Palladium

LAO 950 I

An introduction

UK edition

Johnson Matthey
PRECIOUS METALS MARKETING

The GOLDSMITHS' Company

Palladium Technical Manual

950 Palladium, Fancy Colour Sapphires and Diamond Bracelet
by Brenda Warburton, Austin & Warburton, Ann Arbor Michigan, USA

Johnson Matthey and The Goldsmiths' Company Assay Office London are pleased to present the first edition of the Palladium Technical Manual. This guide for working with palladium features important palladium design and manufacturing information in a topic-specific format. Included under select topics are palladium projects with complete project details which serve to illustrate certain applications.

Throughout this manual, you will also find under the Tech Notes, tips and safety suggestions that offer some insight into various palladium working characteristics.

The manual focuses on information regarding the working properties of palladium as they apply to the most commonly encountered tasks in the fabrication and repair of palladium jewellery.

The content is intended as an important tool for the jewellery trade in its introduction to palladium and will be of interest in the following areas of expertise:

- manufacturing jewellers,
- designers,
- retail jewellers,
- trade schools,
- trade and speciality shops which handle palladium jewellery,
- jewellery professionals,
- retail store owners and
- managers and sales personnel

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Introduction

Why Palladium ?

Design by Lainie Mann, Mann Design Group[1]

Palladium (atomic symbol Pd) is a platinum group metal (PGM). It is the lightest (least dense) and has the lowest melting point of the group. Palladium is naturally white, not requiring rhodium plating for use as jewellery.
It is malleable and ductile in its pure form, but too soft for jewellery unless alloyed. As an alloy containing 950 parts of palladium for jewellery purposes, it is more "pure" than a white gold alloy, but the additional elements make it harder and more durable in the as-cast condition. Its hardness significantly increases as it is cold worked making it ideal for jewellery, and palladium wears similarly to platinum. Palladium resists oxidation at ordinary temperatures but will discolour at soldering temperatures, become brittle with careless, excessive and repeated heating and cooling cycles, and react with strong acids. One of its characteristics that cause it to be sensitive to certain jewellery manufacturing procedures is its ability to absorb considerable amounts of hydrogen and other gases, especially when molten.

Design by Scott Kay[2]. Photo courtesy of Scott Kay

Purity

Palladium alloys for jewellery manufacturing have a high purity level. They are primarily alloyed with other platinum group metals, and other metals, to suit a wide variety of manufacturing methods.

Design by Scott Kay[2]. Photo courtesy of Scott Kay

Hallmarking

In July 2009 the Hallmarking Act was amended to include palladium into the metals that require hallmarking alongside the traditionally hallmarked metals of gold, silver and platinum. From 1 January 2011 the hallmarking of palladium jewellery became compulsory.

Exemption weight

Palladium articles below 1 gram in weight are exempt from hallmarking. The exemption weight is based on the weight of the precious metal content only, excluding, for example, weight of diamonds, stones etc. In the case of articles consisting of precious metal and base metal, the exemption weight is based on the total metal weight:

Standards available for hallmarking

The standards available for hallmarking are 500, 950 and 999 (parts per thousand). It is expected that 950 will be the most common standard.

The solders that are permitted to be used for each individual fineness is shown in the table below.

Fineness	Permitted solder
500*	Gold, silver, platinum or palladium (or any combination) with a minimum fineness of 700ppt.
950	Gold, silver, platinum or palladium (or any combination thereof) with a minimum fineness of 700ppt.
999	

Appearance of the hallmark

A legal UK hallmark must comprise three marks: sponsor's mark, a fineness mark and an assay office mark. These are termed the 'compulsory marks'. For palladium, the fineness mark will take the form of the fineness number contained within three adjoining circles.

Other marks, termed voluntary marks, are also available. Historically, these include a date letter and a traditional fineness symbol, e.g. the crown for gold or the orb for platinum. A traditional symbol for palladium is also available. This is the head of Pallas Athena, the Greek goddess of war, wisdom and craft.

A typical hallmark for palladium, including a date letter and the traditional symbol is shown below:

Sponsor's mark Traditional symbol Fineness mark Assay office mark Date letter

Convention Hallmark

A palladium convention hallmark is also available. Palladium finenesses recognised by the International Hallmarking Convention are 500, 950 and 999. The minimum permitted solder under the Convention is 700ppt precious metal content for all finenesses.

Wearability

Design by Tom McLaughlin[3]. Lennon's Jewelers

950 palladium has a specific gravity of 11.8., which is similar to white gold (most 14 and 9ct white gold alloys are around 12.7) and almost half that of platinum, making it very comfortable to wear larger pieces.

Workability

Design by Lainie Mann[1]. Mann Design Group

Palladium is malleable, making it easy to bend, form and manipulate. It has little or no memory, a characteristic conducive to the setting process of gemstones, machine forming and hand fabrication.

Permanent Whiteness

Design by Scott Kay[2]. Photo courtesy of Scott Kay

Palladium is naturally white, and does not require repeated rhodium plating to keep the finished piece white during normal wear.

Features and Benefits

Jewellery designers and manufacturers are beginning to embrace palladium, and have developed new lines of jewellery products with this metal. Even though palladium is a prominent platinum group metal, consumers are largely unfamiliar with it.

Here are some selling points that will help introduce this desirable metal for sales presentations:

Palladium is a platinum group metal. It does not tarnish or lose whiteness when worn.

Palladium is naturally white, and therefore does not require repeated rhodium plating to maintain its whiteness.

Palladium wears similarly to platinum. As with any piece subjected to daily use, palladium jewellery will show surface wear over time. Surface wear is easily restored by cleaning and re-polishing—a regular practice performed by most retail service departments.

Palladium alloyed for jewellery is mostly 95% pure. Common alloy ingredients are ruthenium and iridium which are also platinum group metals.

Palladium is comparable in weight to 9 and 14ct white gold, making it very comfortable to wear even larger pieces.

In response to the rising interest in palladium as a viable white jewellery metal for designers/manufacturers and increasing number of palladium pieces being stocked in jewellery stores, this manual will focus on the working properties of 950 palladium alloys.

Detection of Palladium

Palladium's colour is very similar to platinum and it is impossible to detect the difference based solely on this. Palladium can also appear very close in colour to high nickel white gold or rhodium plated white. This image shows a palladium sample in the centre, with a non-rhodium plated palladium white gold sample to its left and a platinum sample to its right. The lighting conditions are ideal and it is easy to see the differences between the white gold and palladium and platinum samples. Rhodium plating would have made all three samples appear similar. The following methods will help determine if an item is made in palladium.

Design by Novell[11]

For non-destructive testing, iodine can be used to detect the difference between palladium, platinum and white gold. Place a drop of it on the cleaned surface of the unknown white metal. If you suspect that the item has been rhodium plated, use abrasives to remove the plated surface in the area that you want to perform the test. As the small drop of iodine evaporates and dries, it will take on a body colour that will assist in the detection of the metal. Here are the most common reactions you can expect with a drop of iodine after it has dried:

Alloy	Reaction
Palladium	Iodine turns black (as shown in example)
Platinum	Iodine dries mostly colourless
9ct, 14ct and 18 ct white gold (below a rhodium plated surface)	Iodine turns brownish

After seeing the test results, place the item in the palm of the hand to test its weight. If the drop dries near colourless and the jewellery object feels heavy, it is likely that the sample is a platinum alloy. If the drop dries black and is questionably light for platinum, it is likely to be palladium.

Destructive tests include heating the unknown object to determine if it loses its polished lustre or takes on a blue-violet surface oxide. If the blue-violet colour appears, it is possibly palladium. If it remains colourless and does not lose its polished lustre, it is likely a common platinum alloy. Be sure that the pieces are not rhodium plated. Palladium will turn concentrated nitric acid to an orange/brown colour. Platinum will not be affected, and nickel alloys will turn the solution a greenish colour.

Tech Note: Platinum cobalt alloys are used for some cast platinum pieces. When using high heat, the cobalt in platinum cobalt alloys may oxidise and cause the piece to lose its polished lustre. Depending upon the amount of heat used, the oxidation may show as a light blue or a light purple. The appearance is less intense, and experience with heating both alloys will help in determining the difference.

World Palladium Usage

Please visit the website link below to view the latest "PGM Market Review":
http://www.platinum.matthey.com/publications/pgmreview.html

History of Palladium

The history of palladium begins with the discovery of its sister metal platinum. The noble metals, which are commonly found together, have a shared beginning that is highlighted by early challenges to their widespread use. That is, until modern science and metallurgy unlocked some of the valuable characteristics each offers, and proved them to be essential to 21st century commerce.

Platinum was not identified until the 1560's when Spanish explorers in the Americas encountered a white metal that limited their efficiency in extracting gold from alluvial deposits. Termed Platina, platinum was largely overlooked for two hundred years until 1753, when the Spanish government called for a scientific investigation into possible uses for the metal. The hired scientist discovered the ease with which platinum mixed with gold (a most valuable commodity at the time), and as a result stores of platinum were dumped to prevent forgers from misrepresenting platinum as gold.

Still, samples of platinum managed to make their way to European laboratories, and in 1803 William Hyde Wollaston isolated palladium from platinum and identified it as a separate elemental metal. Named after the Greek goddess Athena's play thing, Pallas, palladium faced issues of marketability due to few known uses for the metal. In 1817, Percival Norton Johnson formed a gold refining company and, in partnership with George Matthey (the origins of Johnson Matthey) some years later, was able to make use of palladium in chemical balances, for rust-free surgical instruments and as a substitute for steel.

