The 25th Santa Fe Symposium on Jewelry Manufacturing Technology

Further research on platinum casting by the industry reinforces previous findings

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Reviewed by Christopher W. Corti

COReGOLD Technology Consultancy, Reading, UK

Email: chris@corti.force9.co.uk

The 25th annual Santa Fe Symposium attracted a record attendance of 165, with delegates from 11 countries worldwide, confirming the more optimistic outlook by the US jewellery industry noted last year. Held in Albuquerque, New Mexico, USA, from 15th–18th May 2011, the Symposium had a very strong programme of presentations covering a wide range of topics (1). Platinum featured and, as usual, attracted much interest. The major sponsors were given the opportunity to have a display table in the lobby area, as last year, and thus both Johnson Matthey New York and Platinum Guild International USA had a strong presence.

Platinum Alloys

The soldering of platinum received attention this year with Jurgen Maerz (Platinum Guild International, USA) reviewing the topic in his presentation, 'Platinum Solders: Proper Use and Application of Platinum Solders in Jewelry Making'. Maerz first addressed the types of solder used in soldering platinum jewellery: this categorised platinum solders into those containing up to 95% platinum and those which contained no platinum, perhaps better classed as plumb and traditional solders respectively. Traditional solders contain no or very little platinum and come in a range of soldering or flow temperatures in grades from extra easy 1000 to extra hard 1400 with additional grades of platinum welding 1500, platinum special welding 1600, platinum seamless 1700 and platinum weld 1773, where the number refers to the approximate flow temperature in ºC.

In contrast, plumb platinum solders have a high platinum content and flow temperatures in the range 1300ºC for the easy flow grade (contains 90% platinum) to 1500ºC for the hard flow grade that contains 95% platinum. Maerz makes the point that these solders enable soldering without fear of under-carating of the platinum jewellery in the USA where there is a zero tolerance on assay. To ensure compliance with this standard, he noted, platinum alloys are often 'sweetened' to 952 fineness to allow use of non-plat-

inum containing solders. He also made the point that solder seams in platinum jewellery tend to have larger surface areas, high polish and open design making solder seams more visible, hence colour match is more important. Traditional solders tend to turn grey over time and are difficult to polish as they tend to drag and be polished out of the seam due to their softness.

Maerz then addressed the techniques of soldering platinum, with many practical tips. For example, use of a flux is not necessary with the higher melting solders. The lower melting solders tend to be based on palladium-silver alloys and do need flux to prevent oxidation. Solder flow is often poor over distance, so Maerz recommends placing many small pieces of solder along a seam close together and following the seam with the soldering flame. Joint gaps should be a close fit too. For soldering prongs to a ring, he recommends pre-melting the solder onto the prong wire and then allowing the heat of the torch to make the connection to the ring (**Figure 1**). Because of the lower thermal conductivity of platinum compared to gold and silver, Maerz advises that preheating the work piece with the torch, as done for gold and silver, is not necessary with platinum. He also advises the use of welding goggles with a number 5 rating to prevent eye damage; UV radiation is released on soldering platinum because of the high temperatures involved.

Maerz ended his presentation, in his own inimitable style, with a series of examples of platinum soldering, using video clips to show how it is done.

Soldering of 950 platinum-ruthenium alloy was also covered briefly by Stewart Grice (Hoover & Strong, Inc, USA) in his presentation, 'Characterization of Jewelry Solders and their Applications in the Manufacturing Process'. Grice discussed the principles of soldering, properties of solders and strengths of joint geometries. He also covered welding. To test the theory that any alloy with a liquidus temperature lower than the solidus temperature of the alloys being joined should give a good soldered joint, provided it wets well, he used normal carat gold alloys rather than solder alloys to solder both gold and platinum alloys. The series included 950 PtRu alloy soldered with a standard 18 carat palladium white gold which had a relatively wide melting range. This gave a good quality joint, which, he considered, proved his point.

Fig. 1. Soldering a prong on a platinum ring (Courtesy of Jurgen Maerz (Platinum Guild International, USA))

Following last year's report on research into investment casting of platinum, conducted in an EU-funded project (see (2)), a further presentation by a major US caster of platinum jewellery was the subject of much discussion this year. Teresa Fryé (TechForm Advanced Casting Technology, USA) reported on a study carried out with Jörg Fischer-Bühner (Legor Group Srl, Italy) to examine the casting behaviour of a number of platinum alloys in popular use in the USA and to determine which performs best from a consumer standpoint. In her presentation, 'Platinum Casting Alloys in the 21st Century: A Comparative Study', she studied Pt-5 wt% Ru, Pt-5 wt% Co and Pt-10 wt% Ir as well as several 950 platinum alloys that had additions to increase hardness, some of which are age-hardenable. Characteristics that were assessed included shrinkage porosity, form-filling, hardness and the effects of post-casting thermal treatments.

