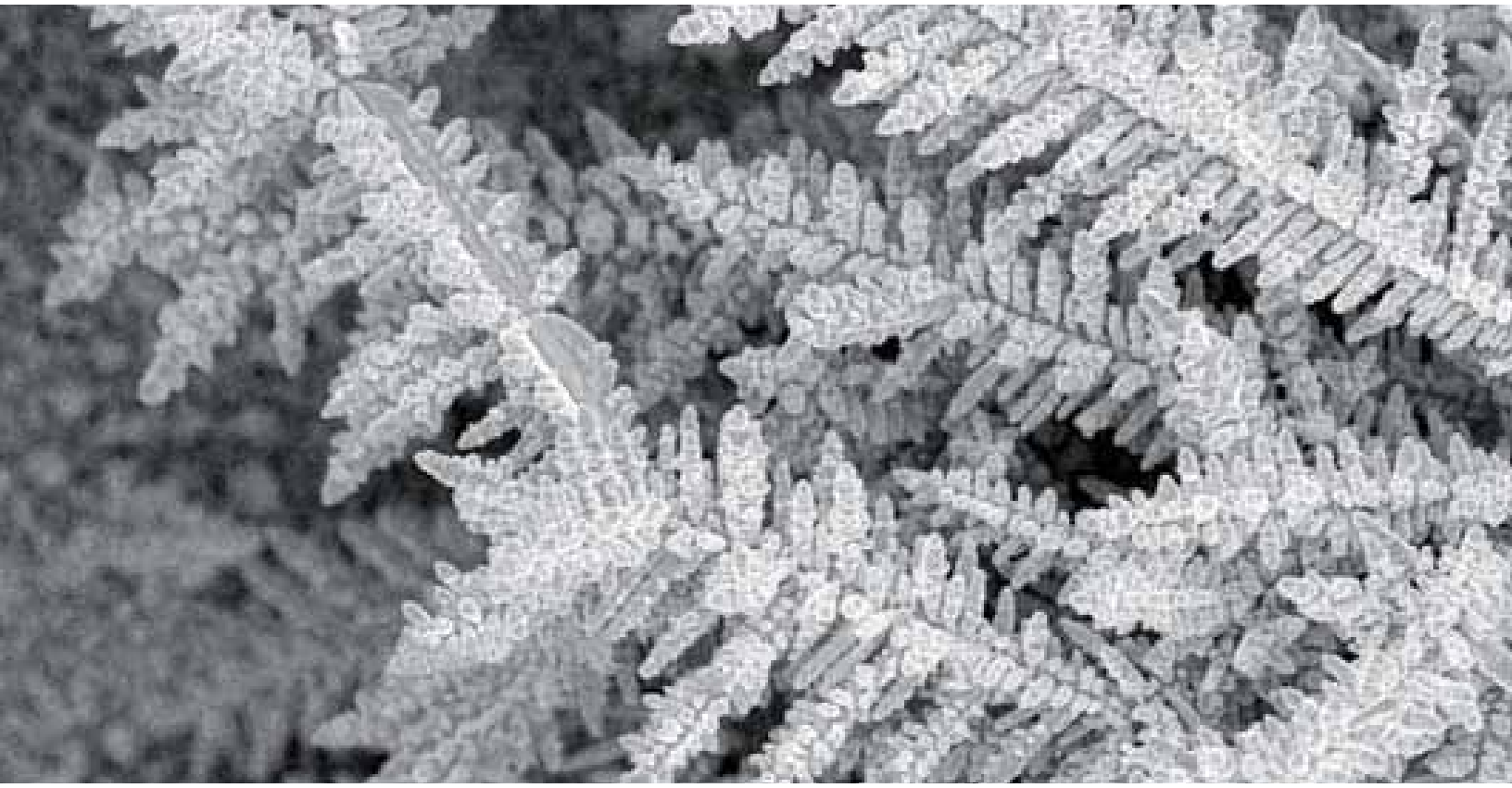
Alberta Nanotechnology Strategy

Unleashing Alberta's *Potential*



When asked what he would do today if he were to start another business from his university dorm? "*Nanotechnology*".

Michael Dell, Chairman
Dell Computer Corporation

When asked what growth business he would start from scratch today? "*Nanotechnology*".

Jeff Bezos, CEO
Amazon.com

ALBERTA ADVANCED EDUCATION AND TECHNOLOGY CATALOGUING IN PUBLICATION DATA

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Unleashing Alberta's *Potential*

Alberta's success in applying science, research and technology has put the province at the forefront in energy, forestry, agriculture and medical advances.

