

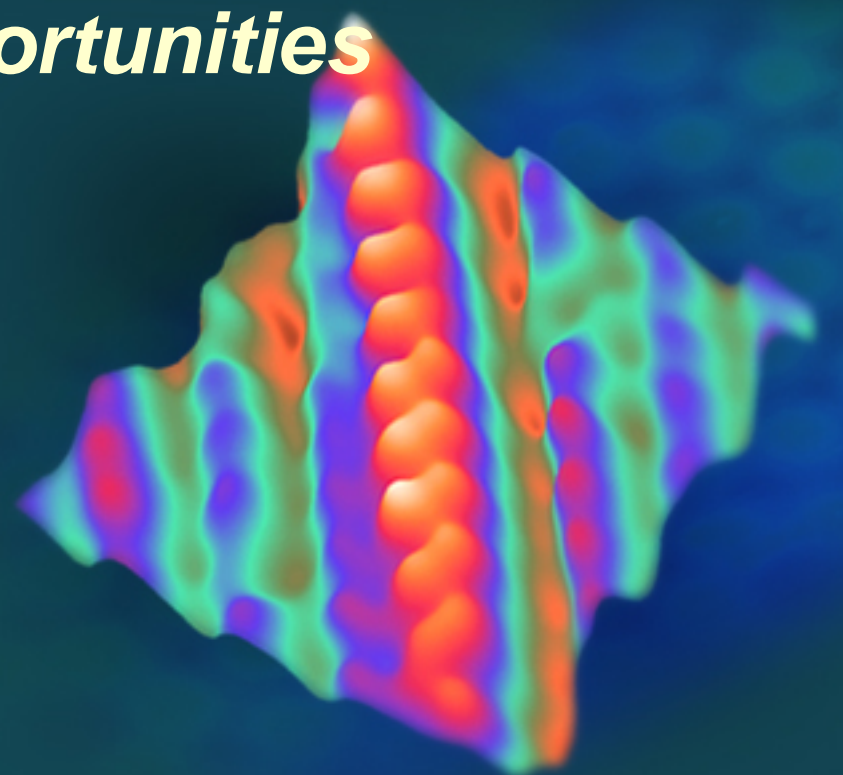


# Nanotechnology Opportunities

*What is Nanotechnology?*

*Why is it exciting?*

*What is happening?*

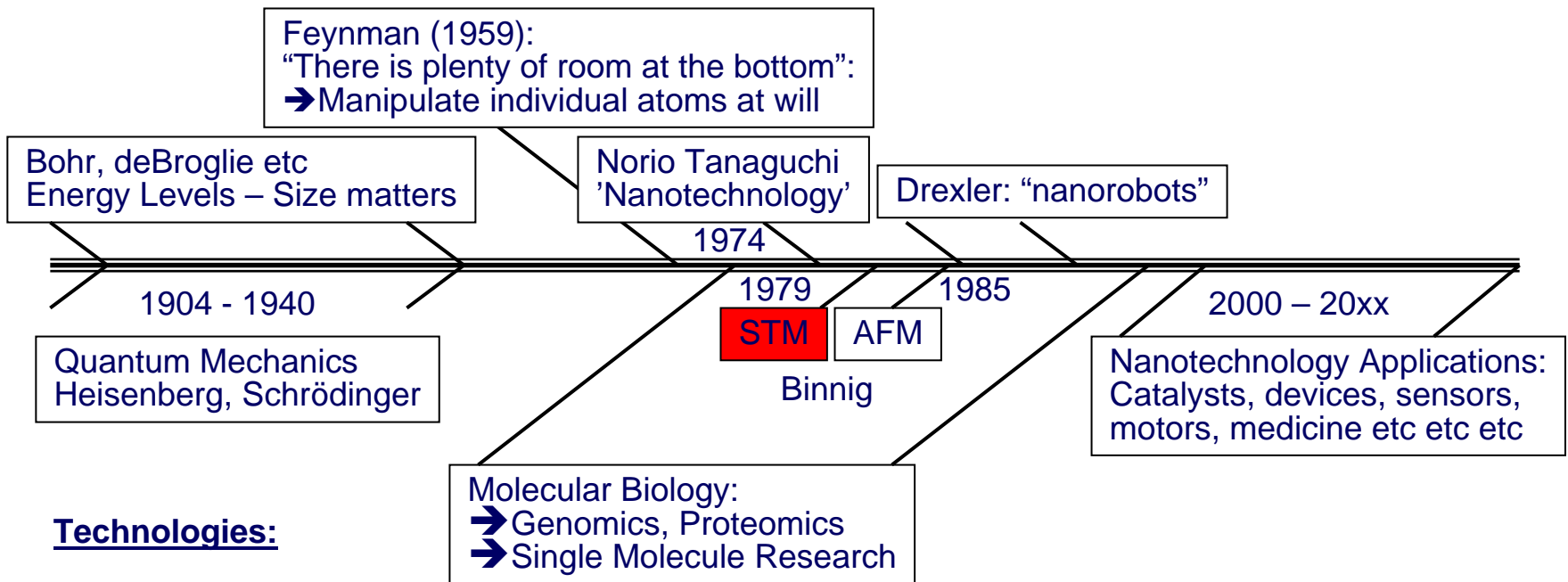


**Nils O. Petersen**  
**Director General, NINT**  
**Professor of Chemistry**

# What is Nanotechnology? - Historical Perspective

## Convergence of a century of science:

### Concepts:



# What is happening?

Steady growth in nanotechnology related activities

Tracking of existing fields redefining themselves through activities and applications

Impact of National Strategies not yet evident (by 2004) although some data show discontinuities in US and Japan in 2002

Emerging clarity of what is counted as Nanotechnology

ONSA: Overview of Nanotechnology Funding (2005)