Fryé commenced her presentation with a review of previously published work that included the early (1995) work of James Huckle (Johnson Matthey New York, USA) (3, 4) on the comparative behaviour of various platinum casting alloys. This showed 950 PtCo to have the best casting behaviour, Pt-10 wt% Ir and Pt-15 wt% Pd to have good behaviour and 950 PtCu and 950 PtRu as having poor casting characteristics. Subsequent work by other US manufacturers has confirmed the preference for 950 PtCo alloy and this alloy is the preferred choice today.

Casting trials in collaboration with Legor Group Srl, Italy, showed that 950 PtRu still results in large amounts of scattered shrinkage porosity, even with a double top sprue (**Figure 2**). It was observed that approximately 1% additions of a metal such as gallium to 950 PtCo can increase hardness to above HV 170 and such an alloy ('950 Pt-Co+') was examined. The metallographic analysis of castings gave hope that porosity levels nearly as low as those for 950 PtCo

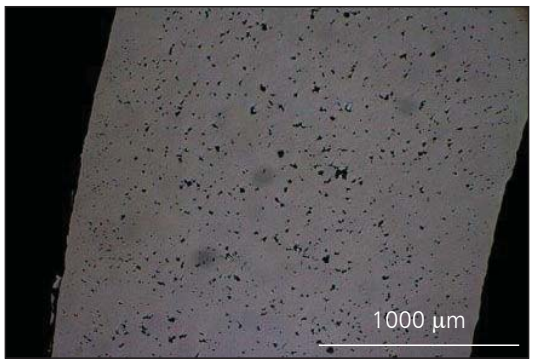

Fig. 2. Microstructure of as-cast coupon of Pt-5 wt% Ru alloy showing porosity distributed throughout section (Courtesy of Teresa Fryé (TechForm Advanced Casting Technology, USA))

(**Figure 3(a)**) alloy can be consistently obtained in alloys based on the significantly harder 950 Pt-Co+ alloy (**Figure 3(b)**).

Fryé also reported on a survey of platinum designers, custom jewellers and retailers carried out by TechForm Advanced Casting Technologies in 2007 which highlighted that the most frequent defect is subsurface porosity that only emerges on polishing. The overall conclusion was that a harder casting alloy that could better hold a high lustre would be desirable.

Following on from his paper at the 2010 Symposium on the metallography of platinum alloys (see (2)), Paolo Battaini (8853 SpA, Italy) extended his work to discuss 'Dynamic Recrystallization and the Hot Working of Precious Metal Alloys'. This covered several precious metals: sterling silver, 18 carat white gold and two platinum alloys – 950 PtRu and 950 PtCu. The beneficial effects of hot working on microstructure and properties were discussed and Battaini demonstrated how hot working leads to more uniform and finer recrystallised grain structures, compared to cold working and static recrystallisation, and tends to close up and seal internal porosity from casting. This latter was well demonstrated for hot worked bars of 950 PtCu alloy (**Figure 4** and **Figure 5**).

Other Precious Metal Alloys

In his presentation, 'New Metals & Alloys of Interest in the Jewelry Industry', Ajit Menon (United Precious Metal Refining, Inc, USA) looked at jewellery materials that are cheaper than precious metals and attracting industry interest at a time of record precious metal prices. This embraced coloured brass alloys, coloured (low fineness) silver alloys, low carat golds, stainless steel, titanium and low fineness platinum group metal (pgm) alloys. He noted the marketing of platinum- or palladium-containing sterling silver alloys but observed that these do not have good hardness values, although improved tarnish resistance is claimed over conventional sterling silvers. He also discussed 420 and 585 fineness palladium alloys and noted that these have better hardness, lustre and scratch resistance compared to 950 fineness palladium alloys. Market demand for such alloys is noticeably low, however.

John Wright (Wilson-Wright Associates, UK) gave a presentation entitled, 'Buy by Weight: Think Volume', in which he emphasised that the size of a piece of jewellery is what attracts customers but the precious metals are sold on a weight basis. Thus, alloying precious metals may improve their properties and can also help to create more volume through lowering of the density (most base metals have lower density).