Throughout the remainder of the 19th century, further research and the discovery of additional platinum group resources in Russia led to the greater intrigue and ubiquity of these metals. But it wasn't until yet more resources and producers of palladium entered the market in the early 1900's that the metal saw widespread use - by the 1930's palladium alloys were being used in dentistry. The biggest breakthrough for the increased use of palladium occurred in 1970 when, in the face of growing environmental concern, it was discovered that catalytic converters consisting of palladium, platinum and rhodium could eliminate a high percentage of all the harmful gases from automobile exhausts.

Palladium Design Considerations

Characteristics

Palladium alloys for jewellery manufacturing usually contain 95% palladium and 5% other metals. Specific jewellery manufacturing methods like casting, machining, chain making, hand fabricating or other processes sometimes call for differing alloy ingredients. Of the alloys currently being used in the U.K. for palladium jewellery, the most commonly used consist of 95% palladium, and a balance of other metals. The inclusion of specific trace elements offer various benefits to the design and manufacturing process (e.g. hardness, better fluidity for casting, ease in machining) or lend to better wear of the finished jewellery. Alloys containing 95% palladium share inherent characteristics of the pure metal, such as:

Malleability: Palladium is readily capable of being shaped or formed by hammering or pressure.

Ductility: Pure or alloyed, these metals are highly capable of being drawn or bent without breaking.

Hardness: Palladium alloys considered to be fit for purpose have an as-cast hardness measured using the Vickers hardness (HV) scale between 110HV and 135HV depending upon the alloy. These hardness measurements relate to tests on the core of the casting, where surface processing has not affected the natural hardness. With this hardness range, palladium is relatively resistant to denting, scratching or bending, and wears similarly to platinum. Softer palladium alloys may still be fit for purpose if cold worked into jewellery – e.g. wedding rings made from tube or sheet – as long as they are not annealed after processing.

Strength: With adequate tolerances, palladium has good strength and will hold shape and form through strain or stress when properly designed. Because of palladium's malleability, tolerances should be slightly heavier or thicker as compared to when using alloys of less purity that contain higher amounts of harder base metals such as nickel.

Whether palladium plays a supporting role to diamonds or coloured gemstones, or takes the spotlight in visual form or tactile comfort, palladium jewellery should be designed to the strengths of this unique metal: the aesthetics of its light, bright, favourable white colour; its density; and its metallurgical assets in setting, fabricating, casting and machining. Here are a few examples:

Example One

This example shows a standard court shape shank (i.e. the inside of the shank is slightly rounded) and a low profile four-claw setting. The inherent characteristics of palladium and the design of the parts were considered in their selection as explained in the following points:

- The overall thickness of the shank is 1.85mm. This thickness is required and offers the support necessary for the shank to hold its shape through normal wear. Palladium's malleability, while desirable in setting, would allow a thin shank to be easily deformed during normal wear. Customers may be assured that the thicker shank is neither bulky nor heavy, since the specific gravity of palladium is comparable to 9 and 14ct gold.

- The shank has a bevelled design. The overall width is 4.10mm and the flat portion at the top of the shank is 2.00mm wide. Palladium has a desirable hardness for jewellery but is softer than the less pure white gold alloys containing nickel. The narrow flat area at the top of this shank will show less wear than a plain flat shank with the same overall width of 4.10mm.

- A low profile setting was chosen with a total height of 5.65mm from the base of the unit to the tops of the claws prior to setting. Taller profiles for this type of assembly are more vulnerable to deformation such as twisting or bending.

- The base of the setting measures 3.25mm offering a good amount of surface area for soldering to the ring shank. Narrower widths would have less contact and therefore be less stable and could possibly bend or break during normal wear.

- The claws measure 1.00mm in width and 1.25mm at the claw top, and broaden to 1.90mm at the base of the claw. The tapering width from bottom to top offers fantastic claw stability for normal wear. Claws of thinner dimensions when made in 950 palladium alloys present a risk of becoming deformed during normal wear.

When the mount is assembled and set, the combined features of this basic assembly provide a secure setting for the 6.0mm gemstone.

Important Notes:

- The contact area between the base of the head and the shank measures 3.25mm (indicated by the red lines) offering good strength and stability for the setting.

- The claws have sufficient length and thickness, providing good security for the 6.0mm gemstone.

Example Two

This example shows a half-round shank and a high profile 4-claw setting. Again, these parts were chosen on the basis of palladium's characteristic strengths and on the merit of their design for the following reasons:

- The overall width of the shank tapers from 3.60mm to 2.10mm at the bottom. This sufficient width will enable the shank to hold its shape through normal wear. The height of the shank begins at 2.50mm at the top and tapers to a thickness of 1.50mm at the bottom. The height at the top is also a key consideration in the structural support of the chosen setting. Thinner shank options would not be desirable as they offer less stability of the setting and are more susceptible to deformation during normal wear.

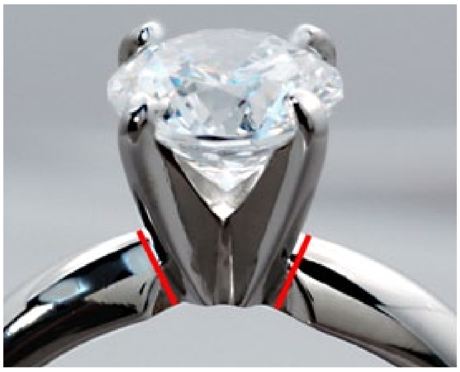
- The setting is high profile with a total height of 8.65mm from the base to the tops of the claws prior to setting (3mm taller then the previous example).

- The tapered claws measure 1.00mm in width and 1.00mm at the top, widening to 2.5mm at the base. The claw design and dimensions offer great stability for normal wear. Claws of thinner dimensions (for a comparably sized stone) when made in 950 palladium alloys present a risk of becoming deformed during normal wear, threatening the loosening or dislodging of the stone.

The method of assembly between this setting and shank differs from the previous example. The top portion of the shank is cut so it precisely interlocks between the claws, providing extra strength and security to the assembly.

Important Notes:

- The height of this shank at the point of assembly is 2.50mm. The width and interlocking feature of this assembly provide ample contact area for added strength and security to the high profile setting.



- The high profile is balanced by proportionately thicker claws, which are wider at the base. This design feature greatly decreases the chance of bending and deformation of the malleable palladium claws during normal wear.

When using pre-made palladium components (findings), choose the ones designed and made with consideration for palladium characteristics, rather than those intended for other less malleable metals. Using dies originally designed for white gold to strike out components for palladium could lead to problems for finished palladium jewellery. White gold alloys can contain nickel and other metals that have different metallurgical characteristics (e.g. low malleability and greater hardness) than 95 percent pure palladium. Dies designed for white gold specifications may prove to be insufficient for use in palladium jewellery components and will possibly fail under normal wearing conditions.

A Designer's Medium

Successful palladium jewellery designers understand the inherent characteristics and numerous positive features of this noble metal. The combination of its density, malleability, ductility and hardness at high levels of purity offer designers a multitude of distinctive design opportunities.

Jewellery by Thomas Dailing, Image by Azad Photo

Advantage – Light Density

Palladium's density is comparable to silver and lower carat gold alloys. Designers can take advantage of this density as an opportunity to create pieces with voluptuous lines and proportions without the weight. This example features substantial claws, a thick shank and ample dimensions which provide comfort and good security for the gemstones.

Jewellery and Image by Elichai Fowler, Paradise Ring Works

Advantage – Bright White Color

The bright white colour of palladium provides an excellent contrast when used alongside metals of other hues, such as yellow, pink and green gold. Characteristically, bi-colour or multi-colour jewellery benefits from the application of surface texturing to one or more of the alloys, to enhance the colour contrast. By comparison, palladium provides a noticeable contrast even when all metal surfaces are polished and highly reflective. This ring shows a pink gold insert, a palladium ring body, and pink gold accents soldered to the surface.

Jewellery by Thomas Dailing, Image by Azad Photo

As this image demonstrates, palladium provides a bright white backdrop that enhances both diamonds and coloured stones. It played a major role in the concept of this design—the colour of the gemstone is reflected back into the stone from the dramatic whiteness of the metal.

Palladium offers superb malleability for setting multiple gemstones. With its combined strength, hardness and durability, it is a very desirable metal in designs for everyday wear.

Palladium's affordable pricing combined with its light weight opens up fashion jewellery options. These hand fabricated drop earrings were cold worked and the fluid form presents a dramatic effect. They are large, yet comfortably light for everyday wear.

Textures, engraved patterns and bright finishes are all possible with palladium. This band exhibits a hand engraved floral pattern which covers the surface, accented by flush (burnish) set diamonds and a highly polished shank.

Alloys

All precious metals in their pure state tend to be relatively soft and not suitable for mainstream commercial jewellery design and manufacturing. The resulting pieces would readily deform and show excessive wear under normal circumstances, compromising the design and the settings in which gemstones are held. Palladium is no exception.

The most commonly used alloys for palladium jewellery are at purity levels of 95% pure palladium and 5% other metals. For example, ruthenium, or a combination of ruthenium and gallium, is added to palladium to improve hardness, workability, castability and resistance to wear. Other palladium alloys contain silver, copper, cobalt and indium exclusively, or in combinations thereof.

Hardness

Comparative metal hardness is determined using a few different methods. Most commonly, jewellery alloys are measured using the Vickers hardness scale. Palladium alloys demonstrating desirable hardness and resistance to wear measure at 120HV to 135HV but some commercially available alloys have shown hardness values of less than 100HV. Studies have shown that jewellery alloys, regardless of the caratage or purity level, are more resistant to wear if they are harder.

