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CONFERENCE REPORT

The 25th Santa Fe Symposium on Jewelry Manufacturing Technology, Albuquerque, N.M., USA, 15–18 May 2011

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Introduction

The Santa Fe Symposium on Jewelry Manufacturing Technology attracted a record attendance in its 25th year, with delegates from 11 countries worldwide. This confirmed its status as the premier international annual conference on jewellery technology and a very strong programme of 23 presentations covered a wide range of topics. There was something of interest for all delegates.

Metallurgy

The symposium started with an updated presentation by Chris Corti (CoreGold, UK) on the 'Basic Metallurgy of the Precious Metals—Part I', which is targeted at those without any formal metallurgical training. This focused on the carat gold alloys and covered the interrelationship between the properties, composition, processing and microstructure and included a quick guide to the phase diagrams of the precious metals. The metallurgy behind hot working was presented by Paolo Battaini (8853 Spa, Italy) in his paper, 'Dynamic Recrystallisation and the Hot Working of Precious Metal Alloys'. This was an excellent review with the advantages conferred (over cold working) in terms of microstructure refinement and mechanical properties discussed and demonstrated with examples of the hot working of several precious metal alloys including white gold.

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Carat golds

Grig Raykhtsaum (Sigmund Cohn Corp, USA) continued the work presented in 2009 on age-hardenable coloured 18-ct golds (see report in *Gold Bull*, 42 (3), 221–223) with the focus this year on 'Age Hardenable 14 Karat White Golds'. In particular, he discussed age-hardenable palladium-based white golds which are easier to process than the nickel whites and have better ductility and corrosion resistance as well as being hypoallergenic. There is relatively little published information on palladium whites and this presentation has added significantly to our knowledge. As well as confirming how the whiteness of the alloy increases with palladium content, he showed how the palladium/copper and palladium/silver ratios are important in conferring age-hardening. There are compositional limitations for hardenability in palladium white golds, which Raykhtsaum demonstrates. Copper plays a fundamental role in the age-hardening mechanism due to the immiscibility gap in the Ag–Cu phase diagram and shows an order–disorder transformation with both gold and palladium (Figs. 1 and 2).

Following his extensive work on 18-ct golds last year (see *Gold Bull*, 43 (4), 324–327), Daniele Maggian (Progold Spa, Italy), discussed the 'Characterisation of 14 karat gold alloys' this year. This is a detailed review of large numbers of 14-ct gold compositions—yellow, red and white—and their properties including melting temperatures, density, colour, grain size, hardness, strength, ductility and work hardening. This is a veritable database of information, bringing together a vast amount of structured data, including the effects of grain refiners and deoxidisers, and serves as a good reference point for alloy design and selection.

Fig. 1 Grig Raykhtsaum presenting at the symposium

Soldering remains an important technology and Stewart Grice (Hoover and Strong Inc, USA) reviewed the topic in his paper, 'Characterisation of Jewelry Solders and their Application in the Manufacturing Process', with particular focus on gold solders. He covered the health and safety aspects of cadmium-containing solders which, sadly, are still used in some workshops and regions of the world. He noted that ordinary (non-solder) alloys, such as the carat golds, can be used to satisfactorily solder precious metals provided they meet the criterion of having a lower liquidus temperature than the solidus of the metals being joined. For example, an ordinary 18-ct white gold was used to solder 950 Pt-Ru and an 18-ct yellow to solder 22-ct golds (Figs. 3 and 4).

New materials

In his presentation, 'New Metals and alloys of interest in the jewelry industry', Ajit Menon, (United Precious Metal Refining Inc, USA), looked at jewellery materials that are cheaper than conventional precious metals and attracting industry interest at a time of record precious metal prices.

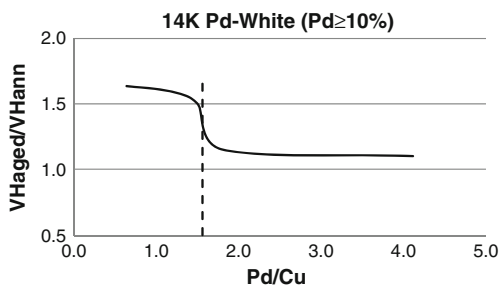

Fig. 2 Hardenability as a function of (Ag + Pd)/Cu ration for 14-ct palladium white gold (Pd≥10%). Courtesy of G. Raykhtsaum

This embraced coloured brass alloys, coloured (low fineness) silver alloys, very low carat golds, stainless steel, titanium and low fineness platinum and palladium alloys. Very low carat golds, from 1 to 6 ct, with good colour, satisfactory tarnish resistance and mechanical properties can be formulated, but he noted that they cannot be called gold under the US Stamping Act. He also noted the marketing of platinum- or palladium-containing sterling silver alloys but observed these do not have good hardness values although improved tarnish resistance is claimed.