Figure G.1: Worldwide growth in nanotechnology papers, 1980-2003

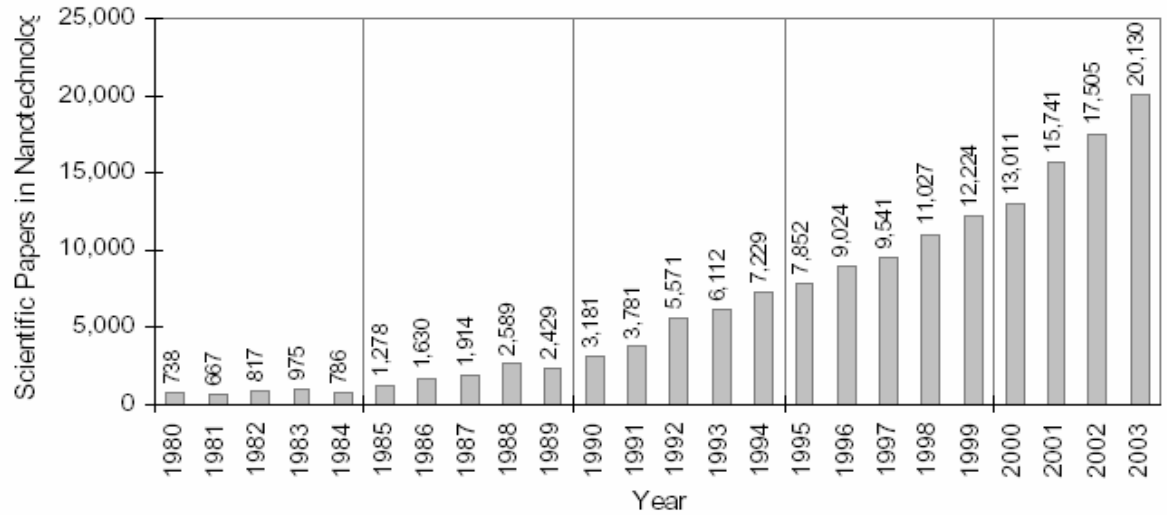
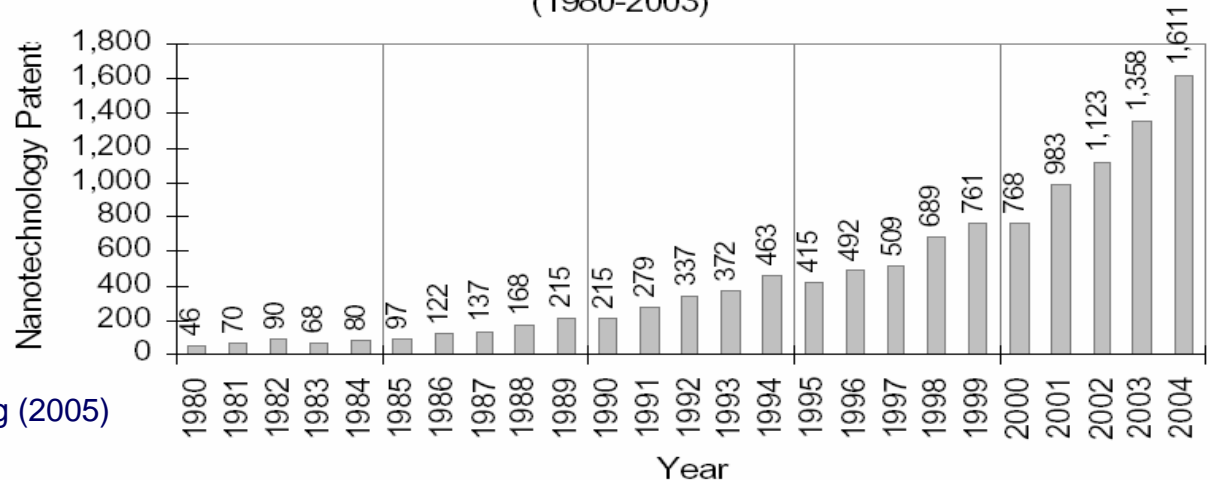


