Nanofabrication – Manufacturing for the future

Innovative Australian companies and organisations are combining their expertise in micro - and nanotechnology to increase their competitiveness and boost their export potential. By Carole Goldsmith.

Based in Dandenong (Victoria), Micronisers specialises in advanced milling and chemical processes for making products at the molecular level. Established in 1987, the company provides state-of-the-art production facilities and technical support for both Australian and global manufacturers.

Its facility is uniquely equipped for the production of ultrafine and nano-sized particles, and has premises licensed by the Therapeutic Goods Administration and the Australian Pesticides and Veterinary Medicine Authority. Micronisers' customers can have products made to specific requirements for particle size, distribution and encapsulation. It is one of the very few Australian nanotechnology companies successfully commercialising nano-fabricated products in the global market. Micronisers' Chief Technical Officer is Dr Terry Turney, a Professor at Monash University's School of Chemistry, Department of Materials Engineering, specialising in nanotechnology and sustainable chemical solutions. Turney explains that nanotechnology is engineering or fabrication at the molecular and atomic scale.

"Nanotechnology has been around for many years and we have gradually developed new techniques to use it much more effectively," says Turney. "Nano is just a measurement scale of between one to 100 nanometres (nm) with one nm being a billionth of a metre."

Turney is also a director/part-owner of Sonic Essentials, a producer of crop protection and micronutrients for the agricultural sector. Sonic Essentials specialises in improving crop yields and quality in the agricultural industry, using high analysis trace-element suspension concentrates and liquid crop nutrition products. Based in Mooroopna in rural Victoria, the company supplies products to farmers in the Mallee and Wimmera as well as into the Eyre Peninsula wheat belt in South Australia. It also now sells its products – by the shipping container load – into South-East Asia, with plans to enter the African, Middle Eastern and Central American markets in the near future. Sonic Essentials' products are manufactured at the Micronisers plant, which has world-class milling and dispersion facilities. During production, a unique process is used to control nanostructure suspensions to enable high concentrations of essential trace elements to be quickly dispersed in water during crop application.

"The technology behind the dispersion of materials is very complex," says Micronisers CEO Ken King. "By knowing the way the particles in the material behave, we can create a nutrient-rich suspension liquid food for plants."

"In Australia, wheat is very seasonal and marketing our products across Asia, where they have different planting and harvesting seasons, is also helping to even out our cash-flow," says Turney. "We supply a range of trace elements in our products like zinc, manganese, copper, calcium and iron, which are necessary for the healthy growth of food crops. Thirty per cent of the world's population is zinc-deficient. We are looking at how we can use our unique skills to improve the food quality and reduce these nutritional deficiencies in the regions affected by micronutrient malnutrition".

Micronisers provides customised milled products with specific requirements for particle size and distribution, for a wide range of industries, including the plastics, personal care, textile, coatings, veterinarian and pharmaceutical sectors. Smaller particles increase product activity, functionality, as well as the ease and uniformity of mixing to improve overall product performance. At the Micronisers plant, nano- and micro-sized particles can be encapsulated or coated to increase their usage.

"Micronisers has a collaborative relationship with many companies like we have with Sonic Essentials," says King. "As an example, we manufacture for a very large multi-national chemical company using nano-particles in the process to make a stronger additive plastic.

The company has also developed an innovative production process for Swiss-based equipment manufacturer Buhler Industries, who originally approached Micronisers to produce nano zinc oxide. Micronisers began producing a dispersion of nano zinc oxide particles sized 30-40nm, which is then exported to Switzerland and modified in Buhler's factory to form the coating additive Oxylink, which has 60-70nm-sized particles. When added to water-based paints, Oxylink improves their scratch-resistance and texture.

"As a result of this successful business operation, we have established a joint venture with Buhler, which now has a minor equity in Micronisers Australasia," adds King. "Together with

Buhler we are now supplying Oxylink into markets across Australia and New Zealand, Asia, the EU and the USA."

Micronisers has also established another joint venture with a German company specialising in nano-coatings for concrete and metals. These coatings strengthen the building materials they cover and protect them from weather erosion.

Micronisers' nano-enhanced products are marketed through Nanokote, a sales and distribution division set up in 2005. Nanokote also works in the research and development of commercial applications of nanotechnology to original equipment manufacturers (OEMs) in South-East Asia and Australia.

Micronisers employs 12-16 personnel, while both Sonic Essentials and Nanokote have just one employee each. To have accomplished as much as they have so far in an area like in nanotechnology commercialisation is an impressive feat. Their case demonstrates that, by establishing the right business models and building strong collaborative frameworks, small Australian companies can thrive in a global market. According to King, the company would not have advanced as far as it has without ongoing financial support from both the Commonwealth and Victorian Governments.

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Dr Mark Bown examining the deposition chamber used to fabricate OLED devices in CSIRO's Class 1000 cleanroom. Source: CSIRO.


The cleanroom at MCN


Thin-film deposition at MCN using atomic layer deposition.

"The Australian government has supported our nanotechnology R&D work by providing large grants on a dollar-for-dollar basis," he explains. "For example, we have recently been involved with two major R&D projects funded by the Advanced Manufacturing CRC. It supported some leading scientific research done for us at Australian universities, and use of the Australian Synchrotron.

