Conference Report

21st Santa Fe Symposium on Jewelry Manufacturing Technology, Albuquerque, New Mexico, USA

Christopher W Corti

chris.corti@gold.org

The 21st annual Santa Fe Symposium was held in Albuquerque, New Mexico from 20-23rd May 2007. Yet again, this well-attended international conference covered a wide range of technical topics covering all the precious metals. Computer modelling of the investment casting of carat gold, use of metallography in problem solving and an innovative alloy development attracted much attention but presentations on tarnish resistant silvers and test methods and in palladium as a jewellery material were also noteworthy. There is increasing recognition that palladium is quite different in its manufacturing behaviour to platinum which, in turn, is well recognised as being more problematic compared to gold.

The conference commenced with a thought-provoking keynote presentation by Andrea Hill, CEO, The Bell Group, entitled 'Top Line Focus' in which she discussed the business approach to a jewellery manufacturing business. The three key themes were (i) know your business, (ii) revenue numeracy and (iii) attention to planning. As usual, Andrea was direct and to the point and made it relevant to the technical people at this conference. The technical sessions followed, firstly with Chris Corti, World Gold Council, introducing "Basic metallurgy of the precious metals" to the attendees, and discussing the metallurgical basis for the various precious metal jewellery alloys, gold, silver, platinum and palladium, and how alloy properties can be tailored by composition and microstructure to suit the application or manufacturing route.

Computer modelling

At last year's Symposium, I noted with some emphasis the important pioneering work on computer modelling of the investment casting of sterling silver at FEM in Germany. This EU-funded work was extended to carat gold casting this year when Joerg Fischer-Buehner, FEM, Germany and Marco Actis Grande, Turin Polytechnic, Italy made two related presentations within the same EU project. They showed how

gold alloys behave quite differently to silver because of their different thermal properties. Actis Grande focused on the mould filling stage of casting whilst Fischer-Buehner examined the solidification stage and porosity formation. The important aspect of their work is that the results of the modelling were verified by experiment, which showed an amazing degree of agreement. There is no doubt that such modelling is a powerful tool for investment (lost wax) casting in terms of understanding the influence of casting parameters – sprue size, melt and mould temperatures, position on tree, etc – and their effect on solidification, casting quality and yield. Extension of the modelling to the behaviour of platinum and palladium alloys would be instructive as their material properties are so very different to gold and silver.

Precious metals

A comparative study of the manufacture of findings was presented by Fred Klotz, Hoover & Strong, USA. He compared 14K and 18K nickel- and palladium-white golds with 950 palladium and 950 platinum-ruthenium alloys for the manufacture of both die-struck and cast settings. The cold forging tests were performed on wire stock, 0.1 inch diameter, in conventional steel dies, using conditions optimised for the white golds. Klotz noted that all alloys cold forged well but that the platinum-ruthenium alloy was not quite so good during blanking operations. In cold forging, metallography revealed the flow of metal around the edge into the overflow area. Some flowed well whilst others did not. Assembly tests on the blanked settings showed all to assemble satisfactorily although the platinum settings showed more drag as they slid together, probably due to the rougher sheared edges from blanking. The 950 palladium blanks were softer than the other alloys and more care had to be taken to stop them bending or distorting when pressure was applied. Soldering tests on the settings showed good solder flow, for all materials.

Machining tests were conducted on wedding bands using polycrystalline diamond tools. As expected, the gold alloys machined well whilst the platinum alloy was the most difficult to machine. The palladium alloy was also found to be difficult compared the gold alloys, when the same tool set-up as for platinum was used. In addition, investment casting tests on cast princess settings showed all alloys to cast well. Subsequent machine finishing revealed few defects and all alloys polished well. Klotz concluded that both the platinum and palladium alloys perform differently to the golds and need to be processed accordingly.

The use of metallography in jewellery fabrication was discussed by Paolo Battaini, 8853 Spa, Italy and illustrated by case studies of defects. He demonstrated how it can be used to determine whether annealing has resulted in satisfactory recrystallisation, for example. This was followed by a similar presentation under the title "Know your defects" when Stewart Grice, Hoover & Strong, USA discussed a number of case histories of manufacturing defects and how use of hardness

testing, optical and electron microscopy and compositional analysis can be used to determine the causes and thus lead to solutions to prevent re-occurrence. Among the many case histories discussed, he included one on incorrect temper of sheet for die-striking and another on prong failure of 14 carat palladium white gold ring castings, both where hardness testing revealed the cause. The value of metallography in elucidating the causes of failure in both die-struck 14 carat nickel white gold ring shanks and in ring blanks as well as surface porosity in 14 carat palladium white gold castings was well demonstrated and the use of the scanning electron microscope in confirming silicon embrittlement as a cause of failure in a 9 carat gold casting served also to demonstrate the usefulness of SEM in failure analysis.

