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The 21st Santa Fe Symposium on Jewelry Manufacturing Technology

TECHNICAL INTEREST IN PALLADIUM REMAINS STRONG IN THE INDUSTRY

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The 21st annual Santa Fe Symposium® was held in Albuquerque, New Mexico, from 20th to 23rd May 2007 (1). Yet again, this well-attended international symposium covered a wide range of technical topics but the strongest interest was in palladium as a jewellery material (see also (2)). There is no doubt that palladium jewellery is causing excitement in the manufacturing industry and, as delegates heard in discussion, there is increasing recognition that palladium is quite different in its manufacturing behaviour from platinum.

The Symposium commenced with a thought-provoking keynote presentation by Andrea Hill (CEO, The Bell Group, U.S.A.), entitled 'Top Line Focus', in which she discussed the business-led approach to running a jewellery manufacturing firm. The three key themes were: (a) knowing your business, (b) revenue numeracy and (c) attention to planning. The technical sessions followed, firstly with Chris Corti (COReGOLD, U.K.) introducing 'Basic Metallurgy of the Precious Metals' to the delegates, and discussing the metallurgical basis for the various precious metal jewellery alloys, including those of platinum and palladium, and how alloy properties can be tailored by composition and microstructure to suit the application or manufacturing route.

Palladium

Mark Mann (Mann Design Group, U.S.A.) spoke on '950 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 non-destructive iodine test (3). He then launched into a comprehensive review of the working behaviour of palladium in relation to general jewellery manufacturing. He covered the practical aspects of annealing, contamination, soldering and welding (by torch and laser), forming and shaping, engraving, finishing and setting. The presentation was supported by a number of case studies of hand techniques, such as ring sizing. While 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 jewellery technical manual being produced by Johnson Matthey for the industry (3).

The welding of palladium was further discussed in a presentation by Kevin Lindsey (Lindsey Jewelers, U.S.A.), entitled 'How To Get the Best Results Welding Palladium: A Comparative Study'. This was the result of a study of the tungsten inert gas (TIG) welding of two 950 palladium alloys, from Johnson Matthey and Hoover & Strong, in which several welding parameters were varied. The model configuration for the test welds was a ring shank, 4 mm × 1.5 mm. The welds were tested by bending to failure. Two tungsten electrode sizes were tested and pure argon was used as the cover gas. Copper plate was used as the welding substrate. Depending on welding conditions, some cratering and poor penetration were obtained in some test welds, but good welds could be obtained in both palladium materials under the correct conditions. The Johnson Matthey alloy performed better in terms of cycles of bending to failure, attaining 94% of the cycles to failure of the unwelded bar stock. The Hoover & Strong alloy showed better flow during welding, but poorer performance in terms of cycles to failure (70% of bar stock). The optimal welding parameters depend on the alloy. Lindsey gives a set of starting values suitable for both alloys which will give reasonable initial welds and serve as a basis for optimisation. The overall conclusion is that 950 palladium alloys can be satisfactorily joined by TIG welding.

A comparative study of the manufacture of findings was presented by Fred Klotz (Hoover & Strong, U.S.A.): 'A Comparison of Nickel White Gold, Palladium White Gold and 950 Palladium in the Manufacture of Findings'. He compared the performance of 950 palladium with those of 14 carat and 18 carat nickel- and palladium-white golds and 950 platinum-ruthenium alloys for the manufacture of both die-struck and cast settings. He noted that both the 950 platinum and palladium alloys showed a comparable degree of whiteness (as measured by the ASTM Yellowness Index (4, 5)), and better whiteness than the Grade 1 white golds used in the study. 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 performed not quite so well during blanking operations. In cold forging, metallography revealed the flow of metal around the edge into the overflow area. The 950 palladium alloy flowed well and annealed to a fine grain structure. In assembly tests, all the blanked settings assembled satisfactorily, although the platinum settings showed more drag as they slid together, probably due to their 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 with a torch showed good solder flow for both palladium and platinum settings.

Machining tests were conducted on wedding bands using polycrystalline diamond tools. As expected, the platinum alloy was the most difficult to machine. The palladium alloy was also found to be difficult compared with the gold alloys, when the same tool set-up as for platinum was used. In addition, investment casting tests on 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 from the golds, and processing needs to vary accordingly.

