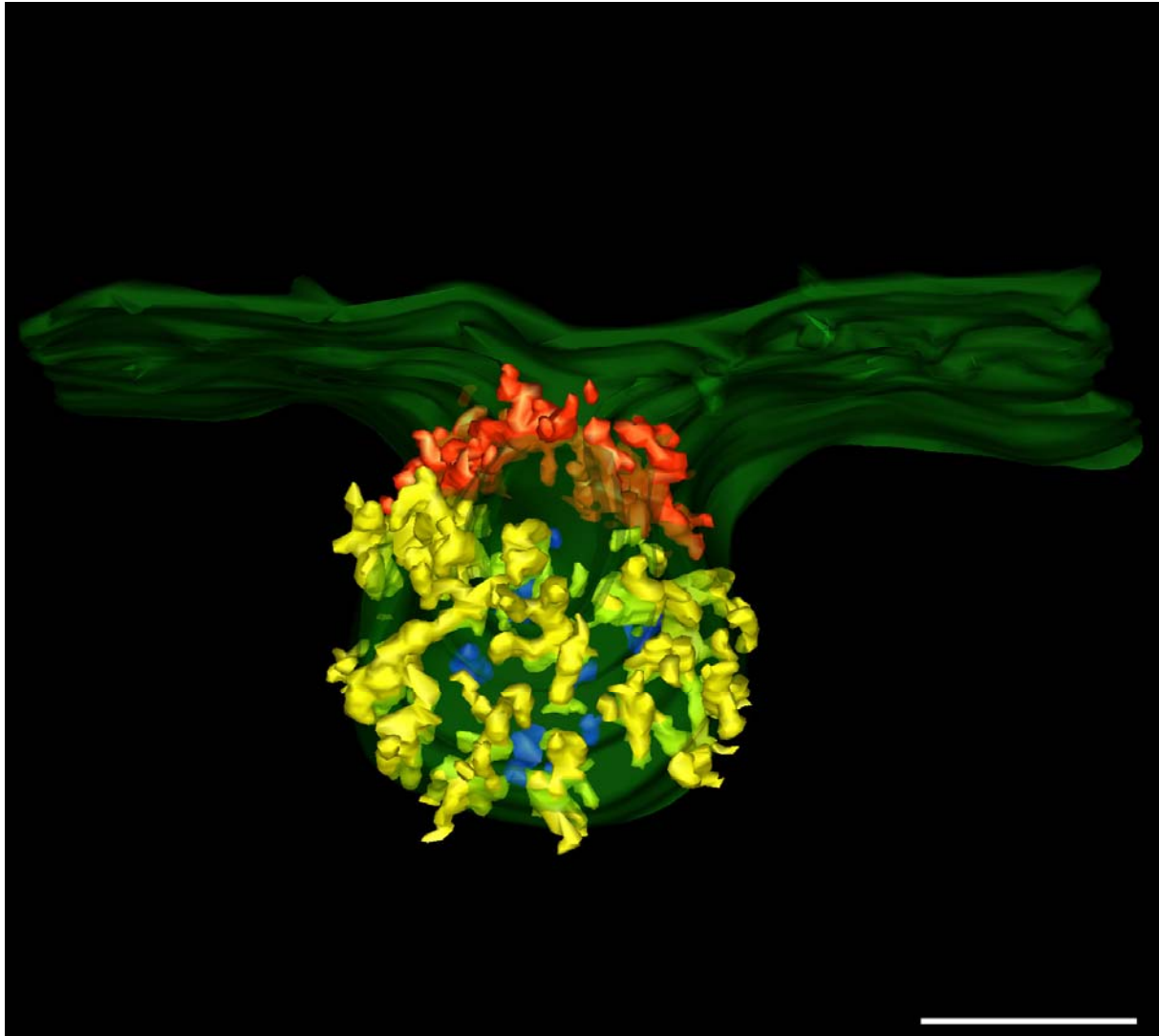


**National Nanotechnology Strategy (NNS) Annual Report 2007–08**  
**Australian Office of Nanotechnology**



**AMMRF @ The University of Queensland**

Centre for Microscopy and Microanalysis

*Image: Dr Matthias Floetenmeyer*

*Technique: Electron tomogram/surface rendered reconstruction*

**Caption:** *High-resolution 3D-tomographic reconstruction of a Caveola in the cell membrane of a fat cell. Caveolae are flask-shaped membrane invaginations that can be found in most Mammalian cell types. They are implicated in lipid regulation, signal transduction and endocytosis.*

**Scale bar length:** 100 nm

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Collecting information nationally is a challenging task, especially when it's done for the first time. People from a number of agencies put in their time and effort to contribute to this report. The Australian Office of Nanotechnology acknowledges the contribution to this report from the following stakeholders:

## Commonwealth departments and agencies

- Department of Agriculture, Fisheries and Forestry (DAFF), including
- Australian Pesticides and Veterinary Medicines Authority (APVMA)
- Australian Quarantine and Inspection Service (AQIS)
  
- Department of Health and Aging (DoHA), including
- Food Standards Australia New Zealand (FSANZ)
- National Health and Medical Research Council (NHMRC)
- National Industrial Chemicals Notification and Assessment Scheme (NICNAS)
- Office of Gene Technology Regulator (OGTR)
- Therapeutic Goods Administration (TGA)
  
- Department of Innovation, Industry, Science and Research (DIISR), including
- Australian Research Council (ARC)
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- National Measurement Institute (NMI)
  
- Department of Infrastructure, Transport, Regional Development and Local Government (DITRD LG)
  
- Department of the Environment, Water, Heritage and the Arts (DEWHA)
  
- Office of the Australian Safety and Compensation Council (OASCC), Department of Education, Employment and Workplace Relations (DEEWR)

- Australian Competition and Consumer Commission (ACCC)
- Australian Nuclear Science and Technology Organisation (ANSTO)

#### State departments

- New South Wales Department of State and Regional Development
- Queensland Department of Tourism, Regional Development and Industry
- South Australian Department of Trade and Economic Development
- Tasmania Department of Economic Development and Tourism
- Victoria Department of Innovation, Industry and Regional Development
- Western Australia Department of Industry and Resources

# Introduction

## Background

Under the National Nanotechnology Strategy (NNS), the Australian Office of Nanotechnology (AON) is required to report annually to the Minister for Innovation, Industry, Science and Research on the implementation of the NNS and nanotechnology development in Australia more generally. This first annual report covers the period of 1 July 2007 to 30 June 2008.

The introduction to the report provides some general information about nanotechnology, a global perspective and information about the Australian nanotechnology capability.

The main part of the report is divided into three sections:

- information on financial support for nanotechnology in Australia during the reporting period
- progress in implementing the National Nanotechnology Strategy (NNS), presented in a way that reflects the structure of the *NNS Implementation Plan*<sup>1</sup>
- other nanotechnology activities at the Commonwealth and state and territory levels.

The next NNS annual report will allow comparisons of levels of support for nanotechnology in Australia and types of activities. It will also start to identify any new trends and arising issues.

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<sup>1</sup> *National Nanotechnology Strategy Implementation Plan*, Department of Innovation, Industry, Science and Research, Canberra, 2008, 4pp.  
<<http://www.innovation.gov.au/Section/Innovation/Documents/NNSFeb08.pdf>>

## Highlights of the reporting period

The first year of the NNS was marked by a number of significant developments and events, some of which are listed below.

*The NNS Implementation Plan* was developed by the AON to outline the main objectives, areas of focus and mechanism of coordinating the NNS.

*The Health, Safety and Environment Working Group (HSE Working Group)* was established to address HSE issues associated with the development of nanotechnology and appropriateness of the Australian regulatory frameworks for regulating nanotechnology. Key Australian regulators with responsibility to ensure human and environmental safety have convened to collectively consider the more immediate issues around human health risk assessment of nanotechnology, align risk assessment practices and to move to build capacity among Australian regulators in assessment of the potential toxicological risks associated with nanotechnology.

*A Review of Possible Impacts of Nanotechnology on Australia's Regulatory Frameworks<sup>2</sup> (the Monash Report)* provided an independent analysis of the regulatory frameworks with regard to their ability to adequately address the health, safety and environmental impacts from nanotechnology.

*The Australian Government Approach to the Responsible Management of Nanotechnology<sup>3</sup>* was developed as a framework for a consistent approach across the Australian Government to nanotechnology.

*The Nanotechnology States and Territories Committee (NSTC)* was established to facilitate a regular dialogue and collaboration on nanotechnology between the Commonwealth, and states and territories in the innovation and industry development area.

*Meeting of the AON with international nanotechnology experts* Dr Clayton Teague, Director of the United States National Nanotechnology Initiative (NNI), and Dr Andrew Maynard, the Chief Science Advisor to the Project on Emerging Nanotechnologies at the Woodrow Wilson Centre (United States).

*Public Forums on Nanotechnology* took place in all capital cities of Australia as part of the NNS Public Awareness and Engagement Program aiming to engage and inform the community on the benefits and risks of various applications of nanotechnology, to provide an understanding of its potential impact upon society and enable community contribution to policy development.

*International cooperation* through the OECD Working Party on Manufactured Nanomaterials (health and environmental safety of manufactured nanomaterials) and the International Organisation for Standardisation (ISO) Nanotechnology Committee – ISO TC229.

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<sup>2</sup> Ludlow K, Bowman D and Hodge G, *A Review of Possible Impacts of Nanotechnology on Australia's Regulatory Framework*, report by Monash University for the Australian Government, 2008

<http://www.innovation.gov.au/Industry/Nanotechnology/Documents/MonashReport2008.pdf>

<sup>3</sup> <http://www.innovation.gov.au/Industry/Nanotechnology/Documents/ObjectivesPaper.pdf>

## What is nanotechnology?

Nanotechnology is the collective term for a range of technologies, techniques and processes that involve the manipulation of matter at the nanoscale—the size range from approximately 1 nanometre (nm = one millionth of a millimetre) to 100 nm. Typically these objects are very small particles of normal materials and can be as small as molecules or clusters of atoms. To understand the scale, a sheet of normal office paper is about 100,000 nm thick; a human hair is about 80,000 nm wide; and a drop of blood contains 5 million red blood cells, with the diameter of one red blood cell being 7000 nm. The term nanotechnology describes the technologies used to create, manipulate and characterise matter and processes at the nanoscale.

**Nanoparticles** have all three external dimensions at the nanoscale and can be divided into three groups:

- Natural nanoparticles exist widely in the natural world and have been with us for millennia. The examples of such natural occurrence are products of photochemical and volcanic activity, salt spray from the ocean, clays containing naturally occurring nanoparticles and used as a construction material.
- Incidental (or waste) nanoparticles are often by-products of industrial processes: combustion and food cooking, and more recently, vehicle exhausts.
- Engineered nanoparticles are designed for specific functions.

**Nanomaterials** are materials with one or more external dimensions at the nanoscale, including nanoparticles, nanotubes, quantum dots, fullerenes, dendrimers, and nanoporous materials.

**Nanoproducts** are any products that incorporate nanotechnology and could include products:

- with nanoscale features
- coated with nanometre-thick films
- containing engineered nanoparticles.

Examples of nanoproducts include sunscreens, cars, clothing, airplanes, computers, consumer electronics devices, pharmaceuticals, processed food, plastic containers, and appliances.

Nanotechnology has only recently started to provide a real indication of its commercial potential. Due to the applicability of nanotechnology to numerous industry sectors across the economy, nanotechnology is often referred to as an enabling or platform technology and is sometimes used in the plural form 'nanotechnologies'.

## Global perspective

Worldwide revenues from products incorporating nanotechnology are projected to reach US\$2.84 trillion by 2015, driven by an expected exponential growth in commercialisation successes in the healthcare and electronics sectors.<sup>4</sup>

According to the Global Industry Analysts Inc. report, the chemical industry currently dominates the nanotechnology arena in terms of maturity of R&D efforts and actual product commercialisation, and worldwide revenues are projected to exceed US\$82 billion in 2008. The pharmaceutical and healthcare industries are projected to post the fastest annual growth rates in terms of annual revenues from nanotechnology-based products over the next ten years. Revenues from products incorporating nanotechnology in the semiconductors and electronics arena are projected to exceed US\$1 trillion by 2014.<sup>5</sup>

The Woodrow Wilson International Centre for Scholars<sup>6</sup> has developed and released in March 2006 the first publicly available online inventory of nanotechnology-based consumer products.<sup>7</sup> As of 21 August 2008, the inventory contained 803 products or product lines out of 21 countries. To illustrate how fast the inventory is growing: 197 products were added between February and August 2008. The majority of products come from the USA.

LuxResearch, in *The Nanotechnology Report*, found:<sup>8</sup>

- Worldwide funding for nanotech research and development reached \$11.8 billion in 2006, up 13 per cent from 2005. Private spending on nanotechnology—through corporate R&D and venture capital—topped government spending for the first time.
- Governments spent \$5.8 billion on nanotech in 2006, a 9 per cent increase from 2005 levels. Of this spending:
  - \$1.8 billion (32 per cent) was in North America, almost entirely accounted for by the USA
  - \$1.7 billion (29 per cent) was in Asia, led by Japan
  - \$2.1 billion (36 per cent) was in Europe, led by Germany and the European Council (EC)
  - \$200 million (4 per cent) was in the rest of the world.
- Established corporations spent \$5.3 billion worldwide on nanotechnology R&D in 2006, an increase of 19 per cent from 2005 spending. Of this:

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<sup>4</sup> Paul Smith, 'Can't afford to waste a nano in this industry', *Australian Financial Review*, 26 August 2008, p. 32., citing *Nanotechnology: A Global Strategic Business Report*, Global Industry Analysts, Inc., 2008.

<sup>5</sup> *Nanotechnology: A Global Strategic Business Report*, Global Industry Analysts, Inc., 2008.

<sup>6</sup> <<http://www.wilsoncenter.org>>

<sup>7</sup> <[http://www.nanotechproject.org/inventories/consumer/analysis\\_draft/](http://www.nanotechproject.org/inventories/consumer/analysis_draft/)>

<sup>8</sup> LuxResearch, *The Nanotechnology Report – Investment Overview and Market Research for Nanotechnology* (5<sup>th</sup> Ed), 2007, p. iii.

- \$2.0 billion (38 per cent) was in North America
- \$2.2 billion (41 per cent) was in Asia
- \$1.0 billion (19 per cent) was in Europe
- \$95 million (2 per cent) was in the rest of the world.

The *The Nanotechnology Report* also notes that every large manufacturer has some form of nanotechnology effort.<sup>9</sup>

There are no comparable data for Australia, although the 2007 report *Government Funding, Companies and Applications in Nanotechnology Worldwide* produced by the Technology Transfer Centre,<sup>10</sup> placed Australia eighth out of 16 nanotechnology leading countries, with a projected Australian Government funding on nanotechnology of \$833 million for 2006–10.<sup>11</sup>

Several countries have government or state nanotechnology-focused initiatives today. Issues and challenges addressed under such initiatives are common across nanotechnology active countries. Information about the nanotechnology initiatives of other countries is at Attachment G.

There are now:

- 976 nanotechnology companies in the USA<sup>12</sup>
- 75 nanotechnology companies in Canada<sup>13</sup>
- more than 300 nanotechnology companies in Europe, with more than a third based in Germany. Germany and the UK lead the way in Europe in nanotechnology in terms of small to medium enterprise activity and big business investment
- more than 250 nanotechnology companies in the Asia-Pacific—a third of which are based in China. Japan, Taiwan and South Korea—lead the way in terms of incorporating nanotechnology into products and processes.<sup>14</sup> In terms of the number of the nanotechnology companies in Asia-Pacific, Australia is the fourth after China, South Korea and Japan.<sup>15</sup>

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<sup>9</sup> Ibid. p.12

<sup>10</sup> the Technology Transfer Centre is an Institute of Nanotechnology spin-out company  
<<http://www.nano.org.uk>>

<sup>11</sup> Countries included are (in order of spending): Japan, US, EU, China, Germany, South Korea, France, Australia, Taiwan, Singapore, US, Finland, The Netherlands, Ireland, Canada, Switzerland

<sup>12</sup> Nanotechnology Links Database search results (USA), June 2008  
<[http://www.nanowerk.com/nanotechnology/Nanotechnology\\_Companies\\_in\\_the\\_USA.php](http://www.nanowerk.com/nanotechnology/Nanotechnology_Companies_in_the_USA.php)>

<sup>13</sup> Nanotechnology Links Database search results (Canada) , June 2008  
<[http://www.nanowerk.com/nanotechnology/Nanotechnology\\_Companies\\_in\\_Canada.php](http://www.nanowerk.com/nanotechnology/Nanotechnology_Companies_in_Canada.php)>

<sup>14</sup> *Government Funding, Companies and Applications in Nanotechnology Worldwide 2007*, Technology Transfer Center.

<sup>15</sup> Ibid.

In terms of market application, most of the companies in Europe focus on healthcare and Life Science (25 per cent), Consumer Goods (10 per cent) and Chemicals (15 per cent). In the Asia-Pacific, Healthcare and Life Science account for 10 per cent of companies, Chemicals (15 per cent), Automotive and Transportation (10 per cent) and Consumer Goods (10 per cent).<sup>16</sup>

Several international organisations have nanotechnology related activities. The two leading organisations are the Organisation for Economic Cooperation and Development (OECD) and International Organization for Standardisation (ISO).

### **The Organisation for Economic Cooperation and Development (OECD)**

Under the Committee on Scientific and Technological Policy (CSTP) a Working Party on Nanotechnology was established in March 2007. The objective of this working party is to promote international co-operation that facilitates research, development, and responsible commercialisation of nanotechnology in member countries and in non-member economies. The OECD Working Party on Manufactured Nanomaterials was established in September 2006 and is looking at international co-operation in health and environmental safety related aspects of manufactured nanomaterials.