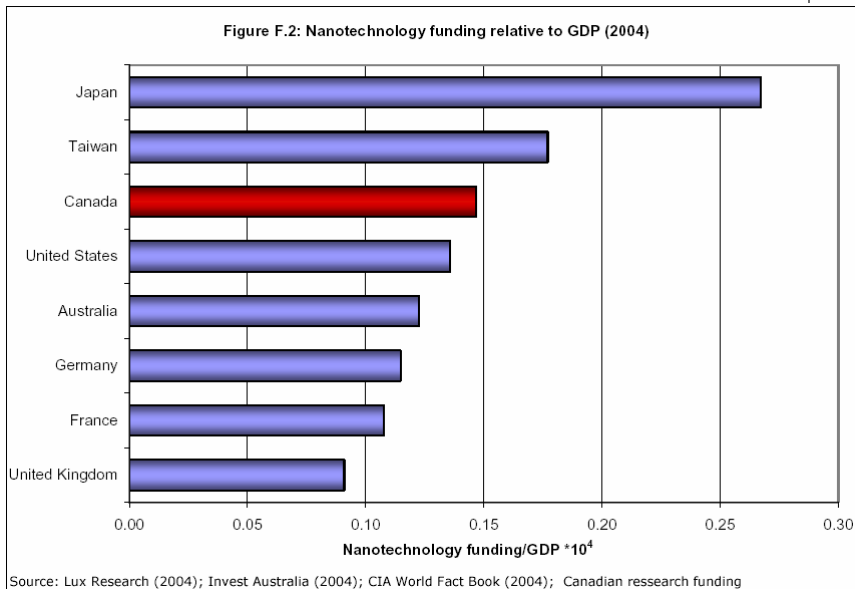
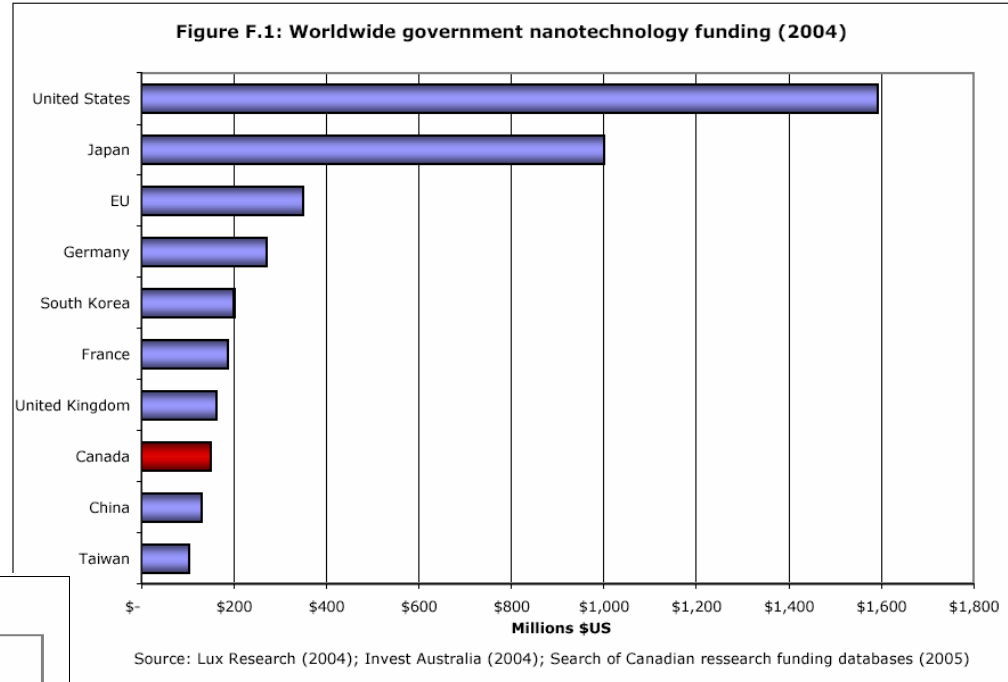
Figure G.8: Growth of nanotechnology patents granted by USPTO (1980-2003)



# What is happening?

US and Japan invests most  
Europe collectively compatible  
In 2004 global investments \$8.6B total  
Of these \$4.6B were in private sector

Canada is beginning to play



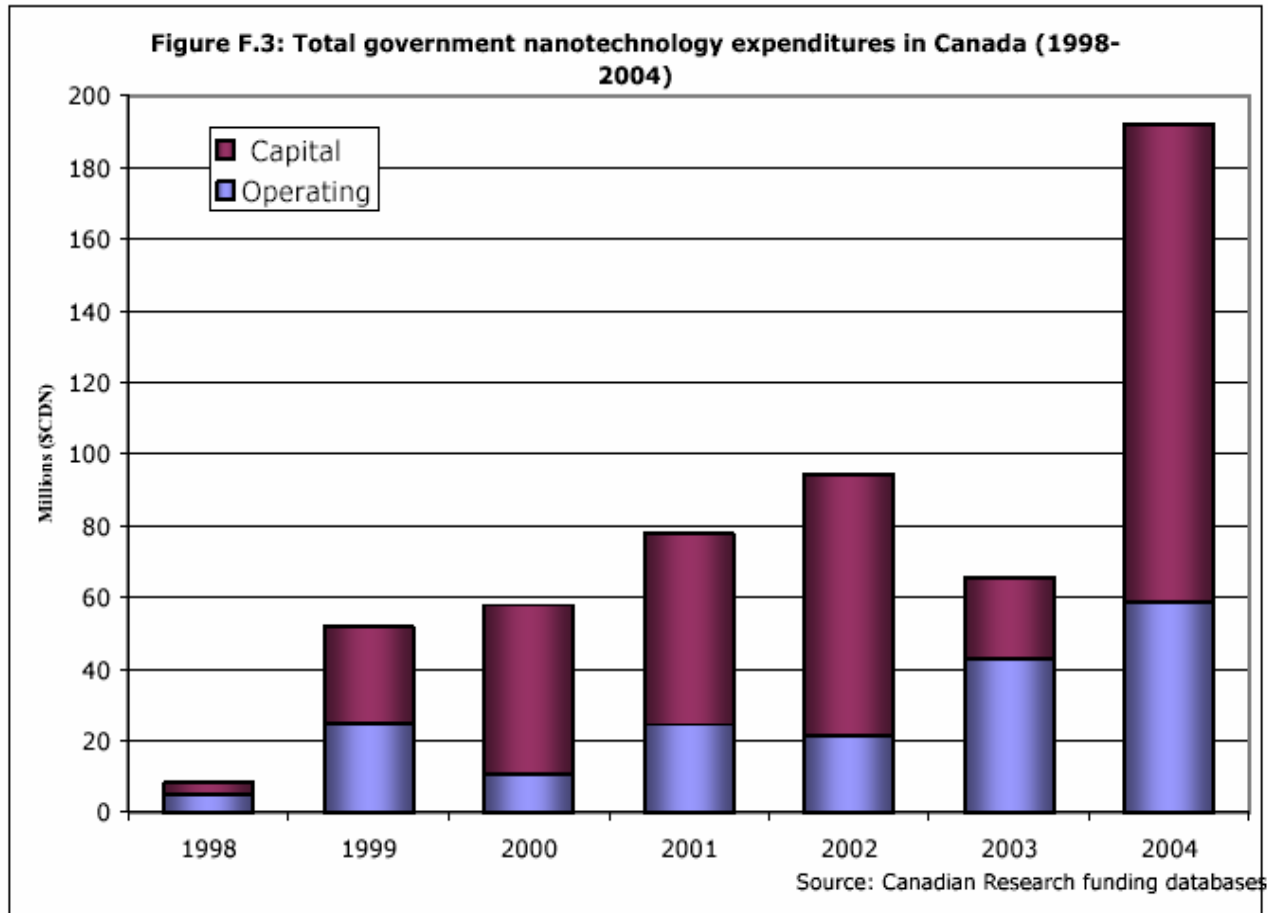
Canadian investments mostly in infrastructure