The use of metallography in jewellery fabrication was discussed by Professor Paolo Battaini (8853 SpA, Italy) and illustrated by case studies of defects: 'Metallography in Jewellery Fabrication: How to Avoid Problems and Improve Quality'. He demonstrated how it can be used to determine whether annealing has resulted in satisfactory recrystallisation for example. Of particular note was an instance of silicon contamination in a 950 palladium alloy during investment casting that caused intergranular embrittlement.

Platinum

A review of casting tree design in the investment casting of platinum alloys was presented by Jurgen Maerz (Platinum Guild International, U.S.A.): 'Platinum Casting Tree Design'. For many manufacturers of platinum jewellery, investment casting is something of a challenge. Maerz believes many of the problems with investment casting are associated with tree design and sprueing techniques and he set out to de-mystify the process. This presentation included sound advice on torch casting, where the metal is melted by gas torch, as well as the use of induction melting. He also discussed various casting machine characteristics before focusing on tree design – describing the 'thick centre' (central sprue) tree, the 'no tree, button-casting' design, the 'diablo' shaped tree, 'four wheel' or circular-sprued tree, thin-sprue trees and inverted trees. Maerz addressed shell casting and the tree/sprue design approach necessary for this method. In addition, he commented on the various platinum alloys and their performance in casting. Finally, Maerz discussed a rapid method of torch casting that he introduced in 1998 (6). Using investment powders derived from the dental industry, the entire casting process can be accomplished in less than one hour, using a T-bar tree design. Maerz's review was certainly very comprehensive. It should benefit all casters of platinum jewellery and encourage new casters to work with platinum with some degree of confidence.

A novel alloy development was the subject of a presentation by Boonrat Lohwongwatana (California Institute of Technology, U.S.A.): 'Hard 18K and .950 Pt. Alloys That Can Be Processed Like Plastics or Blown Like Glass'. This concerned bulk metallic glasses, or 'amorphous or liquid metals' as they are known. In this study, Lohwongwatana has developed two bulk metallic glass (BMG) alloys for jewellery application (Figure 1). One is an 850 platinum containing copper, nickel and phosphorus; the other is a hard 18 carat gold. 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, in which a crystalline structure can be obtained by cooling at less than the critical 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, then moulded in dies or by blow forming. For the platinum alloy, processing can be done at 250 to 270ºC. 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. It will be interesting to see how the jewellery industry responds.

Under the title 'Know Your Defects: The Benefits of Understanding Jewelry Manufacturing Problems', Stewart Grice (Hoover & Strong, U.S.A.) 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 of defects and thus lead to solutions to prevent recurrence. Among the many case histories discussed, Grice included one on surface porosity on a 950 platinum-ruthenium alloy investment cast ring. The casting had a frosted appearance and gas porosity was suspected. However, metallography of a cross-section revealed the cause as massive shrinkage porosity in the head and shoulder areas of the ring. Modifying the sprue and gating solved the problem. Another example on the same alloy involved embrittlement of mill stock made from scrap sprues and surplus castings. The bar had failed catastrophically after only two passes through the rolling mill. The intergranular failure was examined under the optical microscope and the presence of a second phase at the grain boundaries observed. Full chemical analysis revealed the presence of 100 ppm of phosphorus, an element well known to cause embrittlement of platinum at levels of 50 ppm or less. The source of the phosphorus was probably the phosphate-

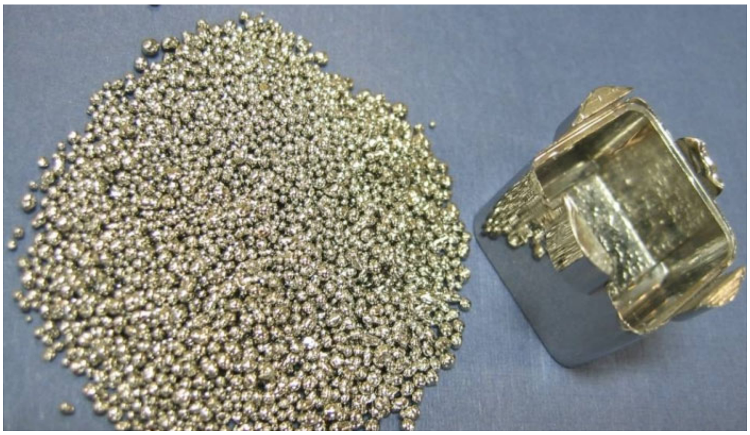

Fig. 1 Thermoplastic forming of 850 platinum bulk metallic glass (BMG) from BMG pellets (Courtesy of B. Lohwongwatana)

bonded investment mould material. Its presence would indicate inadequate removal from the casting scrap.