The Working Party on Nanotechnology has initiated six projects to achieve its objective:<sup>17</sup>

- Indicators and statistics—aims to provide an overview of nanotechnology trends based on available comparable indicators and statistics, while identifying policy-makers' needs for further indicators; establishes a framework for the development and collection of new indicators and statistics
- Impacts on companies and business environments—complements the statistical work with a large set of company case studies across different application areas and countries; analyses the impacts and business environment of nanotechnology to identify possible new challenges for the business community
- International research collaboration—facilitates research collaboration in the field by mapping available research infrastructures and Scientific and Technological Policy agreements globally
- Outreach and public engagement—aims to promote the exchange of experience in outreach and public engagement through questionnaires, possible country case studies, and a set of workshops
- Policy dialogue—aims to facilitate a policy dialogue and help develop an overall synthesis of the work of the Working Party on Nanotechnology. It relies on a questionnaire and other material to highlight policy responses and challenges

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<sup>16</sup> Ibid.

<sup>17</sup> OECD Work on Nanotechnology, <<http://www.oecd.org/sti/nano>>

across countries and combines it with workshops dedicated to specific policy themes

- Global challenges: water—focuses on the contribution of nanotechnology to the purification of water and the barriers that will need to be addressed. The purification of water is a key global challenge, especially for developing countries.

The Working Party on Manufactured Nanomaterials is undertaking eight projects that cover the sharing of research results and strategies, the adjustment of testing protocols and the testing of nanomaterials safety, the sharing of developments in regulatory issues, and the development of alternative methods to testing for the generation of data.

### **International Organization for Standardisation Nanotechnology Committee – ISO TC 229**

The scope of ISO TC 229, which has 30 participating and 10 observer member countries, is standardisation in the field of nanotechnologies. Specific tasks include developing standards for: terminology and nomenclature; metrology and instrumentation, including specifications for reference materials; test methodologies; modelling and simulation; and science-based health, safety, and environmental practices.

ISO TC 229 has been organised into five groups:

- TC 229/CAG – Chairman Advisory Group
- TC 229/WG 1 – Terminology and nomenclature
- TC 229/WG 2 – Measurement and characterization
- TC 229/WG 3 – Health, safety and environment aspects of nanotechnology
- TC 229/WG 4 – Material specifications.

The Australian Government is aware of, and participating in, work that the World Health Organisation (WHO) and Food and Agriculture Organisation (FAO) are doing in relation to risk assessment processes.

### **Australian nanotechnology capability**

A national technology capability including nanotechnology comprises capability in research, industry development and workforce growth and education.

#### **Research**

Government research organisations, medical research institutes, biotechnology research organisations and university research centres undertake research in nanotechnology in Australia. There are 75 of these organisations in total, but a

breakdown for how many of each of these types of research organisations work with nanotechnology is not available.<sup>18</sup>

A significant part of nanotechnology-related research in Australia is funded through the Australian Government's main research funding agencies, for example the Australian Research Council (ARC), Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the National Health and Medical Research Council (NHMRC).

Fourteen of Australia's 41 universities have 31 nanotechnology research groups. Some of these universities are more active in nanotechnology research than others and have more than one research centres (Attachment F).

## Industry

There are an estimated 80 nanotechnology companies in Australia<sup>19</sup>.

Most of the nanotechnology-related companies in Australia are small- to medium-sized enterprises. The following companies are some examples of successfully established nanotechnology companies in Australia:

- Starpharma—exploits properties of compounds known as dendrimers across a range of applications including therapeutics, drug delivery and other non-pharmaceutical applications. Starpharma is a major shareholder in the US-based company Dendritic Nanotechnologies, which has been the recipient of several USA Government grants to further the development and applications of dendrimers
- CAP-XX Ltd (LSE:CPX)—develops supercapacitors with nano-structured electrodes which provide reliable power support to space-constrained electronic devices including camera phones, solid state drives, industrial PDAs, remote sensors and wireless modems. These thin-form, high power supercapacitors can store energy from a variety of sources, and then release it quickly when needed. The company is based in Sydney, with sales offices in the UK and USA.
- Dyesol Limited—a Queanbeyan-based nanotechnology and renewable energy company engaged in the industrialisation and commercialisation of Dye Solar Cell (DSC) technology. DSC is a third generation solar cell technology that utilises nanotechnology and biomimetic activity. DSC technology mimics photosynthesis with the dyed titania nanoparticulate electrodes acting in the same way as chlorophyll to absorb light. The company was formed in 2004 and was listed on the Australian Stock Exchange in August 2005. At the moment the

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<sup>18</sup> *Nanotechnology Australian Capability Report*, Third edition, Invest Australia, May 2007, p 3. <<http://www.innovation.gov.au/Section/Innovation/Documents/Capability07.pdf>>

<sup>19</sup> This estimate was provided both in the *Nanotechnology—Australian Capability Report* (May 2007) and, later, by the AzoNano—the A to Z of Nanotechnology (AZoNano.com) knowledge base and news service.

company is going through the final stage of a two-year project, funded by the Defence Science and Technology Organisation (DSTO), to produce foldable solar power receptors for use in the field. Engineering phase will start soon to commence the designs for manufacturing and licensing to produce camouflaged foldable solar power receptors (or 'Stealthcell') for military applications.

Global companies in every major industry have benefited from Australian nanoscience, from aeronautics (the Boeing Company, Airbus Deutschland GmbH) and information technology (Intel, Sony) to health (Merck, Pasteur Institute of France) and resources (Rio Tinto).<sup>20</sup>

Two Australian industry associations, Australian Nano Business Forum (ANBF) and Australian Nanotechnology Alliance (ANA), are nanotechnology specific. These organisations raise awareness of nanotechnology by Australian industry and link the Australian sector into global networks. A third group, Materials Australia, is a professional association for those in the materials engineering, manufacturing and research industries. The focus of its activities is broader than nanotechnology. However, during the last two years this association has had a number of nanotechnology-focused activities and published some nanotechnology-related interviews and articles in their journal: *Materials Australia*.

## Workforce and education

There are no data available on the nanotechnology-related workforce in Australia. Nanotechnology draws its workforce from a range of disciplines including engineering, chemistry and the biological sciences. In addition, three Australian Universities provide courses in nanotechnology:

- Flinders University the Bachelor of Science in Nanotechnology (Honours) prepares graduates for working in a variety of scientific professions. From year two, students specialise in either Biomedical Nanotechnology or Quantum Nanostructures. They also learn about business, enterprise management, economics and legal issues such as intellectual property. In 2007, 12 undergraduates completed the course. Like other nanotechnology courses, this course is fairly new and so there are no Masters or PhD students yet.
- La Trobe University offers three tailored programs in nanotechnology at the Melbourne (Bundoora) campus:
  - Master of Nanotechnology (two-year coursework degree)
  - Bachelor of Science (Honours) / Master of Nanotechnology (accelerated five-year double degree)
  - Bachelor of Nanotechnology / Bachelor of Science (accelerated four-year double degree).

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<sup>20</sup> *Nanotechnology Australian Capability Report*, p 2.

A key feature of the above degree programs is the offering of specialist courses on nanochemistry, scanning probe microscopies, imaging and materials characterisation, synchrotron science and technology, nanomaterials and fabrication, and sensors and devices. La Trobe University also offers the Nanotechnology Entrance Scholarship Program, which features a \$6000 scholarship during the first year of enrolment in the two La Trobe nanotechnology and double degrees listed above. These courses started four years ago and the first student is expected to graduate in 2008, with more in the coming years.

- Royal Melbourne Institute of Technology's (RMIT) School of Applied Science offers a variety of undergraduate and postgraduate degrees in nanotechnology including Bachelor of Science (Nanotechnology) / Bachelor of Science (Applied Sciences). In 2007, 41 students completed these courses: 13 undergraduates, 20 Honours and eight PhDs.

The AON has undertaken a six-month project to develop a national education resource for a secondary schools program on nano-science and nanotechnology. This national education resource will be based on the St Helena Innovation in Nanotechnology Education (SHINE) program (see page 39).

## Australian Government support for nanotechnology in Australia in 2007–08

Australian Government support for nanotechnology in 2007-08 by agency or program is worth \$141.2 million (Table 1 and 2).

**Table 1:** Support for nanotechnology by the Australian Government in 2007–08

Agency	Funding (\$ million)	Comments
ARC	\$62.3	This amount under the ARC National Competitive Grants Program covers new and existing nanotechnology related projects, nine ARC Centres of Excellence related to nanotechnology, and three nanotechnology related ARC research networks. Projects related to nanotechnology have been identified from the ARC database using the search term 'nano' in project titles, abstract and national benefit text and then examined for relevance.
CSIRO	\$40	The amount covers nanotechnology related research under five flagships and seven research divisions with a total number of 27 themes.
AON	\$1.42	The amount includes 2007–08 allocations to public engagement and policy coordination activities.
NHMRC	\$1.5	Forecast expenditure
ISL	\$1.55	
NMI	\$0.8	2007–08 allocation under the NNS
AusIndustry	\$9.8	These payments were made to projects that were approved under the following programs: R&D Start, Industry Cooperative Innovation Program, Commercialising Emerging Technologies (COMET), and Commercial Ready (closed to new applications in May 2008).
ANSTO	\$3.2	
DoHA	\$0.8	2007–08 allocation under the NNS
DEEWR	\$0.6	2007–08 allocation under the NNS
DEWHA	\$0.09	2007–08 allocation under the NNS
NCRIS	\$19.1	This included support for the Australian National Fabrication Facility to provide researchers with state-of-the-art fabrication facilities for nanoparticles, nanostructures, nanosensors and nanotechnological devices; and support for the Australian Microscopy and Microanalysis Research Facility.
<b>Total</b>	<b>\$141.2</b>	

Note: see Appendix A (page 60) for the full names of the agencies listed in this table

The figures in table 2 below should only be seen as an estimate and an attempt by the AON to identify the level of expenditure by area of activity. These figures were derived by the AON from the stakeholders' inputs to this report. The agencies contributing to this report were not specifically asked to report on funding or expenditure for these areas.

**Table 2:** Expenditure of Australian Government funding by area of activity

Area of NNS focus	Expenditure (\$ million)	%	Comment
<b>Health, safety and environment</b>	<b>\$31.7m</b>	<b>22.5%</b>	Health, safety and environment related work supports efforts to understand risks and benefits from nanotechnology to human health and safety, and environment including nanotechnology developments, applications and impacts.
Nanotechnology impacts on HSE and regulations	\$4.7m (part of the above figure of \$31.7m)	3.3% of \$141.2m) and 14.8% of \$31.7m	This is subset of \$31.7m and covers targeted research of impacts of nanotechnology on human health and safety, environment and regulatory frameworks. The cost was shared between CSIRO, ARC, DoHA, DEEWR, DEWHA, NHMRC, and ANSTO.
<b>Measurement</b>	<b>\$0.8</b>	<b>0.6%</b>	Work at the National Measurement Institute relates equally to both HSE and Industry issues, and so has been identified separately.
<b>Public awareness</b>	<b>\$0.58</b>	<b>0.4%</b>	Covers activities aimed at raising public awareness and understanding of nanotechnology and developing forums of communication between the public, government, industry and academics.
<b>Industry</b>	<b>\$11.1</b>	<b>7.8%</b>	Covers support for industry R&D and commercialisation activities, and events promoting nanotechnology to industry and encouraging uptake of nanotechnology
<b>International engagement</b>	<b>\$0.3</b>	<b>0.2%</b>	Covers participation in the nanotechnology related activities of the OECD and ISO; and in the international nanotechnology events
<b>Other</b>	<b>\$97.8</b>	<b>69%</b>	Covers research on nanotechnology developments and applications in the areas of biosciences, food science, textiles and fibre technology, materials science and engineering, ICT and quantum computing, and policy coordination by the AON
<b>Total</b>	<b>\$141.2</b>	<b>100%</b>	

**Table 3:** Support for nanotechnology by States in 2007-08

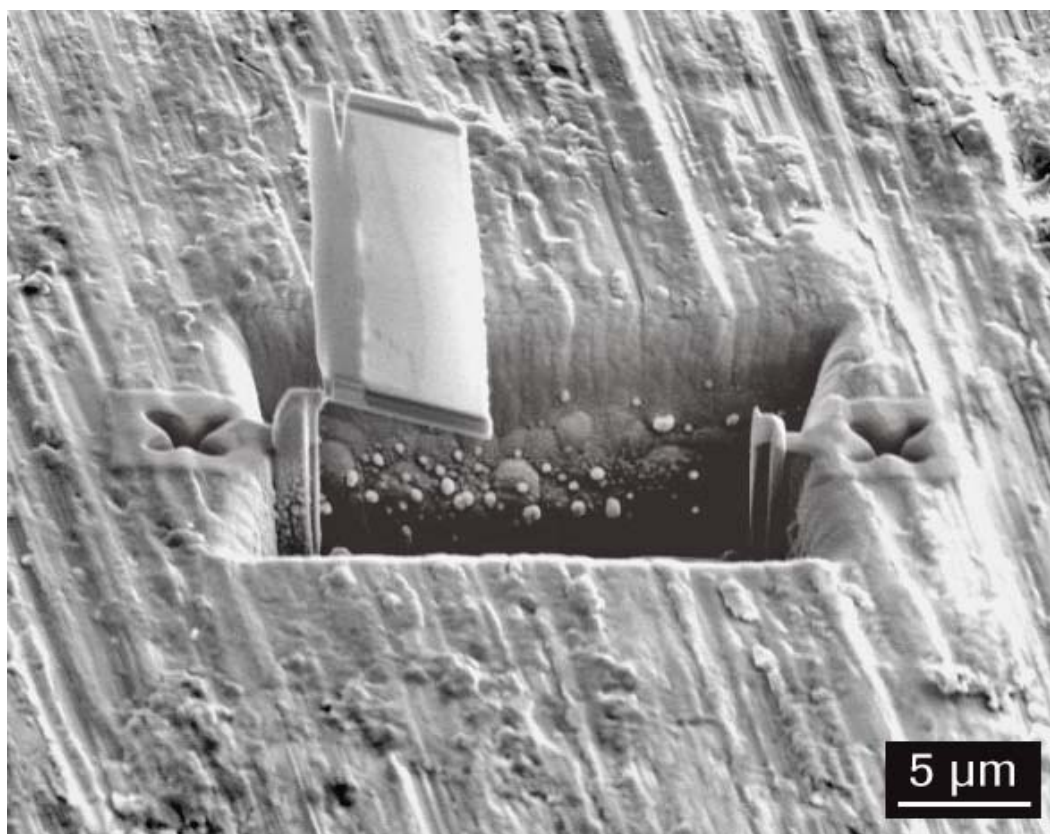
<b>Activity sector</b>	<b>Expenditure</b>	<b>%</b>	<b>Comments</b>
<b>Research</b>	<b>\$3.5m</b>	<b>16.5%</b>	
<b>Industry</b>	<b>\$17.5</b>	<b>83%</b>	Covers activities and events promoting nanotechnology to industry and encouraging uptake of nanotechnology.
<b>International</b>	<b>\$0.15</b>	<b>0.7%</b>	Covers participation in the international nanotechnology events.
<b>Total</b>	<b>\$21.1</b>	<b>100%</b>	

Apart from their own state-level activities / initiatives, the States Governments made significant contributions to the National Collaborative Research Infrastructure Strategy (NCRIS) projects. The total amount of financial contributions to NCRIS by States in 2007-08 is \$13.8 million.

# National Nanotechnology Strategy

## Background

In May 2007, the then Australian Government announced the National Nanotechnology Strategy (NNS) with funding of \$21 million over four years. The objective of the NNS is to help Australia capture the potential of nanotechnology while ensuring emerging social, ethical and safety issues are addressed and to overcome impediments to the uptake of nanotechnology by addressing regulatory frameworks, public confidence and metrology.



RF @ The University of New South Wales

Electron Microscope Unit

*Image:* Dr Charlie Kong

*Technique:* Focused ion beam microscopy (FIB)

*Short caption:* A TEM specimen of an Al composite, made in the FEI Nova Nanolab 200 Dualbeam FIB using the lift-out technique.

As a result of the budget priorities, the NNS was reduced in December 2007 from four to two years with \$9.5 million funding until July 2009. In the context of the Review of the National Innovation System, the incoming Australian Government was considering whether the National Nanotechnology Strategy was still the best approach to responsible management of nanotechnology development in Australia. The review was asked to look at the issues of frontier science and emerging or

enabling technologies to determine how these technologies can best be integrated into the national innovation system as a whole. The review, titled *venturousaustralia – building strength in innovation*, was released on 9 September 2008.<sup>21</sup> The Australian Government will consider the full implications of the review's recommendations and provide a response in its Innovation White Paper, which is expected early in 2009.

The NNS funding of \$9.5 million is allocated as follows:

- \$3.3 million for the Departments of Health and Ageing; Education, Employment and Workplace Relations; and Environment, Water, Heritage and the Arts to address the issues of impact from nanotechnology on HSE
- \$2.9 million to the National Measurement Institute for metrology
- \$1.3 million for public awareness and engagement
- \$2.0 million to coordinate the implementation of the NNS.

Activities occurring under the NNS are reported under the following headings:

- Australian Office of Nanotechnology
- health, safety, environment and regulation
- public awareness and engagement program
- metrology
- industry uptake
- international engagement

## **Australian Office of Nanotechnology (AON)**

### **Role and functions**

The AON, located in the Department of Innovation, Industry, Science and Research, is a small office of eight staff including policy and public awareness officers. The role of the AON is to coordinate the implementation of the NNS.