Hardness values can be misleading if not acquired in a consistent, controlled manner using like samples created by the same procedures, equivalent testing methods and equipment and subjected to the same settings and loads. For example, cast palladium jewellery made from the same alloy can show a wide range of hardness values depending upon post-casting processing. When jewellery is tested at the surface after casting and processing, hardness values for the same alloy have shown a range between 120HV and 180HV. This variance corresponded to the different water and/or bead blasting procedures used to remove investment and other processing factors. When these rings were tested at the core, hardness values ranged between 120HV and 130HV which is the natural hardness of the particular alloy. Core testing for Vickers hardness is a more reliable method of testing hardness than surface testing.

It has also been recognised that some palladium rings could not be drilled using standard twist drills mounted and powered by a flexible shaft (for diamond setting). It was found that post-casting processing had created this work hardening, and that annealing was required to return the palladium to its natural working characteristics.

Palladium Alloys - Applications

95% Palladium – 5% Ruthenium

Used to make seamless wedding bands and other wrought palladium products. This alloy is commonly used to make extruded seamless tubing, which is described later in this publication. This particular manufacturing process which includes extruding, shaping and machining, causes work hardening, resulting in jewellery products of superior hardness. Products made through this manufacturing process hold their remarkable hardness unless annealed or soldered, which causes the metal to return to its natural hardness. The hardness of palladium-ruthenium alloys in an annealed state ranges between 115HV and 125HV. After processing through extrusion, machining and other cold working manufacturing techniques the hardness can increase to 180HV to 190HV.

95% Palladium – Ruthenium – Gallium

Used for casting. This alloy has excellent hardness and resistance to wear.

95% Palladium – Copper

Used by Italian companies for chain making.

Note: Several other palladium alloys exist and are used for a variety of casting and other applications. It is advisable to have the metal you are using tested by a qualified metallurgical laboratory to determine its core hardness and metallurgical composition.

Casting and Melting

Design and Model Guide for Casting

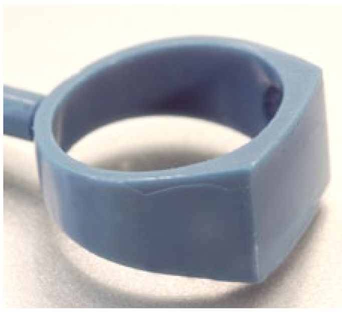
Rapid Prototype model by Stephen Adler[4]

Automated 3D Modeling and Rough Casting by TechForm[5]

Proper designs, models and sprueing systems for palladium pieces can help eliminate casting problems, defects and no-fill issues. To maximise favourable results and to minimise defects or incomplete castings, try these suggestions:

- Wall thickness of wax models should not be thinner than 1.00 millimetre.

Keep your models clean and free of processing chemicals and other bench waste when preparing for casting.



- Avoid extreme thin-to-thick connections.
- Make rings ¼ of a size larger than required to compensate for shrinkage.
- Shrinkage rates are similar to platinum, so compensate accordingly for settings (i.e. claw and bezel thickness, openings for seats and back-holes). As a general rule, smaller pieces are not as likely to shrink as pieces with larger volumes.

Models for casting palladium can be made from injection wax, carving wax or some rapid prototype output from CAD/CAM processes. Some designs produced with photopolymer models can expand and crack the shell and investment mould during burnout. Certain rapid prototype models do not completely burn out leading to casting defects.

Palladium Casting

General Casting Parameters for 950 Palladium Alloys

The parameters listed for casting palladium are applicable to jewellery articles of average weight, with uniform wall thickness, sprued on small trees (100 to 200 grams) and employing specialised induction heating equipment. Specific adjustments must be made in consideration of conditions, materials used, volume of metal, design characteristics, size and quantity of pieces, and other factors, when casting outside this control range.

Palladium casting at AU Enterprises

950 Palladium Density or Specific Gravity: 11.8

Melting Range: 1350° to 1600° C (2,460° to 2,915° F). Note: Temperatures differ according to the specific alloys, processing conditions and equipment)

Melting Method: Induction heating

Melt Time: About 40 seconds

Hold Time after Complete Melting: 7 to 9 seconds.

Flask temperature range: 650° to 950° C (1,200° to 1,750° F)
Note: Temperatures will differ according to tree design, individual pattern weight and equipment used.

Investment type: Phosphate bonded

Crucible type: Carbon-free (**ceramic, not graphite**). Continued reliable results have been acquired when crucibles are preheated to 400° to 650° C (750° to 1125° F)

Atmosphere and cover gas: Partial removal of atmosphere with vacuum pressure in a sealed casting chamber and backfilling with an inert gas such as argon

Sprueing: Shorter, heavier sprues attached at the heaviest cross section of the pattern, or multiple sprues for patterns with thin-to-thick variations in wall thickness

Metal Preparation: Small, uniformly cut palladium alloy pieces

Recycled Material: Maximum of 50%, which has been thoroughly cleaned and cut to uniform size.

De-investing: High pressure water.

Removing flask from oven at Unique Settings, New York, NY, USA

General Notes:

When molten, palladium absorbs excessive amounts of oxygen and hydrogen, and has a tendency to decompose refractory materials such as crucibles and less stable investment. Palladium attempts to give off absorbed oxygen and hydrogen when solidifying so careful attention to sprueing and other casting conditions is required to minimise gas porosity.

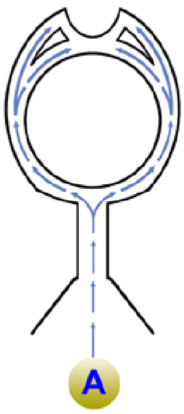
Just-cast palladium flask at Unique Settings, New York, NY, USA

Investing Notes:
Reports from casting facilities have concluded that it is advisable to use only fresh batches of investment with palladium. Older batches of investment may not mix properly and can manifest casting problems. It is important to follow commercial investment mixing instructions and to pay careful attention to mixing, drying and burnout cycles. Atmospheric conditions (like humidity) may have an effect on investment mixing and drying times. Because of changing atmospheric conditions, it is advisable to take notes during investment mixing operations, noting atmospheric conditions and water temperature used. This will allow replication of optimal conditions when undertaking subsequent casts. The investment conditions under which good casting results are obtained will serve as a good guide for future investment mixing operations, allowing good casting reproducibility.

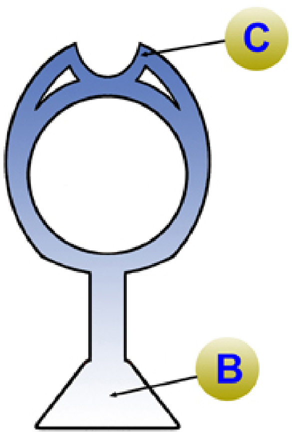
Sprueing Notes:
"Progressive solidification" must be considered when sprueing items for casting. Progressive solidification is the term used to describe the manner of how molten metal should cool and solidify when cast. The metal should solidify from outside to centre and from top to bottom of the flask, i.e. the button should solidify last. This helps to prevent shrinkage porosity and non-fill.

Flask Temperature Notes:
Use of lower flask temperatures is advised when casting heavier items, and higher flask temperatures for casting finer, lighter weight items. Care must be taken when using higher flask temperatures due to palladium's increased ability to decompose refractory materials in investment under these conditions. Lower flask temperatures minimise breakdown or reaction with investment, but can also lead to no-fill of the cast pattern.

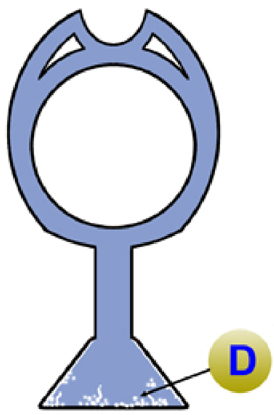
Atmosphere Notes:
Use of an inert gas, such as argon, over the crucible while the metal is melting is important. Prior to the introduction of argon, removal of the atmosphere by vacuum (using machines with chamber sealing capabilities and vacuum) and backfilling with argon may be of assistance. Vacuuming the chamber removes the hydrogen and oxygen, which leads to the reduction or elimination of gas porosity. However this practice can increase the risk of reaction between the investment and the molten palladium, so careful monitoring of this procedure is advised.



When casting, molten palladium enters mold cavity (A).



The mould cavity is filled with molten palladium and it begins to cool and solidify from outside to centre and from top (C) to bottom (B).



When sprued properly, molten palladium cools and solidifies from the outside progressively back to the button. The desired outcome is that button will solidify last which will likely exhibit visible shrinkage and trapped gases within it (D). (Buttons are successfully recycled for casting regardless of visible shrinkage and porosity. See recycling notes for best practices on in-house recycling.)

Over-exposure to investment materials at higher temperatures, and with higher amounts of vacuum, can lead to silicon contamination from the ceramic crucible, which ultimately results in cracking or hot tearing of cast pieces. Better results have been obtained by using a partial, not a full, vacuum followed by backfilling with argon. Use of too much argon can lead to non-fill of lighter weight pieces.

De-investing Notes

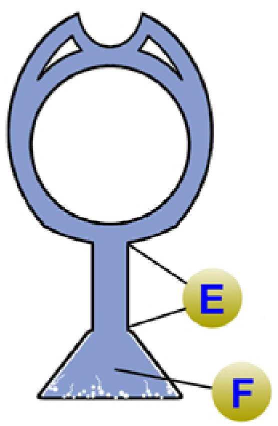
Palladium trees are full of little voids and porosity due to its unique solidification properties, and great care should be taken if investment is removed with hydrofluoric acid or other chemical agent. The acid, along with the lime used to neutralise it, can become trapped in the voids and either later come into contact with the wearer's skin or contaminate any resulting recycled metal.