Manufacturing technologies

For me, one of the highlights of this symposium was the paper presented by Paul W. Nordt III (John C Nordt Company 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 highest

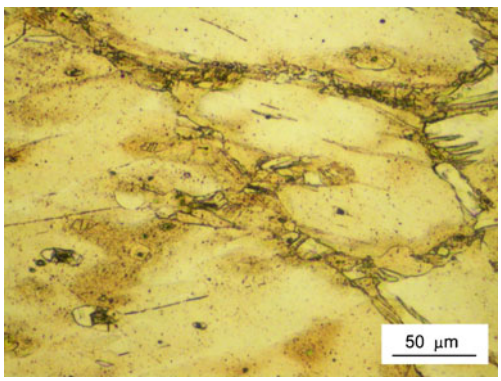

Fig. 3 Hot-hammered 18-ct nickel white gold, showing new small grains on grain boundaries, known as 'necklacing', typical of dynamic recrystallisation. Courtesy of P. Battaini

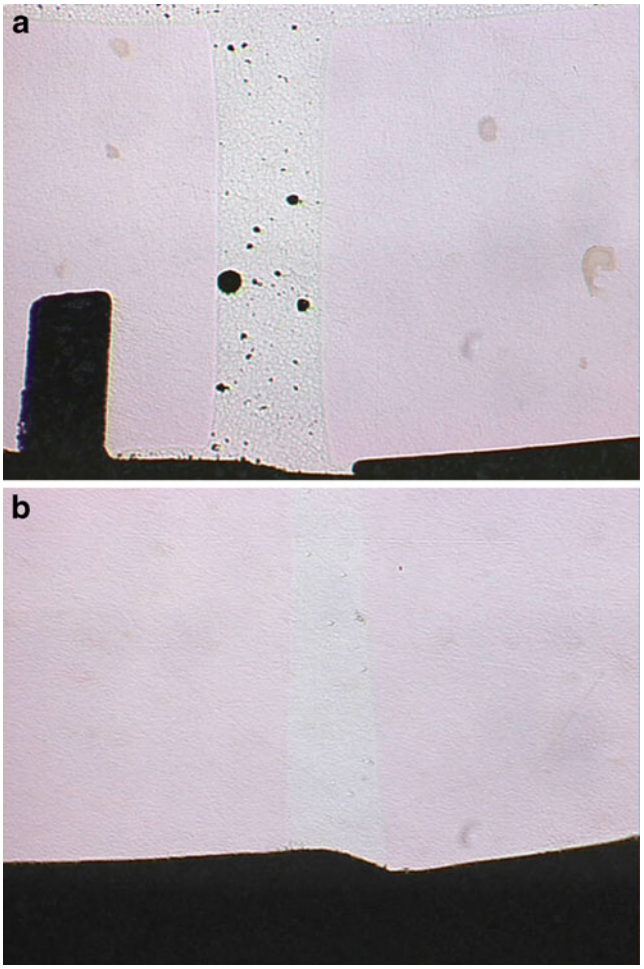

Fig. 4 Soldered joints, 0.5-mm joint gap, in 14-ct gold. **a** Torch soldered with cadmium solder, showing porosity due to volatilisation of cadmium and/or zinc, **b** torch soldered with a cadmium-free solder. Courtesy S. Grice

quality products both economically and responsively to current market conditions. His company produces wrought seamless wedding bands by hot extrusion in gold, silver and other precious metals. 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 CAD code generation integrated with 'on the fly' 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 ISO 9001:2008.