The AON has the objectives of:

- achieving a policy environment that helps the Australian Government make informed decisions on the impacts, opportunities and challenges of nanotechnology
- coordinating and cooperating across Australian Government agencies ensuring a whole-of-government approach to policy issues on nanotechnology

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<sup>21</sup> Cutler, T, *Venturous Australia – building strength in innovation*, Report of the Review of the National Innovation System, Department of Innovation, Industry, Science and Research, Canberra. 2008. <<http://www.innovation.gov.au/innovationreview/Pages/home.aspx>>

- engaging with state and territory governments to encourage complementary policy responses to nanotechnology.

To effectively perform its coordinating role in implementing the strategy, the AON has established three bodies:

- The Standing Interdepartmental Committee on Nanotechnology (IDC) has been established to ensure a whole of government approach to nanotechnology. The IDC considers cross portfolio issues related to nanotechnology and also maintains a network across relevant government departments and agencies to facilitate communication and information-sharing on policy and program issues related to nanotechnology. The IDC met twice during the reporting period. Membership is at Attachment B.
- The Health, Safety and Environment Working Group (HSE Working Group) was established to work on the nanotechnology related regulatory issues. More details on the role of the HSE Working Group are provided on page 23 and the list of the HSE Working Group members is at Attachment C.

In February 2008, the AON established the Nanotechnology States and Territories Committee (NSTC) to engage with state and territory governments on implementation of the NNS and nanotechnology policy development. The committee comprises the six states (see Attachment D). The Northern Territory and the Australian Capital Territory advised that, at this stage, they are not active in the area of nanotechnology and are not ready to participate in the work of this committee, though the Australian Capital Territory is interested in being informed of any developments and initiatives. The committee agreed to meet twice a year and identified the following activities and areas of collaboration:

- raising awareness and uptake of nanotechnology and encouraging industry development
- identifying industry needs and providing information on nanotechnology to industry
- increasing Australian industry participation in international nanotechnology events and using global opportunities to advance Australian nanotechnology
- raising public awareness of nanotechnology and engaging the community in informed debate about nanotechnology development in Australia
- sharing information on state, territory and Australian governments' nanotechnology policies and activities
- collecting data on nanotechnology
- involving international nanotechnology experts where possible in pursuing the agenda of nanotechnology development in Australia.

The AON coordinated the development of the *Australian Government Approach to the Responsible Management of Nanotechnology* (the Objectives Paper),<sup>22</sup> including obtaining the agreement of the Australian Government (see page 26). It also led the process for gaining the Australian Government's agreement to release *A Review of possible impacts of nanotechnology on Australia's regulatory framework* (the Monash Report),<sup>23</sup> and commenced work on a response to the Monash Report in consultation with the relevant departments and regulatory agencies (see page 23).

## Policy advice

The AON provides advice to the Australian Government about the implementation of the NNS and about nanotechnology developments in Australia more generally.

The AON developed the NNS Implementation Plan and obtained the agreement to it by the Minister for Innovation, Industry, Science and Research.

The AON made a submission to the Legislative Council's Standing Committee on State Development of New South Wales, announced on 13 December 2007 by the NSW Minister for Science and Medical Research. The submission included information on the NNS; Australian Government support for research and industry development; the activities of regulators on health, safety and environmental issues; and data from public awareness and industry development surveys. Following the submission, the AON appeared before the committee.

The AON briefed the ministers, whose portfolios relate to nanotechnology developments, seeking their agreement to release the Monash Report and to agree to the Objectives Paper (see page 23).

## Health, safety, environment and regulations

Health, safety and environmental (HSE) issues in nanotechnology were closely examined and discussed in *Options for a Nanotechnology Strategy*.<sup>24</sup> The report made three key recommendations to the Australian Government on how to address HSE issues:

- an HSE forum comprising policy advisors, regulators and funding agencies be established to coordinate the management of and research into HSE issues
- the appropriateness of HSE regulatory frameworks be assessed in light of evidence-based risks posed by nanotechnology

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<sup>22</sup> <<http://www.innovation.gov.au/Section/Innovation/Documents/Objectives%20Paper.rtf>>

<sup>23</sup> Ludlow K, Bowman D and Hodge G, *A Review of possible impacts of nanotechnology on Australia's regulatory framework* (the Monash Report), report by the Centre for Regulatory Studies, Monash University for the Australian Government, 2008, <<http://www.innovation.gov.au/Section/Innovation/Documents/MonashReport2008.pdf>>.

<sup>24</sup> National Nanotechnology Strategy Taskforce, 2006, *Options for a Nanotechnology Strategy*, Report to Minister Industry, Tourism and Resources <<http://www.innovation.gov.au/Section/Innovation/Pages/Nanotechnology.aspx>>

- specific funds be made available to support HSE research in Australia and Australian involvement in international HSE studies.

Addressing the impacts of nanotechnology on HSE and regulatory frameworks is one of the key initiatives under the current NNS.

## HSE Working Group

To coordinate the assessment of existing regulations, the AON established an HSE Working Group. The HSE Working Group comprises policy, regulatory and research funding agencies across the Australian Government. Membership of the HSE Working Group is at Attachment C.

The HSE Working Group has been responsible for:

- analysis of the impact of nanotechnology on regulatory frameworks. The Australian Government departments of Health and Ageing; Education, Employment and Workplace Relations; and Environment, Water, Heritage and the Arts are reviewing regulatory frameworks to ensure regulatory systems address the health, workplace and environmental implications of nanotechnology
- coordinating the assessment of existing regulations with all relevant agencies, including non-government bodies such as Standards Australia. Where appropriate, the HSE Working Group liaises with research bodies on areas of potential scientific and policy research
- international engagement, enabling Australia to leverage off technical and policy developments in other countries and to influence the development of international regulatory guidelines and standards.

Funding has been provided to the relevant government agencies to undertake this work. The HSE Working Group works closely with the Public Awareness and Engagement Program of the NNS on the provision of balanced and factual information to the public.

## The Monash Report

In early 2007, the AON, in close consultation with the HSE Working Group, commissioned *A Review of Possible Impacts of Nanotechnology on Australia's Regulatory Frameworks* (the Monash Report) to obtain an independent analysis of the impact of nanotechnology on regulatory frameworks, which would be used by agencies in responding to the impact of nanotechnology.<sup>25</sup>

All the agencies referred to in the report—including the Office of the Australian Safety and Compensation Council, Food Standards Australia New Zealand, Therapeutic

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<sup>25</sup> Ludlow K, Bowman D and Hodge G, *A Review of possible impacts of nanotechnology on Australia's regulatory framework* (the Monash Report), report by the Centre for Regulatory Studies, Monash University for the Australian Government, 2008, <<http://www.innovation.gov.au/Section/Innovation/Documents/MonashReport2008.pdf>>.

Goods Administration, and National Industrial Chemicals Notification and Assessment Scheme—were consulted in its preparation and given the opportunity to comment on the report.

The Monash Report was provided to the Australian Government in September 2007 and has been under consideration by relevant agencies since then. The Minister for Innovation, Industry, Science and Research released the report on 11 July 2008.<sup>26</sup>

The overall conclusion of the Monash Report is that Australia's regulatory frameworks are generally well suited to the task of regulating nanotechnologies within the next ten years. It notes that 'whilst there is no immediate need for major changes to the regulatory regimes, there are many areas of our regulatory regimes which, potentially, will need amending, and this will be a long-term effort across multiple regulators and regulatory agencies as nanoproducts arise and as new knowledge on hazards, exposure and monitoring tools becomes available'.<sup>27</sup>

Australian Government agencies accept the findings of the Monash Report that:

- Australia's regulatory frameworks are generally well suited to the task of regulating nanotechnologies within the next ten years
- all regulatory frameworks applying to conventional products and chemicals also apply to nanomaterials and nanotechnology-based products
- whilst there is no immediate need for major changes to the regulatory regimes, there are areas that potentially will need amending.

Australian Government agencies also accept that:

- each of the regulatory agencies should now consider in detail the potential regulatory gaps identified in this report
- this will require a long-term effort across multiple regulators and regulatory agencies as nanomaterials and products using nanotechnology are developed and as new knowledge on hazards, exposure and monitoring tools becomes available
- crucial to the next phase—in terms of our regulatory thinking for nanomaterials and nanotechnology-based products—will be steps to improve metrology and risk assessment protocols for nanomaterials.

The report identified six potential gaps in terms of regulatory triggers. The actions being undertaken by the Australian Government in response to these six areas are described in 4.

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<sup>26</sup>

<<http://www.innovation.gov.au/Section/Innovation/Pages/AustralianOfficeofNanotechnology.aspx>>

<sup>27</sup> the Monash Report, p. 4.

**Table 4:** Australian Government actions responding to the Monash Report

Triggers identified in the report		Actions
'New' nano substances or products	✓	Products and chemicals are each regulated differently, depending on the risks associated with each. Regulatory agencies are consulting with stakeholders and commissioning reviews to determine whether any nanoforms should be treated differently to the usual form of a substance and also to understand whether any hazards might be present.
Current definitions of weight or volume	✓	The current thresholds for weight and volume in some regulations and legislation are being reviewed to determine whether they need amending to accommodate the different nature of nanomaterials.
Knowledge of the presence of nanomaterials	✓	Regulators are working to ensure that applicants indicate, at the time of application, size characteristics of ingredients/chemicals in products where those materials possess certain characteristics that could represent additional safety concerns.
Risk assessment protocols	✓	<p>Regulators have sufficient flexibility within their current risk assessment protocols to consider issues specifically relevant to nanotechnology and nanomaterials. National and international guidelines applicable to risk assessment protocols are not, and are not intended to be, prescriptive or restrictive in nature.</p> <p>Within the flexibility of risk assessment protocols, regulators routinely adapt their analytical methods or risk assessment methodologies in order to accommodate the specific challenges presented by, and the characteristics of, the material or product under assessment.</p> <p>Australian Government agencies are continuing to address the adequacy of current arrangements in consultation with bodies such as the National Measurement Institute, other international regulators, and international bodies such as the OECD.</p>
Research and development exemptions	✓	Regulatory agencies are reviewing current research and development exemptions, where they apply, to take account of the potential risks of relevant classes of nanomaterials. This will provide a basis for considering amendments to the regulations.
International standards	✓	Regulatory agencies utilise international standards or guidelines only where they are relevant to Australia's regulatory environment. Guidelines are not intended to be prescriptive, and adoption does not constrain regulators from adapting their risk assessment methodologies and requirements to accommodate the specific issues presented by a given material. Agencies are currently working with their overseas counterparts and international partners to promote consistency in managing risks associated with nanomaterials, where they exist.

## The Objectives Paper

The HSE Working Group was also closely involved in developing the *Australian Government's Approach to the Responsible Management of Nanotechnology* (the Objectives Paper).<sup>28</sup> The Objectives Paper is a framework for a more consistent government approach across Australia to managing nanotechnology. It is intended to guide policy development to ensure public safety, ethical standards and environmental integrity are maintained. The three principle objectives are:

- protection of humans and the environment
- fostering an informed community debate
- capturing the social and economic benefits of nanotechnology.

Members of the HSE Working Group participate in important international forums. This includes the OECD Working Party on Manufactured Nanomaterials and the International Organization for Standardisation Technical Committee 229.

The HSE Working Group met five times during 2007–08.

## HSE activities by Australian Government agencies

### Department of Health and Ageing (DoHA)

DoHA received NNS funding of \$831,000 in 2007–08 under a Memorandum of Understanding signed with the Department of Innovation. Most of this funding was allocated to the following portfolio agencies: the Therapeutic Goods Administration (TGA), National Industrial Chemicals Notification and Assessment Scheme (NICNAS), and Food Standards Australia New Zealand (FSANZ).

The remainder is for the DoHA to:

- coordinate health portfolio advice on any action necessary to address regulatory issues identified in the Monash Report
- monitor developments in nanotechnology and develop policy advice on health implications of nanotechnology
- provide effective coordination of portfolio agencies and departmental input to the NNS development and implementation.

The following is a summary of activities by DoHA's portfolio agencies during the reporting period.

### *Therapeutic Goods Administration (TGA)*

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<sup>28</sup> <<http://www.nanotechnology.gov.au>>

The TGA carries out a range of assessment and monitoring activities to ensure therapeutic goods available in Australia are of an acceptable standard and that the Australian community has access, within a reasonable time, to therapeutic advances.

The TGA is well placed to regulate products incorporating nanoscale materials in that it generally operates in a data rich environment, has a high level of expertise to bring to bear on the assessment of new technologies, and has the legislated authority to require additional data in support of the safety assessment of new materials where this is warranted.

Nevertheless, the TGA is aware that nanotechnology and other emergent new technologies will continue to present substantial policy and scientific challenges to the TGA into the future. The best response to such challenges is the maintenance and continued development of high quality scientific expertise within the agency together with ongoing interaction with sponsors, researchers, regulators and policy makers throughout Australia and internationally.

During 2007–08, the TGA initiated a review of the capacity of existing regulatory arrangements for therapeutic products to adequately manage issues arising from the use of materials derived from nanotechnologies. Key aspects of this project include a comprehensive review of the TGA's regulatory guidelines across the TGA regulators and the development of a register of products that explicitly incorporate materials derived from nanotechnologies.

The TGA has also initiated a review of the scientific literature, focused on therapeutic products incorporating nanotechnologies, to ensure that current assessment criteria and protocols remain appropriate. The TGA already has considerable expertise in this area, publishing for example, a report of the safety of nanoparticulates in sunscreens.<sup>29</sup> Aspects of the review of its regulatory guidelines and the review of the state of the science will be completed in the next reporting period.

In addition, the TGA has established international linkages in order to leverage international research and other relevant activities, harmonise Australian requirements with those being developed internationally, and maintain an advanced knowledge of significant international developments. During the reporting period, the TGA met with the USA's Food and Drug Administration and compared approaches, experience and challenges, participated in the nanomaterials special interest group at the Society of Toxicology Meeting and was involved in the Australia–US workshop on nanomaterials that coincided with the ICONN 2008 conference.<sup>30</sup> The TGA has also continued to monitor international test guidelines under development and to assess those guidelines for potential consequences on industry and regulators.

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<sup>29</sup> See <<http://www.tga.gov.au>>

<sup>30</sup> International Conference On Nanoscience and Nanotechnology. 25–29, February 2008. Melbourne, Victoria, Australia.

## *National Industrial Chemicals Notification and Assessment Scheme (NICNAS)*

The main focus of NICNAS is to provide for:

- a national system of notification and assessment of industrial chemicals for the purposes of:
  - aiding in the protection of the Australian people and the environment by finding out the risks to occupational health and safety, to public health and to the environment that could be associated with the importation, manufacture or use of industrial chemicals
  - providing information, and make recommendations, about industrial chemicals to Australian Government, state and territory agencies with responsibilities for the regulation of industrial chemicals
  - giving effect to Australia's obligations under international agreements relating to the regulation of industrial chemicals
  - collecting statistics in relation to industrial chemicals.
- being a system under which information about the properties and effects of the chemicals is obtained from importers and manufacturers of the chemicals
- national standards for cosmetics imported into, or manufactured in, Australia and the enforcement of those standards.

During the reporting period, NICNAS developed a strategy to ensure that its legislative and administrative processes are able to manage the potential risks arising from industrial nanomaterials. The strategy involves the following elements:

- address potential risks associated with nanomaterials—nanomaterials could pose new hazards to human safety and environmental health. Determination of the applicability of current risk assessment methods (or development and validation of new methods) will improve the credibility and accuracy of results produced. Determination of appropriate controls that are feasible to implement will minimise potential new risks to workers, community and the environment
- setting a working definition for manufactured nanomaterials—adoption of a working definition for manufactured nanomaterials will help industry, and NICNAS, recognise when nanomaterials are present in their goods. However, in order to not be too prescriptive on a size basis and thereby exclude larger materials that might still be of concern, the definition will need to take account of risk
- improving and maintaining stakeholder engagement—members of the public may nominate existing chemicals for priority assessment. A well-informed public, in association with a well-prepared industry, will enable pertinent and efficient assessment of priority existing chemicals. Maintaining a cooperative environment for information sharing between industry and NICNAS will benefit health and safety of people and the environment.

In terms of research activities, NICNAS, like the TGA, worked on the Regulatory Review,<sup>31</sup> providing advice on any action necessary to address regulatory issues identified in the Monash Report. NICNAS undertook an internal assessment of regulatory issues and impact on NICNAS processes, in consultation with the NICNAS Nanotechnology Advisory Group, which includes industry and community representatives and academic experts. As a result, it is determining how it should adjust its chemical assessment programs to ensure that relevant particle-size information is gathered and used as a trigger to obtain risk data on nanoforms of industrial chemicals as appropriate. In 2008–09, NICNAS decided to undertake a second voluntary call for information on the identity, volumes, use (and data holdings) of industrial nanomaterials introduced into Australia in 2008.

NICNAS was also involved in the Capacity Building project looking at capacity and expertise available within the agency to manage future challenges arising from the application of nanomaterials as industrial chemicals.

NICNAS is actively involved in international activities. It leads Australia's involvement in the OECD Working Party on Manufactured Nanomaterials under the Environmental Directorate, to ensure Australia's interests in managing the potential risks of nanomaterials are effectively represented, and that we can access, and participate in, international developments. There are eight projects underway, which cover the sharing of research results and strategies, the adjustment of testing protocols and the testing of nanomaterials safety, the sharing of developments in regulatory issues and the development of alternative methods to testing for the generation of data.

