Conference report

Rainbow's End: Gold-themed papers at the 2008 International Conference on Nanoscience and Nanotechnology

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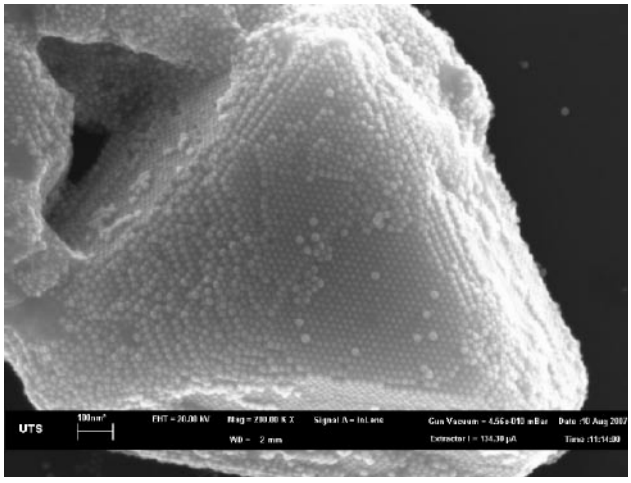
The 2008 International Conference on Nanoscience and Nanotechnology, better known as ICONN 2008, was held in Melbourne, Australia, between 25th and 29th February. The conference co-chairs were Professor Paul Mulvaney (University of Melbourne, Australia) and Dr Abid Khan (Monash University, Australia). Over eight hundred delegates attended with about two hundred and fifty of these being from Europe, Asia and North America. There were over four hundred papers or posters in total and, of course, parallel sessions to cater for them all. As usual, the properties of nanoscale gold featured strongly in the line-up, primarily as the result of gold's interesting nanoscale optical properties and useful surface chemistry. However, the scale of the conference made it impossible to get around to all the talks of interest, and the present account is therefore only a brief summary of some of the highlights.

There are several reasons why gold is so commonly used in nanoscale systems and devices at present. The foremost is that it is one of the very few metallic elements that can be used in the naked metallic nanoscale form under ambient conditions. Most other metallic elements immediately form an oxide coating. This changes their surface chemistry drastically and makes it somewhat tricky to bind organic molecules, amongst other disadvantages. A second reason is that gold nanoparticles or coatings have unique optical properties. In particular nanoparticles and thin films of gold can sustain localized or propagating surface plasmon resonances in the visible and near infrared portions of the electromagnetic spectrum respectively. (Although platinum nanostructures do not oxidize either, this element does not manifest a usable plasmon resonance in the visible or near-visible parts of the spectrum.) These factors have ensured that gold has secured a key role in the emerging nanotechnologies of surface plasmon resonance spectroscopy, biomedical diagnostics, surface enhanced Raman spectroscopy, spectrally selective filters and coatings, and electrochemical sensors.

Optical properties

I will first summarize, in no particular order, the contributions at ICONN 2008 that exploited the optical properties of gold, before moving on to those that targeted its many other interesting features.

Peter Zijlstra and colleagues from the Swinburne University of Technology, Australia, described the potential use of gold nanorods in optical storage devices. The idea is for a write-once kind of optical memory, probably in disk format, where the state of the bit is represented by the shape of a gold nanoparticle. In this case a high power pulse of laser light can be used to irreversibly switch a gold nanorod into a spherical shape by briefly melting it. The resulting change in optical properties can be readily detected and such a storage system should in principle be readable for a very long time. Jonathan Edgar of the University of Technology Sydney (UTS) described the synthesis and optical properties of hollow gold nanoshells, formed by the galvanic reaction of $HAuCl_4$ solution with silver nanoparticles. These particles are arguably more readily synthesized than conventional gold nanoshells formed on latex spheres. Nadine Harris, also from UTS, showed how gold nanoparticles can spontaneously assemble into colloidal crystals, and then went on to analyse the optical properties of these. She was followed by Isabel Pastoriza-Santos of Vigo University in Spain who described how the morphology of gold nanoparticles could be fine-tuned. In this case the intended application was an improved substrate for Surface Enhanced Raman Spectroscopy (SERS). This technique can in principle detect single molecules and has consequently attracted much attention lately. Countryman Luis Liz-Marzán, of the same university, gave an invited talk in which he reviewed