**Important to create facilities since it is expensive to work in nanotechnology**

**BUT**

**Equally important to support operations and research programs**

# What is happening?



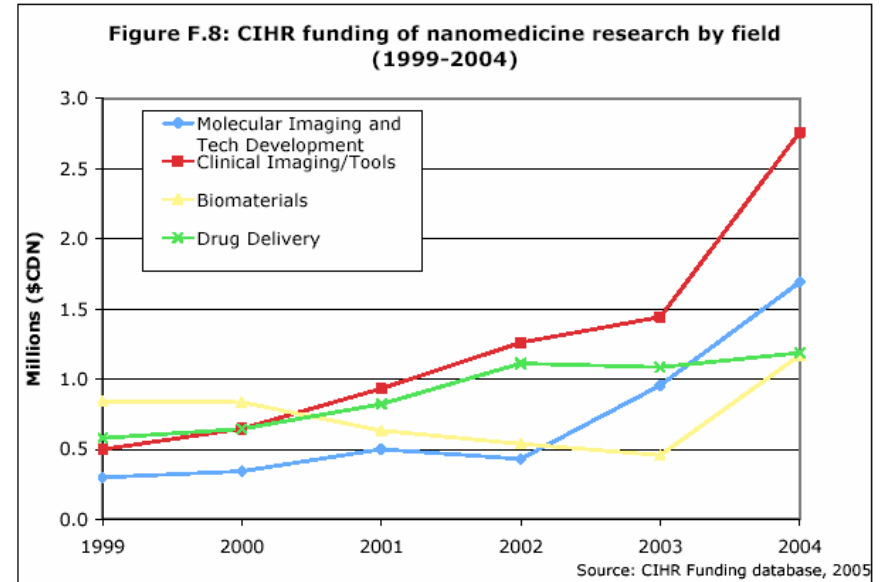
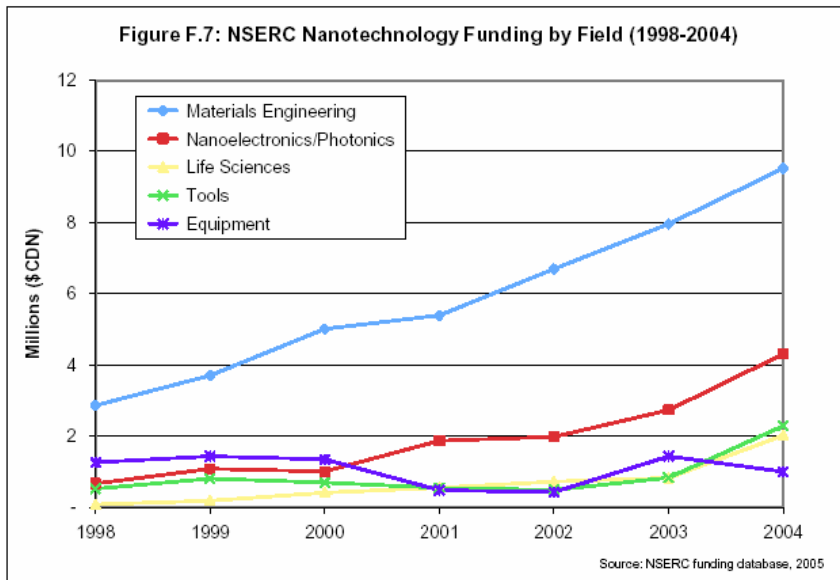
ONSA: Overview of Nanotechnology Funding (2005)

# What is happening?

NSERC nano funding primarily in **Materials, Electronics and Photonics**

CIHR nano funding primarily in **Clinical and Molecular Imaging**

Nanotechnology in Canada is emerging from existing strengths

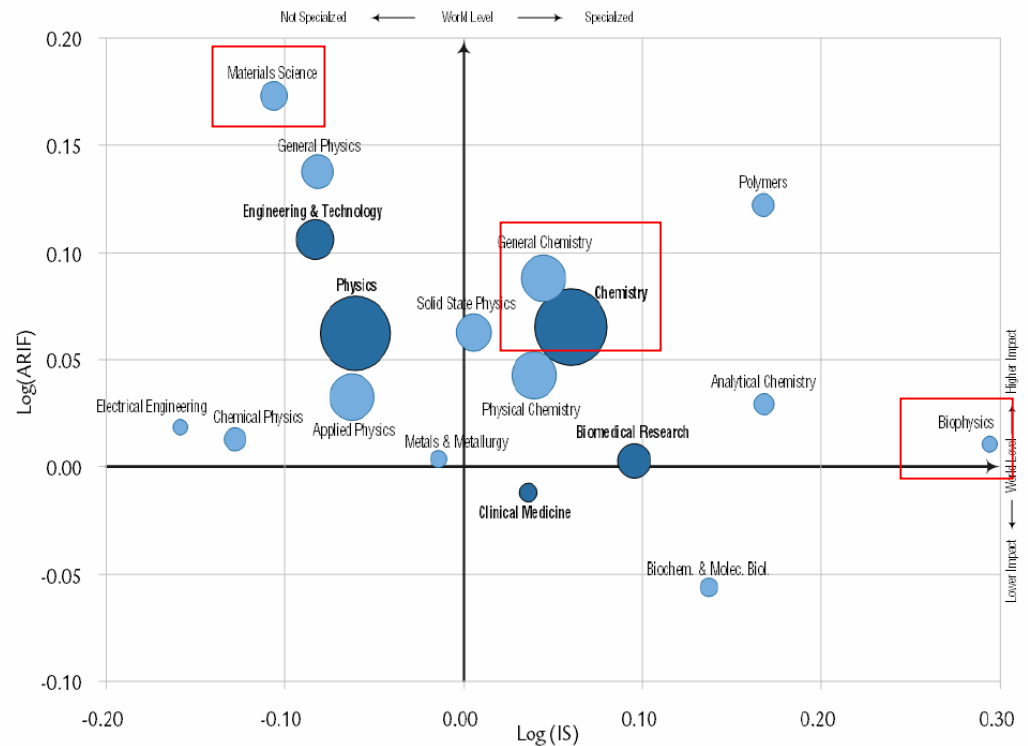


# What is happening?

Canada has high impact in **Materials Science, Physics and Chemistry** (Vertical Axis)

