Dr. Marco Actis Grande

This work deals with the study, development and characterization of innovative transparent coatings applied onto precious metals and obtained through the Plasma Enhanced Chemical Vapor Deposition (PE-CVD) technique. The chemistry of coatings is mainly based on silicon and oxygen, based on the formula SiO$_x$. They have already proved to be inert to the corrosion phenomena deriving from the atmosphere and to provide a good resistance to scratches, making them very appealing for jewelry applications. The aim of the paper is to answer one very simple question: Is the process feasible?

Dr. Marco Actis Grande is assistant professor at the Politecnico di Torino, Italy (Alessandria Campus) and holds a M.Sc. in materials engineering and a Ph.D. in metallurgical engineering from the same college. He is a recipient of the Santa Fe Symposium® Collaborative Research Award. This is his second year presenting at the Symposium.

John J. Alves, Jr.

Early recognition of change (and an early response to it) often leads to a stronger position in the marketplace. Quoting Charles Darwin, “It is not the strongest of the species that survive, nor the most intelligent, but the ones most responsive to change.” This paper will look at many of the important changes over the past 50 years and how those changes have affected the face of the jewelry-making trade.

Mr. Alves is currently the Vice President of Sales at Triad, Inc. in Massachusetts. He was previously the National Sales Manager for findings at B. A. Ballou & Co. Inc. He was part of the original group that introduced the fusion concept to the general jewelry trade. This year he celebrates his 50th anniversary working in the jewelry industry. This is his second year presenting at the Symposium.

Paolo Battaini

In recent years 950 palladium-based alloys have been developed for investment casting. The main problem with these materials is that not only is it necessary to supply the suitable alloys but also to suggest the procedures for using them with the guarantee of success. The research performed until now has been
very useful to highlight the peculiarity of palladium and the ways to avoid the main problems while using this noble metal. At the moment the objective is to provide reliable alloys usable with different casting techniques in which some process parameters can be well controlled. This work is aimed at describing the characteristics of a new hard 950 palladium-based alloy, melted by arc melting and pressure-cast in argon atmosphere. This technique, which will be described in the paper, allows the user to avoid problems like hot tearing or reactions between palladium and the crucible or the investment. In fact, it is successfully used with alloys that demand a good control of the melting and casting atmosphere.

Mr. Battaini holds a degree in nuclear engineering, is a consulting engineer with 8853 S.p.A., and a professor of precious metal working technologies at Milano Bicocca University. He is a recipient of the Santa Fe Symposium® Ambassador Award. This is his fourth year presenting at the Symposium.

**Basic Metallurgy of the Precious Metals - Part III: Cracks, Defects and Their Prevention**

Dr. Christopher W. Corti

In Part I, the effect of alloying on the various properties of precious metals for jewelry and their alloys was examined, and the influence of working and annealing on properties was also explained. In Part II the importance of alloy microstructure, particularly grain size, and the way it can be influenced and controlled through casting, working and thermal treatments was examined. We noted that properties, alloy composition and microstructure are all interrelated.

In Part III, we examine some of the defect issues that can lead to problems in both manufacture and later in service with the customer. The common causes of such defects and the steps that can be taken to minimize their occurrence are reviewed. These include poor quality start materials, bad melting practices, poor ingot or material working practice, incorrect annealing and stress corrosion cracking.

Dr. Corti holds a Ph.D. in metallurgy from the University of Surrey, UK, and is currently a consultant for the World Gold Council and the Worshipful Company of Goldsmiths in London. He is the managing director of COREGOLD Technology Consultancy and has 30 years of experience in the precious metals industry. He currently edits Gold Bulletin Journal and the Goldsmiths Company’s Technical Bulletin. A recipient of the Santa Fe Symposium® Research, Technology and Ambassador Awards, this is Dr. Corti’s fourteenth year presenting at the Symposium.