Two key OECD projects that Australia is participating in through NICNAS are:

- development of an OECD Database on Human Health and Environmental Safety (EHS) Research—Australia, via NICNAS, is leading this project, and OECD delegations will populate the database by October 2008, followed by a public launch in early 2009. Leading this project ensures NICNAS can design the database to best meet our needs for access to data
- Safety Testing of a Representative Set of Manufactured Nanomaterials—Australia participated in a workshop in Japan in April 2008 to refine the technical requirements for the project, whilst an associated sponsorship program has overseen the assignment of different international consortia to specific nanomaterials. NICNAS is facilitating Australian involvement in the project to ensure the testing program includes nanomaterials of commercial relevance to Australia, and to maximise the integration of Australian research capability into the testing consortia. At this stage, an Australian consortium will contribute data

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<sup>31</sup> page 26

to studies on zinc oxide, cerium oxide and silver, and this participation may be upgraded to 'co-sponsor' as the Australian consortium is developed

### *Food Standards Australia New Zealand (FSANZ)*

The main role of FSANZ is to ensure a safe, nutritious and adequately labelled food supply through maintaining food standards for Australia and New Zealand and scientific risk assessment of nanotechnology in relation to food. FSANZ has not received any applications to approve any 'nanofoods'; however, they would be responsible for conducting a scientific risk assessment of any nanofoods prior to them being approved for sale.

The food regulatory issues confronting FSANZ are shared by most nations with developed food regulatory systems. FSANZ has been researching and keeping informed of scientific and regulatory developments related to nanotechnology and food safety occurring around the world.

A significant amount of scientific research into the toxicity of nanomaterials has been commissioned worldwide over the last few years, and the results of these studies are beginning to emerge. These studies will inform the international debate and will be considered by FSANZ where relevant to food. FSANZ is working with the WHO/FAO and sponsoring a joint FAO/WHO Expert meeting on the food safety implications of nanotechnology applications to food and agriculture, which will be held in early 2009. FSANZ provided funds and an officer to assist preparation for this consultation.

Domestically, FSANZ organised and hosted a one-day workshop on 6 June 2008 for key Australian regulators (TGA, NICNAS, APVMA) to collectively consider the more immediate issues around the human health risk assessment of nanotechnology. This workshop was part of a broader plan to build capacity among Australian regulators in assessing the potential toxicological risks associated with nanotechnology. This supported the work of the TGA, which is developing a training package for regulatory risk assessment of the human health implications of nanotechnology.

The food industry is a key stakeholder in the food regulatory system and a valuable information source for FSANZ. FSANZ has scenario-tested possible nano food products against the food regulatory system and has met with representatives of the food industry, in Australia and New Zealand, to inform them about the regulatory requirements for nanofoods and to discuss how they can assist in collecting information about the potential use of nanotechnology by the food industry.

In June, FSANZ published a question and answer sheet: *Small Particles, Nanotechnology and Food*.<sup>32</sup>

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<sup>32</sup> See

<<http://www.foodstandards.gov.au/newsroom/factsheets/factsheets2008/smallparticlesnanote3923.cfm>>

### *Office of the Gene Technology Regulator (OGTR)*

The role of the Office of the Gene Technology Regulator (OGTR) is to support the Gene Technology Regulator in administering the *Gene Technology Act 2000* (GT Act), which regulates dealings with genetically modified organisms.

Nanotechnology involving dealings with genetically modified organisms would attract regulation and risk assessment under the GT Act. OGTR maintains a watching brief to identify technology developments where there could be a nexus between nanotechnology and gene technology. OGTR is not aware of current or proposed applications of nanotechnology that also involve genetically modified organisms. OGTR will include a section in application forms to identify the use, inclusion or production of nanomaterials.

### **Department of Education, Employment and Workplace Relations (DEEWR)**

DEEWR focuses on the occupational health and safety aspects of nanotechnology, working on a number of projects during the 2007–08 year. It has also established two consultative groups to facilitate this work:

- the Nanotechnology OHS Reference Group—chaired by DEEWR and comprising the representatives of five state occupational health and safety authorities, Australian Council of Trade Unions, Australian Chamber of Commerce and Industry and the AON. The role of the group is to provide support for a coordinated national approach to the management of nanotechnology occupational health and safety issues
- the Nanotechnology OHS Measurement Reference Group—chaired by Workplace Health & Safety Queensland and comprising nanoparticle measurement experts, occupational hygienists, nanotechnology occupational health and safety risk managers and regulators. The role of the group is to develop nanomaterial exposure measurement capability.

During 2007-08 DEEWR was engaged in a number of nanotechnology projects and activities.

- Review of OHS Regulatory Framework—started in July 2007 - is focusing on identifying occupational health and safety issues associated with regulation of nanomaterials, and hence providing direction for OHS program work. By the end of the reporting period, DEEWR has examined the overall regulatory framework and identified a number of issues. The results of this project were presented to the first Nanotechnology OHS Reference Group meeting. Members of the reference group were invited to examine the implications for jurisdictional regulations.
- Review of Toxicology of Engineered Nanomaterials — a five-month project (April–August 2008) focusing on the latest research findings to inform Australian stakeholders and progress understanding of the hazardous properties of

engineered nanomaterials. This supports work on accurately classifying the materials, and hence providing information for users on labels and Material Safety Data Sheets (MSDS). A draft report for this project was prepared by the end of the reporting period. Findings were presented shortly after the reporting period (in July 2008) to the first Nanotechnology OHS Reference Group meeting. The final report expected to be published by the end of 2008.

- Review of evidence for the effectiveness of conventional workplace controls to prevent exposure to engineered nanomaterials - April – August 2008 - informs Australian stakeholders (employers, employees, researchers, OHS regulators, unions, employer associations, occupational hygienists and equipment suppliers) about available evidence with the view to help them target future research and provide guidance on material development. Findings from this project were presented to the first Nanotechnology OHS Reference Group meeting, and will be published subsequently on DEEWR's website.
- DEEWR also worked on the Nanotechnology OHS Risk Management project, monitoring research findings and evaluating guidance materials, examining topics such as the initial evaluation of the BSI (British Standards) guide on safe handling and disposal of nanomaterials,<sup>33</sup> labelling for nanomaterials used in the workplace, and laser printer particle emissions.

DEEWR, like other government departments and agencies, has active international involvement. Its international involvement in 2007–08 included coordinating and leading Australian involvement in development of International Organisation for Standardisation (ISO) technical report on health and safety practices in occupational settings relevant to nanotechnologies.<sup>34</sup> To this end, DEEWR staff attended three ISO Nanotechnologies Technical Committee (TC 229) meetings in June and December 2007 and May 2008. A technical report has been completed by the committee and approved by ISO members for publication.

DEEWR staff attended the XVIII World Congress on Safety and Health at Work in Korea in June 2008 and made a presentation on promoting safe use of nanotechnologies in Australian workplaces.

DEEWR also started developing and fostering relationships with the British Nanotechnology HSE Group and the US National Institute of Occupational Safety and Health (NIOSH) through initial discussions in 2007–08.

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<sup>33</sup> PD 6699-2 *Nanotechnologies – Part 2. Guide to safe handling and disposal of manufactured nanomaterials*, 2008. <<http://www.bsi-global.com/en/Standards-and-Publications/Industry-Sectors/Nanotechnologies/>>

<sup>34</sup> ISO/TR 12885:2008 *Nanotechnologies—Health and safety practices in occupational settings relevant to nanotechnologies*. <[http://www.iso.org/iso/iso\\_catalogue/catalogue\\_tc/catalogue\\_detail.htm?csnumber=52093](http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=52093)>

## **Department of Environment, Water, Heritage and the Arts (DEWHA)**

DEWHA develops and implements national policies, programs and legislation to protect and conserve Australia's environment and heritage and to promote Australian arts and culture.

DEWHA's role is to assess and provide advice to other regulators on the environmental impacts of nanotechnology. During the reporting period, DEWHA conducted desktop research into the fate of manufactured nanomaterials in the Australian environment with the objectives to:

- assess the environmental fate of manufactured nanomaterials and determine the possible paths by which biota may be exposed to them or their breakdown or degradation products
- assess and determine if the environmental fate of manufactured nanomaterials is significantly different to the environmental fate of conventional materials
- develop and propose assessment guidelines for the assessment of the environmental fate of nanomaterials that will allow DEWHA to provide regulatory agencies with technically sound advice and recommendations
- release the report for this project to the public domain.

## **Department of Agriculture, Fisheries and Forestry (DAFF)**

The role of the Department of Agriculture, Fisheries and Forestry (DAFF) is to develop and implement policies and programs that ensure Australia's agricultural, fisheries, food and forestry industries remain competitive, profitable and sustainable. This includes encouraging the agricultural and food industries to adopt new, safe technologies and practices, while protecting the health and safety of plant and animal industries and the environment, and facilitating trade.

DAFF is a member of the Standing IDC on Nanotechnology and the HSE Working Group, supporting the whole-of-government approach and maintaining a watching brief on developments in nanotechnology, particularly as they relate to food and agriculture.

DAFF, which includes the Australian Quarantine and Inspection Service (AQIS), Biosecurity Australia, and the Bureau of Rural Sciences, participated in the IDC and HSE Working Group meetings and provided comment on the Monash Report. DAFF maintains ongoing liaison with its portfolio agency, the Australian Pesticides and Veterinary Medicines Authority.

## **Australian Quarantine and Inspection Service (AQIS) and Biosecurity Australia**

AQIS manages the risk to Australia's animal, plant and human health and maintains market access through the effective delivery of quarantine and export services (import and export inspections and certifications and appropriate border

interventions). AQIS takes the science-based risk assessments and policy advice of Biosecurity Australia into consideration to manage quarantine risks to a very low level for imports of animals, plants and their products. Although there is no apparent quarantine risk from nanotechnology, AQIS and Biosecurity Australia maintain a watching brief in the event that nanotechnology is applied to any aspects of animal and plant quarantine, including treatments.

### **Australian Pesticides and Veterinary Medicines Authority (APVMA)**

The role of the APVMA is to protect the health and safety of people, animals and crops, the environment and trade, and support Australian primary industry, through evidence-based, effective and efficient regulation of pesticides and veterinary medicines.

The APVMA administers the National Registration Scheme for Agricultural and Veterinary Chemicals (agvet chemicals). The Scheme registers and regulates the manufacture and supply of all pesticides and veterinary medicines used in Australia up to the point of wholesale sale. Before being registered, the agvet chemical product information supplied by the registrant is independently evaluated by the APVMA using a risk assessment process to decide whether the product is effective and safe for people, animals and the environment and not a trade risk. Australian Government agencies including DEWHA and the Office of Chemical Safety within DoHA, the state and territory primary industry or agriculture departments, environment protection authorities, and independent reviewers provide the APVMA with expert advice on registration applications. Although little activity involving nanotechnology has occurred in the agricultural and animal health sectors to date, nanotechnology is likely to increasingly become part of new product development in this sector.

During 2007–08, the APVMA formulated a strategy for ensuring that agvet chemical products containing nanomaterials are introduced safely and responsibly into Australia. The strategy progressively assesses and addresses the potential gaps in the existing regulatory framework for agvet chemical products containing nanomaterials. To date, significant progress has been made against most elements of the strategy.

The regulatory preparedness strategy formulated by the APVMA entails:

- initiating administrative change to APVMA product application forms by having the registrant identify whether the proposed agvet chemical product contains nanomaterials. Revision of the application form will allow the APVMA to identify these submissions at the time of application
- publishing a call for information for nanomaterials in agvet chemicals and agvet products for industry to identify those nanomaterials likely to be submitted to the

APVMA in the foreseeable future.<sup>35</sup> This will allow the APVMA to focus its efforts on the risk profiles of specific products, increasing the efficiency of the registration process and the regulatory preparedness of the APVMA

- reviewing the potential gaps in APVMA regulatory framework in response to the Monash Report, including approaching the informing policy makers on matters required to strengthen the provisions relating to the suitable amount of agvet active constituent and chemical product containing nanomaterials for research and experimental purposes
- working with the advising agencies in developing technical guidelines for nanomaterial assessment. In the case of DEWHA, this will identify possible approaches to the environmental hazard ranking of nanomaterials, which will provide the framework to conduct hazard and risk assessment of agvet chemical products containing nanomaterials
- provision of relevant APVMA staff training in preparation for assessing the hazards and risks associated with nanomaterials. The training will continue to utilise the APVMA Science Fellows Program as well as involving APVMA technical staff in interagency training sessions and workshops
- continuing to participate in a whole-of-government approach on nanotechnology, with linkages into national and international forums, including representation on the Standing IDC on Nanotechnology, the HSE Working Group, the Nanotechnology Communications and Public Affairs Network, the NHMRC Advisory Committee on Health and Nanotechnology, and the OECD Working Group on Pesticides, and the Task Force on Biocides
- engaging and heightening awareness of nanotechnologies involving agvet chemical products with regulators, industry and community groups. This will continue to be achieved through regular meetings with relevant stakeholders and will be supported by publications, such as the APVMA's position paper on nanotechnology and other nanotechnology resources available on the APVMA website
- supporting the whole-of-government response to nanotechnology regulatory issues, such as contributing to the Objectives Paper and the Australian Government's response to the Monash Report. The APVMA has also appeared before the Standing Committee on State Development Inquiry into Nanotechnology in NSW.

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<sup>35</sup> see the gazette <[http://www.apvma.gov.au/gazette/0809downloads/september\\_gazette\\_08.pdf](http://www.apvma.gov.au/gazette/0809downloads/september_gazette_08.pdf)>

## **Department of Infrastructure, Transport, Regional Development and Local Government (DITRDLG)**

DITRDLG works with the National Transport Commission and all states and territories on the maintenance of the Australian Dangerous Goods Code (Road and Rail) and the nationally harmonised regulatory framework. DITRDLG monitors the work of the Standing IDC on Nanotechnology and the HSE Working Group as findings regarding human and environmental exposure to nanomaterials and the identification of appropriate risk management measures could be relevant to the transport of dangerous goods. Publications during the reporting period are listed in the Attachment H.

## **Commonwealth Scientific and Industrial Research Organisation (CSIRO)**

CSIRO has established the Niche Manufacturing Flagship<sup>36</sup> (p45), which includes Nanosafety as one of its research themes with the goal of using sound science, help Australia capture the benefits of nanotechnology in a safe and socially responsible way, in which appropriate risk strategies are in place for research, manufacturing, consumer use, community and environmental impact.

The CSIRO is closely involved in the project on Safety Testing of a Representative Set of Manufactured Nanomaterials (see page 29). In the context of this project, Australia was assigned to contribute data to studies on zinc oxide, cerium oxide and silver. CSIRO is also involved in investigating the possibility of an Australian consortium co-sponsoring the characterisation and testing of some of these materials.

## **National Measurement Institute (NMI)**

The NMI is an important member of the HSE Working Group. Details of its work are included in the section on Metrology on page 40.

## **Australian Customs Service (Customs)**

Customs is a member of the HSE Working Group. In doing so, they are maintaining a watching brief on the work of other regulators to ensure the risk assessment processes to determine which goods should be excluded from Australia to take into account the risks introduced with nanomaterials.

## **Australian Competition and Consumer Commission (ACCC)**

The ACCC promotes competition and fair trade in the market place to benefit consumers, businesses and the community. It also regulates national infrastructure services. Its primary responsibility is to ensure that individuals and businesses

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<sup>36</sup> Niche Manufacturing Flagship is now renamed to Future Manufacturing Flagship  
<http://csiro.au/org/NicheManufacturingFlagship.html>

comply with the Commonwealth competition, fair-trading and consumer protection laws.

The ACCC understands that nanotechnology has the potential to transform the way we live. However suppliers of consumer products are reminded that the ACCC actively enforces the product safety provisions of the *Trade Practices Act 1974* (C'wealth).

As a member of the HSE Working Group, the ACCC is maintaining a watching brief on the work of other regulators, remaining abreast of research to identify any potential risks that could be introduced by nanomaterials.

## **Public Awareness and Engagement Program**

Under the NNS a \$1.3 million Public Awareness and Engagement Program aims to raise awareness and develop knowledge of the opportunities and potential of nanotechnology and to encourage an informed debate based on balanced and factual information over two years. The outcomes will assist the Australian Government in setting policy directions for research, regulation and development of Australia's involvement in nanotechnology. The program has an overarching national reach and is complemented by states' activities.

The objectives of the Public Awareness and Engagement Program are to:

- increase awareness among the general public about nanotechnology
- inform the public about the benefits and risks of nanotechnology
- create public awareness of Australian regulatory bodies and practices concerning nanotechnology and related health and safety issues
- improve the public's knowledge and understanding of social and ethical issues surrounding the use of nanotechnology to enable an informed public debate
- understand the public's knowledge, concerns and aspirations for nanotechnology
- raise awareness about the Australian Office of Nanotechnology.

The main target audiences for the program are:

- members of the public in metropolitan and regional areas who have an interest and are engaged in science-related activities
- industry, business organisations and researchers, working with nanotechnology
- science teachers, educators and other information channels that reach the general public.

Other target audiences for the program are general media, science-related media, and business, professional associations, and trade journals.

To effectively reach the broader public with limited resources, the program seeks to reach influencers with existing reach and channels of distribution. The AON has established links with Australian, state and territory government agencies and other relevant groups. This network also supports communication and information-sharing on policy and program issues related to nanotechnology.

Before starting the program, a range of research projects was undertaken including surveys of the general public and the business community and media analysis of nanotechnology items in the press and in the broadcast media. Information from these commissioned research reports has been used to refine the Nanotechnology Public Awareness and Engagement Program.

Key public awareness activities conducted in 2007–08 consisted of a combination of public forums, a website, educational materials and ongoing attitudinal research, supported by targeted publicity in metropolitan, regional and rural media.

Free public forums on nanotechnology matters were held in the 2007–08 financial year in all state and territory capital cities around Australia to engage with the public and to assist public debate about nano-science and nanotechnology.