Canada has high specialization in **Biophysics, Biomedical Research and Chemistry** (Horizontal Axis)

Figure G.3: Cartesian representation of Canadian strengths in nanotechnology according to the specialization index and the ARIF by field and subfield (1998-2003)



# What is happening?

Canada's patent filing matches that of US and World trends but differ from Japan and Australia

Most patents in Nano-**Electronics (E)**, **Materials (M)** and **Biotechnology (B)**

Limited correlation between research output and patent activity at this time

Data are limited

ONSA: Overview of Nanotechnology Funding (2005)

Figure G.11: Number of Patents by Cluster, Worldwide (1995-2004)

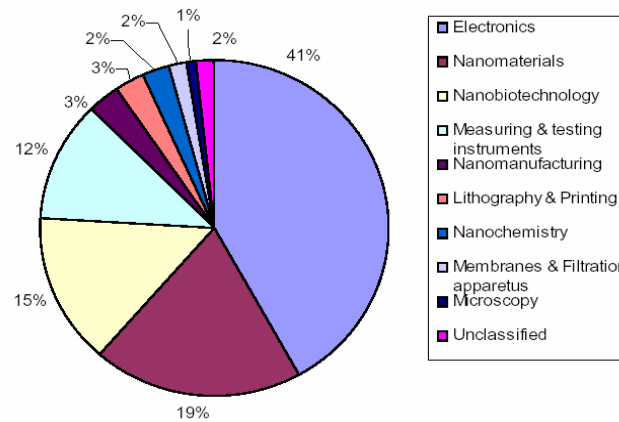


Figure G.12: Number of Patents by Cluster, Canada (1995-2004)

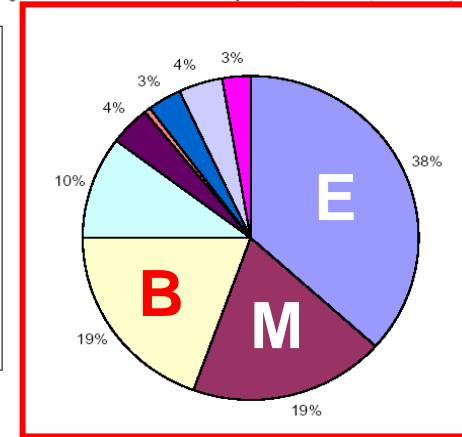


Figure G.13: Number of patents by cluster, United States (1995-2004)

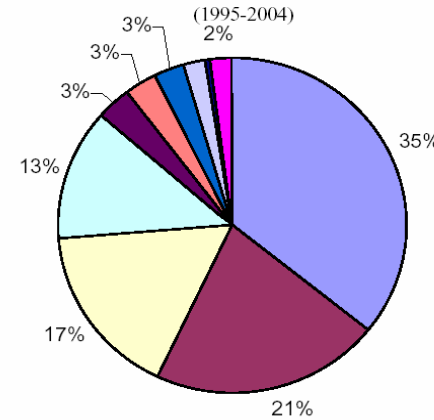


Figure G.14: Number of Patents by Cluster, Japan (1995-2004)

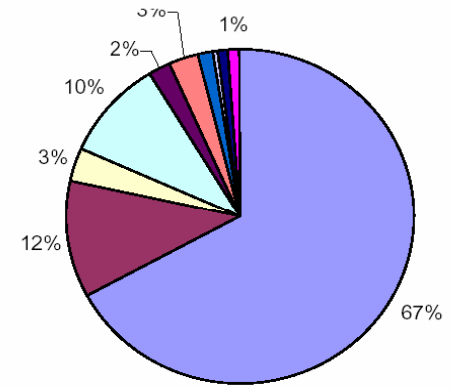


Figure G.15: Number of patents by cluster, Australia (1995-2004)