**The Precious Metal Price Equation**

Dr. Mark J. Danks

In February/March 2008 the price of platinum increased rapidly, approaching $2,300/oz, an all-time high. This bewildering escalation was partly driven by an insatiable global appetite for commodities, but factors of supply (from the mines) and demand (from the industries that use platinum) also played a significant part. Platinum was not the only metal affected, with both palladium and rhodium
also increasing sharply during this period. However, a sharp decline followed in August 2008 and had the industry thinking “where next?” This paper will focus on factors that affect platinum group metal (pgm) prices, describe where else they are being used, and discuss how investors are now affecting the market.

Dr. Danks is the Sales and Marketing Manager for platinum and palladium jewelry products at Johnson Matthey in New York. He holds a Ph.D. in inorganic chemistry from the University of Exeter and started at Johnson Matthey’s Chemicals division as a development chemist in 2001, later moving into technical sales for their PGM Refining business. This is his first year presenting at the Symposium.

The Hardening Effects of Mechanical Burnishing.... 103

Gary Dawson

Our preliminary experimental data, based on qualitative hardness testing, has shown that rotary and vibratory tumbling may result in a deeper hardening than previously understood. Further study may yield surprises with regard to hardness, hardness penetration, wear resistance and media interaction with various alloys. This study will analyze the effects of studio- and production-level burnishing on hardness, depth of hardness and abrasive wear resistance on at least four common alloys. We will utilize macro- and micro-hardness testing of samples to determine depth of hardness and surface hardness. In an effort to fully understand our results, we may also use scanning electron microscopy, metallography, electron backscatter diffraction (EBSD) analysis, a comparison of resistance to wear of treated and untreated alloys, and a calculation of tensile strength.

Mr. Dawson established Goldworks Jewelry Arts Studio in 1975 and has been involved in every facet of its operation, including design, research and bench work. He has been an instructor in jewelry and metalsmithing, has conducted in-studio seminars and has been a frequent contributor to MJSA Journal on various topics. He is a recipient of the Santa Fe Symposium® Ambassador Award. This is his third presentation at the Symposium.

Challenges for Palladium Casting Alloys............... 129

Dr. Jörg Fischer-Bühner

While the market has been recognizing an increasing interest in 950 palladium jewelry, the development of Pd casting alloys and casting procedures for consistently high quality outcome has remained a real challenge for alloy suppliers and casting companies for some time. Among others this is related to some unique material properties of palladium compared to other jewelry components and the relative young history of investment casting Pd jewelry, which lead to a large spectrum of different casting process conditions favored by jewelry casters.

The present paper first briefly reviews background information from literature, followed by a summary of the main results of a casting study sponsored by the Palladium Alliance International (PAI) and conducted at the German Research
Institute for Precious Metals and Metal Chemistry (FEM).

In the second part the paper reports on alloy development work at Legor: alloy design considerations and corresponding alloy properties, followed by results from casting trials at the Legor casting lab and manufacturing companies in the US. The paper is an update of the work already presented at the Santa Fe Symposium in 2007, which showed that consistently good quality casting of 950 Pd jewelry with reasonably high as-cast hardness and low susceptibility to cracking is possible with the combination of strict casting process control and optimized alloy composition.

Dr. Fischer-Bühner holds a Ph.D. in physical metallurgy and materials technology. Since 2007 he has been active in research and development with Legor Group Srl, Italy, and Indutherm GmbH, Germany. He was formerly head of the Physical Metallurgy and Precious Metals Research division of FEM. He is a recipient of the Santa Fe Symposium® Research, Ambassador, Outstanding Technical Presentation, Applied Engineering and Collaborative Research Awards. This paper, given in 2008, was his seventh for the Symposium.

NEW OPPORTUNITIES FOR BLUE AND PURPLE GOLD IN JEWELRY CASTINGS

Dr. Jörg Fischer-Bühner

The attractive color of blue and especially purple gold alloys has always intrigued jewelry designers and producers. The reality of using these colors for jewelry has been very limited, however, mainly due to the inherent brittleness and poor corrosion resistance of this special class of gold alloys.