Progress in optimising the burnout characteristics of resin patterns produced by rapid prototyping/manufacturing technologies, was discussed by Ian McKeer (SRS Ltd, U.K.), in terms of their use for direct investment casting: 'Improvements in the Burnout of Resin Patterns'. Clean burnout of the resin has been a major problem. Casting, using platinum investments, showed some problems with surface quality. The fast 'dental' cycle approach, described by Maerz (see above) did produce some improvements.

Other Papers of Interest

McKeer's presentation was focused on product quality and two further presentations took up this theme. Alexandre Auberson (Cartier, U.S.A.) spoke about the testing of jewellery made by Cartier to ensure 'fitness for purpose': 'Tests for Jewellery: A Must in the Development and Quality Process'. Appropriate testing is a 'must' for both product development and quality assurance. Auberson described a number of test methods and machines developed by Cartier to simulate in-service conditions for 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, Figure 2, designed to simulate the effects of jewellery kept in a woman's handbag; as Auberson remarked, it can reveal inherent weaknesses in jewellery construction.

Chris Corti (COReGOLD, U.K.) took up the quality theme, assessing progress made by the industry over the ten years since he first addressed this topic and identified the need for industry-wide standards: 'Quality in the Jewellery Industry Beyond 2000: A Review of Progress 1998–2006'. Appreciable progress has been made, for instance 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 standards and even basic alloy data sheets for the common alloys used in jewellery.

Klaus Wiesner (Wieland GmbH, Germany) spoke about sheet metal manufacturing of precious metals, and addressed some basics in terms of processing, defects and tolerances related to customer requirements: 'Sheet Metal Manufacturing – Some Basics'. Greg Raykhtsaum (Leach & Garner, U.S.A.) revisited the topic of nickel testing of white gold and the amended EU Directive (7), showing how this modified regulation opens up new opportunities for nickel-containing golds: 'White Gold Piercing Jewelry and the "Nickel Directive", 2004/96/EC'. There were several presentations on tarnish measurement, in relation to the new tarnish-resistant silvers on the market. The need for improved tarnish test standards and procedures was identified. This topic was also taken up by Dippal Manchanda (Birmingham Assay Office, U.K.), who discussed recent progress in amending the EU Directive, and the Assay Office's development of a new, faster test procedure which is showing some promise as an alternative, accurate test: 'Comparative Performance of Nickel Release Test Procedures: PD CR 12471:2002 and EN 1811:1998'.

Two related presentations on computer modelling of investment casting were made by Jörg

Fig. 2 Cartier handbag test (Courtesy of A. Auberson)

Fischer-Bühner (FEM, Germany): 'Advances in the Prevention of Investment Casting Defects Assisted by Computer Simulation' and Marco Actis Grande (Turin Polytechnic, Italy): 'Computer Simulation of the Investment Casting Process: Widening of the Filling Step'. Their work concerned carat golds and they showed how gold alloys behave differently from silver (2). There is an urgent need to examine the behaviour of platinum and palladium alloys in these modelling experiments, as their material properties are very different from those of gold and silver.

Concluding Remarks

The presentations relating to palladium as a jewellery alloy now provide a firm technical underpinning of this exciting metal and its manufacture into jewellery. The technology of platinum jewellery manufacture was also addressed, adding to our already substantial knowledge base. From these and other standpoints, year 2007 proved to be yet another excellent vintage for the Santa Fe Symposium®. 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-ROM. They can be obtained from the organisers (1). The 22nd Symposium will be held once again in Albuquerque, New Mexico, from 18th to 21st May 2008.

References

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The Reviewer

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