Recycling Notes:

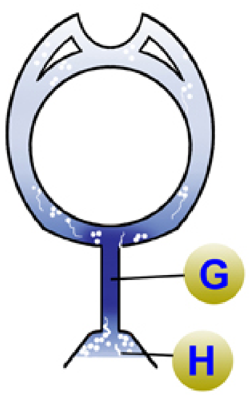
It is important to thoroughly clean palladium that is planned for in-house recycling. Use of high pressure water and bead/sand blasting is commonly used but if the latter is used, this process must be followed by use of an ultrasonic cleaner to remove the blast media residue. Trees should be bead/sand blasted until all evidence of investment has disappeared, and then thoroughly water blasted or blown with compressed air to ensure there is no residual blast media.

The heads, and any areas that appear as though they could trap media from the blaster, should be cut off and placed in a separate container. The above cleaning process should be repeated before melting them in a crucible (ideally in an induction furnace) with argon cover. Trapped investment/sand will rise to the top of the melt, and when it solidifies the button may have a crater like surface appearance in areas. This is not a concern, and the button can then be placed in hydrofluoric acid to remove any silica, etc. that will have floated to the top of the melt. To finish, neutralise with lime and thoroughly water blast.

The button can be cast into a special tree made up of rods that can be later cut for casting pieces, since better melt and cast results can be obtained using material that has been rolled down and cut into small shapes suited for quick, even melting properties.



In this case, correct techniques included placing a sufficiently thick sprue (E) at the ideal entry point for the ring and providing for a large button (F).



In this example, the diameter of the sprue is too small. The molten metal will therefore solidify first in the sprue, prior to the metal solidifying in the ring pattern. As a result, shrinkage and porosity will likely be trapped within the ring pattern. Shrinkage and trapped gasses appear as hot tears or cracks, and as pinpoint porosity or other forms of defects.

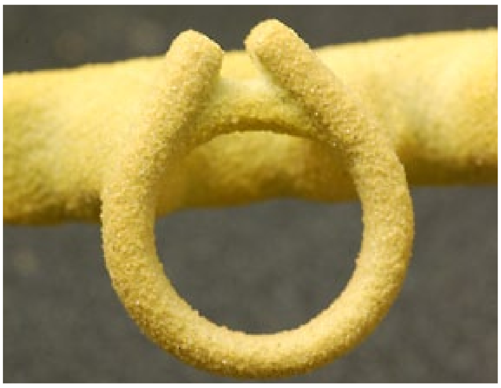
As mentioned earlier, molten palladium absorbs large amounts of hydrogen and oxygen, compared to other precious metals. With this in mind, sprueing is very important when preparing a tree for casting. To ensure successful, non-porous castings, some casting facilities use multiple sprues or vents. Multiple sprues allow the metal to be cast into flasks with cooler temperatures, ensuring good mould filling, and providing additional "avenues" for absorbed gases to be given off during solidification.

Sprues and the Investment Procedure

Shell casting palladium has been used with considerable success[5]. After the models are assembled on the tree, the tree is coated with a shell. When it is dry, investment is poured around the coated tree.

A technician is preparing injection wax models for casting in palladium by building up the sprues. Ideally, the diameter of the sprue should be slightly larger than the cross section of the largest portion of the item being cast, to aid in eliminating shrinkage porosity. Placement of the sprue should be directly on the heaviest section. For optimal results, each sprueing system should be tailored to the piece. Some palladium pieces have been cast more successfully using a multiple sprueing system.

The next step in the process is to build a tree (if casting multiple pieces). One at a time, pieces are strategically attached to the tree system. Because palladium is lighter by volume compared to platinum, more pieces can be attached without causing damage to the investment mould during the casting process. (The lower density reduces the force with which the metal enters the mould.)



With the tree built, the next step in shell casting is to apply a ceramic shell coating. This image shows the ceramic shell over a wax model that is attached to a tree for casting. Several layers of the shell material are built up through a dipping process prior to investing.

A phosphate-based investment is used for palladium and platinum casting, which is different from the gypsum-based investment used when casting gold and sterling. Investing is completed in a room with a highly controlled environment. The humidity is kept at an even level and the temperature of the deionised water used to mix the investment is monitored. After mixing, the investment is poured over the top of the shell-coated tree and into the flask. Invested flasks stand for three hours prior to being placed in the oven for the burnout process.

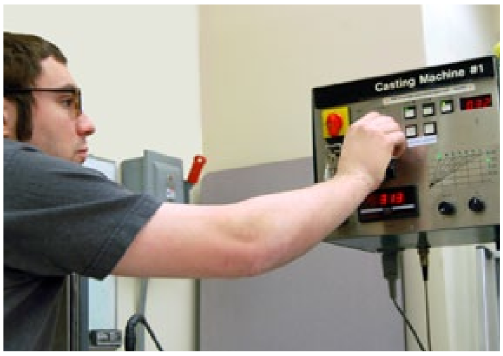
Casting

High frequency induction centrifugal casting machines are typically used for the palladium casting process. The machines have pre-programmed power controls for each alloy that is cast. Power is reduced as pre-programmed settings are reached to avoid overheating (which can cause brittleness and cracking in palladium).

High temperature ceramic crucibles are used for melting palladium. The crucibles are coated with zirconium oxide in order to prevent reactions between the molten palladium and the crucible, as well as to extend crucible life. In this image, a casting and processing technician vacuums investment that may have become loose or dislodged during the burnout process, prior to placing the flask in the cradle.

Tech Note: Palladium is best melted under an argon protected atmosphere to prevent gas absorption. Induction casting equipment with a sealed melt chamber is very beneficial.

The burnt out flask is then placed in the casting chamber and the process begins. The palladium alloy is melted by energy from the high frequency induction coil. An optical pyrometer reads the temperature of the 950 palladium, as the technician watches and makes fine adjustments to the melting process as needed. Once the metal has reached its desired pour temperature, it is ready to cast.



The best results are achieved when casting is synchronised. Both technicians audibly count down as one controls the machine and the other checks the pyrometer and opens the kiln. The following are general parameters for palladium casting alloys:

Melting range	1350 - 1380°C
Casting range	1548 - 1600°C
Flask range	675 - 730°C
Crucible	Carbon-free ceramic
Cover gas	Inert, preferably argon
Investment	Phosphate bonded

Tech Note: All casting alloys have slightly differing parameters. Casting machines, even of the same make, have varying temperature readouts. It is advisable to make notes on parameters and casting configurations and compare the outcome to enable repetition of successful casts.

This image shows a just-cast flask removed from the casting machine. It is placed on a fire brick to cool while additional flasks are cast. The flasks are completely cooled to room temperature. After cooling, the palladium trees are de-vested using water blast followed by treatment with hydrofluoric acid. It is believed that this method of cooling offers the best results for obtaining optimum hardness.

Summary

Palladium alloys are best cast using techniques somewhat similar to those used for platinum alloys due to their high melting point. Phosphate bonded investment (standard for platinum) must be used. Palladium is best melted under an argon protected atmosphere to prevent gas absorption. Induction casting equipment with a sealed melt chamber is very beneficial. The melting chamber should be placed under vacuum after loading the charge, and then back-filled with argon. If an open crucible is used, care must be taken to ensure complete cover with argon.

After casting, flasks are quenched and de-vested once the button has returned to room temperature. Final de-vesting requires techniques that are standard to platinum alloy de-vesting procedures.

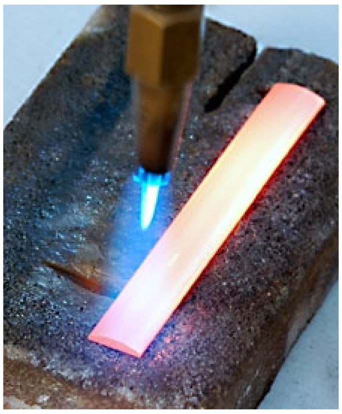
Torch Casting of Palladium

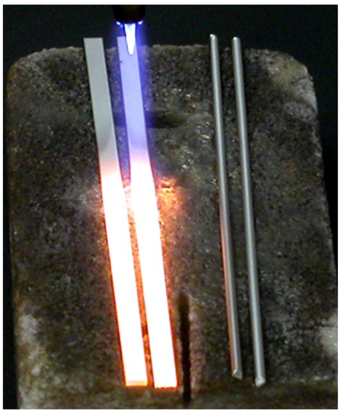
Palladium absorbs hydrogen and other gases, so using a torch for casting in an exposed environment leads to a high risk of gas absorption. Hydrogen is the lightest and most abundant element in the universe. Water, for example, consists of hydrogen and oxygen. Hydrogen is also found in most organic compounds, and in small amounts in the atmosphere as a gaseous mixture.

Excessive hydrogen absorption can cause palladium to become brittle and crack. The resulting jewellery castings will ultimately fail when tested under a stress, as shown in these images of a palladium torch cast ring.

Handworking

Annealing





To anneal palladium wires prior to shaping and forming, a high-heat soldering block is used with a natural gas or propane and oxygen torch. The flame should be adjusted to bring the metal up to annealing temperature quickly but moderately. The metal is evenly heated with the flame directed over the top. The torch is moved slowly back and forth covering the metal being annealed. The metal is brought to a bright orange colour, briefly held at this temperature, and then quenched in water or allowed to air cool. It is important to reach proper annealing temperatures and to hold them for at least 15 to 30 seconds. Temperatures for annealing range between 890 to 1098 °C (1650 to 2010 °F) depending upon whether the palladium is pure or alloyed.

Cold Working

Pure or alloyed, palladium is highly ductile and malleable, and can be readily cold worked to include rolling, forging, forming, spinning, drawing and other forms of metal manipulation. Palladium work hardens at about the same rate as higher carat yellow gold alloys, and must be annealed as this condition develops.

Cold Working Precautions

When cold working palladium with steel tools, clean the metal before annealing to remove surface traces of iron from the tools. This can be done mechanically with abrasives, or chemically in hot hydrochloric acid. After annealing, the metal can be quenched in water or air cooled. Oxidation can be removed by applying a neutral flame.