The basis of this work was the need to build a better business model for the company in the face of intense overseas competition and he noted five attributes as guiding the 'value' equation and leading to the company's USP. To meet these objectives, Nordt noted, the manufacturing operations needed to parallel them. He described the fabrication options for ring manufacturing and their pros and cons that enabled the manufacturing approach adopted by his company to be selected. He then discussed in detail the whole production process. For example, he noted that gold and silver alloy billet casting is done under atmospheric pressure under a natural gas cover. His discussion included observations on product yields and how this has led to implementation of improved technologies (minimising numbers of basic extruded tube sizes, cutting tubes with no metal loss, upsetting of basic tube blanks to give a range of ring blank sizes, for example), how to service customer delivery requirements and quality management. This, for me, is an outstanding paper on how mass manufacturers should approach their business model and implement it in a sector that is notoriously conservative.

The use of CAD/rapid prototyping is growing rapidly in the industry and the current trend is to move to a rapid manufacturing approach where rapid prototyping (RP) models are used for direct casting of jewellery rather than their use as master models for the traditional approach of lost wax casting; however, there are problems with this approach that are not well understood. So it was timely to hear two presentations on the latest research into the direct investment casting of RP resin models. Marco Actis Grande (Turin Polytechnic, Italy) spoke on 'Quality Excellence in the Direct Casting of RP Resins: Reality or Fiction?'. He examined various RP resins from different producers, looked at their thermal characteristics and then cast various models in sterling silver, with varying surface/volume ratios and using a range of burnout cycles and investment moulds made with varying powder/water ratios. The flasks were fitted with thermocouples to allow the casting process to be monitored. These trials showed that the surface quality of castings could vary significantly and that several parameters are involved in getting good surface quality. Understanding the resin's properties was a key factor and both powder/water ratio of the investment and burnout cycle also play an important role.

Taking a more practical approach, Alan Andrews (Best-Cast, USA) presented 'The Quest for the Perfect RP Burnout'. He conducted burnout and casting trials on the shop floor, using a range of model shapes and two RP resins currently used in the factory. He found that the resins have much higher melting points than injection waxes and that they start to char at 200°C and then shrivel at 375°C. The expansion of the resins was a significant factor and a stronger investment was therefore desirable in the range 20° C to 375°C . Andrews found it was possible to greatly strengthen the investment by baking the flask at 100°C for 3 h, followed by 3 h at 177°C. Successful castings were made.

Mokume Gane (Japanese for 'wood grain') materials made the traditional way are not efficient due to difficulties in diffusion bonding and material usage; an alternative,

powder metallurgy approach was presented by Chris Ploof (Glass and Metal Alchemy, USA) and Joe Strauss (HJE Co Inc, USA) in their paper, 'Mokume any other Way?'. Using mixtures of metal shots and twisted wires in silver and copper, they produced interesting structures and colour combinations by simple hot pressing techniques which they showed could be easily formed into jewellery such as rings. Such an approach can be easily adapted to gold-based Mokume Gane materials.

Other presentations

Professor W. Boehm (Pforzheim University, 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 have 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. The structure is random and makes each piece unique and the product is akin to traditional Mokume Gane materials, similar to the work of Ploof and Strauss described above.

In a similar vein, Gay Penfold (JIIC, Birmingham, UK) discussed 'Knowledge Exchange Programs and Collaborative Projects – Do these Initiatives really work and are they worth pursuing? How can the jewelry Industry benefit from them'. She described projects under three types of initiatives funded by UK government and the EU. She concluded it was possible to record successful outcomes, but success depends on a structured mechanism for exchange of knowledge. John Wright (Wilson-Wright Associates, UK) gave an unusual perspective to the industry in his presentation, 'Buy by Weight: Think Volume', in which he emphasised that the size of a piece of jewellery is what attracts customers but precious metals are sold on a weight basis. Thus, alloying precious metals not only improves properties but can also help to create more volume through lowering of the density (most base metals have lower density). This makes for cheaper jewellery.

New analysis technology was discussed by A Zielonka (FEM, Germany) in his presentation, 'X-ray computed tomography: A powerful tool for non-destructive materials analysis'. This very large piece of equipment allows high resolution analysis of structure and defects in large objects in either 2D or 3D modes. Examples of this technique applied to complex jewellery in gold and to other engineering components were given. It is truly an impressive technique!

Chuck Hunner (Golden Spirit, USA) spoke on 'Passion and Spirituality in Jewelry Design', otherwise defined as 'Inspiration'. As might be anticipated, this was about how his work is influenced by the spiritual aspects in his life and he illustrated this with examples of his work. In similar vein, Frank Cooper (JIIC, University of Birmingham City, UK) discussed a bent & folded ancient gold cross, found in the recent Staffordshire Hoard discovery of gold artefacts in the UK, and the steps taken to make a replica copy, using both modern and traditional technologies, in his presentation, 'A Gift fit for a Pope, 1,500 years after its first Creation'.