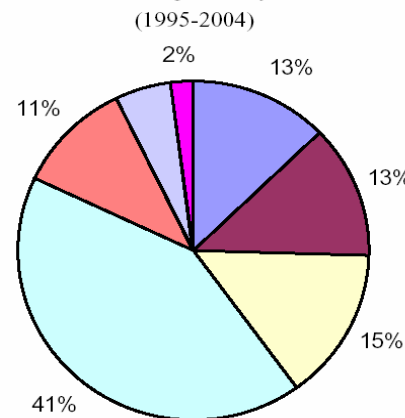
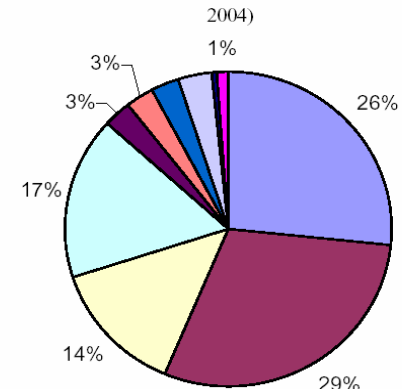
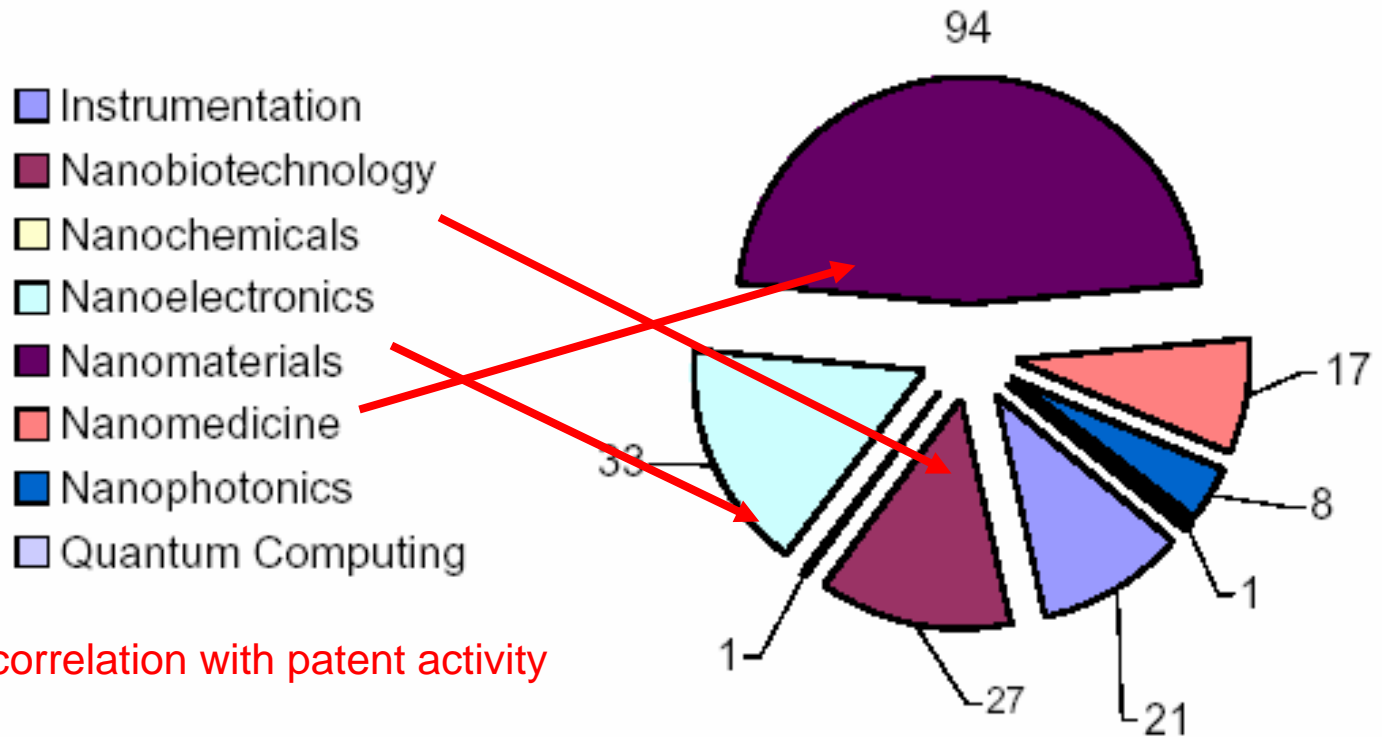


Figure G.16: Number of patents by cluster, Germany (1995-2004)