The province leads Canada in most economic indicators, including growth, employment, productivity, average family income and standard of living.

To continue to prosper, Albertans must fully participate in the opportunities that nanotechnology offers, as Alberta's primary industries will need to embrace nanotechnology applications to remain on the leading edge and stay competitive.

Encouraging the development of new businesses involved in nanotechnology will help to ensure that Alberta is competitive in global markets and provides high quality jobs for future generations.

Vision & Mission

The vision for Alberta in nanotechnology is that:

Alberta will be a leading contributor in placing Canada amongst the top five nations in the world by helping it produce 10 per cent of the world's nanotechnology based economic activity.

Alberta's mission is that:

By 2020, Alberta will achieve a two per cent share of the global nanotechnology market – generating an estimated $20 billion of new economic activity – by developing nano enabled products and applications specific to industries in the energy and environment, health and medical technologies, and agriculture and forestry sectors.

Meeting the Priorities of Albertans

Albertans expect their government to support a framework for success. To do so, government is providing tools to meet the demands of the 21st century knowledge-driven economy, such as research, innovation and support for development of new technologies and processes.

They expect their government to provide the infrastructure needed for growth and prosperity, and also to protect the environment, so that there is safe water, air and land today and tomorrow.

Good health is a priority for Albertans. So is a healthy environment and a healthy, knowledge-based economy. Advancing nanotechnology in Alberta will help meet these goals.

Today's Opportunities, Tomorrow's Promise lays out a course for Alberta for the next 20 years to ensure continuing prosperity.

The four strategic pillars are:

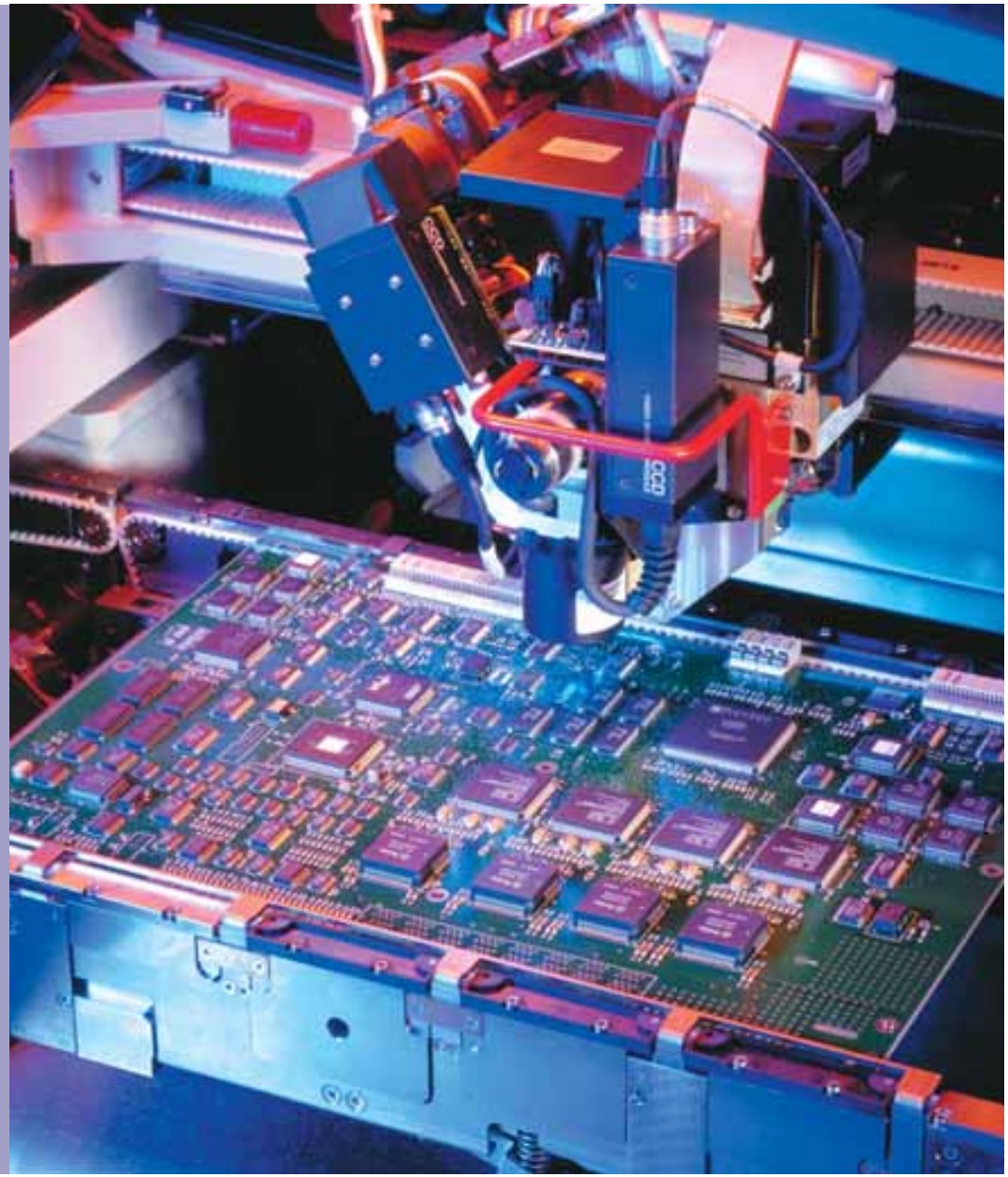
- unleashing innovation
- leading in learning
- competing in the global marketplace
- making Alberta the best place to live, work and visit.