The paper reports on some improvements in crack resistance that are obtained by particular additions to 14K blue and 18K purple colored gold alloys. Opportunities to incorporate such colors in jewelry design with these modified, colored gold alloys using investment casting (as well as the still existing limitations) are discussed. Special attention is given to biometal casting technologies that can be used to manufacture multi-colored jewelry. A protective, transparent and wear-resistant coating finally needs to be applied to minimize corrosion and improve long-term stability of the colored pieces.

This is Dr. Fischer-Bühner's eighth presentation at the Symposium.

GOLD FILLED – ITS USAGE IN JEWELRY MANUFACTURING

Richard Greinke

With the unstable gold market, gold filled materials can be used as an alternative metal to higher priced 10 and 14 karat materials. The nature of gold filled material must be understood and the process parameters must be carried out so the thin layer of gold on the surface is kept intact during fabrication and finishing. This paper will include a brief overview of the history of gold filled. Metal fabrication, alloy compositions, and current use in the jewelry industry will
AN INVESTIGATION INTO THE PRACTICAL APPLICATION OF NEW STERLING SILVER ALLOYS .................................................. 197

Mark Grimwade

In recent years, new sterling silver alloys have become available that could represent real opportunities for workers in the jewelry craft and in the manufacturing industry. Claims have been made in relation to these that include tarnish resistance and a reduced incidence of firestain. The Worshipful Company of Goldsmiths, UK, has undertaken a practical review of two of these alloys currently available, namely 'Brilliante Sterling Silver' and 'Argentium Sterling Silver.' Four workshops and a mint specializing in medals assisted in a series of trials involving the construction of a box-like trial item, a casting trial using standard wax test patterns and stamping a medal. Tarnish resistance was measured by standard tests developed at the Birmingham Assay Office, UK. Comparisons were also made with two conventional silver/copper sterling silver alloys supplied by two different companies. The characteristics of the various alloys found during the study are reported, together with some observations and opinions of those involved.

Mr. Grimwade is a metallurgical consultant to the Worshipful Company of Goldsmiths in London. He holds a B.S. degree in physics, chemistry and mathematics from London University and a Masters of Technology in metallurgical quality control from Brunel University. He is a recipient of the Santa Fe Symposium® Ambassador, Technology and Lifetime Achievement Awards and the author of soon-to-be published book Introduction to Metallurgy for Jewellers and Silversmiths. This is his sixteenth year presenting at the Symposium.

 proto-Types and Models Using Unconventional Methods and Materials ................................................................. 217

J. Michael Jones

Cruising down the aisles of any local big box home improvement center you can discover huge numbers of materials and parts that can be used in model making. Anything that can withstand temperatures of 163°C (325°F) and 3500 pounds of pressure is a candidate: nuts, bolts, screws, drawer pulls, wire, plumber’s chain, etc. While searching for flat medium to cut with a laser and assemble into a model, I was reminded that putting a hot pan down on Formica didn’t always burn it. That fact has led to the development of a rapid proto-typing method that is unconventional and a little weird. Actually, Formica is a trade name and there are many brands of laminate that work equally well. It should be pointed out
that good designs are essential, and competent graphic arts skills dramatically improve the models. Specifically, the paper will illuminate the use of a method for creating proto-types and models using computer-generated graphics, a pulsing CO$_2$ laser, and laminates. The paper will also demonstrate the use of laminates decoratively.

Mr. Jones is a designer and model maker at Evangel Arts in Albuquerque, New Mexico. He has been involved in the jewelry industry for over 25 years. This is his first year presenting at the Symposium.