Contamination

Contamination of palladium can occur through a variety of careless practices. The problem arises when gold, silver or other metals become attached to palladium and when soldered, the lower melting point metals diffuse into and become permanently embedded in the palladium. Since most bench jewellers process multiple metals at their workstation, metal transfer can occur if the bench is not cleaned prior to a palladium project. A dedicated bench is not essential for palladium jewellery making but good cleaning habits are. The workspace must be clean and free of debris when handling palladium.

Essential for palladium is the use of dedicated files, grinding and sanding materials, polishing wheels and storage. This practice keeps dissimilar metals away from palladium, minimising the potential for contamination. It also increases your return when abrasive debris, filings and scrap are submitted for refining.

PROJECT:
Hand Fabricating Palladium Earrings

Design by Lainie Mann[1]

Forging, Shaping and Forming

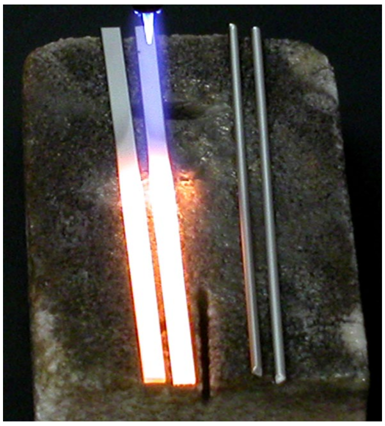
The hand fabrication project that follows serves to illustrate the desirable forging, shaping and forming capabilities of palladium.

This project provides an example for procedures used to hand fabricate palladium earrings. Palladium wire materials used in this project include:

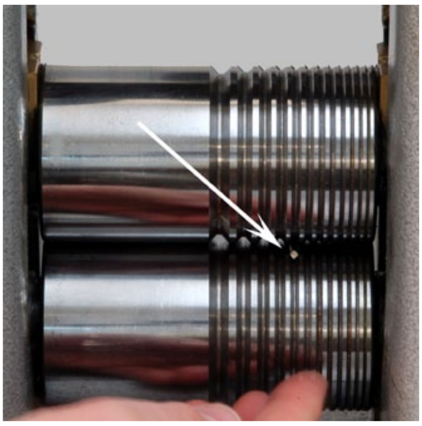
- 3x1 rectangular wire
- 14 gauge round wire
- 18 gauge round wire
- 24 gauge sheet
- Easy, medium and hard palladium solder

These custom designed earrings feature cultured 'Mabe' pearls and pink sapphires set into hand formed and fabricated palladium.

Wire pieces were cut to the circumference of the 'Mabe' pearls for the bezels. After cleaning thoroughly, they were placed on a high-heat soldering block for annealing. A vented torch tip was selected and the flame adjusted for annealing. The wires were then evenly heated with the flame directed over the top, and the torch moving slowly back and forth along the length of the wires. The pieces were brought to a bright orange colour, briefly held at temperature, and then allowed to air cool.



Tech Note: Over-annealing can cause excessive grain growth ultimately affecting forming and finishing operations. If the palladium wire is pre-polished, the annealing process will cause it to lose its lustre, turning it to a dull white. It is important to remove oxidation that may have formed on the surface of palladium prior to doing further work after annealing. A suitable working surface is easily restored by using light abrasives or re-polishing. Submerging palladium in standard pickling solution has no deoxidising or brightening affect.



After annealing, the wires were sized for this project using a rolling mill. Several reductions are possible due to palladium's ductility.

Using forming pliers, the bezel wires were shaped around the circumference of the 'Mabe' pearls.

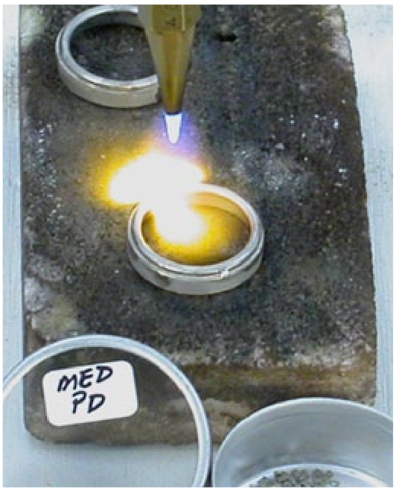
The bezels were prepared for soldering by forming and flush-fitting the two flat ends. The individual bezel wires were placed on the soldering block with the joint facing upward. A small piece of palladium hard solder was placed directly over the joint **(see the palladium soldering table on page 33 for palladium solder melt and flow temperatures)**.

Then, a hot oxidising flame was used to directly pre-heat and solder the joint. This is necessary due to the low thermal conductivity of palladium. No flux, fire coating solution or other materials were used in the soldering process. Each of the bezels and lower bezel support wires were soldered in the same manner.

Tech Note: Use Eye Protection - When annealing or soldering palladium, view your work through rated welding lenses. In this example, a number five rated welding lens is hand-held between the item being soldered and the technician's eyes. Some suppliers offer welding glasses with protective lenses and visors with magnification and rated lenses.

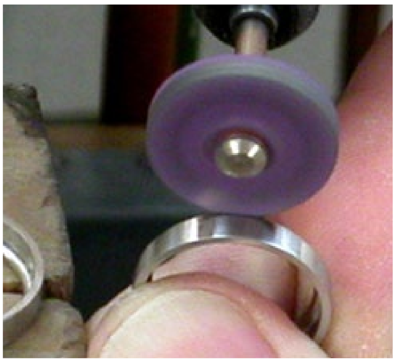
All the bezel wire components were rounded and trued. The 14 gauge round wire was then fitted to the base of each rectangular wire, forming a seat for the 'Mabe' pearl. In preparation, a 45° angle was ground on the inner edge of the rectangular bezel wire by using abrasive bands.

The pieces were then pre-finished using three grits of abrasive bands – 400, 1200 and 3000 – and then washed in the ultrasonic unit and dried. The rectangular bezel wires were placed face down on a high temperature soldering block. The 14 gauge round wires were positioned into the angled rim. Four small pieces of medium palladium solder (or equivalent) were placed equally around the joint.



The pieces were heated from the top in a circular motion and the solder flowed completely around the connection.

Soldering creates a dull white finish on the surface of pieces. It is simple to remove by using fine abrasives. Here, a 1200 grit abrasive sanding stick is used.

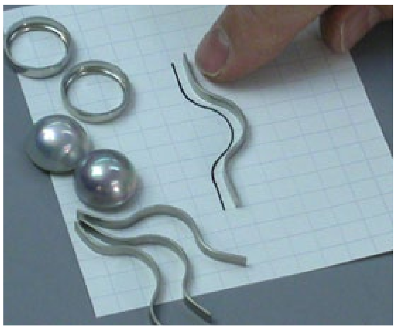


Another product well suited for pre-finishing this alloy is a ceramic impregnated abrasive wheel. They are available in 6 different colour coded grits ranging from 120 to 1500.

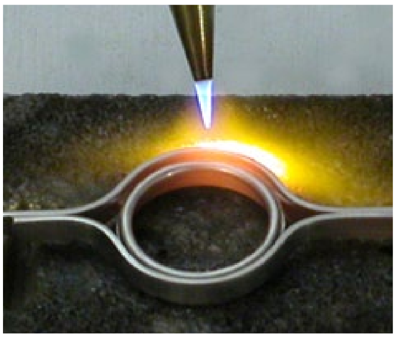
Tech Note: Using a progressive, multiple-step abrasive process with palladium helps to produce the finest finish.

The wires for each side of the bezel assemblies were annealed then hand formed. A ring mandrel provided a suitable forming tool.

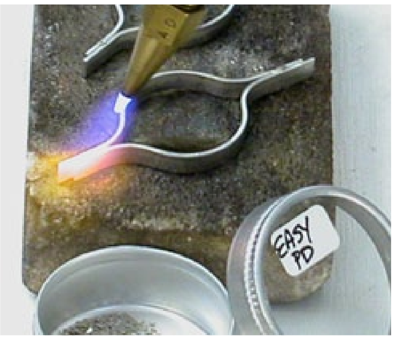
After soldering, the pieces were pre-finished on the top and bottom using a sanding board. This board has 320 grit abrasive paper adhered to it.



To ensure consistent forming, a guide was drawn on graph paper. Each piece was confirmed identical in size and shape.



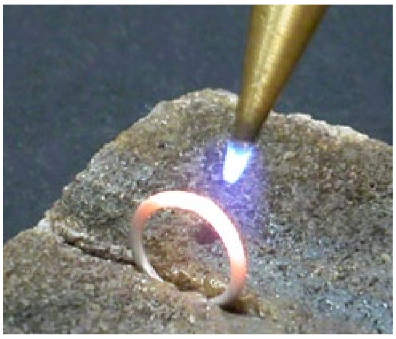
The bezels were fitted into the frames and placed face down on the high temperature soldering block. Small pieces of easy palladium solder (or equivalent) were placed along the solder seam on each side of the bezel. The pieces were heated along the top and side and soldered.



The wires were formed and pre-finished for soldering. The bare wires were placed on the platinum soldering block and small pieces of easy flowing solder were placed along the top portion at the joint. The area to be joined was saturated with heat from a pinpoint flame and then soldered.

To make the small domed shapes for the tops of the earrings, small discs were cut from 24 gauge sheet. Next, they were formed in a dapping block using dapping punches. To get the desired shape, three progressively sized punches were used to form the disc in 5 progressively sized cups in the block. The final shaping form is indicated by the red arrow.