Providing a place to exchange ideas with other world-class nano experts will keep the province at the forefront of both nanotechnology research and industry growth.

This nanotechnology strategy complements the province's long range plans for growth of a knowledge-based economy. It also reflects the opportunities that nanotechnology provides to meet the objectives of the *Accelerating Innovation in Alberta* strategy, the *Water for Life* strategy, and the energy, information and communications technology (ICT) and life sciences strategies.

Nano – *What is it?*

In nature, nanoscale design, techniques and principles are responsible for phenomena such as a gecko's ability to walk upside down on any surface - due to nano hairs on its feet called spatulae. The regeneration of broken human bones is an example of nature's self-assembling nanoscale structural processes. Depending on their size, gold nanoparticles are responsible for the red, blue or gold colours in stained glass in medieval cathedrals and modern art glass.



While nanoscale is not new in nature, in areas such as engineering, physics, chemistry, mathematics and biology, the deliberate engineering of materials at the nanoscale – nanotechnology – is new.

Nanotechnology research, such as that undertaken at the National Institute for Nanotechnology (NINT) in Edmonton, Alberta, explores the unique properties of biological structures and engineered materials at an atomic and molecular scale to find out how changing the structure, size or chemical composition creates an improved or significantly different and beneficial application.

To be a world leader in unlocking the secrets of nanoscale particles, Alberta needs to attract the best and brightest in many disciplines, from our home-grown students to world renowned researchers. As the home of NINT, and an emerging nano- and micro-electromechanical systems (NEMS/MEMS) industry, Alberta is strongly positioned and is quickly becoming an international centre of excellence for nanotechnology. Working together, NINT and the University of Alberta are attracting leading experts from various nano specializations around the world and linking them together into one multi-disciplinary research system. Developing this critical mass is providing the optimal conditions for discovery and for speeding up the cycle of innovation.

To take advantage of the province's traditional economic strengths, the Alberta Nanotechnology Strategy focuses on improving the products and processes which have already established Alberta as a global competitor.

The prefix "nano" is used in the metric system to refer to "billionth"; a nanometre (nm) is one-billionth of a metre.

For example:

- Normal office paper is about 100,000 nm thick.
- A human hair is about 50,000 nm wide.
- A drop of blood contains 5 million red blood cells - the diameter of one red blood cell is 2500 nm.

Where Science & Industry *Converge*

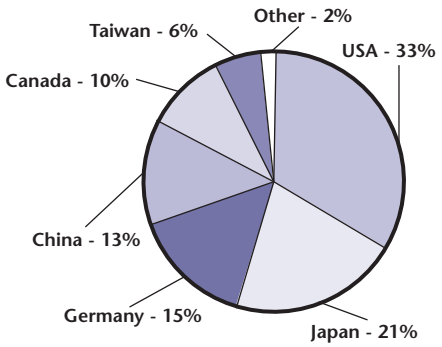
At nanoscale, medicine, engineering, physics, chemistry, biology and other disciplines overlap, making collaboration on common challenges possible.

By 2020, structural materials and composites, packaging and protective materials, devices and sensors and modeling software are expected to evolve as the largest sub-sectors of nanotechnology. Beyond 2020, it is anticipated that agriculture, biotechnology, health and medical, and information technology applications will flourish.