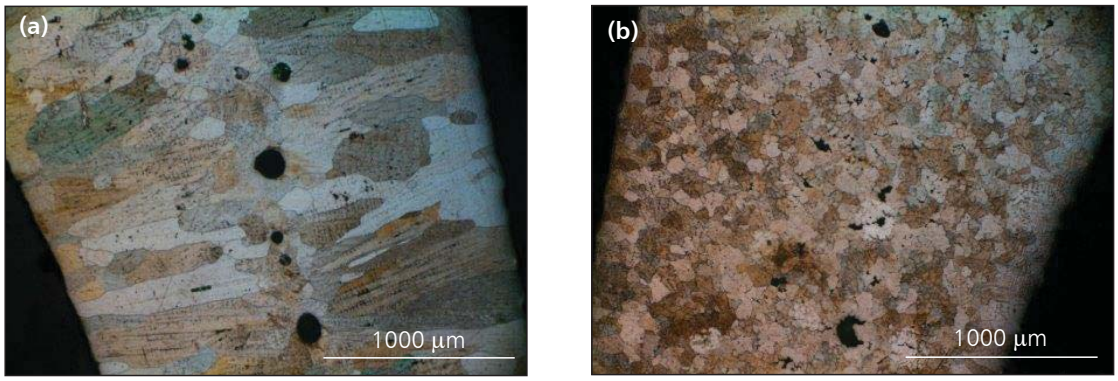

Fig. 3(a). Grain structure of as-cast conventional Pt-5 wt% Co alloy; (b) refined grain structure of '95-Pt-Co+' alloy hardened with gallium (Courtesy of Teresa Fryé (TechForm Advanced Casting Technology, USA))

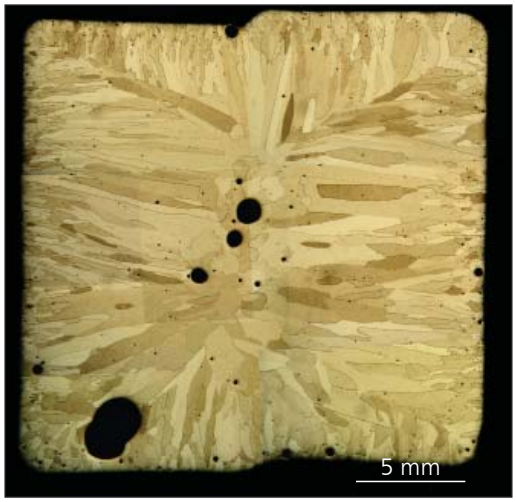

Fig. 4. Transverse section of Pt-5 wt% Cu alloy as cast bar (hardness HV 130). Columnar grains and porosity are visible (Courtesy of Paolo Battaini (8853 SpA, Italy))

One example he cited was the development of a 505 fineness platinum-palladium alloy in which nearly 2/3 of the atoms are palladium by volume, although only 49.5% by weight.

Manufacturing Processes

One of the highlights of this Symposium was the paper presented by Paul Nordt III (John C. Nordt Co, Inc, USA). His presentation, 'Modern Manufacture of Seamless Wrought Wedding Bands – An Engineering Approach', examined how modern engineering and metallurgy have been applied to the manufacture of products in response to current market conditions. His company produces wrought seamless wedding bands by hot extrusion in platinum, palladium, gold and silver. The key aspects of the work he reported include vacuum melting and hot working to achieve a fine grained microstructure, near net-shape processes to maximise precious metal yield, customer-accessible computer aided design (CAD) code generation integrated with 'on the fly' computer numerically controlled (CNC) code generation for precision machining, the application of 'lean manufacture' principles for one-piece flow, maximised inventory turnover and loss control and quality systems consistent with the International Organization for Standardization ISO 9001:2008.

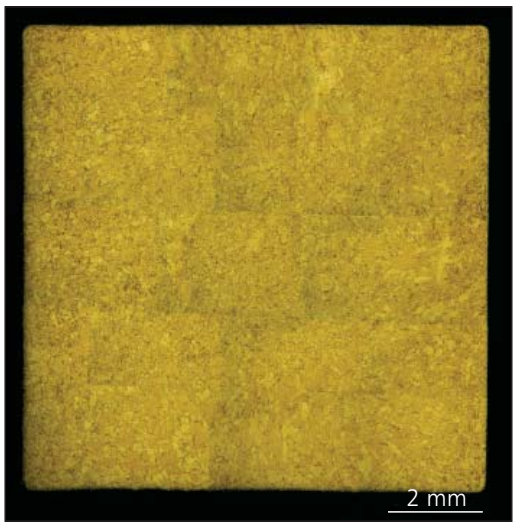

Fig. 5. Microstructure of Pt-5 wt% Cu alloy bar after hot hammering to 12 × 12 mm section, annealed and cold drawn to 10 × 10 mm section (hardness HV 200). Hot hammering has produced a grain refinement through dynamic recrystallisation (Courtesy of Paolo Battaini (8853 SpA, Italy))