The forums provided the AON with an opportunity to hear public comments about nano matters first hand. They also provided an opportunity for members of the public to hear a range of experts speaking about nano-science and nanotechnology. Speakers included CSIRO scientists, ARC Federation Fellows, university staff working in nano-science and ethics, government departments' representatives on occupational health and safety matters (OH&S), National Measurement Institute scientists and representatives from the Friends of the Earth.

Forums were generally held in conjunction with local partner agencies, which were able to provide advice on venue, moderator and some guest speakers. The general format for the forums was a two-hour evening event, with three expert speakers explaining the technology, its applications and health and safety issues associated with it. This was followed by a discussion with the audience.

Audience sizes in the states and territories ranged from 12 to 100 participants. Advertising of the forums in relevant local media was supported by media promotion and by placing video casts of the forum speakers on the AON website.

Several fact sheets have been under development during 2007–08, including *Nanotechnology – working with the smallest things*, *Nanotechnology and Food*, *Nanotechnology and Ethics*, and *Nanotechnology and Occupational Health and Safety Issues*. The first, *Nanotechnology – working with the smallest things*, was published on the AON website during the 2007–08 reporting period.<sup>37</sup>

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<sup>37</sup> <<http://www.nanotechnology.gov.au>>

Two activities towards the development of a national educational resource on nanotechnology were held with science teachers with assistance from various stakeholder groups. The events were held at the CSIRO Discovery Centre in September 2007 (Canberra) and at the St Helena School in December 2007 (Melbourne). St Helena runs the St Helena Innovation in Nanotechnology Education (SHINE) Program developed with funding from the Department of Education and Early Childhood Development in Victoria. The SHINE Program includes a number of initiatives such as nanotechnology curricula, a web-enabled e-learning package, and the NanoVic Nanotechnology Laboratory.

In early 2008, the AON undertook a stocktake of existing nanotechnology education resources and found SHINE was the best product to be developed into a national education resource.

The Melbourne workshop was conducted with assistance from the Australian Science Teachers Association and an outcome of this workshop was the clearly stated need for a national educational kit on nanotechnology. A consultant has now been contracted to work, in conjunction with the SHINE Program, on providing secondary school science teachers with a modular learning program on nano-science and nanotechnology.

This six-month project incorporates information gained during the Melbourne science teacher workshop and involves collaboration with Australian Science Teachers Association and experts working on the SHINE program, and it will be continued in 2008–09. The product, AccessNano, will have ten modules, comprising six modules for Years 9–10, two modules for junior science, one senior chemistry module, and an ethics and society module.

The staff of the Public Awareness and Engagement Area participated in ICONN 2008 in Melbourne in February 2008 through having an information booth, conducting a public forum, and providing a sponsorship of a concurrent media briefing on nanotechnology issues.

A national community-attitudes survey of 1100 people was conducted in May 2008 and aimed to understand the public's knowledge, concerns and aspirations for nanotechnology, and to learn how the public's concerns and aspirations might be used to inform government policy. This is the third survey of this kind to be conducted on behalf of the Department of Innovation, Industry, Science and Research on nanotechnology matters and enables tracking data to be obtained, showing change in attitudes over time. The results of this latest survey are available on the AON website.<sup>38</sup> The overall conclusion from these results is that perception of nanotechnology by the public is mostly positive even though the awareness and understanding of nanotechnology is still fairly low.

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<sup>38</sup> <<http://www.nanotechnology.gov.au>>

An analysis of Australian media newspaper and broadcasting items on nanotechnology provided the department with details on which items concerning nanotechnology appeared in the Australian media during 2007–08. The research was used to highlight any growing interests in nano-science in the media, which while not high, was dominated by occupational health and safety issues.

## **Metrology**

The National Measurement Institute (NMI) aims to enhance the uptake and growth of an internationally competitive nanotechnology industry in Australia by establishing a world-class nanometrology infrastructure and an advanced nanoparticle measurement and characterisation laboratory.

2007–08 saw the establishment and rapid growth of a new nanometrology section at the NMI. The foundations for a new, high-quality scientific team were established, involving the recruitment, both external and internal, of four research scientists. The skills and experience of the team range from nanoscale systems and functionalised nanoparticle films to the synthesis and measurement of nano-sized structures and particles to general high-level metrology skills such as uncertainty determination, experimental design, and instrumentation and quality systems.

An advanced nanoparticle laboratory intended to provide nanoparticle standards, measurement and characterisation capabilities and conduct high level research and development was created. A state-of-the-art dynamic light scattering (DLS) instrument has been purchased and is already providing a new National Measurement Institute calibration service for standard reference powders and nanoparticles from 6 micrometres down to 1 nm. A new laser diffraction system has been ordered, capable of quickly characterising particle systems with a wide range of size distributions over the range from 100 nm to several millimetres. The new instrument will extend the range of particle size measurements and be complementary to DLS methods. Further equipment purchases include a high-level optical microscope system, and a water purification system.

An extensive program of international engagement was conducted, including visits to other national measurement institutes and major international nanotechnology laboratories. These visits were combined with conferences and training programs, rapidly increasing our knowledge of overseas developments and techniques. In particular, the design of metrological atomic force microscopes has been thoroughly investigated, leading to a detailed project plan for the development of an instrument capable of providing traceability for dimensional nanoscale measurements in Australia.

The NMI's international and national comparison program continued with:

- operation of an Australian comparison of nanoparticle size measurements involving industry and research organisations. Ten Australian laboratories

measured the sizes of samples of latex spheres of nominally 30, 50 and 100 nm diameter suspended in water. These measurements were compared with the NMI measurements on the same samples and with each other and a report is about to be published

- participation in an APEC-sponsored project featuring measurements of nanoscale thin-film thickness, with participants from eleven economies and fifteen laboratories.

Two workshops for industry, government and the research sector were conducted on nanoparticle metrology: the first on 19 November 2007, at the University of Technology Sydney, attracting more than fifty participants; the second on 3 March 2008, held at the NMI, featured Dr Clayton Teague, Director of the US National Nanotechnology Coordination Office, and Dr Andrew Maynard from the Woodrow Wilson International Centre for Scholars. In addition, the NMI nanometrology staff participated in numerous conferences, workshops, media interviews and public for promoting the importance of measurement and standards for nanotechnology.

The NMI continues to provide the chairmanship of the Standards Australia Technical Committee on Nanotechnologies (NT-001) and represent Australia at the International Organisation for Standardization Nanotechnologies Technical Committee (TC 229). This work has strongly promoted Australian nanotechnology internationally by involvement in TC 229 projects such as the business plan, terminology development, road-mapping and strategy development, and various work items and projects.

The NMI has been recently accepted as the Australian member of the Versailles Project on Advanced Materials and Standards (VAMAS), a vehicle for member countries to collaborate on pre-normative research on advanced materials, including nanomaterials, to help the incorporation of advanced materials in industrial products and processes by providing the basis for developing commonly acceptable standards.

In addition to its participation on several Australian Government consultative forums, the NMI continued its collaboration and sharing information with an extensive number of networks and organisations throughout Australia, with Nanotechnology Victoria and nano-networks such as the ARC Nanotechnology Network (ARCNN).

## **Industry uptake**

Under the NNS, the AON works with relevant agencies, industry groups and state and territory governments to raise industry awareness about nanotechnology and potential benefits from it, to encourage uptake of nanotechnology by Australian industry and to help integrate Australian nanotechnology capability into global supply chains.

During the reporting period, the AON worked with a number of industry and other groups and provided them with financial support for projects aligned with the priorities set out under the NNS.

The main groups representing the interests of nanotechnology industry in Australia today are the Australian Nano Business Forum (ANBF), the Australian Nanotechnology Alliance (ANA), and Materials Australia (MA).

The ANBF is a national body representing and promoting Australian industries and companies involved in nanotechnology. In its activities the association focuses on:

- providing information to members on nanotechnology developments and issues effecting the industry
- providing a forum for interaction between nanotechnology companies, their suppliers and collaborators
- providing a collective view of industry needs to political and regulatory decision-makers and a focal point for international and export representation
- conducting strategic consulting exercises
- enabling regular meetings (including a national conference) as mechanisms for collection and distribution of information and covering business interests.

In 2007–08, the AON provided ANBF with financial support for two projects:<sup>39</sup>

- \$70,000 for organising and leading the Australian delegation to the Nano Tech Exhibition and Conference—the biggest annual nanotechnology international event—held on 13–15 February 2008 in Japan
- \$13,500 for conducting an Australian consultation as part of the global initiative by the United Kingdom on developing Responsible NanoCode<sup>40</sup>, October 2007.

The ANA encourages collaboration between the three key stakeholder groups in the Australian nanotechnology community: researchers, developers and manufacturers. Its aim is to increase the awareness of nanotechnology to organisations with a view to promoting regional innovation, economic development and employment.

In 2007–08, the AON provided the ANA with \$40,000 for their national project Building a Technology Bridge for Manufacturers (a ‘road show’ involving a series of public forums targeted to industry in various locations in Queensland, Australia from April 2008 to March 2009).<sup>41</sup>

Materials Australia (MA) provides technical materials support to those in the materials engineering, manufacturing and research industries.<sup>42</sup> This includes written

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<sup>39</sup> <<http://www.anbf.com.au>>

<sup>40</sup> International Code of Conduct for Responsible Nanotechnology (Responsible NanoCode)

<sup>41</sup> <<http://www.nanotechnology.org.au/about/>>

<sup>42</sup> <<http://www.materialsaustralia.org.au>>

information, training, conferences and seminars. It conducts training courses designed to focus on specific industry related materials and materials related conferences ranging from major international meetings to one-day seminars.

In 2007-08, the AON provided MA with \$20,000 financial support for the Nano Awareness Road Show in regional South Australia in January 2008 as part of the national series of the Nano Awareness Road Shows conducted by MA.

Some other examples of AON supporting industry-related activities in 2007–08 are:

- \$28,500 to the ARC Nanotechnology Network for the joint Australia–USA event on Sustainable Nano-Manufacturing held from 22–25 February 2008 in Brisbane and Melbourne; and \$30,000 for the biannual ICONN 2008
- \$25,000 to the Australian National University to host the Industry Forum as part of the International Conference on Electronic Materials 2008.<sup>43,44</sup>

Separately to the AON, the Innovation Department provided support for a range of nanotechnology related projects through R&D Start grants, the Industry Cooperative Innovation Program, the Commercialising Emerging Technologies Program and the Commercial Ready Program. In 2007–08, this amounted to \$9.8 million.

## **International engagement**

International engagement enables Australia to leverage off technical and policy developments and research in other countries; and to influence the development of international regulatory guidelines and standards. Several of Australia's international engagement activities have already been described in detail earlier in report.

### **OECD Working Party on Nanotechnology**

The AON is involved with OECD work on nanotechnology and represents Australia at the OECD Working Party on Nanotechnology (WPN), which was established under the OECD Committee on Scientific and Technological Policy (CSTP) in March 2007. The objective of the WPN is to promote international co-operation that facilitates research, development, and responsible commercialisation of nanotechnology in member countries and in non-member economies.

Australia is among 20 active members of the WPN, with Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hungary, Ireland, Japan, Korea, Netherlands, Norway, Poland, Portugal, Sweden, Switzerland, the United Kingdom and the USA. Other members are Italy, Russia, South Africa and Turkey.

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<sup>43</sup> IUMRS-ICEM 2008 International Conference on Electronic Materials 2008, Hilton Sydney, Sydney, Australia. 28th July to 1st August 2008.

<sup>44</sup> The time of the event is outside the 2007–08 annual reporting period. However, all organisational activities for this conference, including drafting and signing a Deed of Grant between the ANU and DIISR, happened during the first half of 2008.

At its first meeting in May 2007 the Working Party agreed to a work program involving the following projects:

- Project A: Statistics and Measurement
- Project B: Impacts and Business Environment
- Project C: International Research Collaboration
- Project D: Outreach and public engagement
- Project E: Dialogue on Policy Strategies
- Project F: The Contribution of Nanotechnology to Global Challenges (current focus in Nanotechnology and Water).

Australia is on the steering committees for projects A, B, D. In 2007–08, the AON also participated in the following work for the Working Party projects:

- Project B Impacts and Business Environment—survey of nanotechnology companies to develop case studies on the issues impacting on nanotechnology industry. The AON commissioned the Centre for Strategic Economic Studies to survey two Australian nanotechnology companies: MiniFab and Advanced Nanotechnologies
- Project D Outreach and Public Engagement—Communication and Public Engagement Questionnaire. The steering group for this project decided to consider the following issues:
  - the challenges in communicating nanotechnology to the public—examining and developing good practices and developing a comprehensive approach to the communication of nanotechnology
  - the challenges in public engagement in nanotechnology—developing good practices and a policy framework that can support policy development in member countries.
- This questionnaire was intended to help provide information on both sets of issues. The project steering group synthesised the similarities, differences and main challenges that characterise communication and public engagement issues related to nanotechnology in OECD countries.
- Project E Dialogue on Policy Strategies—OECD Nanotechnology Policy Questionnaire. This consolidated questionnaire addresses the information needs in relation to commercialisation of nanotechnology; approaches to science, technology and innovation policy; and informed dialogue between policy makers and other stakeholders in science, technology and innovation policy. The questionnaire provides cross-country comparable information on key issues. The information provided for this questionnaire will be used to develop a synthesis report on the main trends, developments and challenges that characterise science, technology and innovation policies related to nanotechnology. This

report will also contribute to highlighting common areas of interest and concern across countries.

The AON staff attended two meetings of the OECD Working Party on Nanotechnology in Paris in November 2007 and April 2008 and three regular major international events: Coms 2007<sup>45</sup> and ICONN 2008<sup>46</sup> in Melbourne, and the nanotech Japan.

### **Other collaborations**

The AON had meetings with two prominent international nanotechnology experts Dr Clayton Teague, Director of the United States National Nanotechnology Initiative (NNI), and Dr Andrew Maynard, the Chief Science Advisor to the Project on Emerging Nanotechnologies at the Woodrow Wilson Centre (United States). Dr Teague visited Canberra in February 2008 to address the Standing Inter-Departmental Committee on Nanotechnology. He spoke about the then \$1.5 Billion NNI, which is a US federal Research and Development Program. Dr Teague also met with the staff of the Minister's Office, senior officers of the Department of Innovation, Science and Industry, and the AON staff. Dr Andrew Maynard was in Australia in September 2007 at the invitation of the CSIRO through the Niche Manufacturing Flagship. The AON invited him to participate in the September meeting of the NNS HSE Working Group. Dr Maynard also met with the AON to discuss the issues of public engagement and perceptions by the public of nanotechnology.

The Australian Government has actively promoted Australia's nanotechnology capability through the Australian Nanotechnology Capability Report and the support of international delegations. The Australian Government supported delegations to attend the NSTI 2007 conference and tradeshow in USA, and nano tech Japan 2008.

Several of the Australian Government agencies involved in NNS implementation have active links to international projects, including the OECD Working Party on Manufactured Nanomaterials, and to overseas regulatory and research bodies (see page 28, for example). In addition, Standards Australia is actively involved with the International Standards Organisation Nanotechnology Committee (TC 229).

## **Other Australian Government activities**

### **Commonwealth Scientific and Industrial Research Organisation (CSIRO)**

CSIRO is Australia's premier publicly funded research agency. Its Future Manufacturing Flagship (see footnote p 36) has a goal of supporting the development

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<sup>45</sup> COMS2007 – International Conference on Commercialisation of Micro and Nano Systems, 2–7 September 2007, Melbourne, Australia.

<sup>46</sup> International Conference On Nanoscience and Nanotechnology. 25–29, February 2008. Melbourne, Victoria, Australia.

of niche manufacturing businesses based on nanotechnology, which is estimated to be worth in excess of \$3 billion per year by 2020. The Niche Manufacturing Flagship incorporates five of the nanotechnology related research themes:

- Carbon Nanotube Yarn theme—the goal is to establish a new Australian business activity in the production and use of carbon nanotube yarn worth in excess of \$1 billion per year by 2020
- Nanomaterials for Medical Delivery—the goal is to deliver by 2015 superior therapeutic outcomes for patients by developing and transferring to industry a new generation of therapeutic delivery technologies through the design and development of well-defined polymer-therapeutic conjugates
- Electroactive Materials theme —the goal is to develop new platform technologies that provide a basis for the creation and growth over the next 5–10 years of world-leading companies in Australia based on (printable) polymer electronics. Build CSIRO's Materials' platform by developing new materials, rapid prototyping and fabrication expertise for use in the energy, water, climate change, health, manufacturing, communication and security domains
- Analysis at Point of Sampling (APOS) theme —the goal is to transform by 2020 the Australian instrumentation industry into a sensor industry based on advances in nanotechnology to enable real time, *in situ* assessment of chemical, biochemical and biological species at laboratory quality (the 'laboratory to sample' transformation in sensing)
- Nanosafety theme —the goal is, using sound science, help Australia capture the benefits of nanotechnology in a safe and socially responsible way, in which appropriate risk strategies are in place for research, manufacturing, consumer use, community and environmental impact.

CSIRO places a very strong emphasis on the establishment of strong and relevant international engagement and has established links with international universities and research organisations, for example: University of Texas (Carbon Nanotube Yarn Theme) and CSIR India (Advanced Water Treatment Theme).

CSIRO also supports the OECD Workshop for the Sponsorship Programme for Testing Manufactured Nanomaterials. CSIRO scientists attended the Workshop in Tokyo on 25 and 26 April 2008. The objectives of this workshop are to explore the implications of the use of nanomaterials for human health and environment safety, focussing on testing and assessment methods.