Global Nanotechnology Market

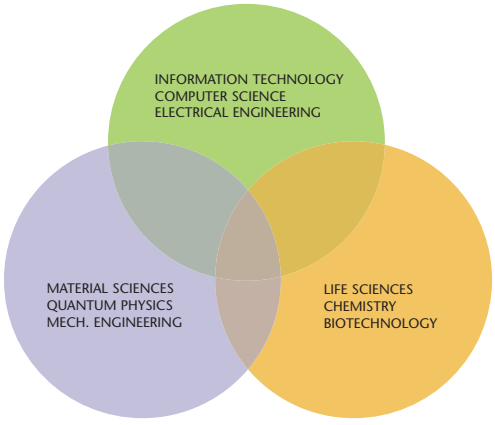
(US $1 trillion by 2020)

Based on current investment and patent information, it is anticipated that the global nanotechnology market will be dominated by the United States, Japan, Germany and China, with the potential of Canada building to a 10 per cent share worth an estimated $100 billion by 2020.



Source: Projected from RNCOS market share, expenditure, and patent data - 2005

Technology Convergence at the Molecular Level



Nanotechnology is not an industry unto itself; rather, a series of advanced technologies that can greatly improve products and processes in existing industries and, through the convergence with information technology, biotechnology and other technologies, has the potential to create entirely new industries.

Benefits to *Albertans*

The ability to control the layering of atoms has Alberta nano experts exploring interdisciplinary applications such as using magnetic charges to separate contaminants from water or to control the growth of metals on semiconductors for faster, more secure applications.

The Alberta Nanotechnology Strategy builds on the province's investments in infrastructure and people to help Alberta compete at a global level.

The strategy offers a blueprint to maximize the potential of nanotechnology to expand Alberta's leading sectors, increase value-added activity and create new areas of economic diversity.

This approach to advancing nanotechnology in Alberta will produce significant gains for the province. The most significant gains are anticipated in the areas of:

- Energy and Environment
- Health and Medical Technologies
- Agriculture and Forestry

The strategy focuses on solving major global challenges that have specific relevance in Alberta.

The strategy enhances the commercialization potential of our investment in research across disciplines.

The strategy attracts the brightest minds and builds a province of researchers, innovators, entrepreneurs and leaders.

The strategy places Alberta, and Canada, at the forefront of innovation and as a leader in using science to solve global challenges.

The materials and devices developed by Alberta's 'nanoelectronic' experts are expected to lead to smaller, smarter and speedier circuits for entertainment, communications and medical applications.

Source: Masato Aizawa/Jillian Buriak

The Alberta Nanotechnology *Strategy*

By 2005, about 120 Canadian companies were involved in nanotechnology development.

Alberta, with its improving research infrastructure, has been a significant contributor to the nanotechnology agenda across the country and is increasingly recognized as an emerging nanotechnology centre of excellence.

The Alberta Nanotechnology Strategy opens opportunities to accelerate the cycle of innovation. It creates the foundation for an Alberta nanotechnology community through strong collaborations between industry, academia and government.

The following strategies are proposed to accomplish the vision and achieve the mission for successful nanotechnology development in Alberta.

Strategy *One*

Grow and develop a new generation of businesses and entrepreneurs that commercialize nanotechnology solutions

Collaborate with industry to determine effective approaches to develop nanotechnology applications in identified priority sectors: energy and environment; health and medical technologies; agriculture and forestry.

Create an Industrial Applied Research Partnership Program to fund nanotechnology research initiatives jointly with industry.

Establish programs to engage students from technical institutions in technology development with NINT and universities.

Create a Nano Entrepreneur Program to mentor and train nanotechnology experts in business principles, help inform business people interested in nanotechnology ventures, and to advise them on the market potential and opportunities for their new nanotechnology products and processes.

Build a Nano Entrepreneurs Club that would bring together innovators and investors to build partnerships, share experiences and identify gaps in the Alberta system.

Establish an annual Alberta Nano Venture Prize to be awarded to a start-up company with a solid business case, and a demonstrated nano related technology focused on Alberta's priorities that would be prototyped and manufactured in Alberta facilities.

Theoretically, carbon nanotubes are 100 times stronger than steel yet have only one sixth the weight. Adding carbon nanotubes to materials like plastic, ceramics and metals may one day make such materials stronger, harder and longer lasting.

Source: Yuan Gao/Jillian Buriak

Strategy *Two*

Nano structured coatings and nano engineered surface treatments are improving the performance of thousands of medical implants annually, including orthopedic prosthetics, medical catheters, and cardiovascular grafts.

Build, attract and retain world-class, quality talent

Establish a graduate student scholarship program for basic and applied nanotechnology research in Alberta's priority sectors: Energy and Environment; Health and Medical Technologies; and Agriculture and Forestry.

Expand training capacity to include an additional 100 nanotechnology students each year for five years, to meet industry requirements for growth.

Recruit and retain world-class research, product design and management talent to Alberta.