A novel alloy development directed to jewellery manufacture was presented by Boonrat Lohwongwatana, California Institute of Technology, USA. Lohwongwatana has developed two Bulk Metallic Glass (BMG) alloys (or liquid or amorphous metals as they are known) for jewellery application. One is a hard 18 carat gold ($\text{Au}_{76.26}\text{Ag}_{4.69}\text{Pd}_{1.93}\text{Cu}_{13.5}\text{Si}_{3.62}$), and the other is an 850 platinum containing copper, nickel and phosphorus. After describing BMGs and their characteristics, in particular their glass transition temperature and the need to cool rapidly to preserve the amorphous structure (there is a critical cooling rate), he went on to describe how such materials can be processed with reference to a Time- Temperature diagram and the onset of crystallisation. BMGs can be moulded by blowing, injection moulding or by thermoplastic forming. Shapes can also be obtained by casting where a crystalline structure can be obtained by cooling at less than the critical cooling rate. Particular attention was given to thermoplastic processing in which BMG alloy grains (in the amorphous condition) are heated above the glass transition temperature to become a viscous liquid and moulded in dies or by blow forming. For the gold alloy, processing can be done at 150 – 170°C and the platinum alloy processed at 250 – 270°C. The processed alloy can be allowed to crystallise or cooled to maintain the BMG state. Enormous deformations can be obtained and interesting shapes can be made, with very good surface detail and finish. This is a very innovative development ready for commercial exploitation and it will be interesting to see how the jewellery industry responds.

Progress in the burnout characteristics of resin patterns produced by Rapid Prototyping/ Manufacturing technologies, were discussed by Ian Mckeer, SRS Ltd, UK, in terms of their use for direct investment casting. Clean burnout of the resin has been a major problem in their use for direct casting. Some useful progress has been made with improvements to both resins and to the burnout cycles to ensure clean burnout. Returning to wrought products, Klaus Wiesner, Wieland GmbH, Germany spoke about sheet metal manufacturing and some basics in terms of processing, defects and tolerances related to customer requirements.

Greg Rakhtsaum, Leach & Garner, USA, revisited the topic of nickel testing of white gold and the amended EU Directive,

showing how it opens up new opportunities for nickel-containing golds. This topic was also taken up by Dippal Manchanda, Birmingham Assay Office, UK, who discussed recent progress in amending the EU Directive and his development of a new, faster test procedure which is showing some promise as an alternative, cheaper and accurate test to the one prescribed by the EU directive.

Quality

Several of the presentations focussed on product quality and two further presentations took up this quality theme. Alexandre Auberson of Cartier, USA spoke about the testing of jewellery to ensure 'fitness for purpose'. It is a must for both product development and for quality assurance, he asserted. He described a number of test methods and machines

Figure 1 (a)
The Cartier 'Handbag' test module

Figure 1 (b)
The Handbag test in operation

Figure 2

Dr B Lohwongwatana speaking on bulk metallic glasses

Figure 3

Component in 18 carat gold bulk metallic glass made from bar (B Lohwongwatana)

Figure 4

Gas porosity and glassy inclusions, 14 carat palladium white gold casting (S Grice)

developed by Cartier to simulate wear, strength, flexibility, mechanical shocks, durability and tarnish and corrosion among others. Of particular interest and amusement to the audience

was Cartier's simulated Handbag test, designed to simulate the effects on jewellery when stored in a woman's handbag; as Auberson remarked, it can reveal inherent weaknesses in jewellery construction. This should be an essential test for all jewellery manufacturers!

Chris Corti, World Gold Council, took up the quality theme in his presentation, 'Quality in Jewellery Manufacture beyond 2000: A review of progress 1998 – 2007' in which he assessed progress made by the industry after 10 years (when he first addressed this topic and identified the needs for industry-wide standards in a number of areas). Some progress has been made, e.g. in adopting quality assurance schemes and defining white gold colour standards, but much remains to be tackled such as industry standard product test procedures, hallmarking and solder designation standards and even basic Alloy Data Sheets for the common alloys used in jewellery. Such progress needs some leadership by the national and international industry manufacturing associations, he asserted.