**Blue and Purple Gold: Chance and Challenge .......... 229**

Dr. Ulrich E. Klotz

Blue and purple gold alloys have been recognized for a long time. They form in alloying systems that combine gold with gallium/indium and aluminum, respectively. The alloys, however, are known to be very brittle and possess low corrosion resistance. Taking into account these negative aspects, this paper describes the results of a European-funded research project. Surface engineering techniques and investment casting were used for manufacturing jewelry items with selectively coated colored surface. Coatings of AuGa$_2$ and AuIn$_2$ blue gold alloys were applied on 18K gold, sterling silver and 950 Pt jewelry by electroplating, laser/torch cladding or dipping into liquid gallium. The properties of the blue and purple gold alloys and coatings, such as corrosion resistance, metal release rates, hardness and color, and the influence of alloying additions on these properties are presented and discussed. The suitability of blue gold coatings for jewelry purposes will be discussed in the light of reliability and feasibility.

Dr. Klotz has a Ph.D. in physical metallurgy and is currently a Department Head at the Research Institute for Precious Metals & Metals Chemistry (FEM) in Pforzheim, Germany. His research work has included phase diagram determination and modeling, micro/nanostructure investigations, alloy development and brazing and soldering. This is his first year presenting at the Symposium.

**Evaluation of Hot Tearing in 925% Silver Alloys .... 247**

Daniele Maggian

Hot tearing is the formation of a fracture in a metal casting during solidification as a result of hindered contraction. In this study we tried to evaluate the hot tearing susceptibility of different silver alloys with 925% fineness. Several studies on hot tearing susceptibility of casting alloys are known, but we have not been able to find information on precious alloys. Therefore, we wanted to characterize 925% silver alloys that, according to our experience, are more prone to this kind of problem.

A classic 925% silver alloy was taken into consideration, and we evaluated the effects of additions of other elements. We compared the different behavior of binary, ternary and quaternary alloys with and without small additions of
elements such as deoxidizers or grain refiners. In addition, we carried out a metallurgical analysis on cracked areas, trying to correlate the behavior of the alloys with their microstructure.

This paper is a part of a wider research aimed at developing silver alloys with high resistance to tarnish and a reduced tendency to hot tearing.

Mr. Maggian is the R & D Manager at ProGold S.r.l. in Italy and holds a degree in materials engineering. ProGold is a three-time recipient of the Santa Fe Symposium® Research Award. This is Mr. Maggian’s third year presenting at the Symposium.

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**Fire Assay – Laboratory Design** ............................... 271

**Dr. Raj K. Mishra**

Lead (Pb) and litharge (PbO) are extensively used in the fire assaying of precious metals (PM). It is well known that Pb is the best collector of PM. Fire assaying is extensively used in the determination of PM. However, lead is very toxic. The OSHA Permissible Exposure Limit (PEL) set by the standard is 50 micrograms of lead per cubic meter of air (50µg/m³), averaged over an 8-hour workday. Looking at these stringent standards, it appears that these low exposure levels cannot be achieved without substantial capital expenditure. The fate of lead in fire assaying seems to be the same as that of asbestos. Asbestos possibly is the best high-temperature material on the planet. Lack of proper guidelines for safe handling and bad publicity killed the industry.

Many collector metals have been investigated to replace lead but none has been universally accepted. The reasons are obvious. Lead is cheap, has a low melting point and is very easy to handle. Preferential collection of PM in lead and its subsequent separation by simple oxidation of Pb to PbO makes it the metal of choice for fire assaying.

Based on engineering principles and the knowledge of skilled fire assayers, laboratories were designed and operated to meet all the OSHA standards for the laboratory environment and safety of the workers. Years of monitoring lead in the laboratory and in the assayer’s blood samples proved the successful design. The system was designed to have a minimum of capital and energy requirements. The design and operating aspects of this laboratory are discussed.

Dr. Mishra is the assistant to the president of A-1 Specialized Services and Supplies, Inc. in Pennsylvania. He holds a M.Sc. degree from New Mexico Tech and a Ph.D. from the University of Utah, both in metallurgical engineering. He has authored more than twenty publications in the field of precious metals. He is the recipient of the Santa Fe Symposium® Research and Outstanding Technical Presentation Awards. This is his third year presenting at the Symposium.
Japanese Irogane Alloys and Patination – A Study of Production and Application

Dr. Cóilín Ó Dubhghaill

Japanese metalworkers use a wide range of irogane alloys (shakudo, shibuichi), which are colored with a single patination solution (niiro). This approach allows different alloys to be combined in one piece and patinated, producing a multi-colored piece of metalwork.