Increase nanotechnology awareness and hands-on learning opportunities in K-12 programs to expose Alberta's youth to the fundamentals of engineering and applied sciences.

Develop monthly lecture and discussion series led by researchers, industry leaders, ethicists, and thought leaders to increase public awareness, engagement and discussion on nanotechnology issues.

Alberta's investment in innovation has turned what was an unreachable bog little more than 50 years ago into what is now recognized as one of the richest, most vast and potentially productive oil deposits in the world.

Source: Masato Aizawa/Jillian Buriak

Strategy *Three*

Scaling technology to smaller and smaller sizes reduces costs and increases performance, creating competitive advantages.

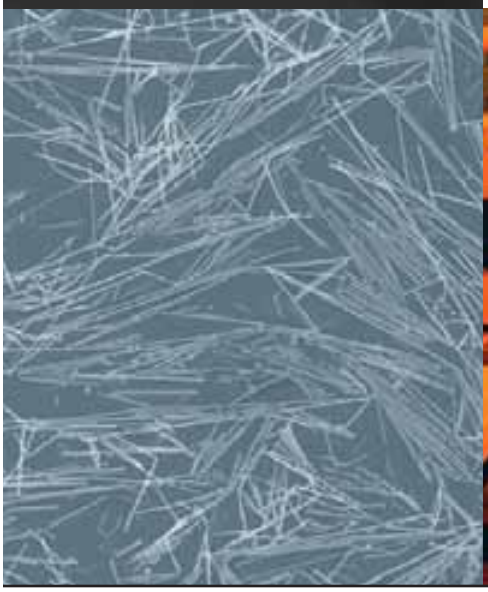
Take advantage of, and continue to enhance and develop, Alberta's nanotechnology infrastructure and intellectual capital resources to capture its commercial potential and applications

Invest in an open-use nano packaging and product development center to provide low-volume manufacturing and testing facilities for entrepreneurs and industry partners.

Enhance the capability and capacity of key facilities such as the NanoFab facility and the Advanced Microsystems Integration Facility (AMIF) to support on-going development and facilitate open access.

Increase the operating budget for Microsystems Technology Research Initiative (MSTRI) prototype development activities to meet market demand.

Create an operating support program to ensure the maintenance, replacement and ongoing operation of necessary equipment for core facilities.



nanoAlberta will promote industry-academic collaboration, attract private investment and foster the formation of industrial clusters to enable decision makers to identify market opportunities in specific sectors.

Source: NanoFab, Faculty of Engineering at the University of Alberta

nano*Alberta*

Many nanoAlberta programs will flow through existing government programs. This integration will:

- Ensure a high degree of policy alignment
- Minimize the barriers to implementation
- Reduce duplication

The Alberta Nanotechnology Strategy is driven by the current opportunity to provide technology solutions to the challenges facing Alberta industries, by the potential to attract major multi-national companies to Alberta, and by the lasting benefits of helping nanotechnology companies get started.

To lead the collaborative efforts a new organization, *nanoAlberta*, would be created based on the following principles:

- Engagement of key stakeholders to mobilize the main players and resources in the province
- Strong industry focus and involvement to ensure that outputs meet industry needs and benefit the Alberta economy
- Leverage existing investments, mechanisms and organizations; and
- Build on existing and emerging strengths.

The core of *nanoAlberta* is a board of stakeholders to provide vision, mission and strategic leadership. The board would include members of NanoMEMS Alberta and the Alberta Science and Research Authority (ASRA) nanostrategy planning committee. Other members representing industry members would add important insight into their respective industry issues and challenges, and representatives of organizations such as NINT, universities, research foundations, all levels of government and industry agencies focused on technology development and commercialization.

nanoAlberta

nanoAlberta would be operated under Alberta Advanced Education and Technology much like the ASRA research institutes, to maximize synergies and administration resources.

Wherever possible, *nanoAlberta* would work with existing programs and organizations to minimize personnel and infrastructure in:

- Providing advice and support on training, scholarship and fellowship programs to be implemented by the province's universities, colleges and technical institutes working with Alberta Advanced Education and Technology;
- Encouraging new research and development initiatives aligned with industry technology needs. Actions could be structured and implemented under Alberta Ingenuity, possibly in collaboration with the Alberta Heritage Foundation for Medical Research (AHFMR); and
- Enhancing collaboration, coordination and oversight for an integrated suite of business-related programs in the design, development, fabrication and packaging of nano products. Implementation would be undertaken through new and existing organizations and facilities such as MSTRI, NanoFab and the nano product development centre.

nanoAlberta would provide functions including sectoral analysis, community outreach, single point of contact for external and internal entities, and monitoring of program reports and expenditures.

