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INQUIRY INTO NANOTECHNOLOGY IN NEW SOUTH WALES

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Submission to the Inquiry into Nanotechnology in NSW

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Executive Summary

Nanotechnology is generally taken to mean "*the science, engineering and technology of materials and devices at the nano-scale (<100 nm)*". Nanotechnology encompasses a broad and rapidly developing area of research and development with applications ranging from additives to sunscreens to the manipulation of materials at the atomic level. Nanotechnology is widely acknowledged to have the potential to be a highly disruptive technology across a range of industrial sectors and that it could be as significant as the development of electricity or the microchip[1]. The development of a NSW Nanotechnology Strategy is urgently required to ensure that:

1. The State's existing nanotechnology research and development capabilities are supported and enhanced.
2. The opportunities for developing new industry and commerce based on nanotechnology are exploited within NSW and not lost to other States or overseas.
3. The need for improved education and training in nanotechnology in NSW are met.

University of Newcastle Capability

There is a long-standing history of nanotechnology research at the University of Newcastle with established nanotechnology projects in the Science (primarily through Physics and Chemistry) and Engineering (primarily through Chemical Engineering) Faculties. The facilities at the University include several scanning probe microscopy units, which are capable of imaging surfaces down to the nanoscale. The University is also a node of the Australian National Fabrication Facility[2] and as part of the ANFF provides access to advanced nanotechnology based fabrication facilities, including a class 1000 clean room, inert atmosphere glove boxes and a state-of-the-art plasma enhanced chemical vapour deposition system (PECVD) for fabricating nanotubes of various materials) to users across Australia. These facilities are located within the Centre for Organic Electronics (COE), which is exciting new nanotechnology-based initiative at the University of Newcastle focusing on the development of new electronic devices at the intersection between semiconductors and plastics[3]. The COE brings together researchers from Physics and Chemistry to address the scientific challenges associated with developing new organic electronic materials and devices with applications in renewable energy research, biotechnology and photonics.

Current and Future Nanotechnology Applications

The specific current and future applications for nanotechnology in New South Wales are extremely difficult to define given the broad range of activity encompassed within the area. However, the applications of nanotechnology that will impact significantly upon New South Wales and its citizens can be grouped into two broad topic areas. Firstly, the use of n*anoscale materials* is already reaching the end user in a number of products.

Secondly, *nanoscale technologies* based on fabricating and characterising nanomaterials are being rapidly developed.

Nanoscale Materials

The physical, electronic and optical properties of many materials are significantly changed when their dimensions are reduced to only a few nanometres. For example:

Effective surface areas of materials are massively increased at the nanoscale resulting in increased chemical activity with applications in catalysis and other chemical-based processes. In one application, Samsung Electronics[4] has released new refrigerators incorporating nano-silver particles to the water dispenser system and deodorizer unit due to their high antibacterial reactivity.

Carbon nanotubes have strengths and electrical conductivities far higher than traditional bulk carbon materials. These materials are already being integrated as electron emitters for nano-emissive displays[5].

In almost every industrial and technological area, there are applications for nanotechnology via either new, or existing materials. However, the general level of awareness of nanotechnology and of its potential to transform industry and business is, in general, low in NSW. As such, there is a high risk that opportunities for implementing improvements to existing industrial processes and developing new industries based on nanotechnology will be lost due to a lack of awareness in the NSW industry and business sectors.

Nanoscale Technologies

Fabricating devices and structures at the nanoscale requires new tools and instruments for fabricating, manipulating and characterising these structures. For example:

Carbon nanotubes are typically fabricated using precision control of carbon-rich gas mixtures in computer-controlled furnaces.

Scanned probe technologies incorporate extremely fine tips with motors capable of positioning with atomic scale precision and are a key technology for characterising nanoscale surfaces and materials.

As devices and structures incorporating nanotechnology become increasingly prevalent within industry, business and society at large, so will the need for instrumentation to characterise and manipulate these devices. As such there are considerable opportunities for the development of new industries in NSW based on fabricating and characterising nanoscale materials as well as the challenges associated with training the next generation of engineers and technicians with these skills and knowledge.

Health, Safety and Environmental Risks and Benefits of Nanotechnology

The tiny length scale of nanoscaled materials, especially in particulate form, presents a number of potential Health, Safety and Environmental Risks. The body's primary natural defence systems for preventing the ingress of particles relies primarily on physical barriers such as the skin and membrane lining of the respiratory tracts and lungs etc, While these systems are effective against micron sized particles, nano sized particles can potential migrate through these barriers with ease. For example, there is some

concern about nano-particles in sunscreens that could diffuse straight through the skin and into the body. However, for all of these potential risks, there have not been any major nanotechnology-based health scares. At the research level, the relatively small quantities of materials that are produced means that the existing protocols and guidelines for dealing with potentially hazardous materials provide excellent protection for research workers and students. However, the risks associated with large scale implementation of nanotechnology will require the development of new risk assessment and management strategies coupled with enhanced public education of the possible dangers of exposure to nanoscaled materials. Indeed, perhaps the greatest risk with regards to nanotechnology based materials and devices arises from the potential for public perception to be driven towards believing that there is a major health risk associated with nanotechnology. The GM crisis across Europe in the 1990's and the public backlash against the spectre of "Frankenstein food" illustrated the issues that can arise from inadequate risk management and public education associated with new technology[6].

The potential benefits of nanotechnology to health and safety considerably outweigh the risks. For example, there is considerable interest in the role of gold nanoparticles (spheres and rods) in cancer therapies, where they can be selectively attached to tumour cells and then irradiated to destroy only the target tumour and not any surrounding tissue[7]. At Newcastle, a joint project between the COE and the Mater Hospital is currently investigating the role of nanoparticles in the blood clotting process and whether artificial nanoparticles could be used as clotting agents.

Adequacy of Existing Education and Skills Development Opportunities

Improved education is the key to addressing all of the issues that are raised in the terms of reference to this Inquiry. Understanding and exploiting the applications of nanotechnology, managing the risks and hazards associated with nanomaterials, and improving public awareness of nanotechnology are all addressed by improving research, training and education in nanotechnology.

The approach to education and training in nanotechnology is patchy and ad-hoc. The most developed programmes are at the University level, with a few NSW Universities offering specific programmes in nanotechnology (e.g. UNSW, UTS, UoW). Other Universities (e.g. UNew) offer courses in nanotechnology as components of a BSc programme. However, in the absence of an overarching State nanotechnology body there is little oversight of course content or training outcomes. The development of a NSW Nanotechnology Strategy coupled with the establishment of a NSW nanotechnology educational framework (possibly via a NSW Institute of Nanotechnology) would facilitate the development of new nanotechnology educational programmes across the State. Such an Institute would be able to coordinate efforts in nanotechnology teaching and skills training across the education sector and would be able to stimulate new programmes in regional centres. In addition, there is a serious lack of nanotechnology research and training infrastructure across the education sector, which could also be addressed by funding from such an Institute.

Recommendations to the Standing Committee

The development of NSW Nanotechnology Strategy that addresses the specific needs of NSW industry and business.

The development of a NSW Institute of Nanotechnology to oversee training and educational programmes focussed on nanotechnology.

Direct State funding for critical research infrastructure for nanotechnology to allow NSW Universities to compete with their counterparts in other States.

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