At present the production of irogane alloys and their patination is an unreliable process. This study aims to develop reliable alloy production and a safe, easy-to-use and repeatable patination process using standard ingredients available from chemical suppliers.

The study has examined the production of shakudo and shibuichi alloys, characterizing the alloys produced by casting into cloth molds in hot water, into steel molds, and using continuous casting. The influence of traditional polishing methods was assessed using surface texture (Sₐ) measurements. Traditional rokusho, an ingredient of the niiro solution, was analyzed by XRF and XRD. Niiro-patinated surfaces on a range of alloys were examined using XRD and L*a*b* color measurements.

Dr. Ó Dubhghaill is currently a Senior Research Fellow at Sheffield Hallam University in England. He holds a Doctor of Fine Arts degree from the Tokyo National University of Fine Arts and Music. His work has been exhibited worldwide and he is the recipient of several design awards. This is his first year presenting at the Symposium.

Mokume Gane Billet Reductions and Their Effects on Bond Strength

Chris Ploof

Mokume gane (wood-grained metal) is an ancient Japanese metalworking technique involving the diffusion bonding of pure metals and alloy sheets into a billet that is forged, rolled and patterned, resulting in patterned materials. In 2005, James Binnion, Andrew Nyce and Stewart Grice studied diffusion bond strength as a function of open and closed torque plate bonding apparatus, utilizing the newly developed Thermal Expansion Mismatch Torque Plate System (TEMTP). Their paper demonstrated that the TEMTP system resulted in increased bond strength as compared to the open torque plate system. However, the authors did not include downstream processing within the scope of their study, nor did they consider the effects of time and temperature on bond strength.

This study is a continuation of the work they began and includes the effects of time and temperature and selected downstream processing techniques on bond strength, where bond strength was measured by rolling samples to failure on edge. Based on the results of this study, it was found that longer firing cycles produce stronger bonds. Cold forging, either by hand or using a hydraulic press, produces bonds that were among the strongest of the tested methods of reduction. Hot and cold forging using the hydraulic press creates strong
materials. Hot forging takes advantage of the elastic deformation of the heated billet, which allows for much greater reductions. This method is a good fit for the small, well-equipped shop. Cold rolling, as accomplished with the smaller diameter rolls of the typical small shop rolling mill, seems to be less than adequate when compared to hot and cold forging.

Mr. Ploof is owner and principal artist of Chris Ploof Studio, manufacturer of high-quality wedding rings and other jewelry specially created using laminated materials. He is also founder of Chris Ploof Tools, a specialty tool company involved in the production of quality jewelry tools. His background includes studies ranging from large-scale casting and glasswork to lapidary, blacksmithing and machining. This is his first year presenting at the Symposium.

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**Age Hardenable Colored Karat Golds**

**Greg Raykhtsaum**

The continuous high and unstable price of gold presents a challenge to the jewelry manufacturing industry. There is an increasing demand for jewelry alloys with low gold content since the use of these alloys overcomes the rising material cost. However, such alloys cannot be called 'gold,' and their tarnish behavior and the color are often compromised. To reduce the material cost of karat gold jewelry, the only alternative appears to be in the use of the hardenable alloys that allow the manufacture of thin wall and lightweight products. This presentation reviews the metallurgy of gold alloy and the hardening mechanisms. It also reveals the compositional limitations for hardening, and yet shows the variety of yellow/green/red colors that may be achieved in the hardenable karat gold-silver-copper-zinc system. The benefits of using the hardenable alloys are supported by comparative data on mechanical testing of finished jewelry made with both regular and hardenable alloys.

