

# Gold 2003: Highlights of this International Conference on the Science, Technology and Industrial Applications of Gold, Vancouver 28 September – 1 October 2003

This landmark event began on Sunday afternoon with welcoming addresses by *Jim Burton*, Chief Executive Officer of World Gold Council, and *Yvan Jacques*, Executive Director, The Canadian Institute of Mining, Metallurgy and Petroleum. The importance of the new gold science currently emerging from research laboratories to the future development of new applications for gold was emphasized. This very well attended first session was then addressed by four keynote speakers who introduced the four principal themes of the conference, ie gold catalysis, chemistry, materials, and nanotechnology.



## 1 Plenary Keynote Lectures

***New Directions in Gold Catalysis*** *Graham Hutchings*, University of Cardiff, UK, described the increasingly wide use of gold as a heterogeneous catalyst for chemical transformations. It was shown that Au-based catalysts are active and selective in the oxidation of alcohols to aldehydes and acids and in the *in situ* production of hydrogen peroxide from a mixture of H<sub>2</sub> and O<sub>2</sub>. In particular, Au-Pd/Al<sub>2</sub>O<sub>3</sub> is a very efficient catalyst for the direct manufacture of H<sub>2</sub>O<sub>2</sub>, an oxidant that may, for example, become important in the synthesis of fine chemicals. The influence of gold metal particle size and oxidation state were discussed together with the role of the oxide supports. There has been a marked increase in rate of growth of interest in catalysis by gold in recent years, as illustrated by the rapid increase in numbers of publications.

***Fundamental Knowledge in Gold Chemistry: A Sound Basis for Multidisciplinary Development*** *Hubert Schmidbaur*, Technical University of Munich, indicated that progress in gold chemistry is possible through a multidisciplinary approach to the subject which allows a deeper understanding of the special position held by gold amongst the metals in the Periodic Table. Theoretical physics and chemistry have become of great value in understanding relations between the structure and intriguing properties of gold and its compounds, and predicting compositions and novel functionality. Theoretical chemistry and relativistic effects have played an important role in understanding the unique character of this element, the relations between the structure and properties of its compounds and, more recently, in the prediction of new derivatives.

***The Weird World of the Nanoscale*** *Michael Cortie*, University of Technology, Sydney, Australia, indicated the unique potential of gold within this field. Due to plasmon resonance, the colour of gold nanoparticles varies with their size, and gold structures at the bottom end of the nanoscale may, depending on shape and substrate, be semiconductors with a significant band gap. At the nanoscale, gold can be semi-conducting, purple or crystalline. Applications are foreseen in monitoring body fluids, new electronic devices and in decorative effects.

***Commercial Aspects of Gold Applications: from Materials Science to Chemical Science*** *Christopher Corti* and *Richard Holliday*, World Gold Council, London, UK, contrasted the traditional uses for metallic gold in industrial applications and jewellery with the new opportunities for gold applications based on the exciting results emerging from current research into gold catalysis, chemistry, and nanotechnology, including fuel cell systems, pollution and emission control, chemical processing and development of new coatings. The availability and price stability of gold provide strong additional incentives to apply gold in new projects being progressed in all four areas represented by the conference.

matrix composites were described, with potential application in **high conductivity and high strength bonding wires** (*Kageeporn Wongpreedee*, Iowa State University, USA). Masayuki Ishikawa, Mitsubishi Materials Corporation, Japan described the application of **gold-tin solder pastes for fine pitch devices in radio frequency and optoelectronic device packaging**. These can be applied flexibly and have achieved void reduction by optimising powder size, flux composition and reflow condition. A major new potential use for gold was identified by *Eamonn Maher*, 3C's, UK, who described the need for **metallic protection layers on new low temperature superconducting tapes** for use in power distribution and superconducting magnets. Based on the complex requirements for high thermal and electrical conductivity, high specific heat capacity, and resistance to oxidation, gold is envisaged as a likely candidate material for the protection layers.