The bezel wire for the pink sapphires was created by rolling flat a piece of 14 gauge palladium round wire. The resulting thickness was 0.75 millimetres. After rolling, the wire was annealed and cut to length. The bezel wires were formed using round/flat forming pliers, then soldered.



18 gauge round wire was formed to create a support at the base of each dome and soldered using hard palladium solder (or equivalent). A slit cut in the high-heat soldering block supported the wire for soldering. This block has various carved indentations to support or hold a variety of parts for soldering – allowing for hands-free soldering sequences.

> **Tech Note:** If tweezers or solder pokers are used, they must be made of tungsten carbide to avoid metal transfer contamination.

After the wire ring was soldered and trued, a 45° taper was flat sanded around its circumference (indicated by the red arrow). This flat angle allows for greater metal-to-metal contact with the inside of the dome. They were soldered together using easy palladium solder.

> **Tech Note:** It is important to have metal-to-metal contact for solder joints. Palladium solder does not bridge gaps or irregularly fitting joints

The dome assembly was filed and shaped on one side to accommodate the bezel. The bezel was soldered on with easy palladium solder. A crossbar to support the earring post was then soldered in place. To complete the top component an earring post was soldered securely to the cross bar.

Holes were marked and drilled in the top portion of each earring unit to allow for free movement on the jump ring. The pieces were pre-finished, polished and set. The earring components were assembled and the jump rings were pulse-arc-welded to secure the assembly.
The polishing was quick and efficiently accomplished because the work was pre-finished as it was assembled. No rhodium plating was required because palladium alloys are white and bright.

Cutting and Filing

This file has a build-up of palladium particles and needs cleaning. If not cleaned, the larger particles could damage the surface of the piece being filed.
Use a standard file cleaner to remove built up debris.
To minimise build-up and to increase the life of the file, apply a thin coating of oil of wintergreen on the file surface and use less force when filing.

A jeweller's saw with standard blades (2/0, 4/0 and 8/0) is used for hand-sawing palladium. Use beeswax to lubricate the saw blades.

Hand Engraving

Design by Novell[11]

While hand engraving is an art unto itself, graver work in some form is used at every level in jewellery making, including:

- Preparation, grain setting, cleaning and bright cutting of pavé, and threadwork.
- Claw setting (leveling seats, adjusting claws for uneven pavilions, shaping claws, cleaning).
- Flush, channel and bezel setting.
- Removing metal flashing after burring.
- Adding definition or cleaning after repair work.
- Cleaning castings.

The natural beauty of this palladium ring is enhanced with hand engraving of initials done in relief.

This palladium ring was cast[5] with a heavy sprue at the base of the ring shank. The finished rough casting after the sprue was removed weighed 13.64 grams. The outside surfaces of the signet ring after finishing are dead flat and have high polish with crisp edges. To prepare the ring for engraving, the ring was polished using a flat lap and platinum Tripoli. Then it was cleaned and another flat lap with white Hyfin was used. For the last step in the polishing process, a stitched muslin mop was used with 8000 grit Platinum white polishing compound – a process which also softened the edges.

A relief engraver[6], designed a layout of the initials to fit the top of the ring, and then transferred the design onto it. Next he isolated the letters using a square graver. In this image, he begins the removal of metal between the lettering by making a set of parallel cuts in one direction and then crossing those with another set of parallel cuts in the opposing direction. He will later finish the metal removal and smooth the recessed area with a narrow flat bottom graver. When completed, the letters will be raised, and the recessed background will have a fine stipple finish.

The engraver completed the relief engraving and applied the stipple to the deeply recessed portion using a pointed tungsten carbide tip mounted in his graver.

After the engraving was completed, the top was re-finished with abrasive lapping film and lightly re-polished.

Engraver comments: "Engraving palladium was similar to engraving platinum. One notable difference was that the palladium flaked away and did not clog up my graver tips in the way platinum engraving does. Even though this was a cast ring, the metal was uniform and smooth, making metal removal more consistent."

Soldering and Welding

Eye Protection

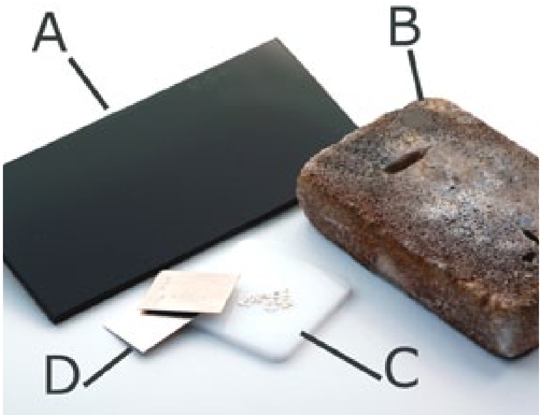
The temperatures required to melt and flow some palladium solders exceed 1250° C. When casting palladium alloys, the melting temperatures range between 1350°-1380° C. The emanating white light at these temperatures is intense and hazardous to the unprotected eye. Even short exposures are certain to leave an after-image on the retina that will persist for several minutes and distort both positioning and colour judgement. Longer exposures can cause permanent damage to the retina.

Eye protection is mandatory for soldering, welding and casting, and requires a filter. Filters are known as welding lenses and they shield the eye from harmful white light. These lenses are available in a variety of ratings. The lowest rating recommended for soldering is a No. 5 welding lens. A No. 5 lens allows suitable protection and visibility for the placement of parts during short soldering operations, although a No. 7 lens is better for prolonged periods of soldering. A No. 10 lens is recommended for casting or other intense palladium melting and handling situations.

The No. 5, 7 and 10 rated lenses are available as lens plates, goggles and flip-up type head mounted eyewear. The No. 5 rated lens is also available in safety glasses. Individual lenses in all ratings are available and jewellers may find these most beneficial because they can be clamped to magnifiers or other optic enhancers.

Joining Overview

Joining palladium requires mechanical rivets, soldering or a form of welding. When soldering palladium using palladium or platinum solder, prolonged exposure to intense soldering heat can lead to brittleness of the alloy. Here are a few examples for palladium soldering and welding.



Torch Soldering and Service Work

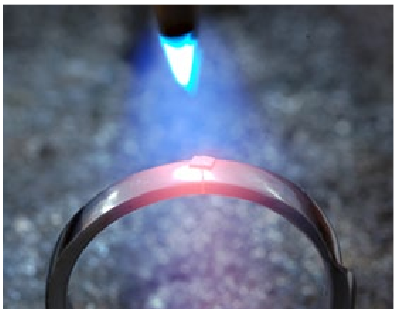
Essential tools for torch soldering of palladium require:
Eye protection (A)
A high heat soldering block (B)
Palladium (or platinum) solder (C & D)

Palladium	Melting °C	Melting °F	Pt solder alternative (Melting °C)
Hard	1,295	2,365	1,300
Medium	1,210	2,210	1,100/1,200
Easy	1,095	2,005	1,000

Palladium solder is used for soldering palladium alloys and is available from a variety of suppliers. It is provided in 'hard', 'medium' and 'easy'. The above table shows what the general flow temperatures should be.

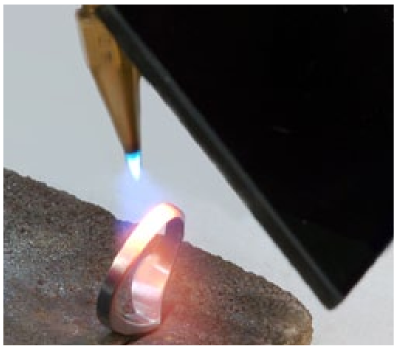
Higher melting point platinum solders (1,400 and up) are made with gold, palladium and platinum. When using higher melting point platinum solders in conjunction with palladium, there is a greater risk of melting the palladium.

When using higher melting point solders, palladium will take on a surface oxidation that is blue-violet.

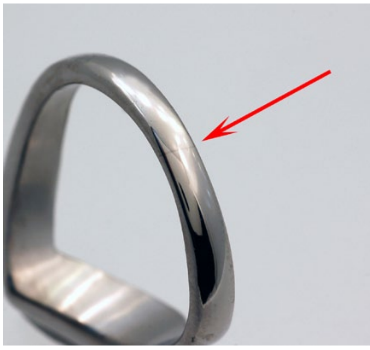


When soldering palladium, do not use non-ceramic firestain solutions or flux. The joint must be completely flush with no gaps or irregularities. Palladium solder will not fill gaps.

To remove the surface oxidation, use a neutral flame (equal parts of gas and oxygen) and in a few seconds, the oxidation is no longer evident. After the oxidation was removed on this ring, it returned to its original polished lustre.



Use No. 5 or darker welding lens for eye protection. Palladium loses its polished lustre during the soldering process, in much the same way as gold. However, the finish is easily restored through minor re-polishing.



After re-polishing the shank, you may notice a dark visible line – the solder joint. This is an extreme close-up which makes the line more apparent - it is less noticeable to the unaided eye. To remove traces of the joint, burnish the seam and re-polish.

Type of Solder	Flow °C	Flow °F
Platinum Solder		
Hard	1,295°	2,365°
Medium	1,210°	2,210°
Easy	1,095°	2,005°
Platinum Solder		
1,300	1,300°	2,372°
1,200	1,200°	2,192°
1,100	1,100°	2,012°
White Gold Solder		
20ct White Gold Hard	880°	1,615°
18ct Palladium White Gold Hard	1,005°	1,840°

Solders

Lower melting point solders for platinum are well suited for use in palladium soldering applications. Platinum solders ranging from 1,000 to 1,300 contain palladium and gold and are ideal.

Platinum solders contain gold and palladium. Due to the amount of gold in platinum solders, a colour matched solder joint when used with palladium is not obtainable. Regardless of the quality of the solder joint, a slightly darker visible line will be apparent.

For seamless looking solder joints at the ring shank or other obvious locations 20ct white gold welding solder is often used.