During 2007–08, nanotechnology-related research in CSIRO was undertaken in the context of five flagships and seven research divisions with a total of 27 themes and funding of approximately \$40 million:

- Niche Manufacturing National Research Flagship (see footnote p 36)—seven themes (includes two themes not officially part of the flagship but funded from the flagship) (~\$9.5 million)
- Energy Transformed National Research Flagship—two themes (~\$6 million)
- Water for Healthy Country National Research Flagship—one theme (~\$1.8 million)
- Preventative Health National Research Flagship—two themes (~\$1.6 million)
- Wealth from Oceans National Research Flagship—one theme (~\$1.7 million)
- CSIRO Materials Science and Engineering—three themes (~\$4 million)
- CSIRO Textiles & Fibre Technology—two themes (~\$3.6 million)
- CSIRO Molecular & Health Technology—three themes (~\$3.7 million)
- Food Science Australia—two themes (~\$0.2 million)
- CSIRO ICT Centre—one theme (~\$1.2 million)
- CSIRO Forest Biosciences—one theme (~\$0.2 million)
- CSIRO Australia Telescope National Facility —one theme (~\$0.35 million)
- CSIRO Energy Technology—one theme (~\$5.5 million).

### **Australian Research Council (ARC)**

The ARC administers a range of research funding schemes under the National Competitive Grants Program (NCGP) and provides advice on research matters to the Minister. Funding under the NCGP is provided to all disciplines except clinical medicine and dentistry. It is provided on the basis of a competitive peer review process.

In 2007–08, funding allocated under the ARC NCGP to nanotechnology-related research was estimated to be approximately \$62.3 million (compared with \$58.8 million in the previous year).<sup>47</sup>

In addition to new research projects, the ARC continued to provide support for nanotechnology research projects awarded funding commencing in previous years. Ongoing projects include a number of ARC-funded research centres that incorporate nanotechnology research to varying degrees:

- ARC Centre of Excellence for Electromaterials Science (University of Wollongong)
- ARC Centre of Excellence for Functional Nanomaterials (The University of Queensland)

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<sup>47</sup> These funding figures are based on projects extracted using the search term 'nano' in project titles, abstract and national benefit text and then examined for relevance.

- ARC Centre of Excellence for Anti-matter Matter Studies (The Australian National University)
- ARC Centre of Excellence for Quantum Computer Technology (The University of NSW)
- ARC Centre of Excellence for Advanced Silicon Photovoltaics and Photonics (The University of NSW)
- ARC Centre of Excellence for Ultrahigh-bandwidth Devices for Optical Systems (The University of Sydney)
- ARC Centre for Solar Energy Systems (The Australian National University)
- ARC Centre of Excellence for Quantum-Atom Optics (The Australian National University)
- ARC Centre of Excellence for Design in Light Metals (Monash University).

ARC Centres of Excellence play a strong role across the breadth of activities associated with building research capacity including building long-term partnerships with national and international organisations (including industry) on research of national interest; supporting the development of research skills and sponsoring public awareness and engagement activities.

The ARC also continued its support for 24 research networks originally established in 2004. Networks link researchers, research groups and other involved in innovation, both nationally and internationally. They include the following specifically identified in the nanotechnology area:

- Australian Nanotechnology Research Network (\$380,000)
- ARC Molecular and Materials Structure Research Network (\$300,000)
- Australian Research Network for Advanced Materials (\$300,000).

### **Australian Nuclear Science and Technology Organisation (ANSTO)**

ANSTO has several areas undertaking nanotechnology research. The Institute of Materials Engineering has a group of 12 researchers working in the field of material science broadly classified under the nanotechnology banner. This includes a major activity that focuses on the synthesis and characterisation of novel organic-inorganic materials in the form of nanoparticles and thin films. These nanoscaled materials have applications in photovoltaic devices, in adaptive responsive materials and in the controlled degradation of organic materials.

Another project is investigating the potential for nanomaterials to have an adverse effect on human health and to formulate a series of tests that could be used with confidence to screen new and existing nanomaterials for potential health risks. It is hypothesised that different nanoparticles could have different adverse effects depending on their size and surface characteristics. ANSTO is developing radio-

labelling technologies using ANSTO OPAL reactor to detect and quantify the effect of nanoparticles in various biological studies. These biological studies will include effect on the environment and their bioaccumulation in various aquatic species as well as imaging in animals such as rats and mice using positron emission tomography and single photon emission computer tomography technology. ANSTO also expects to develop high-throughput screening assays for industry in order to assist in product development.

CeramiSphere, a wholly-owned subsidiary of ANSTO, has evolved from ANSTO's long-held expertise in ceramics processing. CeramiSphere provides controllable release of active molecules from ceramic micro-particles and nanoparticles for a wide variety of applications, including drug delivery, encapsulation and controlled release of chemicals for surface protection and delivery of actives for cosme/nutriceutical applications. CeramiSphere's patented technology encompasses the room temperature encapsulation of active materials inside ceramic spheres and their controlled release over hours to months. This technology enables it to produce a wide range of particle sizes, ranging from less than 10 nm to 100 micrometres. CeramiSphere is currently working with a range of large international companies on product development projects ranging from anti-corrosion in aircraft to the controlled release of sweetener and flavours for the food industry. CeramiSphere is also assessing its technology in such areas of interest as oral and topical delivery of proteins and single-shot vaccines.

For the financial year 2007–08, ANSTO committed funds in the vicinity of \$3.2 million, of which \$0.5 million was dedicated to research related to health, safety and environment.

### **International Science Linkages program**

The Department of Innovation provides support for international research collaborations through the International Science Linkages program, which helps Australian scientists to collaborate with international partners on leading edge science and technology. Within the Department of Innovation, the International Science Branch in the Science and Research Division has responsibility for delivering the program.

The International Science Linkages program aims to leverage access to international research funds, to raise the profile of Australian research, and to support the development of strategic alliances between Australian researchers and international researchers and industry. The program increases Australia's capacity to attract overseas R&D investment, promote innovation, and increase the economic and social impact of Australian research nationally and internationally.

Under the International Science Linkages Program, 19 current projects (awarded competitive grants totalling \$5.7 million) involve nanotechnology. This represents about 10 per cent of the total number of current grants and around 20 per cent of the

overall funding. Funding in the year 2007–08 is \$1,552,144. These projects have been supported under the following categories:

- Competitive funding—provides support in collaborations with specific countries and in a specific eligible field of research. Under the competitive grants there have been various nanotechnology projects with countries in the European Union, Israel, Japan, Taiwan and the USA (value: \$742,397).
- Australia-China Special Fund for Scientific and Technological Cooperation (value: \$283,814)
- French Australian Science and Technology Program (value: \$79,420)
- The Australia-India Strategic Research Fund (value: \$369,900)
- The Strategic Policy program—enables the Australian Government to support international scientific cooperation in priority areas of science with key countries. Under the strategic policy there have been various nanotechnology project grants with countries such as India, Italy and the US (value: \$76,614).

### **National Health and Medical Research Council (NHMRC)**

The NHMRC is Australia's principal agency for funding health and medical research, developing health advice for the Australian community, health professionals and governments. The organisation also provides advice on ethical behaviour in health care and in the conduct of health and medical research.

The NHMRC currently funds nanotechnology research through its annual research and infrastructure support schemes. From 1997 to 2008, the NHMRC committed funding of \$7.6 million for 21 nanotechnology-related research projects. Seven nanotechnology-related projects were funded during 2007–08 with the total grant amount of \$2.2 million.

The NHMRC Advisory Committee on Health and Nanotechnology was appointed in March 2007. Its role is to provide expert advice to the CEO, regarding the health related aspects of nanotechnology, particularly in the areas of health advice, collaboration with relevant stakeholders, and commissioned research. The NH&MRC has an ongoing involvement with working groups and activities concerning the health, safety and environmental impacts of nanotechnology.

### **National Collaborative Research Infrastructure Strategy (NCRIS)<sup>48</sup>**

Through NCRIS, \$542 million from the Australian Government during 2005–11 will provide researchers with major research facilities, supporting infrastructure and networks necessary for world-class research. From this investment, \$60 million will

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<sup>48</sup> <[http://www.dest.gov.au/sectors/research\\_sector/policies\\_issues\\_reviews/key\\_issues/ncris/default.htm](http://www.dest.gov.au/sectors/research_sector/policies_issues_reviews/key_issues/ncris/default.htm)>

be used on nanotechnology related activities under the Fabrication and Characterisation projects.

The NCRIS Fabrication Project has the total value \$137 million over the five-year period of 2006–11.<sup>49</sup> Australian Government support of \$41 million is provided to build on existing research infrastructure to help establish a comprehensive fabrication capability for Australia's emerging nanotechnology industry. The nodes for this project across the country are: the Victoria node (the Melbourne Centre for Nanofabrication), the ACT node, the Queensland node, the NSW nodes (the Macquarie University and the Materials nodes) and the South Australian node.

NCRIS Characterisation Project has the total value \$238 million over the five-year period of 2006–11.<sup>50</sup> The Australian Government support of \$19 million over five years is provided to support the Australian Microscopy and Microanalysis Research Facility (under the Characterisation Project, this facility is the one out of four directly relating to nanotechnology).

### **Cooperative Research Centres (CRC)**

Today, several CRCs are involved in nanotechnology: the Advanced Composite Structures CRC; the CRC for Polymers; the Australian Biosecurity, CRC for Emerging Infectious Diseases; and the Advanced Manufacturing CRC.

### **State and territory government activities**

Following the announcement of the NNS in 2007, the Department of Innovation, Industry, Science and Research invited all state and territory governments to collaborate on implementation of the NNS and establish a national dialogue on development of nanotechnology policy.

- As part of a commitment to engagement process with Australian Government Agencies, state and territory governments and external stakeholders, the AON has established in February 2008 the Nanotechnology States and Territories Committee (see page 21 for more information).

The AON recognises that HSE issues associated with nanotechnology are likely to impact on state and territory regulatory frameworks. In this context there are well-established mechanisms for interaction between the Australian, state and territory governments on HSE issues. Some examples include: the Australia and New Zealand Food Regulation Ministerial Council, which is chaired by the Minister for Health and Ageing and represented by Health Ministers of the Australian, state and territory governments and New Zealand; and the Australian Safety & Compensation Council (ASCC) with members representing all jurisdictions.

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<sup>49</sup> <<http://ncris.innovation.gov.au/capabilities/default.htm>>

<sup>50</sup> Ibid.

Nanotechnology public forums, and events and projects conducted by various industry and other bodies and financially supported under the NNS are also part of the AON collaboration with states and territories. See the details of financial support for events and projects under the NNS in the Industry Uptake section (page 41).

## Victoria

The February 2008 *Victorian Nanotechnology Statement* provided a framework for an overall nanotechnology strategy for Victoria.<sup>51</sup> The statement articulates five key priorities: industry uptake; international linkages; skills and education; responsible development; and building platforms of the future. The statement was funded and coordinated by the Department of Innovation, Industry and Regional Development in consultation with key external stakeholders. A nanotechnology action plan that will define specific activities related to research, industry, public awareness and engagement, international engagement and education and skills is currently under development.

The Science Technology and Innovation (STI) Initiative with a total budget of \$620 million from 2000 to 2008 was focused on building Victoria's science and technology capabilities. The period 2007–08 has seen a continuation of grant management and facilitation within the STI Initiative. Investments in collaborations such as Nanotechnology Victoria Ltd, the Small Technologies Cluster, and the Victorian Centre for Advanced Materials Manufacturing have stimulated a coordination of research activity to focus on applications and engagement with industry. A new \$145 million Victorian Science Agenda, recently announced as part of the government's Innovation: Victoria's Future Initiative, will focus on enhancing and leveraging these capabilities for economic and social benefits.

Nanotechnology Victoria Ltd. and the ANBF, both supported by the Victorian Government, were instrumental in promoting Australian nanotechnology internationally and securing partnership and investment opportunities. The ANBF secured Memoranda of Understanding with nanotechnology business networks in Japan and Taiwan. During the 2007–08 reporting period, the Victorian Government provided a further \$300,000 (in addition to a previous grant of \$450,000) to assist the establishment of the Australian Nano Business Forum (see p 32).

Victorian Government provided sponsorship of \$30,000 plus in-kind resources through the ANBF and Invest Victoria, and in partnership with Invest Australia to lead Australian nanotechnology business delegations to *Nano Japan Expo 2008* and *NSTI Nanotech* and *Cleantech* in 2008.<sup>52</sup>

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<sup>51</sup> Department of Innovation, Industry and Regional Development, *Victorian Nanotechnology Statement*, State of Victoria, 2008.  
<[https://www.business.vic.gov.au/busvicwr/\\_assets/main/lib60021/2008%20nanotechnology%20statement.pdf](https://www.business.vic.gov.au/busvicwr/_assets/main/lib60021/2008%20nanotechnology%20statement.pdf)>

<sup>52</sup> see <<http://www.nsti.org/Nanotech2008/>> and <<http://www.ct-si.org/Cleantech2008/>>

The Victorian Government hosted two international nanotechnology conferences in Melbourne during 2007–08: COMS 2007<sup>53</sup> and ICONN 2008.<sup>54</sup> A total sponsorship of \$100,000 plus in-kind support was provided to attract key international experts and industry participants. The conferences provided an excellent platform for public awareness and engagement. Skills and education were also themes of these conferences.

Nanotechnology Victoria Ltd. and the ANBF were also instrumental in hosting an Australian workshop on developing Responsible NanoCode as part of a global initiative by the United Kingdom in November 2007.<sup>55</sup>

The Victoria Prize and Fellowships is an annual event that recognises and rewards excellent scientific contribution to important challenges in our society. In 2007, prizes were awarded to Mr Luke Connal for the improvement of magnetic nanoparticles to enhance medical procedures; and Mr Andrew Walter for electronic and magnetic properties of nanometre thin metallic films and their data storage applications. The event costs around \$250,000 to run and invites key representatives of the scientific, industry, government and general communities.

In the 2007–08, the SHINEsecondary school curriculum was developed with the support of Nanotechnology Victoria Ltd and Design Victoria. The program has gained international recognition and is currently under consideration as a national nanotechnology resource titled Access Nano.

## **New South Wales**

The NSW Parliamentary Inquiry into nanotechnology is a highlight of activities during the reporting period.<sup>56</sup> The committee handed down its final report on the 29 October 2008.

The NSW Government does not have any nanotechnology specific programs, but supports nanotechnology through a range of programs:

- The Science Leveraging Fund, established in 2008, provides financial support to innovation and research and is aligned to three key Australian Government programs: the ARC Centres of Excellence program, CRC program and the NCRIS program. The Science Leveraging Fund has funded the following nanotechnology research groups in 2007–08: ARC Centres of Excellence (Advanced Silicon Photovoltaics and Photonics; Ultrahigh Bandwidth Devices for

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<sup>53</sup> COMS2007 – International Conference on Commercialisation of Micro and Nano Systems, 2–7 September 2007, Melbourne, Australia.

<sup>54</sup> International Conference On Nanoscience and Nanotechnology. 25–29, February 2008. Melbourne, Victoria, Australia.

<sup>55</sup> International Code of Conduct for Responsible Nanotechnology (Responsible NanoCode)

<sup>56</sup>

<http://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/0/60CE9A9B34382DC5CA2573AA00045168>

Optical Systems; Quantum Computing Technology; and Electromaterials), and NCRIS (Characterisation, Fabrication and Bioplatforms Projects). Additionally, the NSW Government funds NSW researchers to access the Australian Synchrotron and use NSW Government beamtime on the Synchrotron.

- The BioBusiness Proof of Concept Grant program helps NSW life science companies to take projects from research to early stage commercialisation. The 2007 funding round included support for projects involving nanotechnology applications in the life science sector:
- The Industry Development Program has the function of identifying opportunities and barriers to growth for various industry associations and bodies. It provided sponsorship for the Technical Textile and Non Woven Association 2007 annual conference, which included a focus on sol gels and nanocoatings. It also funds an industry liaison officer for the ARC Centre of Excellence for Electromaterials Science (at the University of Wollongong), which is responsible for developing links with industry partners.
- The Australian Technology Showcase is a promotional and networking government program that is targeted at small- and medium-sized Australian companies involved in high technology, including those involved in nanotechnology.

The NSW Government recognises the role of public awareness and engagement with regard to new technologies development. During the reporting period, it supported and participated in a number of activities raising public awareness and understanding of nanotechnology:

- The NMI and the NSW Government's Office of Science and Medical Research co-hosted on 3 March 2008 a Public Engagement Forum: International perspectives on nanotechnology and the role of measurement (see Metrology, page 40).
- The University of Western Sydney Nanotechnology Network is a forum that is hosted quarterly at the University. It aims to share ideas and knowledge from University of Western Sydney researchers with industry about nanotechnology. It also aims to investigate and develop opportunities for research engagement with industry and to showcase innovative ideas between the university and industry through nanotechnology. The NSW Government's Office of Science and Medical Research participates in this group's events and also provides promotional support in the Western Sydney manufacturing region.
- Society of Plastics Engineers – Innovation in Polymers through Nanotechnology is a forum that communicates to industry stakeholders innovations in high performance materials that are becoming available through engineering at the nanoscale from both researchers and industry. The Department of State and

Regional Development provided promotional and facility support for the forum held on 13 March 2008..