The West Midlands jewellery industry featured in Gay Penfold's presentation from the Jewellery Industry Innovation Centre, University of Central England, Birmingham, UK on 'Product development and the impact of design support'. Using several case studies, she showed how the JIIC has benefited the business of several jewellery manufacturers through innovative design support from JIIC. Surprisingly, there is nothing like this support facility in the USA and some envy was noted from USA manufacturers.

There were several presentations on tarnish measurement of sterling silver, relating particularly to the new tarnish-resistant silvers on the market and the need for improved tarnish test standards and procedures was identified. Ajit Menon, United Precious Metals Inc, USA, spoke about the effect of alloying elements on tarnishing and other behaviour of sterling silver alloys and reported some interesting results. This was followed by a presentation on tarnish testing by Sam Davis of Stern-leach, USA, and he described a new test procedure that he considered more appropriate for examining the tarnish resistance of the new tarnish-resistant silvers, such as Argentium. A similar presentation was made by Andrea Trentin, Pro-Gold Srl, Italy who discussed testing methods. From subsequent discussion, the need for an improved industry-approved test procedure was identified.

On the palladium front, Mark Mann, Mann Design Group, USA and technical consultant to the Palladium Alliance International spoke on "Palladium: Manufacturing basics for servicing, assembly and finishing". He started his presentation by discussing the basic properties of palladium that make it attractive as a jewellery metal and how to distinguish it from platinum and white gold, using the iodine test. He then launched into a comprehensive review of its working behaviour related to general jewellery manufacturing. He covered the practical aspects of annealing, contamination, soldering and welding (by torch & laser), forming & shaping, engraving, finishing and setting. This was supported by a

Figure 5

Dr J Fischer-Bühner (FEM) speaking on the computer modelling of the investment casting of carat golds

Figure 6

Computer modelling of investment casting: Solidification time (J Fischer-Bühner, FEM)

Figure 7

Dr M Actis Grande (Turin Polytechnic) presenting his work on computer modelling of investment casting

number of case studies of hand techniques, such as ring sizing. Whilst palladium solders are available, he demonstrated that low melting platinum-based solders could be used. The information presented in this paper will form the basis of a

new technical manual being produced by Johnson Matthey for the industry.

The welding of palladium was further discussed in a presentation by Kevin Lindsey, Lindsey Jewelers, USA, entitled "How to get the best results welding palladium: A comparative study". This was the result of a study into the TIG (Tungsten Inert Gas) welding of two 950 palladium alloys, from Johnson Matthey and Hoover & Strong, in which several welding parameters were varied. A model weld of a ring shank, 4mm X 1.5mm was used and, after welding, the welds were tested to failure by bending. Depending on welding conditions, some cratering and poor penetration was obtained in some test welds, but good welds could be obtained in both palladium materials under the right conditions. The overall conclusion is that 950 palladium alloys can be satisfactorily joined by TIG welding.

A review of casting tree design in the investment casting of platinum alloys was presented by Jurgen Maerz, Platinum Guild International, USA. For many manufacturers of platinum jewellery, investment casting is challenging. Maerz believes many of the problems are associated with tree design and spruing techniques and he set out to demystify the process. This presentation included sound advice on torch casting, where the metal is melted by gas torch, as well as use of induction melting. He also addressed various casting machine characteristics before focussing on various tree designs and their characteristics. He also discussed shell casting and the tree/sprue design approach necessary for this method as well as the various platinum alloys and their performance in casting. Finally, Maerz discussed a rapid method of torch casting that he introduced in 1998. Using investment powders derived from the dental industry, the entire casting process can be attained in less than 1 hour, using a T-bar tree design. This was certainly a very comprehensive review that should benefit all casters of platinum jewellery and encourage new casters to cast platinum with some degree of confidence.

Further presentations were made on 'Reverse engineering of complex geometries for CAD/CAM applications' by Steve Adler, USA, 'Refining 201' by Kim Michalik, Pease & Curren Inc, USA and 'Laser safety in jewelry manufacturing' by Johnny Jones, Laser Professionals Inc, USA.

Summary

This was yet another excellent vintage year for the Santa Fe Symposium in which gold featured strongly. The quality of presentations and range of topics were noteworthy within the context of practical use by – and relevance to – the jewellery industry. It is an unmissable event for all serious jewellery manufacturers. The Santa Fe Symposium proceedings are published as a book and the Powerpoint presentations are available on CD. They can be obtained from the organisers at www.santafesymposium.org. The 22nd Symposium will be held once again in Albuquerque, New Mexico on 18th – 21st May 2008 (see Calendar in this issue).