The basis of Nordt's work was the need to build a better business model for his company. He described the fabrication options for ring manufacturing and their pros and cons, then discussed the whole production process in detail. For example, he noted that platinum and palladium billet casting is done under vacuum with a special pour cycle to inhibit pipe formation during solidification. His discussion included observations on product yields and how this has led to improved technologies (for example, minimising numbers of basic extruded tube sizes, cutting tubes with no metal loss or upsetting of basic tube blanks to give a range of ring blank sizes), how to service customer delivery requirements and quality management.

Professor Wolfgang Böhm (University of Pforzheim, Germany) gave an interesting presentation on 'Where to Direct Development Money? Some Examples of Successful and Not-So-Successful Projects'. He described a number of projects on innovative materials and manufacturing processes that his university has undertaken for the jewellery industry in recent years. Some have been successfully exploited but others have foundered. One project he described was the use of powder metallurgy to fabricate jewellery with colour contrasts. In particular, he gave an example of mixing platinum wire studs and nuggets with a red gold powder using a 'press and sinter' approach to give a material with high colour contrast (**Figure 6**). The structure is random, making each piece unique, and the product is akin to traditional *mokume gane* materials.

Other Presentations

As usual, there were a number of other presentations, some of which were focused on gold and silver. The

Fig. 6. Platinum wire studs and nuggets in red gold powder, pressed and sintered

Symposium commenced with the return of 'Basic Metallurgy of the Precious Metals – Part I' by Chris Corti (COReGOLD Technology Consultancy, UK). The link between the jeweller and jewellery design was discussed by Chuck Hunner (Golden Spirit, USA). Investment (lost wax) casting was discussed by Marco Actis Grande (Politecnico di Torino, Alessandria Campus, Italy) with respect to direct casting of rapid prototyping resin models and a similar paper was presented by Alan Andrews (Best Cast Inc, USA) from a production standpoint. The application of glass and epoxy enamels was reviewed by Rick Greinke (Award Concepts, Inc, USA), and Nora Isomäki (Beneq Oy, Finland) gave new wear results on her company's anti-tarnish nano-coatings on silver.

Frank Cooper (Birmingham City University, UK) gave an interesting report on the production of a gold-plated silver copy of a medieval gold cross found in the Staffordshire hoard in 2009 in his presentation, 'A Gift Fit for a Pope, 1500 Years after Its First Creation'. The manufacturers' approach to refining precious metal scraps was discussed by Brett Gober (Freedom Design & Contracting, USA), showing that it pays to be analytical. The properties of carat golds were discussed in two presentations by Greg Raykhtsaum (Sigmund Cohn Corp, USA) and by Daniele Maggian (Progold SpA, Italy). A novel powder metallurgy approach to manufacture of *mokume gane* materials that gives higher yields of useable material was discussed by Chris Ploof (Chris Ploof Studio, USA) and Joe Strauss (HJE Company, Inc, USA). Lastly, new analysis technology was discussed by Andreas Zielonka (The Research Institute for Precious Metals and Metals Chemistry (FEM), Germany) in his presentation, 'X-Ray Computed Tomography – A Powerful Tool for Non-Destructive Materials Analysis'. This allows high resolution analysis of structure and defects in large objects in either 2D or 3D.

Concluding remarks

This was another excellent international symposium for jewellers, and was particularly special as it celebrated the 25th anniversary of the Santa Fe Symposia. Speakers past and present marked the occasion with the presentation of a gift (a photograph album of speakers throughout the 25 years) to one of the co-founders, Eddie Bell.

As noted, platinum featured strongly at this symposium and interesting new results have emerged that should lead to better platinum jewellery.

References

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The Reviewer

Christopher Corti holds a PhD in Metallurgy from the University of Surrey (UK) and has recently retired from the World Gold Council after thirteen years, the last five as a consultant. During this period, he served as Editor of Gold Technology magazine, Gold Bulletin journal and the Goldsmith's Company Technical Bulletin. He continues to consult in the field of jewellery technology and as a recipient of the Santa Fe Symposium® Research, Technology and Ambassador Awards, he is a frequent presenter at the Santa Fe Symposium. From 1978–1988 he was a Research Manager at the Johnson Matthey Technology Centre, Sonning Common, UK, and from 1988–1992 he was Technical Director at Johnson Matthey's Colour and Print Division.