Mr. Raykhtsaum is the Chief Metallurgist at Sigmund Cohn Corp. in New York. He holds a M.S. degree in physics from Polytechnic Institute, St. Petersburg, Russia. He has co-authored eleven patents and a number of articles. He is a recipient of the Santa Fe Symposium® Research and Ambassador Awards. This is his eleventh year presenting at the Symposium.

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**Innovative Mold Preparation and Cutting for Very Thin and High Precision Items**

**Dr. Hubert Schuster**

Recently developed mold materials, in combination with special mold preparation and cutting systems, now allow us to produce very lightweight items that were not possible using traditional materials and methods. Furthermore, highly precise pattern results (with fewer parting lines on wax and no fins) are now also obtainable. Silicon, for example, in combination with other new materials and the use of CAD, can produce extremely thin and complex patterns in wax as well as in plastic that were not achievable with other mold materials or
even with complex and expensive metal molds. Developed in collaboration with Dr. Dario Nicetto of Nicem S.p.A., Italy, this newly developed system allows us to now produce very thin and lightweight moldings (25% thinner than traditional molds) that will offer us extraordinary jewelry manufacturing results.

Dr. Schuster is an independent technical consultant and formerly served as the Director of the Jewellery Technology Institute in Creazzo, Italy. He has more than 35 years of experience in jewelry production and four patents for jewelry applications. Dr. Schuster has served as a technical consultant for more than 110 major companies worldwide. He is a recipient of the Santa Fe Symposium® Applied Engineering and Ambassador Awards. This is his seventh year presenting at the Symposium.

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**ON THE USE OF AN INCREMENTAL CASTING TECHNIQUE TO OBTAIN COLOR GRADIENTS IN JEWELRY COMPONENTS**

**Dr. F.S. Silva**

The production of colored gold-based components (white, red, pink, blue, green, purple, yellow, etc.) is widely known but the production of multi-colored pieces (with two, three or more colors and a smooth gradient in between) in one casting step (without components soldering) is a totally new manufacturing process. This process applies to the production of gold artifacts including the jewelry field. Its main advantage is the ability to develop and produce jewelry pieces with innovative designs. The basis of the process is the production of gold-based components with a controlled color gradient. This is obtained with the control of the alloy chemical composition along the piece. The component's production will be based on an incremental process of melting and solidification.

The process is essentially based on a continuous melting of the base materials by induction heating inside a mold with the addition of new elements or alloys in order to continuously change the component's chemical composition. By the control of the process variables (materials added, melting and solidification rates) it will be possible to obtain a component with the desired chemical composition gradients. The chemical composition gradient will be selected considering the aesthetic of the component and the physical, metallurgical and mechanical properties of the intermediate phases formed in the component. The end of the process yields jewelry pieces (polychromatic pieces like rings, pendants, etc.) with controlled color gradients along the component in both a micro and macro scale.

Dr. Silva is currently an Auxiliary Professor at Minho University in Guimarães, Portugal, and holds a M.Sc. and Ph.D. in mechanical engineering from the same university. He has worked for several jewelry companies and has published many papers for journals and conferences. This is his first presentation at the Symposium.
Rapid Manufacturing (RM) and Precious Metals

Dr. Joseph Tunick Strauss

Rapid Manufacturing (RM) is the ultimate goal of Rapid Prototyping (RP). Whereas RP produces a part of a surrogate material (for example, plastic or wax), which may subsequently be transformed into a metallic part by conventional investment casting, RM builds the part directly from the metal.

There are currently several RM technologies that are commercially available. This paper will review the technologies and relate them to the potential of making precious metal parts.

Dr. Strauss is president of HJE Company, Inc. He holds a Ph.D. in materials engineering from Rensselaer Polytechnic Institute. He has authored more than 40 published works and writes an annual column for International Journal of Powder Metallurgy. He is a recipient of the Santa Fe Symposium® Ambassador and Applied Engineering Awards. This is his ninth year presenting at the Symposium.