PROJECT:

Preventing Oxidation

Palladium oxidises when heated to soldering temperatures required for sizing and assembly of components. To prevent oxidation on finished jewellery set with gemstones, a ceramic flux coating spray can be used, such as Firescoff™, should be used. Firescoff™ is a ceramic-based firestain preventer, heat shield, and non-fluorinated flux combined in a liquid spray. After use, it is water soluble and safe to use.

As previously mentioned in this manual, normal non-ceramic, anti-firestain coatings are not useful for palladium, and oxidation forms on the surface regardless of them being used. To make matters worse, the oxidation is not easily removed by any methods other than mildly reheating with a neutral flame. When this is done, the surface requires re-polishing, which in the example below, would diminish the engraving.

The image above shows the example ring in two views. It was made using 950 palladium, ruthenium and gallium. After casting, finishing and setting, the ring needs sizing. The ring is:

- Decoratively hand engraved.
- Partially bezel set with a green tourmaline and side diamonds.

Standard soldering procedures cause oxidation and dulling of the palladium surface. This can include the surface area in places that are inaccessible for re-polishing, such as the area below the gemstone. Oxidation cannot be removed by standard pickling. In addition, re-polishing would diminish the hand engraved surface, make the back-holes dull below the gemstones (where they cannot be polished) and cause extra work.

To prepare the ring for soldering, place it in a third hand holding device. Clamp the tweezers portion over the centre stone. The tweezers will serve as a heat sink, dissipating potentially harmful heat away from the stone.

Gently heat the ring to about 200 to 250° Fahrenheit (90 to 120° Celsius). Next spray it with Firescoff™ so it covers the entire ring, including in the back-holes under the gemstones. The spray should turn white as it comes in contact with the pre-heated surface of the jewellery item.

Now evenly and gently re-heat and spray again. The metal and gemstones should be amply covered and no reflection off of either should be visible through the white coating. Firescoff™ is also a flux, so no other flux is required for the soldering procedure.

After soldering, allow the piece to return to room temperature. To remove the coating, use warm water and a soft brush and lightly scrub it, or submerge into an ultrasonic. No pickling solution is used. After removal, the ring is in its original brightly polished and finished condition, requiring only mild polishing with extra fine rouge for final brightening.

For more information visit - **www.firescoff.com.**

PROJECT:

Soldering 18ct Yellow Gold and Palladium Bands Together

This project highlights a technique for soldering two rings together continuously around the ring. Two bands were cast and pre-finished, one in 18ct yellow gold and the other in 950 palladium.

After pre-finishing, a 1.50 millimetre high speed round ball burr was used to create small depressions in the side of the yellow gold band. After creating evenly spaced depressions, the band was then filed to remove the flashing (the raised metal ridge) left around the depression from the burring process.

The yellow gold band was then fire-coated with a mixture of denatured alcohol and powdered boric acid. It was placed on the high-heat soldering block and pre-heated. Next, small paillons of 18ct easy white gold solder were placed over each depression. Using a torch and gold soldering methods, the solder was melted into each depression. The ring was then filed, pickled, and inspected to ensure that each depression was completely filled with solder.

The rings were evenly aligned and then a small amount of Firescoff™ was released between the two rings. The unit was preheated. After preheating and checking the alignment, the rings were then soldered together. The solder that was melted into each of the depressions was reactivated, and it ultimately provided a continuous seam of solder around the two rings.

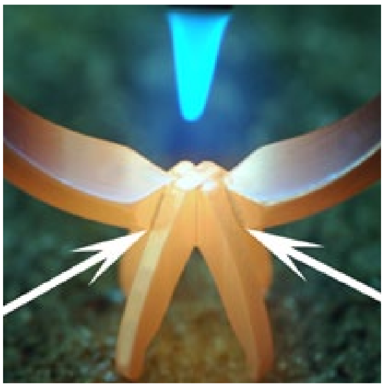
After soldering, the rings were finished and polished. The easy white gold solder provided a continuous seam of solder matching the palladium band.

PROJECT:
Assembly of Palladium Stock Findings

These parts are palladium die-struck shanks and settings for 1 Carat gemstones. The shanks are size N. This sequence will highlight the fitting, assembly and soldering of these solitaire rings. The parts precisely fit as supplied, and little or no alteration is required.

Easy solder will be used to complete this assembly. The tension of the shank is all that is holding the assembly together. The ring has been placed with the claws facing down on the high-heat soldering block in preparation for soldering. No flux or fire coat solution is used for palladium soldering.

Tech Note: The claws are placed downward to help protect them from becoming overheated during the soldering process. (The soldering block serves to dissipate the heat.)



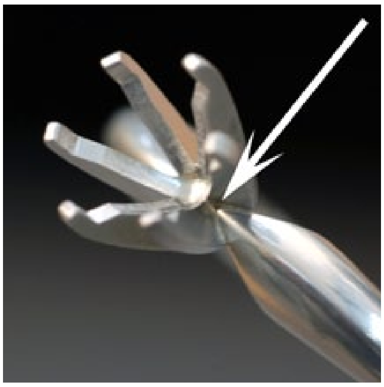
This image shows the soldering process being conducted through a No. 5 welding lens. A torch tip with no vents and an opening of about 1.2 millimetres is used to heat the joint. The torch is positioned so the hottest part of the oxidising flame (the area about a ¼ inch beyond the blue cone) directly heats the joints. The torch is moved slowly from side to side. Because of the low thermal conductivity of palladium, the heat is concentrated in this specific area. The ring is heated and the solder flows down each side, at which point the torch is immediately pulled away to avoid overheating, porosity or melting. The white arrows indicate the small amount of excess solder on each side of the junction of the setting and shank.

The ring was inspected after soldering. Notice that the palladium has lost its polished lustre in the area where it was heated. There is no surface discolouration around this joint because lower temperature easy-flowing solder was used.

Tech Note: : Inspect solder joints after the piece has cooled. Be sure that solder has filled the area from the base of the setting (at the finger hole) to the top on both sides.

This image shows a loss of lustre at the solder joint. Notice how the lustre of the palladium was not diminished on the lower portion of the ring shank, which is the metal furthest away from the heat and solder joint.

The same procedure was used when soldering this palladium six-claw setting and shank. Again, there was good metal-to-metal contact between each joint, and a paillons of easy solder was placed on each side. When heating, it is not necessary to direct the torch heat beyond the area indicated by the white lines on this image.



After the soldering was completed, the joint was inspected. The solder has flowed smoothly and evenly between the setting and the shank – indicated by the arrow.

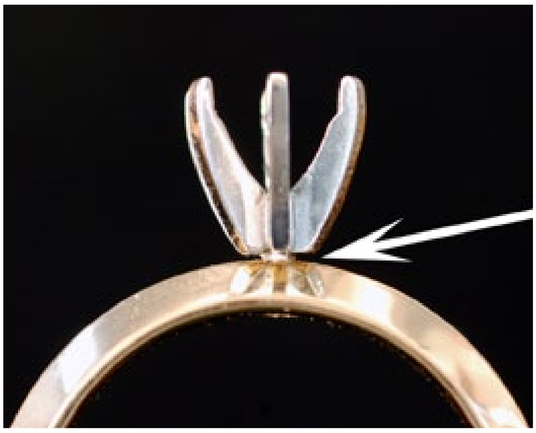
Ring Sizing Overview for a Heavy Palladium Men's Ring

Preparation procedures for sizing palladium rings are accomplished much like those for gold or platinum rings. In this image, a heavy palladium men's ring is being sized up 1.5 sizes. A piece of square palladium wire was fitted and placed into the ring to expand its size. The joints between the sizing stock and the ring are flush and even. The ring was placed on a high temperature soldering block with the solder joints facing upward. Small paillons of 950 palladium hard solder were placed over each joint. A No. 5 rated welding lens was used to protect the eyes during the soldering process. With a large vented torch tip, the ring shank was directly and evenly heated from side to side.

Palladium has low thermal conductivity so the heat stays concentrated where the torch is directed. The solder reached its melt and flow point as the ring was heated and the soldering procedure completed.

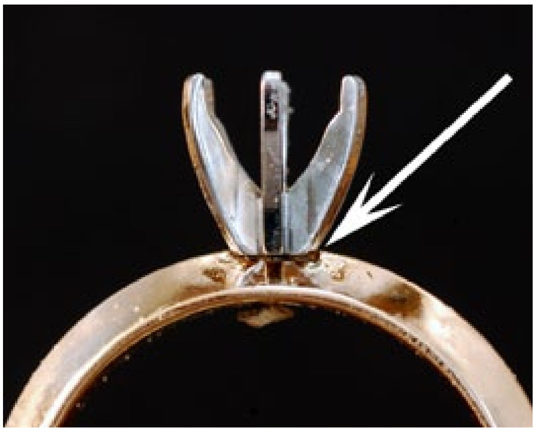
The surface discolouration was removed by using a neutral flame (equal parts of gas and oxygen). After allowing it to cool to room temperature without quenching, this ring was ready for pre-finishing and polishing.

Soldering Gold to Palladium



When soldering gold to palladium, firecoat the assembly as you would with gold. Standard gold soldering flux and easy flowing gold solders should be used.
In this example, the palladium setting was fitted into the gold shank. Because the peg is slightly tapered, the base of the setting and the shank do not meet. If soldered at this point, without adequate surface contact at the joint, the assembly will fail. The soldering process naturally anneals the peg. Without contact between the shank and the base of the setting, the claws will bend back and forth and eventually break while being worn. The setting and the gemstone in it will likely be lost.

Tech Note: ALWAYS have good contact between the base of a peg setting and the shank. This image shows INSUFFICIENT contact, and the assembly will fail during normal wear.