"One of these projects, which also involved a local personal care product manufacturer, Baxter Laboratories, enabled us to establish the safety of our additives in sunscreens and similar products. The other project allowed us to improve the performance of our plastics additives, which are now exported globally."

A Victorian technology hub

Clayton is fast emerging as a key hub for the development of nanotechology in Australia. The south-east Melbourne suburb is home to CSIRO, Monash University, the Australian Synchrotron, the Australian National Fabrication Facility, the Melbourne Centre for Nanofabrication, and the Australian Manufacturing and Materials Precinct, as well as a sizeable portion of Victoria's manufacturing companies.

Dr Swee Mak is the National Research Director for the CSIRO's Future Manufacturing Flagship program.

"We work across many areas like health, infrastructure, defence, aerospace, transport, resources and building products," says Mak. "Every year the Future Manufacturing Flagship works with more than 1000 firms and partner organisations. We collaborate with companies to develop and commercialise technology, assist with product innovation and help them to improve manufacturing processes while being sustainable. Nano and micro fabrication is used extensively in future manufacturing."

Dr Gerry Wilson, the Flexible Electronics Leader for the Future Manufacturing Flagship program, describes some of the innovative nanotechnology projects that CSIRO is doing with industry.

"In the flexible electronics group, we are developing new electronic materials and processes in order to print devices like solar cells and lights directly onto plastic film," says Wilson. "At 100nm, these multilayer devices are extremely thin – 1000 times thinner than a human hair. For example, with our partners in the Victorian Organic Solar Cell Consortium (VICOSC) and BlueScope Steel, we are developing the next generation of roof-integrated solar cells.

"In another electronics research project, we are using similar materials and processes to convert electricity into light using organic light emitting diodes (OLEDs). These thin and flexible multilayer devices are exceptionally efficient, low-power and very lightweight. We are working with Boeing, General Motors Holden and several Australian companies to explore the use of this revolutionary type of lighting for interior and exterior applications in the automotive and aerospace industries."

The Australian National Fabrication Facility (ANFF) provides state-of-the- art micro- and nanofabrication facilities across Australia for researchers and industry. Research areas include creating new drug delivery techniques, designing innovative engineering systems, and developing energy storage and capture devices. Operating as a membership organisation, ANFF links 21 different institutions across Australia, including 19 universities, the CSIRO and the Bandwidth Foundry, an international micro- and nanotechnology business.

"Although ANFF is mainly used by Australian and international research organisations, in the 2013 financial year, 15% of access was for industry-related work," says ANFF CEO Rosie Hicks. "This is made possible by the national team of more than 80 staff dedicated to supporting users.

"Nanofabrication is used to convert ideas into prototypes and product commercialisation. We want to encourage more enterprises to use our facilities and our researchers' expertise. Businesses should contact ANFF and we will refer them to the most suitable facility in our network. Commercial usage arrangements are available, as well as innovative government grants to assist for some projects."

Each of ANFF's facilities specialises in a different micro- and nano-fabrication areas. These range from optoelectronics, chemo- and bio-manipulation of nano-structures, bio-nano device fabrication, organic electronic device fabrication, micro-fluidics and laser machining, to mention a few.

"Our organisation is funded by state and federal government as well as by its members," adds Hicks. "Over $200m has been contributed since ANFF commenced and this is distributed across the facilities for their operations".

"Australia is one of the world leaders in nanotechnology research. Our network is certainly ensuring that this research is moving forward".

As host for the ANFF's headquarters, the Melbourne Centre for Nanofabrication (MCN) provides cutting-edge equipment, a consulting base of academic and CSIRO investigators, as well as a team of experienced process engineers. MCN is an AMTIL member. Managing Director Dr Dwayne Kirk gave AMT a tour of the Centre's advanced manufacturing facilities, which opened in January 2011, and explained the centre's capabilities. These include: design and additive manufacturing; characterisation, such as nano-array printing; etching; thin-film deposition techniques such as electroplating; and a variety of lithography services at micro- and nano-scales.

Kirk discussed a partnership that MCN provides for one of its industry clients, Brisbane-based Vaxxas, which is pioneering the Nanopatch, a vaccination delivery platform. Vaxxas uses MCN's development-scale manufacturing equipment, technical expertise and clean room facilities for product R&D.

"The Centre's Micro Electro Mechanical System (MEMS) infrastructure enables Vaxxas to produce Nanopatches in Australia for product development," said Kirk. "The Nanopatch is manufactured from mono-crystalline silicon wafer using a deep reactive ion etching process widely used to fabricate micro-electronic components found in smartphones and tablet PCs."

The Nanopatch has significant potential as a pain-free method of vaccination. It enables robust immune system activation by targeting vaccines to abundant immunological cells immediately below the surface of the skin.

Kirk described the three different ways that MCN can work with industry in nanofabrication: "Firstly our technical staff can train people to use the facility's equipment and then usage is on a fee-for-service basis. Secondly, we can perform quality-control services on new materials. As an example, a company may order nanoparticles from China and we can characterise the particles. Thirdly, a business may have developed a concept device that we can convert to a working prototype or manufacture on a pilot scale.

"When you manufacture at the nano scale, you can change the functionality of what you are working with. Pure material on a nano scale gives you more efficiency and can reduce the cost of production and logistics." AMT

www.micronisers.com
www.sonicessentials.com
www.csiro.au www.anff.org.au
www.nanomelbourne.com