Improvements in the chemical, physical and mechanical properties of a material offer the opportunity to ultimately expand and diversify its industrial applications. The final materials related session was therefore devoted to the latest research on **improved properties of advanced gold alloys**. *Joerg Fischer Buehner*, FEM, Germany, described how the age hardening behaviour of 22ct and 990/995 Au alloyed with Co or Ni could be significantly influenced by additions of Sb. The alloys developed from his work could be exploited in electronics applications, alongside jewellery and decorative uses. *Liz Glaner*, Mintek, South Africa, presented the results of an investigation into the influence of additions of gold to Fe-Cr-Al ('Fecraloy') alloys used in industry as substrates for high performance metallic catalysts. 5wt% additions of Au to 'Fecraloy' were found to be beneficial to the **oxidation resistance** of the alloy at high temperatures.

The lively poster session allowed those delegates with a primary interest in materials related topics to interact with delegates from the other three technical themes. Materials related posters included those prepared by *Olaf Andersen* from the Fraunhofer Institute for Manufacturing and Advanced Materials, Germany who had carried out work on the melt extraction of gold fibres and preparation of **porous gold fibre structures**. On-going work at his centre was focused on developing applications utilising the functional properties of the sintered fibre structures. *Felix Levin*, Unifine Works Ltd, Israel, described a promising approach for a cyanide free gold immersion method for producing a wide range of gold coating thicknesses.

In conclusion, the high quality of the presentations in the Materials sessions fully contributed to the overall success of the conference and most importantly highlighted some very promising new technologies that had the potential to lead to the increased application of gold in industry.

## 6 Nanotechnology

The nanotechnology sessions were entitled 'Manufacture of Nanoparticles', 'Nanoparticle Composites', 'Advances in Nanotechnology', 'Future Horizons in Nanotechnology' and 'Nanotechnology Applications'. In addition there was also a multidisciplinary session on 'Gold Extraction' which contained nanotechnology papers on mineral nanotechnology by *Hugh Abercrombie* of Birch Mountain Resources, Canada, and gold phytomining by *Christopher Anderson* from Massey University, New Zealand.

*Michael Cortie*, University of Technology, Sydney, talked about potential applications for **mesoporous gold**. It has the unique property of being both metallic and highly resistant to oxidation. This material is relevant to potential applications in catalysis, biosensors, optical coatings, in analytical chemistry and as a basis for a new kind of ultra-capacitor. *Christina Graf*, Utrecht University, The Netherlands talked about the enhancement of fluorescence by surface plasmons in gold dielectric core-shell colloids for **photonic applications**. By varying the thickness of the gold layer and the radius of the shell it is possible to adjust the plasmon resonance of the gold shell particles over the whole visible and infrared region of the spectrum. [The use of gold CDs as biochemical sensors was described by Hogan Yu, Simon Fraser University, Vancouver: after removing the protective polymer film with nitric acid, species in body fluids containing -SH groups would react with the gold to form self-assembled monolayers on the surface. It was also confirmed that these substrates are suitable not only for surface wetting measurements, but also surface electrochemical studies.](#)

*Ayako Iwakoshi* of Nippon Paint, Japan described highly concentrated **pastes of gold nanoparticles** produced using a special kind of protective polymer and a mild reductant. The solid part of the paste consists of up to 85wt% of gold nanoparticles 10 – 30nm in diameter, and a residual protective layer. The application fields foreseen include electronics, optics, catalysts, colourants and decorative surface metal coatings. *Masami Nakamoto* from Osaka Municipal Technical Research Institute, Japan, described production of useful gold nanoparticles by controlled thermolysis of gold thiolate complexes: the rate of growth of the gold nuclei varied according to heating temperature and reaction time.

*Peter Bishop*, Johnson Matthey Technology Centre, Reading, UK, described the use of **gold inks** for decorative applications: these inks contain soluble nanoparticle precursors that thermally decompose to form bright gold films. Preparation of thiol-stabilized gold nanoparticles has been achieved using the monolayer protected cluster methods first described by Brust *et al* (University of Liverpool, UK) and stabilizing ligands employed have been aromatic thiols, monosubstituted with branched alkyl moieties.