Colloidal crystal comprised of gold nanoparticles. Photo courtesy Mrs Nadine Harris, University of Technology Sydney, Australia

the methods by which long chains of nanoparticles could be spontaneously assembled onto carbon nanotubes. Once again it was the resulting optical properties that were of interest. Carolina Novo of the University of Melbourne displayed a poster in which her work on single-particle optical spectroscopy was explained. In this technique the optical scattering spectrum of a *single* gold nanoparticle is captured and analyzed and, with some effort, the same nanoparticle that produced the spectrum can be isolated and imaged in an electron microscope. This technique has permitted the direct verification of the theoretically calculated optical properties of gold nanoparticles.

Chemical and structural properties

Nanowires and other one-dimensional shapes are of great interest at the moment, particularly when made of semiconductors, due to their potential use in light-emitting devices. Lars Samuelson of Lund University in Sweden gave a well illustrated talk on such structures, but the main point of interest for me is that gold nanoparticles are the catalyst of choice used when growing such structures by chemical vapour techniques. The generally accepted mechanism is that the molten gold nanoparticles serve as a reservoir for a reactive element, such as zinc or silicon, which continuously reacts on the surface of the gold particle to produce a solid whisker or nanowire. Arrays of semiconductor nanowires can be obtained by laying down the gold nanoparticle catalyst in the desired patterns.

Gold nanoparticles have also been widely exploited as the basis of several types of sensor technology. Edith Chow of Australia's CSIRO research organisation gave a talk focusing on using films of gold nanoparticle aggregates as chemiresistors. Their device is able to detect 0.1 ppm toluene, 10 ppm dichloromethane or 3000 ppm ethanol in water, although not selectively. In a related presentation Jan Herrmann and colleagues, from the same organization, showed how similar films could serve as ultra-sensitive strain gauges. Both Prof. Ian Snook of the Royal Melbourne Institute of Technology and Amanda Barnard of the University of Melbourne gave talks in which the structure of gold nanoparticles was addressed by computer modelling. The very smallest of particles do not necessarily have the face centred cubic crystal structure of bulk gold, but may instead possess less symmetrical arrangements of atoms that cause the particles to have icosohedral or decahedral shapes. The issue to which this phenomenon might contribute to the now well-known catalytic efficacy of gold nanoparticles remains an interesting topic.

Poster action at ICONN 2008: Ms Dakrong Pissuwan of University of Technology Sydney, Australia explains how gold nanoparticles can be used to target and destroy parasites such as Toxoplasma gondii

Medical applications

Finally, there is continued strong interest in use of gold nanoparticles in medical applications. Already well known in the context of specialised diagnostic stains for biomedical microscopy, gold nanoparticles have recently become the basis for a family of experimental therapies in which the particle is targeted to a cell, such as a cancer cell or an invading pathogen, and then irradiated with a suitably tuned laser to unleash a highly localised source of heat. Jingliang Li of Australia's Swinburne University and Dakrong Pissuwan of The University of Technology in Sydney presented posters on this topic, with that of Li explaining how cancer could be targeted and that of Pissuwan giving the results of trials that targeted *Toxoplasma gondii*, a widespread parasitic organism in mammals. In other medically-targeted developments Wai Lam Yuen of Australia's Monash University described how superparamagnetic iron nanoparticles (which are used in MRI imaging) could be coated with gold to provide greater bio-compatibility, while Benjamin Thierry of the Ian Wark Institute in Australia mentioned a similar technology in regard to Gd_2O_3 nanoparticles.

The many gold-related talks and posters at ICONN 2008 confirmed that there are a large range of promising applications for gold in the rapidly evolving field of 'nanotechnology'. The high value of several of the technologies, coupled with the very small amount of gold used in most of the devices or treatments, imply that the consumption of gold for these purposes will be relatively insensitive to the gold price.