## What is happening? – Industry

Figure 3: Nanotechnology Companies by Topic



# Creating the National Institute for Nanotechnology

The dream

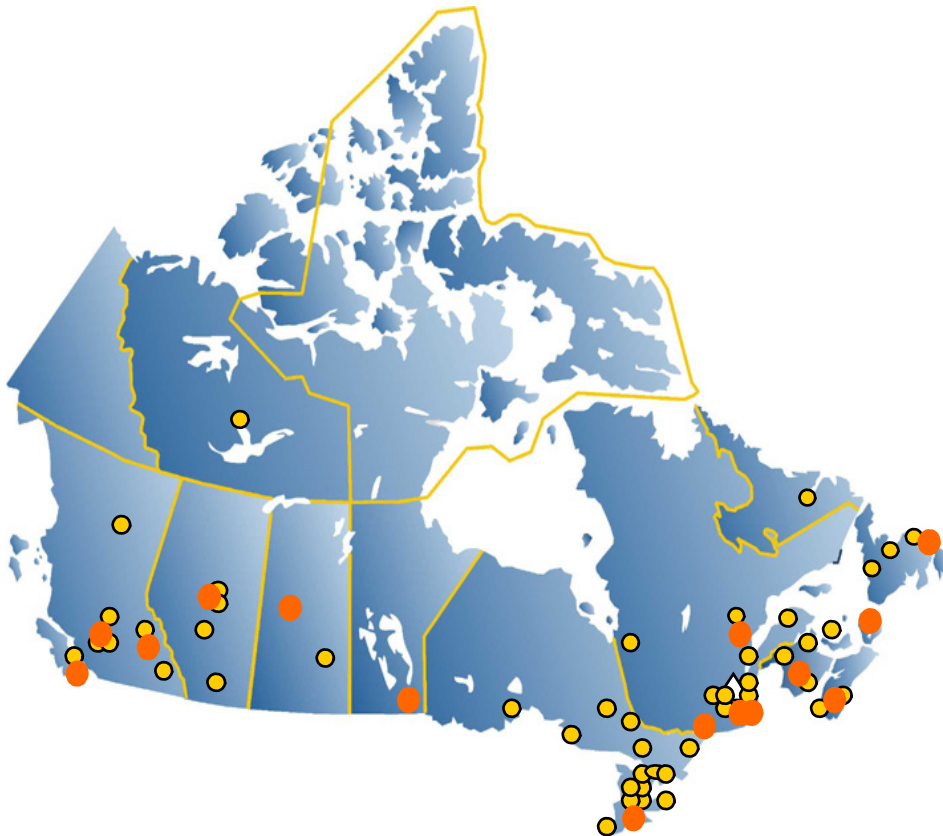


Fall 2005 – move in May 1, 2006



# *NRC: A National Institution*

- NRC Research Facilities
- IRAP Office

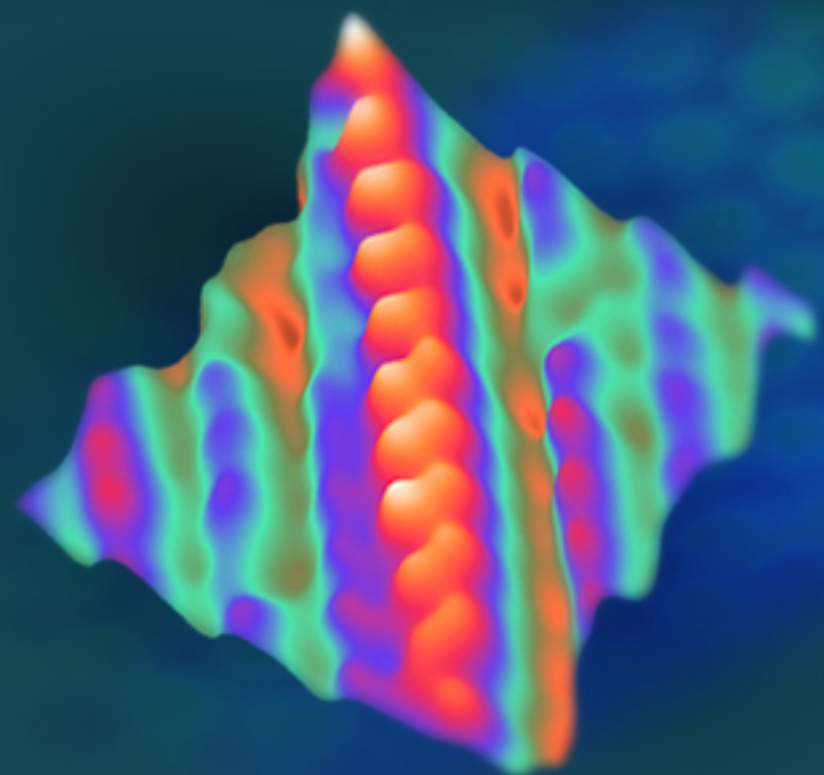


- National organization, federal government agency
- Provides essential elements of national S&T infrastructure
- 4,526 full-time employees
- 1,446 guest workers
- Labs and facilities across the country
- Total expenditures 2003-2004: \$696M
- Income 2003-2004: \$107M



# Some Comments on Nanotechnology in Canada

Tom Malis  
Materials  
Technology  
Laboratory  
Natural  
Resources  
Canada



## **Overview**

A Canadian perspective from our National Institute

A Canadian company with a pedigree

Additional data and comments

# Additional data and comments-2

**“Where Has My Money Gone? Government Nanotechnology Funding and the \$18 billion pair of pants” (cientifica - [www.Cientifica.com](http://www.Cientifica.com))**

**Over 8 year period, nano \$ roughly same as spent on the Apollo Program; they reached the Moon, we have stain-resistant pants!**

**Why so slow to see results?**

- **Labs are not built overnight**
- **Easy to announce, hard to dispense**
- **Cash is hard to get at**
- **Research has a long time constant, e.g. 7 yr R&D-to-product cycle**
- **Similar numbers, different story, e.g. US and EU vs Japan**
- **Only just begun re private sector \$\$**
  - *“When we [venture capitalists] invest in Nobel prize winning research, we do it by mistake. Venture capitalists should very rarely invest in enabling technology. Venture capitalists should not invest in earlystage, high-risk technology research.”*
  - *- David Morgenthaler, former president of the National Venture Capital Association.*

# Additional data and comments-2

## Positives

“I expect there to be impacts in a number of areas, including energy storage and generation (batteries, fuel cells, hydrogen storage), lightweight materials (metallic and polymeric composites), heat transfer (thermoelectric materials, glass, paints), and much more.” (Ford)

Another recent article saying sensors would be the focus of nano-transport, NNI mention of high performance auto battery, 350 km range, 3 min recharge, Standardization is approaching (ISO effort).

## Negatives

Nano has low media profile globally, and public remains largely ignorant

Where awareness is increasing, it is increasingly oriented toward toxicity and environmental effects, like the GMO scare (e.g. ETC Group), yet----

Very low fraction of nano funds going into this area, so no clear answers for a while. Be careful of nano-particulate applications (or nano-scale debris)!

Plan carefully for commercialization, e.g. the Xerox Canada example of convincing the Board via taking a ‘bottom-up’ approach to toner and making big bucks, so now have a green light for ‘smart organic paper’



# *Nanocrystalline Cobalt-Phosphorous Alloy Coating Alternative for Hard Chrome / Cr<sup>6+</sup>*

## **Integran Technologies Inc.**

**March 2006**

# About Integran

## Background

Integran is one of the world's premiere suppliers of nano-structured materials, serving its customers through materials sales, contract manufacturing, technology licensing, and joint technology development initiatives.

## Intellectual Property

Over 100 patents dealing with the production of metallurgical nanostructures, including one of the first nanotechnology patents ever issued- US 5,352,266 (1994).