Developments in nanotechnology may lead to memory chips that will store as much as, or more, than 100 GB per card. These miniature data storage systems could store entire libraries of documents or hundreds of hours of movies.

Source: Masato Aizawa/Jillian Buriak

The following performance measures should be given serious consideration in assessing the progress towards achieving the mission:

- Percentage of graduates from Alberta's post-secondary institutions in nanotechnology taking their first job within Alberta, and remaining within the region after five years;
- Number of nanotechnology-related firms, employees, sales, IPO value;
- Venture and angel funds invested in Alberta-based nanotechnology-related firms;
- Number of nano related technologies transferred to industry, and the estimated ROI;
- Percentage of nano related research and development initiatives co-financed by industry

As more is learned about how the "science of small" can be applied to opportunities and challenges in today's world, nanotechnology will drastically transform the basis of global competition for existing companies and will lead to the creation of entirely new industries.

The Canadian Nano *Landscape*

It is anticipated that Canada will develop a National Nanotechnology Strategy to leverage the different strengths and expertise that exist across the provinces currently expanding nanotechnology capacity.
By acting now, Alberta can influence the development of the national nanotechnology strategy and be a key contributor to collaboration between independent areas of excellence.

In addition to Alberta, three provinces are investing significantly in nanotechnology and may be expected to take leadership roles in areas of excellence that reflect their current industrial strengths. Quebec has established numerous alliances with industry and other research institutions in biotechnology, pharmaceuticals, aerospace and paper products. Ontario is building deep competencies in nanotechnology-based materials, optical communications and medical devices which support its existing industrial strengths in medicine, telecommunications, manufacturing and automotives. British Columbia's nanotechnology strategy has identified information technology and quantum computing as the primary focus for growth.

As home to the National Institute for Nanotechnology, Alberta can help accelerate the discovery process and build expertise in fields that are important to all Canadians by spurring collaboration among the university, business and research communities. Alberta will focus on nanotechnology as it applies to energy and environment, health and medical technologies, and agriculture and forestry.

International Investment *Trends*

After roughly 20 years of discovery and applications, about 300 consumer products, including sunscreen, golf clubs, print heads on ink-jet printers and components of automotive airbag safety systems, are currently incorporating materials improved by nanotechnology.

Nanotechnology is considered by many to be the catalyst for social and economic impacts larger than those of the computer revolution. Exponential growth is on the horizon.

Over $3 billion per year in basic and applied research is being invested at universities and research institutes in Asia, Europe and North America, and an estimated $1.6 billion per year of private capital is being invested in global organizations with a nanotechnology focus.

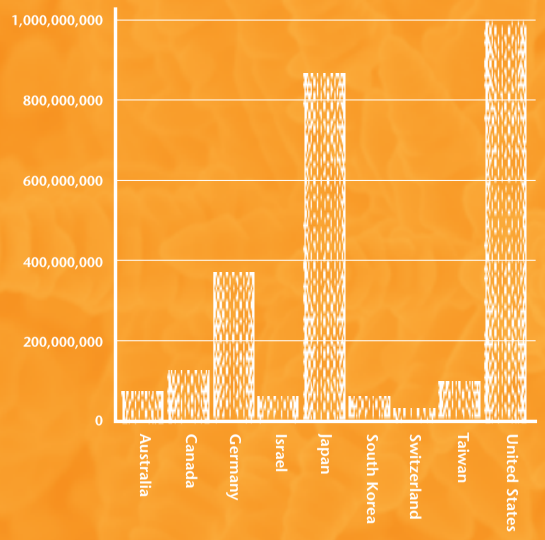
Applications in medicine, health, engineering, energy, agriculture, forestry, environment, and others are all emerging as potential multi-billion dollar markets.

The race to capture part of the estimated US$1 trillion global market by 2020 is on. To achieve the greatest market share with available resources, most regions are targeting their approach to align with existing expertise.

Examples of successful regional strategies include: Germany's focus on sensors in the automotive industry, Taiwan's focus on information technology in the semiconductor industry, and Israel's focus on water remediation through films and membranes. Only Japan and the United States are taking a broader approach.

Positioning Alberta - and Canada - as an international leader in nanotechnology is a substantial undertaking. Achieving a two per cent share of the global nanotechnology market will require significant front-end investment in research and market development to compete and excel in world markets.