## Queensland

The Queensland Government undertook a number of nanotechnology-related activities and initiatives through the Department of Tourism, Regional Development and Industry (DTRDI) in 2007–08, including:

- development and launch by Premier Anna Bligh MP, of a new version of the Smart State Strategy, designed to foster innovation and commercialisation. Importantly, the new strategy emphasises the importance of enabling technologies to the achievement and includes funding of \$23.3 million to attract and retain talented scientists and researchers, \$25 million to attract leading clinical researchers to improve Queensland health services, and \$60 million for innovation projects targeting research-industry collaborations
- through the earlier version of the Smart State Strategy, the Queensland Government had made a number of strategic investments in nanotechnology research and development infrastructure to support cutting-edge research and innovation that will deliver long term business, environment and social outcomes. The Australian Institute for Bioengineering and Nanotechnology (AIBN) at the University of Queensland is the lead example of the Queensland Government's investment. Having helped to establish both the Institute and other core research platforms, the Queensland Government is committed under the Smart State Strategy<sup>57</sup> and Towards Q2: Tomorrow's Queensland strategies to further strengthening the fundamental connections between research and knowledge and economic and social outcomes. Nanotechnology is regarded a one of the key enabling technologies that will help to deliver these outcomes
- establishing an Emerging Industries Sectoral Development Team including nanotechnology within the DTRDI
- initiating and supporting a senior representative from the ANA to attend the nanotech Exhibition and Conference in Japan in February 2008 to promote Queensland's emerging nanotechnology capabilities at the conference and on the Australian stand, and undertake business development with the support of the Queensland Government Trade and Investment Office, Tokyo
- participating and exhibiting at ICONN 2008 and promoting through the confecence Queensland's commercial and research strengths in nanotechnology

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<sup>57</sup> see *Queensland's Smart Future 2008–2012*, Department of Education, Training and the Arts, Queensland, 2008, 6pp.  
<[http://www.smartstate.qld.gov.au/strategy/strategy08\\_12/DPC1446\\_Smart\\_State\\_Strategy\\_6pp\\_WEB.pdf](http://www.smartstate.qld.gov.au/strategy/strategy08_12/DPC1446_Smart_State_Strategy_6pp_WEB.pdf)>

as well as Queensland Government services and support for nanotechnology businesses and research and development organisations

- supporting the Queensland University of Technology's Smart Train program between 12 May and 20 June 2008 with stops across Queensland including a nanotechnology seminar on 23 May 2008 in Rockhampton prepared jointly by the Queensland University of Technology and the ANA.. The purpose of the Smart Train was to inform, demonstrate and stimulate community interest in innovation, science and technology, and social issues by encompassing a wide range of knowledge-based areas and issues, a broader spectrum of partners, and a greater cross-section of the community.
- conducting specific nanotechnology industry awareness-raising events in conjunction with the ANA, targeted at the Queensland priority industry sectors, including the Advanced Manufacturing Workshop in Brisbane on 14 April 2008, and the Marine – Building a Technology Bridge for Queensland Manufacturers, at Coomera on 11 September 2008
- developing a series of industry profiles showcasing Queensland's commercial and research strengths in nanotechnology.

## **South Australia**

Under the National Collaborative Research Infrastructure Strategy, the South Australian Government provided \$2 million to the University of South Australia's Ian Wark Research Institute to help establish a nano-fabrication facility to support minerals processing, optics and bio-pharmaceutical research as part of the Australian National Fabrication Facility. The Australian Government also contributed \$2 million and the University of South Australia \$4 million, and user income will contribute \$1.3 million. To date, Commonwealth and State Funding agreements have been developed and executed, and staffing and equipping have been completed. Progress will be reported in 2011.

## **Tasmania**

The Tasmanian Government, through its Department of Economic Development and Tourism, supports the development and commercialisation of enabling technologies including nanotechnology through a number of initiatives:

- Springboard Business Accelerator—in 2006 the Tasmanian Government committed \$2.4 million over a two-year period to a science and technology business incubation service and grant-funding program. The program provides hands-on business development assistance, from early stage business mentoring to later stage business growth services.
- research and industry linkage—research group and business visits, and networking events aimed at awareness raising and network establishment

- IDEAS Workshop—the Innovation Development Early Assessment System (IDEAS) program is a one-day workshop that is designed to assist budding entrepreneurs to evaluate the commercial feasibility of their ideas
- Market Ready Commercialisation Program—assists early-stage businesses with the skills necessary to take innovative ideas to market and to undertake commercialisation and business growth
- Research Partnerships Program—provides financial assistance to support collaboration between Tasmanian-based enterprises and research institutes on a project basis. It aims to support the early stage research and development of innovative products, processes or services that have the potential to be commercialised
- Tasmanian Innovations Program—provides financial assistance to help early stage businesses to commercialise innovative products, processes and services
- Biotechnology Strategy—released in mid-2007, it includes a program of activities aimed at growing the sector, such as promotional activities, commercialisation skill development, market and infrastructure access, and communication and collaboration facilitation.

## Western Australia

During the reporting period the Western Australia Department of Industry and Resources was doing preparatory work for the future 'Discussion paper on nanotechnology'. This work included literature search; liaising with other Western Australian Government agencies about nanotechnology and nanoproducts in the environment, workplace and the market research with the purpose of evaluating a scope for industry interaction and exploring community perceptions. The discussion paper outlines a path to future nanotechnology related activities and was circulated for an internal review by the Strategic Policy area of the department.

The Department of Industry and Resources organised a visit to Western Australia by Dr Steffi Friedrichs, the Director of the Nanotechnology Industry Association of the UK, who on 23–24 July 2007 visited the Western Australian Nanochemistry Research Institute at Curtin, Advanced Nanotechnology Ltd, University of Western Australia and Nano and Micro Photonics at Edith Cowan University. Dr Friedrichs also made a presentation at the Department of Industry and Resources. The attendees included representatives from other state government agencies, Work Safe, Public Health and Department of Environment and Conservation.

The Department of Industry and Resources provided support to the AON with organising a nanotechnology public forum in Perth on 18 June 2008. The forum was

attended by about 60 people representing a cross-section of students, academics and public.

## List of Attachments

- A. Acronyms
- B. Standing Interdepartmental Committee on Nanotechnology Membership
- C. Health, Safety and Environment Working Group Membership
- D. Nanotechnology States and Territory Committee Membership
- E. Industry Stakeholders
- F. Nanotechnology Research at Australian Tertiary Institutions
- G. Nanotechnology Initiatives of Other Countries
- H. Publications

## Attachment A: Acronyms

<b>ACCI</b>	Australian Chamber of Commerce and Industry
<b>ACS</b>	Australian Customs Service
<b>ACTU</b>	Australian Council of Trade Unions
<b>AFGC</b>	Australian Food and Grocery Council
<b>AISRF</b>	The Australia-India Strategic Research Fund
<b>ANA</b>	Australian Nanotechnology Alliance
<b>ANBF</b>	Australian Nano Business Forum
<b>ANSTO</b>	Australian Nuclear Science Technology Organisation
<b>AON</b>	Australian Office of Nanotechnology
<b>ANF</b>	Asia Nano Forum
<b>APVMA</b>	Australian Pesticides and Veterinary Medicines Authority
<b>AQIS</b>	Australian Quarantine and Inspection Service
<b>ARC</b>	Australian Research Council
<b>ARCNN</b>	Australian Research Council Nanotechnology Network
<b>ASTA</b>	Australian Science Teachers Association
<b>ATS</b>	Australian Technology Showcase Program
<b>CDER</b>	Centre for Drug Evaluation and Research
<b>CFSAN</b>	Centre for Food Safety and Applied Nutrition
<b>CRC</b>	Cooperative Research Centres
<b>CSIRO</b>	Commonwealth Scientific and Industrial Research Organisation
<b>CSTP</b>	Committee on Science and Technology Policy
<b>DAFF</b>	Department of Agriculture, Fisheries and Forestry
<b>DEEWR</b>	Department of Education, Employment and Workplace Relations
<b>DEWHA</b>	Department of the Environment, Water, Heritage and the Art
<b>DIIRD</b>	Department of Innovation, Industry and Regional Development (Victoria)
<b>DIISR</b>	Department of Innovation Industry, Science and Research
<b>DOD</b>	Department of Defence

<b>DOHA</b>	Department of Health and Ageing
<b>DSC</b>	
<b>DSRD</b>	Department of State and Regional Development
<b>DTRDI</b>	Department of Tourism, Regional Development and Industry (Queensland)
<b>EC</b>	European Council
<b>FAO</b>	Food and Agriculture Organisation
<b>FAST</b>	French Australian Science and Technology Program
<b>FDA</b>	Food and Drug Administration
<b>FSANZ</b>	Food Standards Australia New Zealand
<b>HSE</b>	Health, Safety and Environment
<b>HSE Working Group</b>	Health, Safety and Environment Working Group
<b>ICONN</b>	International Conference of Nanoscience and Nanotechnology
<b>IDC</b>	Interdepartmental Committee
<b>ISB</b>	International Science Branch
<b>ISL</b>	International Science Linkages
<b>ISO</b>	International Organisation for Standardisation
<b>NCGP</b>	National Competitive Grants Program
<b>NCRIS</b>	National Collaborative Research Infrastructure Strategy
<b>NHMRC</b>	National Health and Medical Research Council
<b>NICNAS</b>	National Industrial Chemicals Notification and Assessment Scheme
<b>NMI</b>	National Measurement Institute
<b>NNS</b>	National Nanotechnology Strategy
<b>NSTC</b>	Nanotechnology States and Territories Committee
<b>OECD</b>	Organisation for Economic Co-operation and Development
<b>OGTR</b>	Office of the Gene Technology Regulator
<b>OHS</b>	Occupational Health and Safety
<b>R&amp;D</b>	Research and Development
<b>SHINE</b>	St Helena Innovation in Nanotechnology Education
<b>SLF</b>	Science Leveraging Fund

<b>STI</b>	Science, Technology and Innovation
<b>TFB</b>	Taskforce on Biocidea
<b>TGA</b>	Therapeutic Goods Administration
<b>TTC</b>	Technology Transfer Centre
<b>VAMAS</b>	Versailles Project on Advanced Materials and Standards
<b>WGP</b>	Working Group on Pesticides
<b>WHO</b>	World Health Organisation
<b>WPNM</b>	Working Party on Manufactured Nanomaterials

# **Attachment B: Membership of the Standing Interdepartmental Committee on Nanotechnology (IDC)**

## **Department of Agriculture, Fisheries and Forestry (DAFF)**

Australian Pesticides and Veterinary Medicines Authority (APVMA)

Australian Quarantine and Inspection Service (AQIS)

## **Attorney-General's Department (AG's)**

Australian Customs Service

## **Department of Broadband, Communications and the Digital Economy (DBCDE)**

## **Department of Defence (DoD)**

Defence Science and Technology Organisation (DSTO)

## **Department of Education, Employment and Workplace Relations (DEEWR)**

Office of the Australian Safety and Compensation Council (ASCC)

## **Department of the Environment, Water, Heritage and the Arts (DEWHA)**

## **Department of Finance and Deregulation (DFD)**

## **Department of Foreign Affairs and Trade (DFAT)**

## **Department of Health and Ageing (DoHA)**

Food Standards Australia New Zealand (FSANZ)

National Health and Medical Research Council (NHMRC)

National Industrial Chemicals Notification and Assessment Scheme (NICNAS)

Office of Gene Technology Regulator (OGTR)

Therapeutic Goods Administration (TGA)

## **Department of Innovation, Industry, Science and Research (DIISR)**

National Measurement Institute (NMI)

Australian Research Council (ARC)

Commonwealth Scientific Industrial and Research Organisation (CSIRO) - observer

## **Department of Infrastructure, Transport, Regional Development and Local Government (DITRD LG)**

## **Department of the Prime Minister and Cabinet (PM&C)**

Treasury

Australian Competition and Consumer Commission (ACCC)  
**Department of Resources, Energy and Tourism (DRET)**

# **Attachment C: Membership of the Health, Safety and Environment Working Group (HSE Working Group)**

## **Department of Agriculture, Fisheries and Forestry (DAFF)**

Australian Pesticides and Veterinary Medicines Authority (APVMA)

Australian Quarantine and Inspection Service (AQIS)

## **Attorney-General's Department (AG's)**

Customs

## **Department of Defence (DoD)**

Defence Science and Technology Organisation (DSTO)

## **Department of Education, Employment and Workplace Relations (DEEWR)**

Office of the Australian Safety and Compensation Council (OASCC)

## **Department of the Environment, Water, Heritage and the Arts (DEWHA)**

## **Department of Health and Aging (DoHA)**

Food Standards Australia New Zealand (FSANZ)

National Health and Medical Research Council (NHMRC)

National Industrial Chemicals Notification and Assessment Scheme (NICNAS)

Office of Gene Technology Regulator (OGTR)

Therapeutic Goods Association (TGA)

## **Department of Innovation, Industry, Science and Research (DIISR)**

Australian Nuclear Science and Technology Organisation

Australian Research Council

CSIRO Manufacturing and Materials Technology

National Measurement Institute (NMI)

## **Department of Infrastructure, Transport, Regional Development & Local Government (DITRD LG)**

## **Treasury**

Australian Competition and Consumer Commission (ACCC)

## **Attachment D: Membership of the Nanotechnology States and Territories Committee (NSTC)**

<b>Commonwealth</b>	Australian Office of Nanotechnology
<b>New South Wales</b>	Department of State Development Ministry of Science and Medical Research
<b>Victoria</b>	Department of Innovation, Industry and Regional Development
<b>Queensland</b>	Department of State Development
<b>Western Australia</b>	Department of Industry and Resources
<b>South Australia</b>	Science & Innovation Directorate, Department of Further Education, Employment, Science & Technology
<b>Tasmania</b>	Department of Economic Development

## **Attachment E: Industry Stakeholders**

### **Australian Nano Business Forum Limited**

Suite 1B, Mezzanine  
257 Collins Street  
Melbourne Victoria 3000 Australia  
ABN: 47 116 890 272  
Telephone: +61 3 9654 9700  
<http://www.anbf.com.au>

### **Australian Nanotechnology Alliance**

PO Box 609  
Hamilton Queensland 4007 Australia  
ABN: 45 120 844 224  
Telephone: +61 7 3216 4717  
[www.nanotechnology.org.au](http://www.nanotechnology.org.au)

### **Nanotechnology Victoria**

Suite 201  
Level 2  
3 Chester Street  
Oakleigh Victoria 3166 Australia  
Telephone: +61 3 9567 3777  
[www.nanovic.com.au](http://www.nanovic.com.au)

### **The Institute of Materials Engineering Australasia Ltd**

Suite 205 / 21 Bedford Street ,  
North Melbourne Victoria Australia 3051  
PO Box 19, Parkville, VIC 3052, Australia  
Tel: 61 3 9326 7266 Fax: 61 3 9326 7272

### **Standards Australia**

GPO Box 476  
Sydney NSW 2001  
1800 035 822 (Customer service information)

# Attachment F: Nanotechnology Research at Australian Tertiary Institutions

## Australian National University

Physical Sciences and Engineering School (PSPPhysSE) at ANU involves several hundred academics, graduate students, four ARC centres of excellence, a CRC and hosting of three ARC research networks:

- ARC Centre of Excellence for Quantum-Atom Optics (ACQAO)
- ARC Centre of Excellence for Ultrahigh Bandwidth Devices for Optical Systems (CUDOS)
- ARC Centre of Excellence for Antimatter-Matter Studies (CAMS)
- The Centre for Complex Systems (CCS)
- CRC for Functional Communications Surfaces (CRC Smartprint)
- Australian Research Network for Advanced Materials (ARNAM)
- ARC Complex Open Systems Research Network (COSNet)
- Australian Research Council Nanotechnology Network (ARCNN)
- Optical Society of America ANU Student Chapter

There are four nanotechnology focused research groups at the PSPPhysSE:

- Nanotechnology and Mesoscale<sup>58</sup> Physics – research by this group includes:
  - Quantum wells, wires and dots
  - Nanocrystals in semiconductor materials
  - Nanotubes
  - Mesoporous materials
  - Complex fluids such as liquid crystals
  - Study of the inigmatic processes of long range ordering and self assembly
- Atomic and Molecular Physics Laboratory (AMPL)

The work in the laboratory is focussed on the study of fundamental atomic and molecular processes, the electronic structure of matter and their application to technological devices, and the understanding of atmospheric and astrophysical processes.

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<sup>58</sup> Mesoscale – systems of the order of millimetres in size

- The Electronic Materials Engineering (EME) Department conducts interdisciplinary research in areas such as condensed matter physics, materials science and device engineering. This includes world-class research in the growth, structure, properties and applications of electronic materials.
- Nanotube Research Group- objectives are to produce carbon nanotubes, boron nitride (BN) nanotubes, nanoparticles, nanowires and other nanomaterials in larger quantities and high yield by using a high-energy ball milling and annealing method, which was developed by the group in 1998; and also conduct fundamental research in exploring new properties and applications of these nanomaterials at a large scale.

### **University of Queensland**

*Australian Institute for Bioengineering and Nanotechnology (AIBN)* – merges the skills of the engineer, chemist, biologist and computational scientist to conduct a research program in nanoscale science, technology and engineering, technology transfer and commercialization.

*Centre for Computational Molecular Science (CCMS)*- an interdisciplinary research centre focussing on cutting-edge research in the area of molecular scale computations. This involves a range of important application-based modelling in targeted areas of biological science, materials science, nanotechnology and environmental science as well as a world-leading program in the development of new molecular theory and computational methodologies.

*Centre for Microscopy and Microanalysis (CMM)* is an interdisciplinary research, teaching and service centre which also plays an integral role within the science programs of The University of Queensland.

*Nano Optics Group* aims to develop a technology for the self-assembled growth of novel nanostructures based on colloidal quantum dots.

*Nanotechnology and Biomaterials Centre* focuses on the formation of novel materials and devices for medical and diagnostic needs.

### **University of Melbourne**

*Department of Chemical & Biomolecular Engineering* works on nano- and bioprocess engineering.