Advantages and Limitations of Electro-Mechanical Finishing

Dr. Alex Verdooren

Electro-mechanical finishing is a very new electro-polishing method used to finish silver and copper alloys such as brass, bronze and nickel silver (alpaca) jewelry. This mass-finishing process eliminates the lengthy cut-down steps of traditional mass finishing. This paper summarizes the results of a technical study carried out in a real production environment. In addition, this article will discuss the advantages and limitations of electro-mechanical polishing.

Dr. Verdooren is currently a research engineer for the Technical Research team at Rio Grande and holds a M.Sc. and Ph.D. in chemical engineering from Lehigh University. This is his first year presenting at the Symposium.

Tube Manufacturing – Some Basics

Klaus Wiesner

This paper is the last in a series of four presented at this Symposium, and it describes how to produce tubes made from precious metals according to various specifications. It will provide an overview of methods to produce tubes, seamless or not, in precious metals – following the complete production process from the melt to the finished product. You will learn how to achieve tight specifications on inner and outer diameter, wall thickness, straightness, surface quality and other physical properties. Theoretical and practical information, together with helpful tips and tricks for everyday use, are also included.

Mr. Wiesner has more than 20 years of experience with precious metals. He is a Key Account Manager for Wieland, Precious Metals Division, in Pforzheim, Germany, and is responsible for the development and technical support for customers and for production of semi-finished products. He holds a M.Sc. in industrial fabrication and is a publicly...
certified expert for precious metals. Mr. Wiesner is a recipient of the Santa Fe Symposium® Ambassador and Applied Engineering Awards. This is his ninth year presenting at the Symposium.

JEWELRY ALLOYS: HARDNESS & HARDENABILITY .............. 453

Dr. John C. Wright

Mechanical and physical properties for silver and gold alloys have been used for at least 140 years to select working processes and find their limits. Hardness was once an adequate indicator to a gold/silversmith or a craft jeweler; no longer. Batch production and new alloys have complicated the assumption that jewelry alloys are always ductile, malleable and sufficiently wear resistant. Platinum group alloys, white golds, stain-free silvers, stainless steels, titanium and niobium have expanded the jewelry alloy spectrum greatly. We now need a better understanding of hardness test data.

The history of hardness testing is used to show different measures of hardness, and instrument settings give significantly different results. A penetration hardness impression involves local work hardening, which depends on alloy composition and on the latent hardness to create an equilibrium stress reading. So the softest and fastest work hardening alloys give a measured hardness higher than their true latent hardness.

Hardness tests are surface tests at a point; they may not represent the average hardness of the material. Surface/interior differences may depend on electroplating, porosity, reactions in melting and casting. Some polishing, machining and surface working operations produce a thin, hard layer. Some alloys are prone to shrinkage, gas porosity or coring, which may not need to be eliminated but cause at least micro-hardness variations. A good understanding of work hardenability is very important in jewelry manufacture and the hardness test is a very useful, cost-effective tool.

A standard penetration hardness value is a good indicator of the state of a specific jewelry alloy. But hardness tests are empirical; they do not accurately simulate life performance or further processability across a wide range of materials. There is no need for further hardness test development to suit jewelry alloys. The industry does need more exact contextual reporting and wider exchange of test data to better appreciate the meaning and limitations of hardness data.

Dr. Wright holds a B.Sc. in metallurgy and a Ph.D. in gas turbine technology from the University of London. He is a Fellow of the Institute of Materials, Minerals and Mining, Fellow of the Gemological Association of Great Britain, and Fellow of the Institution of Engineering and Technology. He is a materials consultant and expert witness with Wilson-Wright Associates in England. He has worked as a consultant with several assay offices, Johnson Matthey, Platinum Guild International, World Gold Council and several jewelry and equipment manufacturers. Dr. Wright is a recipient of the Santa Fe Symposium® Ambassador and Applied Engineering Awards. This is his eleventh year presenting at the Symposium.