Jewellery Manufacturing Technology

LATEST ADVANCES REPORTED AT THE FOURTEENTH ANNUAL SANTA FE SYMPOSIUM

The 14th Santa Fe Symposium on jewellery manufacturing technology was held in Albuquerque, New Mexico, from 21st to 24th May 2000 and this year attracted a record 188 delegates from 19 countries. Twenty-five presentations on the latest research results and advances in technology covered all the precious metals and gems, with platinum jewellery receiving considerable attention – as it has over recent years – and illustrating the considerable interest in this fashionable jewellery metal.

The Symposium opened with Mark Grimwade (Consultant, U.K.) giving his now customary 'Introduction to Metallurgy & Jewellery Alloys' lecture, which this year was widened to include a detailed section on platinum jewellery alloys. This was followed by John Wright (Consultant, U.K.) talking about 'Mechanical Properties and Jewellery', which gave an insight into how such properties impact on manufacturing processes and the design of jewellery from an engineering perspective. The advantages to fabricators of the unique properties of platinum in jewellery manufacture were highlighted.

The unusual machining properties of platinum have been the subject of much investigation, see (1) for example. More recently, new work to optimise machining parameters for surface quality has been undertaken by C. Volpe (Tiffany & Co.) and R. Lanam (Engelhard-CLAL) and their initial results on platinum-5 per cent ruthenium alloy were presented at Santa Fe last year. The second part of their results, presented at this Symposium, extended their earlier work to other platinum jewellery alloys including a new age-hardenable 950 platinum alloy. Surface quality was evaluated by surface roughness measurements and by examination under a scanning electron microscope, and results showed polycrystalline diamond tools to be superior to cermet tools. The best surface texture was found on the age-hardenable alloy.

Powder metallurgy as a process for producing precious metal jewellery has long been attractive, but has not seen commercial application. Its use for the production of wedding rings in carat golds and platinum was described by P. Raw (Consultant to Engelhard-CLAL, U.K.). Based on a press and sinter technique using water atomised powders, the process not only leads to better technical properties, such as smaller grain size and increased ductility (facilitating a higher degree of ring sizing), but it is also faster and has higher productivity, and hence it is more economic. This process is a major breakthrough and is already attracting attention from other jewellery fabricators.

The electroplating of the platinum group metals: platinum, palladium and rhodium, for decorative and functional applications was reviewed by E. Salomon (Consultant, Technic Inc., U.S.A.), with many practical tips for the small electroplater. Rhodium, of course, finds application on white gold jewellery to improve colour.

The rapid production of platinum jewellery in the small workshop by high speed investment casting (lost wax casting) was described by Jurgen Maerz (Platinum Guild International). Using magnesia-based dental investments, which can be fired quickly, it is possible to make a successful casting in less than 2 hours. This will prove to be a boon to the designer/smith making individual pieces to order. Modern investment casting of jewellery was originally developed from the dental industry technology in the 1950s. This work once again illustrates how technology has been successfully transferred across into the jewellery sector.

On the broader precious metal jewellery front, a number of papers were presented on aspects of jewellery technology. R. Carter (Ransom & Randolph, U.S.A.) described the effect of water quality and temperature on investments for lost wax casting of precious metals. The use of deionised water to maintain a consistent quality was recommended. New research into the thermal stability of investments was also reported by G. M. Ingo (CNR, Italy). The stability of investments is important to the lost wax casting of jewellery.

Instability is often a cause of a number of casting defects including gas porosity; progress is being achieved in improving stability.

The influence of the metallurgy and chemistry of jewellery materials on the processes used in jewellery manufacture was discussed by D. Ott (FEM, Germany). This topic was also picked up by H. Freye (Techform, U.S.A.) in considering the ceramics used in shell casting of high temperature alloys including platinum.

G. Normandeau described the metallurgical training programmes used by his company, Imperial Smelting & Refining Ltd., Canada. This includes subject matter unique to platinum as well as gold and silver. All staff on the shop floor are trained and the impact of this on staff performance and training evaluation was discussed.

Other presentations looked at copyright and patent law, quality assurance and at the metallurgy and properties of other precious metals.

The presentations at this Santa Fe Symposium and previous Symposia are available from: The Santa Fe Symposium, 7500 Bluewater Road NW, NM 87121, U.S.A. Tel: +1 505 839 3249; Fax: +1 505 839 3248; E-mail: ct@tbg.riogrande.com.

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References

1 R. W. E. Rushforth, *Platinum Metals Rev.*, 1978, 22, (1), 2

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High Breakdown Voltage of Au/Pt/GaN Schottky Diodes

In power electronics (power > 1 MW), silicon carbide, gallium arsenide and gallium nitride (GaN) are being developed as alternative materials to silicon. Silicon carbide is already used in solid-state power electronic devices, such as diodes, thyristors and transistors. Wide bandgap GaN, with high breakdown voltage, is also under extensive investigation for power device uses, but little work has been reported on breakdown in GaN diode devices.

Schottky diodes can switch faster than junction diodes and are often used to measure the quality of material. Now, a team of researchers, from the National Central University, Taiwan, the University of Florida, Sandia National Laboratories, Bell Laboratories, and a consultant, U.S.A., have examined breakdown using Au/Pt/GaN Schottky diode rectifiers (G. T. Dang, A. P. Zhang, M. M. Mshewa, F. Ren, J.-I. Chyi, C.-M. Lee, C. C. Chuo, G. C. Chi, J. Han, S. N. G. Chu, R. G. Wilson, X. A. Cao and S. J. Pearton, *J. Vac. Sci. Technol. A*, 2000, 18, (4), 1135–1143).

GaN was grown by MOCVD on sapphire via NH_3 and trimethylgallium precursors. The ohmic contacts were formed by Pt/Au liftoff. They were annealed before Pt/Au deposition. Optimised high-density plasma etching conditions were developed for GaN, to give minimal degradation in reverse current leakage in *p-i-n* mesa diodes. Reverse breakdown voltages (V_{RB}) of up to 550 V on vertically depleting structures and > 2000 V on lateral devices were obtained. Values for the figure-of-merit $(V_{RB})^2/R_{ON}$, (R_{ON} = on-state resistance) were 4.2 to 4.8 MW cm^{-2}. The reverse leakage currents and forward on-voltages were slightly higher than theoretical minimum values, but comparable with reported SiC Schottky rectifiers. The GaN-devices show promise for use in ultrahigh-power switches.

Damping in Ruthenium Alloys

An important physical property of an alloy is its damping capacity in response to an imparted mechanical force. High damping in iron-ruthenium alloys is closely linked to the amount of ε martensite present.

Scientists at Yonsei University, Seoul, Korea, have investigated the damping capacity of iron-ruthenium alloys, containing 25 and 13 per cent Ru at room temperature, using samples processed to contain various amounts of ε martensite (H.-C. Shin, J.-H. Jun and C.-S. Choi, *Scr. Mater.*, 2000, 42, (10), 981–986).

Fe-13% Ru, which undergoes a $\gamma \rightarrow \alpha'$ martensite transformation to give α' single phase, showed poor damping capacity. Fe-25% Ru undergoes a $\gamma \rightarrow \varepsilon$ martensite transformation and has high damping capacity, dependent on the strain amplitude. For Fe-25% Ru, damping capacity increases with increasing ε martensite content at $< 3 \times 10^{-4}$ strain amplitude. At strain amplitude $> 4 \times 10^{-4}$ it reached a peak for a volume fraction of ~ 42 per cent of ε martensite. Stacking fault boundaries inside the ε martensite plates act as damping sources.