## Staff

Over 25 scientists and technical staff

## Facilities

Materials production and fully equipped materials characterization laboratory in Toronto, Canada

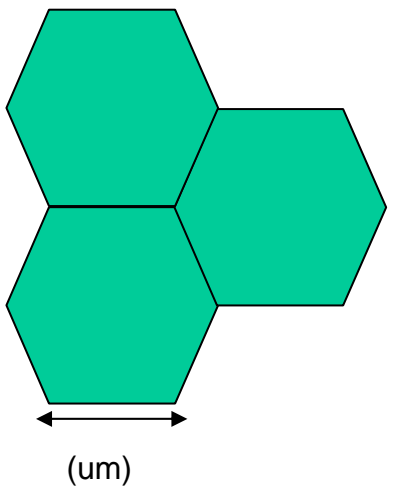
## Affiliations

Member of the US National Defense Industrial Association  
Society for the Advancement of Material and Process Engineering



# Core IP Background: Germany + Canada + Power Utility (Herbert Gleiter student+Karl Aust student+nuclear plant corrosion)

Polycrystalline Structure (um)

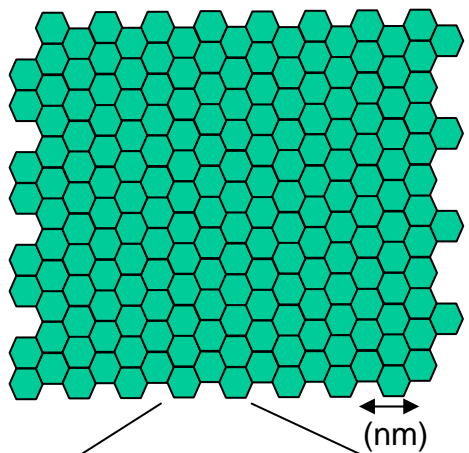


**nanoPlate** - Core IP is a **low-cost, repeatable process** for producing nanocrystalline metals and alloys (nano-material)

When grain size is reduced, as per the Hall-Petch effect, there's a corresponding increase in mechanical properties

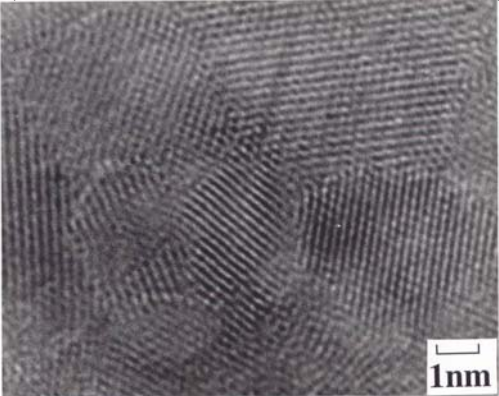
Strength	↑	10x
Hardness	↑	10x
Wear	↓	10x
Friction	↓	5x

Nano-crystalline Structure (nm)



## Grain boundary engineering (GBE®) -

Via patent-protected thermomechanical processes (forming+heat treatment), the internal structure of conventional metals and alloys is optimized locally on a nanometer scale to yield breakthrough improvements in material reliability, durability and longevity .



SEM of Integran's nano-material

# Integran's Nano Co-P in Hydraulic Systems

## Aerospace Landing Gear

- Performance  
Equal to or better than Hard Chrome / Cr<sup>6+</sup>
- Deployment  
Currently in Demonstration/Validation phase under the ESTCP (PP-0411) program
- Conditions



most demanding applications



## Industrial Applications

- Requirement  
Corrosion protection  
Long wear
- Performance  
Salt Spray corrosion testing superior results

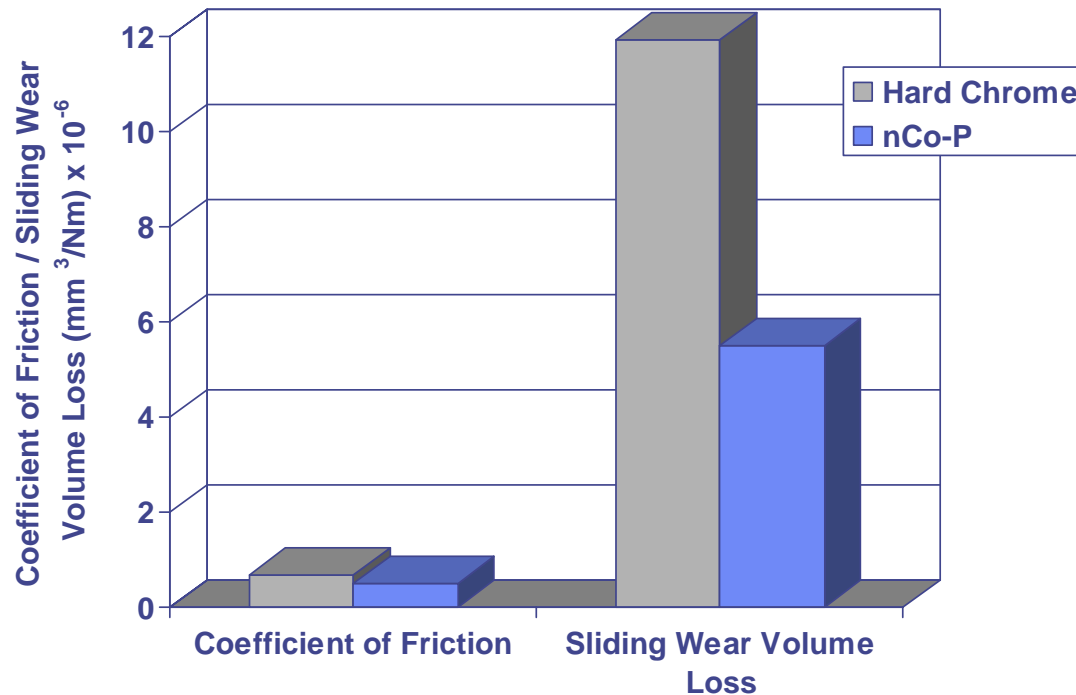
Nano Co-P being validated for hydraulics in the most demanding environments

# Nano Co-P vs. Hard Chrome - Wear

## Wear Resistance

Coefficient of friction is superior to that of hard chrome  
Sliding wear is more than 2X better than hard chrome

### Coefficient of Friction & Sliding Wear Resistance



Superior coefficient of friction & sliding wear performance