Government Research and Development Nano Funding*
Nanotechnology or near-nanotechnology focus

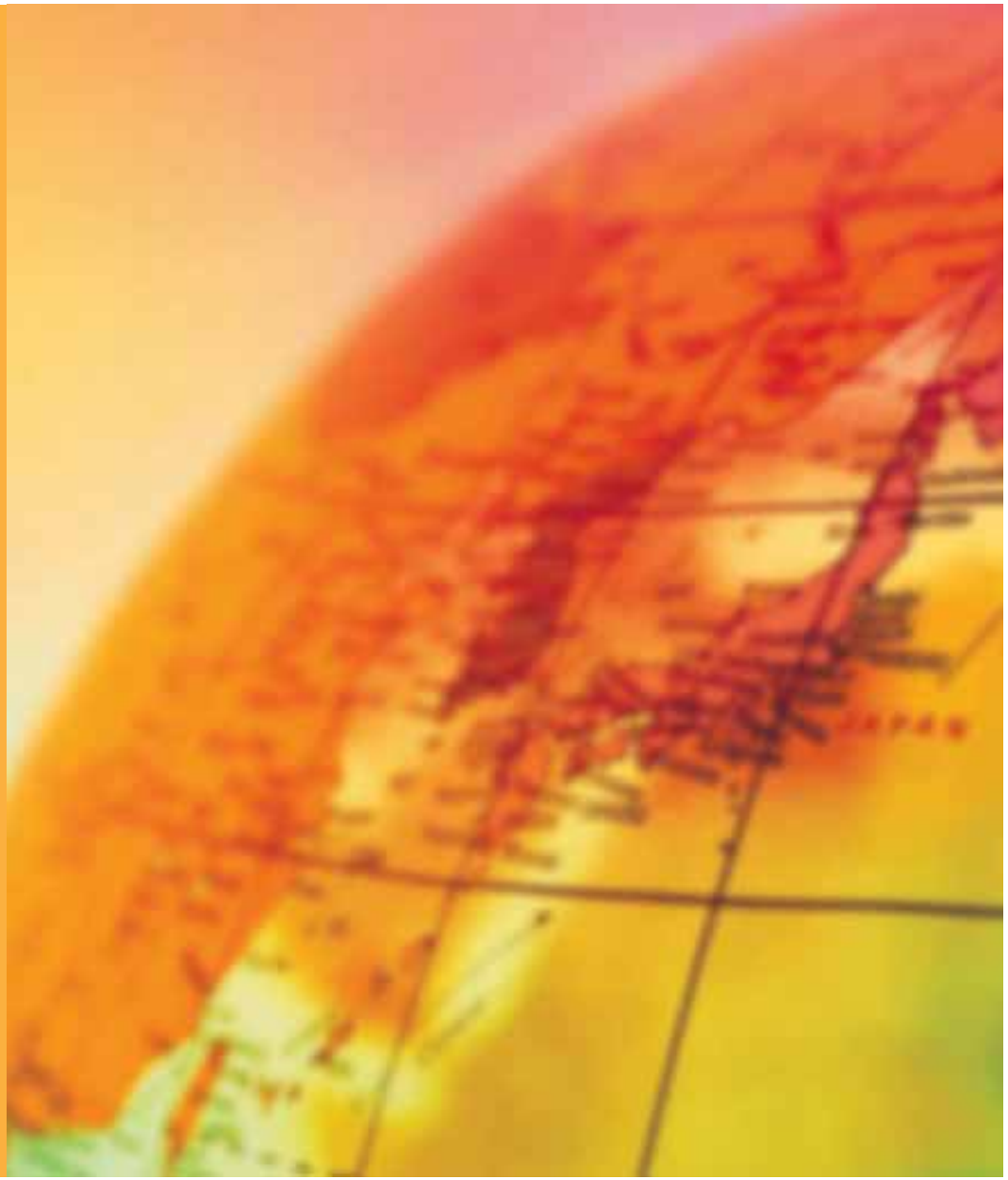


** Source: SCI (publication data) and USPTO (patent data) 2005*

Source: Masato Aizawa/Jillian Buriak

Measures of *Success*

The success of this strategy must be assessed over time to evaluate the implementation of the strategy, the outcomes and impact for the province.



Summary

Alberta is well-positioned for global success through the National Institute for Nanotechnology and its universities. It has small, but growing nano and micro technology industries. The province is investing significant resources in key components of nanotechnology infrastructure.

Adoption of nanotechnology in Alberta's primary industries is becoming critical for international productivity, competitiveness and relevance.

Providing a platform from which Albertans can better understand and support nanotechnology research, development and applications is an important step.

Implementing the Alberta Nanotechnology Strategy and establishing nanoAlberta will attract new companies to Alberta and help to ensure sustainable growth in existing industries. In developing new, globally competitive nanotechnology companies, Alberta will continue to be a leading economic force in North America, and remain prosperous and innovative for generations to come.