*Nanocrystals and Nanosensors Paul Mulvaney Group*, Faculty of Science, School of Chemistry, focuses on nanocrystals and nanosensors. In addition, the group is also developing microcantilever based sensors in collaboration with Dr John Sader in Applied Maths.

*The Centre for Nanoscience and Nanotechnology (CNST)* is a collaboration between researchers at the University of Melbourne, from the Department of Chemical and

Biomolecular Engineering, the School of Physics, the School of Chemistry, and the Bio21 Molecular Science and Biotechnology Institute.

*The Nanostructured Interfaces & Materials Group* focuses on surface modification of particles, biosensors, colloidal crystals and drug delivery systems.

### **University of Wollongong**

*The ARC Centre for Nanostructured Electromaterials* aims to explore the science of nanomaterials having an electron or charge transfer functionality; to prepare such nanomaterials, study and develop theories for their behaviour, and exploit these new behaviours in useful applications.

*The Intelligent Polymer Research Institute (IPRI)* focuses on developing more processable Inherently Conducting Polymers and to integrate these functional materials with other host structures with desirable mechanical properties.

*The Nanomechanics Group* focuses on mathematical modelling of fundamental physical properties exhibited by nanoparticles and nanoparticle composite materials.

### **University of Western Sydney**

*The Nanoscale Organisation and Dynamics Research Group* works on developing novel experimental (especially NMR-based) techniques and theoretical models for studying molecular association, organisation and dynamics.

*The Nanotechnology Project* aims to transfer knowledge of opportunities in nanotechnology from UWS to the manufacturing industries of the Campbelltown - Camden region.

### **Monash University**

*Micro/Nanophysics Research Laboratory* – activities centre around micro/nano-electro-mechanical-systems (MEMS/NEMS) and micro/nanofluidics.

*Robotics and Mechatronics Laboratory*

Research includes Micro/Nano precision manipulation.

### **Swinburne University of Technology**

*Centre for Micro-Photonics* an internationally leading Centre in biophotonics and nanophotonics.

*Centre for Molecular Simulation (CMS)* utilises Monte Carlo, equilibrium molecular dynamics and non-equilibrium molecular dynamics techniques used to explore a wide range of phenomena such as phase equilibria, transport phenomena and nanotechnology.

### **Curtin University of Technology Nanochemistry Research Institute**

The research undertaken by the group ranges from government-funded fundamental research to confidential one-on-one industrial projects. The NRI is also part of the

West Australian Nanochemistry Institute (WANRI) that comprises groups from Curtin University, Murdoch University and the University of Western Australia.

#### **Griffith University Nanoscale Science and Technology Centre (NSTC)**

NSTC will investigate problems that are integral to the development of intelligent systems for the coming revolution in Nanotechnology. These include the development of new sampling and sensing devices, next- and future-generation electronics, advanced functional materials, better understanding of the fundamental nature of nanostructures and the 'micro-meets-nano' (M@NT) issues of scale that must be addressed as we progress from micro-scale to nanoscale devices and systems.

#### **Macquarie University Nanobiophotonics Research Group**

The focus in the Nanobiophotonics research group at Macquarie University is on ultra sensitive detection of trace analytes.

#### **Murdoch University Murdoch Applied Nanoscience Research Group**

The main areas of research are nano-Engineering; nano-Environment; nano-Industrial; bio-nanotechnology.

#### **University of Newcastle Surface and Nanoscience Group**

The mission of the Surface and Nanoscience group is to be a centre of excellence for the modelling and analysis of surfaces and nanometre scale materials.

#### **University of South Australia - Ian Wark Research Institute**

The institute conducts research on minerals and materials, and the underlying theme is particle and material interfaces including: interparticle forces and adhesion, wetting and particle adsorption, nanotechnology and nanolubrication, biotechnology, bio and polymer interfaces, composite materials, surface modification and coatings, surface engineering, molecular modelling.

#### **University of Sydney**

The university's Institute for Nanoscale Technology has two major research programs, applying Nanotechnology to the areas of Biomedical Nano-materials and Devices and to Energy Efficient Nano-materials and Devices.

#### **University of Western Australia - Centre for Strategic Nano-Fabrication (CSNF)**

The integrated core activities of the Centre cover nanoparticles, nano-devices and nano-surfaces (based on biology and 'soft chemistry').



## Attachment G: Nanotechnology Initiatives of Other Countries

### *United States*

The US government has set up in 2001 a multi-agency coordinated program called the National Nanotechnology Initiative (NNI). The NNI involves nanotechnology-related activities of 26 Federal agencies, 13 of which have budgets for nanotechnology R&D for 2008. The 2008 NNI budget request for nanotechnology R&D across the Federal government is over \$1.44 billion. The role of the NNI is to support basic research, infrastructure development and technology transfer for a wide range of industries such as healthcare, electronics, aeronautics and energy.<sup>59</sup> For more information on the NNI, visit <http://www.nano.gov/>.

### *Japan*

Japan has been investing in nanoscience since the 1980s and is now number two to the USA in terms of government investment. Along with China, South Korea and Taiwan, Japan has increased its budget substantially since the launch of the US National Nanotechnology Initiative. In Japan five government agencies have a role in nanotechnology research with the Ministry of Education, Culture, Sports, Science and Technology (MEXT); and the Ministry of Economy, Trade and Industry (METI) having the dominant roles. For more information, visit <http://www.nanonet.go.jp/english/>

### *Canada*

The Canadian National Institute for Nanotechnology (NINT) is a \$120 million joint initiative of the National Research Council (NRC), the University of Alberta, and the Government of Alberta. The NINT was established in 2001 and its main focus of research is the integration of nanoscale devices and materials into complex nanosystems that are connected to the outside world. For more information, visit <http://nint-innt.nrc-cnrc.gc.ca/>. Parallel to this, the Government of Alberta is developing a Nanotechnology Strategy that recognizes the role of NINT for Alberta. In 2007 the Alberta Nanotechnology Strategy with a \$130-million investment over five years was announced. The Strategy is aimed to expand research capacity and develop new commercial applications that will support Alberta's traditional economic strengths and spur economic growth. For more information, visit [http://www.technology.gov.ab.ca/en/Nanotechnology\\_Strategy.cfm](http://www.technology.gov.ab.ca/en/Nanotechnology_Strategy.cfm)

### *Germany*

The German Government's High-Tech Strategy is initiated by the Federal Ministry of Education and Research. By 2009, it is estimated that up to 15 billion euros will have been invested in the strategy. The strategy aims to improve the interface between basic

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<sup>59</sup> National Nanotechnology Initiative FY 2009 Budget & Highlights

research and rapid implementation through *the* Nano Initiative – Action Plan 2010. Annual public funding on nanotechnology research in Germany is approximately \$520m (€296m). Eight Ministries, each with its own nano representative, put together the Action Plan. This plan clearly documents the German approach to developing nanotechnologies, taking into consideration all societal aspects. For the first time, a unified framework across seven key federal ministries has been presented. The Federal Ministries for Labor and Social Affairs (BMAS), Environment, Nature Conservation and Nuclear Safety (BMU), Food, Agriculture and Consumer Protection (BMELV), Defence (Bevy), Health (BMG) and Commerce and Technology (Bowie) together with the BMBF have laid the foundations to, among other things, lead an intensive dialogue with the public on the chances of nanotechnology including its risks. To this end, possible effects on health and nature will be analyzed, a common strategy on environmental risks of insoluble nanoparticles developed, and modern means of information and participation of the public applied.

For more information, visit <http://www.german-business-portal.info/GBP/Navigation/en/Business-Location/Industrial-sectors/nanotechnology.html>

#### *Denmark*

The purpose of the Danish Nanotechnology Network (NaNet) is to build bridges between the Danish industry and research institutions within the area of nanotechnology. The goal is to create growth and innovation for existing and future players in the field. The vision is to advertise and promote the utilization of nanotechnology in Denmark. NaNet's mission is to create platforms for the exchange of information on nanotechnology to facilitate the utilization on all levels of society, from research and education to industrial application and development.

<http://www.nanet.nu/English.aspx>

#### *Russia*

The Nanotechnology Corporation of Russia – a national initiative on the development of nanotechnologies and nanomaterials – was announced in 2007. It is estimated that the Russian government would allocate 200 billion rubles (approximately US\$7.7 billion) to develop nanotechnology until 2015. It aims to encourage interaction between business, government and scientists for implementing the state policy in nanotechnology. It also provides financial and organizational assistance for nano projects and programs. In August 2008, the Russian Nanotechnology Corporation has launched its first 20 million dollar investment project - nano optic lenses. The first production line will open in four years.

<http://engnano.on.ru/>

#### *Taiwan*

The Taiwan National Science and Technology Program for Nanoscience and Nanotechnology initiated in 2003 has a total budget of around US\$620 million over six years (2003-2008) during its first phase. It aims to improve basic research, accelerate nanotechnology commercialization and establish core research facilities. The program coordinates multidisciplinary and multiagency research teams, promotes industrialization of nanotechnology, provides education program to the public. The funding agencies for the Initiative include the Ministry of Economic Affairs, the National Science Council and the Ministry of Education. For more information visit

<http://nano-taiwan.sinica.edu.tw/index.php?eng=T>

#### *India*

In May 2007, the Government of India launched a Mission on Nano Science and Technology (Nano Mission) and allocated about A\$264 million (Rs.1000 crore) for five years. The Department of Science and Technology is responsible for implementing the Nano Mission. The Nano Mission is focused on capacity-building in research and training expert personnel. It aims on development of products and processes in areas such as safe drinking water, materials and sensors development and drug delivery. For more information visit <http://nanomission.gov.in/>

#### *Korea*

The Korean Nanotechnology Initiative was announced following the Nanotechnology Promotion Bill. The Initiative includes investment of approximately A\$16 billion (14,850 billion KRW )<sup>60</sup> in R&D over a period of 10 years from 2001 to 2010. It seeks to encourage industrialization and development of skilled personnel.

In December 2006, the National Science and Technology Council reviewed the five year outcomes of the Nanotechnology Initiative, and approved the revised plan for nanotechnology development for the next 10 years. It seeks to reinforce the development of nanotechnology in areas such as infrastructure construction and aims to support nanotechnology related education and training programs. For more information, visit <http://www.nanonet.info/nanonet/wsp/english/main/index.jsp>

#### *Singapore*

The government funding agencies, including Ministry of Education (MOE), and Agency for Science, Technology and Research (A-STAR) have been placing stronger emphasis on nanotechnology. A-STAR has called for strategic research programs on nanotechnology such as 'Nano-Manufacturing' and 'Molecular and Polymer Electronics'. The Singapore Government has committed US\$10 billion (SGD 13.55 billion) on R & D for the period of 2006-2010 (over 200% increase from the previous five year period).

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<sup>60</sup><http://www.nanonet.info/nanonet/wsp/english/overview/policy.jsp>

### *China*

The Chinese Academy of Sciences, and the National Natural Science Foundation jointly issued a Compendium of National Nanotechnology Development (2001–2010). The Compendium lays out the key tasks for nanotechnology development in China, such as improving nanotechnology R&D, consolidating intellectual property protection and aligning innovation policy with nanotechnology development.

<http://www.nanoctr.cn/english/index.html>

### *Israel*

The Israel National Nanotechnology Initiative (INNI) recognizes the need to increase exposure for Israeli nanotech, as well as to encourage the investment and industrial communities to identify attractive Israeli research and applications. Its goal is to:

- Proactively engage key nanotech players in Israel and abroad.
- Promote Israel's nanotech capabilities in our strategic fields to leaders and groups interested in collaboration.
- Initiate and manage direct contacts in Israel and abroad.
- Maintain key Israeli nanotech statistics and market information.
- Create models for successful interaction with Israeli nanotech research and industry in a variety of disciplines.

[http://www.nanoisrael.org/mapping\\_engine.asp](http://www.nanoisrael.org/mapping_engine.asp)

### *Europe*

The Commission of the European Communities plays two important roles in the development of nanosciences and nanotechnologies – as policy maker and as funding body for research and innovation. European Union Institutions, member states, industry, researchers and other interested parties have worked together, sharing information and regularly consulting one another, so that by and large, Europe has been 'talking with one voice'. For more information, visit

<http://cordis.europa.eu/nanotechnology/>.

The Organisation for Economic Co-Operation and Development (OECD) published in April 2008a draft report titled 'Nanotechnology at a Glance'. The report is not yet a public document. The report is planned to be released by December 2008 and will include internationally comparable data sources on market forecasts, analysis of internationally comparable and available indicators on nanotechnology developments R&D and patents. The forecast of this report is that the future market size of nanotechnology to be in the range of US\$150 billion in 2010 to as much as US\$2.6 trillion in 2014. More information about government nanotechnology programs can be found on <http://www.nanotech-now.com/government.htm>

### *Asia*

The Asia Nano Forum (ANF) is a network organization, founded in May 2004, to promote excellence in research, development and the economic uptake of

nanotechnology within the Asian region. This collaborative network seeks to benefit its member economies educationally, socially, environmentally and economically by fostering collaboration and acting as a focus for regional and global nanotechnology issues. The ANF Network is supported by 13 economies in the Asia Pacific Region including Australia, China, Hong Kong, India, Indonesia, Korea, Japan, Malaysia, New Zealand, Singapore, Taiwan, Thailand and Vietnam

<http://typo4.apnf.org/>,

## Attachment H: Publications

Name of the publication	Description / focus / area of research	Author and Publishing date	Availability Hard copy / website
<b>CSIRO</b>			
Comparative toxicity of nanoparticulate ZnO, bulk ZnO, and ZnCl <sub>2</sub> to a freshwater microalga ( <i>Pseudokirchneriella subcapitata</i> ): the importance of particle solubility	Refereed journal article: ecotoxicology of zinc oxide nanoparticles	Franklin, N.M., Rogers, N.J., Apte, S.C., Batley, G.E., Gadd, G.E. & Casey, P.S. 2007	Environ. Sci. Technol. 41(24), 8484-90.
The importance of physical and chemical characterization in nanoparticle toxicity studies	Learned discourse: toxicology of nanoparticles	Rogers, N.J., Franklin, N.M., Apte, S.C. & Batley, G.E. 2007	Integr. Environ. Assess. Manag. (2007) 3(2), 303-4.
Fate of Manufactured Nanomaterials in the Australian Environment		Batley, G.E. & McLaughlin, M. 2008	Desktop study contracted by DEWHA
Ecotoxicology of Manufactured Nanoparticles In: Environmental and human health effects of nanoparticles Ed: J.R. Lead	Book chapter	Apte, S.C., Rogers, N.J. & Batley, G.E. 2008	
Controlled synthesis of luminescent polymers using a bis-dithiobenzoate RAFT agent	Refereed journal article: Chemical Communications	M. Chen, K. P. Ghiggino, E. Rizzardo, S. H. Thang and G. J. Wilson 2008	website, by subscription only
Synthesis of host polymers and guests for electrophosphorescence	Refereed journal article: Macromolecule Research	S. E. Watkins, K. L. Chan, S. Y. Cho, N. R. Evans, A. C. Grimsdale, A. B. Holmes, C. S. K. Mak, A. J. Sandee and C. K. Williams 2007	website, by subscription only
Polyfluorenes without monoalkylfluorene defects	Refereed journal article: Journal of the American Chemical Society	S. Y. Cho, A. C. Grimsdale, D. J. Jones, S. E. Watkins and A. B. Holmes 2007	website, by subscription only
Various internal and customer reports	All areas	Various 2007/8	confidential

Name of the publication	Description / focus / area of research	Author and Publishing date	Availability Hard copy / website
<b>NMI</b>			
Book "New Global Frontiers in Regulation" edited by Graeme Hodge, Diana Bowman and Karinne Ludlow, Monash University	Chapter in book on Metrology and Standards for Nanotechnology	John Miles January 2008	Published by Edward Elgar
ICONN Conference paper, peer reviewed	"Metrology for Nanotechnology".	Åsa Jamting and John Miles	To be published in late 2008 as an IEEE proceeding by Causal Productions Pty Ltd
<b>National Industrial Chemical Notification and Assessment Scheme</b>			
NICNAS website – pages entitled "Nanotechnology – Your Online Guide"	Provides an overview of work being undertaken by NICNAS, and includes previous publications.	NICNAS On-going	<a href="http://www.nicnas.gov.au/Current_Issues/Nanotechnology.asp">http://www.nicnas.gov.au/Current_Issues/Nanotechnology.asp</a>
<b>Food Standards Australia New Zealand</b>			
Small Particles, Nanotechnology and Food	Food regulation & nanotechnology Questions & Answers	FSANZ 10 June 2008	<a href="http://www.foodstandards.gov.au/newsroom/factsheets/factsheets2008/smallparticlesnanote3923.cfm">http://www.foodstandards.gov.au/newsroom/factsheets/factsheets2008/smallparticlesnanote3923.cfm</a>
<b>Victorian Government</b>			
Victorian Nanotechnology Statement	Framework for nanotechnology focus and priorities	DIIRD February 2008	<a href="http://www.business.vic.gov.au">www.business.vic.gov.au</a>
<b>New South Wales Government</b>			
Nanotechnology	Public engagement and information sharing	NA June 2008	Availability - website <a href="http://www.osmr.nsw.gov.au/resources/nanotechnology">http://www.osmr.nsw.gov.au/resources/nanotechnology</a>
NSW: First for Innovation	Information sharing on NSW research strengths	NA 2007	Hardcopy

Name of the publication	Description / focus / area of research	Author and Publishing date	Availability Hard copy / website
Science and Medical Research Directories	The research directories detail the breadth of research currently being undertake in NSW within universities and associated research centres	NA 2006	Hardcopy and online Website <a href="http://www.osmr.nsw.gov.au/research_directories">http://www.osmr.nsw.gov.au/research_directories</a>