Nora Isomäki (Beneq Oy, Finland) gave a further presentation on a nanotechnology oxide coating in her presentation, 'Thin-film Anti-Tarnish Method for Silver – Further Study of Wearing and Nanoscale Properties' (see *Gold Bull*, 43 (4), 324–327) where she shared new results, particularly on wear properties. This approach to anti-tarnish protection of silver shows promise and is low cost. It could also have application to low–medium carat golds which can also suffer from tarnishing.

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 in jewelry making'. Maerz first addressed the types of solder used in soldering platinum jewellery: Traditional solders contain no or very little platinum and are typically white gold solders; they are available in several grades with a range of soldering or flow temperatures. In contrast, plumb solders, patented in the 1990s, have a high platinum content and flow temperatures in the range 1,300°C to 1,500°C. Maerz addressed the techniques of soldering platinum, with many practical tips, and ended his presentation with a series of video clips of soldering to show how it is done.

Teresa Fryé (Techform Inc, USA; co-authored by Jörg Fischer-Bühner, Legor Group Srl, Italy) reported on a study to examine the casting behaviour of a number of platinum alloys to determine which performs best from a consumer standpoint in her presentation, 'Platinum alloys in the 21st century: A comparative study'. She studied several standard platinum alloys at 900 and 950 finenesses as well as some 950 platinum alloys that had alloying additions to increase hardness, some of which are age hardenable.

Fryé commenced her presentation with a review of previous published work, which showed 950 Pt–Co to have the best casting behaviour. The softness of some platinum casting alloys was also highlighted. A survey also highlighted the problem of sub-surface porosity that only emerges on polishing. Initial casting trials focused on

solidification behaviour. Of the alloys tested, 950 Pt–Co had, by far, the lowest porosity, with the pores mainly located along the centre-line. In contrast, the other alloys had large amounts of shrinkage porosity, fairly evenly distributed.

Work at Legor Group Srl, Italy has shown that approximately 1% additions of metals such as gallium to 950 Pt–Co can increase hardness to above HV170 and such an alloy ('950 Pt–Co+') was examined in part II of this study. These casting trials showed that porosity levels nearly as low as those for 950 Pt–Co alloy can be consistently obtained in the significantly harder '950 Pt–Co+' alloy. This alloy showed low levels positioned near the centre of the casting, a much refined as-cast grain structure and also without the magnetic properties for normal 950Pt-Co, which tends to attract accidental iron contamination when worked at the bench. This is seen as a significant attribute. Hot Isostatic Pressing trials of castings showed that porosity can be entirely removed. Fryé concluded that casting behaviour is significantly affected by the choice of casting alloy with 950 Pt–Co alloy superior to other standard 950 platinum alloys. The industry desire for harder casting alloys to improve polishing and customer experience appears to be a realistic target and further work on the harder 950 Pt–Co+ alloy is in progress.

The use of coloured enamels, both glass and resin, for the decoration of precious metal jewellery was reviewed by Rick Greinke (Award Concepts) in his presentation, 'Enamel and Epoxy Resins—A look at their Usage in Jewelry Manufacturing' and Brett Gober (Freedom Design and Contracting, USA) looked at financial returns from the refining of scraps in his paper, 'Trust but Verify: A Survey of Refining Returns'. This was most educational! He showed how returns from many different toll refiners varied significantly and choice of the wrong one could cost the business substantially. Finally, Sam Davis (U Design Jewelry, USA) spoke about computer modelling of investment casting in his paper, 'Combining Art and Science to Optimise the Investment Casting Process'.

Concluding remarks

Once again, this symposium proved to be a great technology symposium with a varied range of topics to enable jewellers to achieve a better manufacturing quality and to innovate. It is, without doubt, the premier international jewellery technology conference and the attainment of the 25th anniversary is worthy of congratulation. This symposium continues to attract the experts from academia and industry as speakers and maintains a high standard.

The Santa Fe Symposium proceedings are published as a book and a CD of the PowerPoint presentations is also available, both from the organisers, www.santafesymposium.org. An archive of previous symposia papers is being made available on the website. The 26th symposium will be held next year in Albuquerque, 20–23 May 2012.