Adult Dose
Pediatric Dose
Contraindications
Interactions
Pregnancy
Precautions
Drug Name
Adult Dose
Pediatric Dose
Contraindications
Interactions
Pregnancy

Appendix: *Alberta Momentum*

Since 2001, Alberta has achieved much; examples include:

Strategic partnerships and investments

- Jointly owned and operated $120 million National Institute for Nanotechnology (NINT) at the University of Alberta
- One-of-a-kind transmission electron microscope secured for NINT
- NINT Innovation Centre devoted to attracting and facilitating commercialization of nanotechnology and related technologies
- Advanced simulation and modeling data centre at the University of Calgary
- Open-access NanoFabrication Facility at University of Alberta
- Advanced Microelectronics Integration Facility at University of Calgary
- Centre of Excellence in Integrated NanoTools (CEIN) in partnership with Sun Microsystems as part of Integrated Nanosystems Research Facility (INRF)
- Collaborative research partnership with University of Alberta and National Laboratories in China focusing on nanotechnology, environment and energy
- Nanoscale sensor research initiative with Hewlett Packard
- COMS2004 Conference bringing the NanoMEMS world to Alberta
- The annual Canada Nanoscience and Nanotechnology Forum held in Edmonton in 2004 and 2006

Exploring and marketing new applications

- Biomedical device and microsurgical robot trials at Foothills Medical Centre
- Cost-effective hand-held tools for cancer detection and treatment through the Alberta Cancer Diagnostic Consortium
- Molecular transistors to revolutionize electronic miniaturization
- Swallowable “smart” MEMS pills for real-time internal monitoring
- Mass production of silver coated wound dressings and pipeline coatings
- Large scale production of metal coatings and advanced coating powders
- Integrated MEMS sensors with industry-specific GPS and wireless devices
- Custom micromachining, thin film deposition and test/assembly capacity
- Next generation MEMS-based surveying for Oil and Gas exploration and recovery
- Establishment of over 45 private companies with nano based applications

Appendix: *What We Heard*

The primary goal of this strategy is to create opportunities for Albertans through building a sustainable national competitive advantage. The recommendations were derived from three sources: (1) members of the nanotechnology community, (2) secondary industry, regional and trend information accessible in the public domain, and (3) interviews conducted with members of the nanotechnology and technology commercialization value chain, including leaders from:

- Alberta Science and Research Authority
- Alberta Advanced Education and Technology
- Alberta Research Institutes – Energy, ICT and Life Sciences
- Alberta Ingenuity Fund
- Alberta Heritage Foundation for Medical Research
- Alberta Research Council
- Medical and health products industry
- Nanotechnology industry and MEMS industry
- Biotechnology and Information and Communications Technology Industry
- Angel, private equity and venture capital experts
- National Institute for Nanotechnology
- National Research Council
- Western Economic Diversification Canada
- Alberta's Regional Health Authorities
- Industrial Research Assistance Program (IRAP) West
- Informatics Circle of Research Excellence (iCORE)
- University of Calgary, University of Alberta and University of Lethbridge
- Northern and Southern Alberta Institutes of Technology (NAIT and SAIT)
- TEC Edmonton
- University Technologies International Inc.

Canada's $52.2 million **National Institute for Nanotechnology** (NINT) in Edmonton, Alberta is one of the world's most technologically advanced research facilities. Designed to provide the essential environment for nanoscale research and to foster collaboration between researchers, it includes 'Canada's quietest space', which for scientists means a place with ultra-low vibration and minimal acoustical noise or electro-magnetic interference. The facility is home to more than $40 million of the latest generation of scientific equipment including electron and scanning probe microscopes, and chemical and material analysis instruments. There are already over 185 research and technical support staff working on such challenges at the National Institute for Nanotechnology.

The building is shared by the National Research Council (NRC) National Institute for Nanotechnology and the University of Alberta and includes the NINT Innovation Centre, a research transfer facility where tenants working on commercializing nanotechnology will lease both lab and office space. Other specialized spaces include: laboratories for chemical and biochemical synthesis and analysis of the material structure at the atomic scale; and a Class 1000 clean room for the production of nano structured systems.

The Government of Alberta provided $47.4 million for the building and equipment as a part of their commitment to the NINT facilities, and the University of Alberta provided $12.6 million in support. The remaining funding, approximately $70 million in total, came from the Government of Canada through the NRC, Western Economic Diversification Canada and the Canada Foundation for Innovation.

Alberta Advanced Education and Technology

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