To correct an ill-fitting assembly, a small notch was filed at the top of the shank so the setting would have good metal-to-metal contact. The depth of the notch is only 0.1mm, yet it allows the setting to be securely soldered to a flush base. This image shows the assembly after fire coating, preheating and placement of solder. The 14ct white gold easy solder was adhered to the setting with flux.

Tech Note: White gold solder was used with this project. Yellow gold solder could have been used, but would have been difficult to remove from the palladium setting between the claws if it flowed upward. This would have left a puddle of yellow solder visible on the white metal. The choice of solder is based on the colour of the solder, placement and possible difficulty of removing excess solder after completing the process.

After preheating, a small amount of flux was placed around the base of the setting. The assembly was again heated with a vented torch tip from the finger hole. The heat was conducted upward, and the 14ct white easy solder flowed upward from the base of the peg, through the shank and around the base of the setting.

The assembly was air cooled and then pickled, rinsed and inspected. Notice the solder filled completely around the joint between the base of the setting and the shank.

When soldering gold to 950 palladium, it is important that cadmium-free solders are used. If not, the resulting joint is sure to fail under normal wear.

The bezels for the gemstones were all modified from 4-claw die stuck settings. The yellow were 14ct gold and the white were palladium settings. The claws were cut off and the tops filed flat.

Tech Note: Manufacturers are continuing to expand their lines of palladium findings as well as sheet and wire for fabrication. Explore the possibilities of modification or an innovative combination of palladium raw materials if the products you need now are unavailable.

PROJECT:
Fashioning the Perfect Contrast

Striking differences between elements such as colour, tone, texture, reflection, refraction, pattern and shape create contrast. Contrast not only enhances the qualities of each juxtaposed element, but can also create a pleasing balance in a design. This 950 palladium and 14ct yellow gold pendant contains cabochon tourmalines and a cultured freshwater pearl. It is an excellent example for showing the contrast of the whiteness of palladium against yellow gold.

The bezels for tourmaline cabochons for this pendant were fashioned from palladium wires. Next, three palladium wires were cut and formed into "U" shapes using a pattern. The wires were soldered to the bezel using medium palladium solder. After the wires were soldered to the bezel, they were shaped to curve downward. (This was easily done due to the high malleability of palladium.)

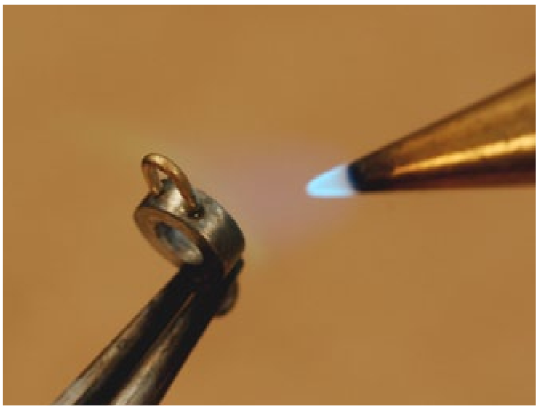
Tech Note: Pre-finish all parts throughout the assembly process. This practice enables a thorough smoothing of the roughest surfaces which may be difficult to access at later stages of progress (without marring other components). It also saves time in the final finishing and polishing of a piece.

Next, a yellow gold wire was shaped to form the lower gallery for the pendant. After the yellow gold wire was filed to receive the palladium assembly, the two were soldered together. When soldering palladium, good metal-to-metal contact is critical for secure joints.

Tech Note: Use palladium solder progressively, beginning with the one of the highest melting point. In this project, palladium hard solder was used to join the bezel wire ends, and then medium was used to connect the inner seat into the bezel.

The palladium wire which holds the lower assembly was formed, fit and soldered. This piece was held in place by tacking it with a tack-welder. After tacking, it was soldered using easy palladium solder.

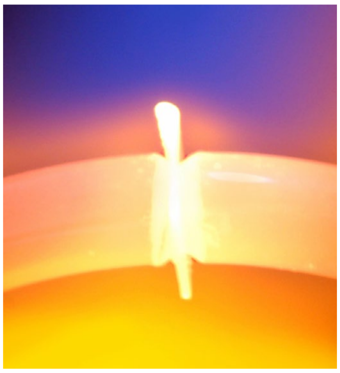
Tech Note: When soldering palladium to other alloys, consider each metal individually, employing the same techniques you would use in fabricating with that metal alone. For this project, 14ct easy white gold solder was used to connect the palladium assembly to the yellow gold. The heat from the torch was concentrated at the base of the yellow gold wire. Standard soldering flux was used. The yellow gold was fire coated with a mixture of denatured alcohol and powdered boric acid. There was no treatment necessary for the palladium and it did not oxidise during this or any step of the project.



The bezel for the round cabochon and the "U" shaped loops for the upper assembly and pearl drop were pre-finished and semi-polished. The wire loops were tacked on to the palladium bezel (use a PUK3 Professional) and then soldered. The palladium loop is soldered first, using easy palladium solder and the yellow gold loop is soldered next using 14ct easy white gold solder.

Tech Note: These loops were held in place by tack-welding. Without tack-welding it would have been necessary to hold them in place with tweezers or another holding device for soldering. For palladium soldering procedures, holding devices such as tweezers should have high-heat tungsten or palladium tips.

Torch Welding




Welding palladium with a torch is risky as this practice exposes molten metal to hydrogen absorption. This absorption may result in porosity upon solidification. When molten, palladium dissolves or absorbs large amounts of hydrogen and oxygen and becomes a "homogenous liquid" in the sense that the elemental oxygen is mixed with the liquid palladium on an atomic level. When the metal solidifies, the oxygen is released as a gas and wants to escape from the metal. However, the metal usually solidifies before all the gas escapes and the trapped oxygen is revealed as porosity throughout the joint.

For the best results when sizing a ring, use a standard butt joint and hard palladium solder. If hard palladium solder is not available, 1300 platinum solder will provide good results. Be sure to use the soldering techniques detailed in the soldering section on page 33.

Palladium Laser Welding

Equipment settings and technical procedures for laser welding 950 palladium products differ from those specified for products made from other precious metals.

Laser welding any precious metal causes the alloy to become molten, even if for just a millisecond. In this state, palladium most readily absorbs hydrogen and oxygen, and if careful procedures are not followed, the gases will be retained upon solidification, causing the joint to be brittle. Techniques used for laser welding of 950 palladium products require fine tuning on the part of the operator due to the variable factors in equipment, equipment settings and other laser welding parameters.

The 3 major applications for laser welding palladium are:

1 Filling porosity created during casting
2 Minor assembly
3 Ring sizing

The laser welding machine used in this example is a Rofin StarWeld Laser® machine with pulse forming capabilities. It is important to remember that laser welding equipment varies by manufacturer, so the settings listed in this reference are specific to the equipment being used.

Overall maintenance of equipment can also have an affect on the settings and final outcome.

1. Filling Cavities and Porosity

Cavities and porosity can appear with all jewellery alloys, including palladium whether cast, milled, machined or die struck stock products. To repair these irregularities with a laser, you may consider the suggestions that follow.
In the previous image the laser operator uses 0.5mm dead soft round palladium wire as the filler wire. The following procedures were used to obtain the best results for laser-filling voids.

- The equipment settings were 250 Volts, 5 to 10 ms, 1.3HZ with a beam or focus of 5 to 15. (The variables ranged according to the width and depth of the void.)
- 99% pure argon was used.
- The cavity in the ring was hit with a few laser pulses to open and shape it.
- The tip of the wire was held in direct contact within the cavity, and a laser pulse melted palladium from the wire into the hole.
- Each cavity was overfilled with palladium and then filed flush with the surface of the ring.

Tech Note: When filling porosity with a laser, start by directing laser pulses directly into the hole. This will melt the base of the cavity, exposing fresh metal from which to build upon[7].

2. Minor Assembly

For assembly of palladium pieces, the most efficient manner is to tack the parts in position using a laser. This procedure is then followed by torch soldering to complete the process. In this example, the top portion of the earrings consists of three partial bezels and a jump ring. These pieces are tacked using laser technology for temporary joining. The pieces are then checked for proper alignment, and adjustments are made before the final assembly is torch soldered. The following procedures were used to obtain the best results for laser tacking prior to torch soldering and final assembly.

- The equipment settings were 250 Volts, 5 to 10ms, 1.3HZ with a beam or focus of 5 to 15. (The variables depend upon the size of the components being joined.)
- 99% pure argon was used.
- When tacking only, it is not necessary to use weld-filling wire.
- This procedure included pulse shaping.

Tech Note: According to the **Rofin website**, laser welding success with any alloy depends both on material properties such as temperature-dependent reflectivity, heat conductivity and viscosity, as well as specific laser parameters like pulse energy, spot diameter or temporal pulse intensity. Pulse shaping calls for a series of calculated settings used in progressive pulses. Each setting factors in both the duration of the pulse of energy and the total amount of energy used, for optimal control.

The pulse shaping technique can be used to avoid over-heating of the material, because the series begins with high laser intensity, and then incrementally reduces laser power, once the melting point has been reached. Pulse shaping can also reduce cracking in the metal which can occur during quick cooling of a weld, important for palladium alloys.

Pulse shaping for palladium alloys used for this research included six incremental steps.

Reference	X (Pulse Duration)	Y (Total Energy)
1	0	90%
2	20%	100%
3	40%	100%
4	50%	70%
5	80%	30%
6	100%	20%

3. Ring Sizing

When heat sensitive gemstones are part of the design, it is not always safe to solder palladium rings with a torch

for sizing purposes. Here are the steps for sizing this palladium ring with a laser.

Here are the steps for sizing this palladium ring with a laser.

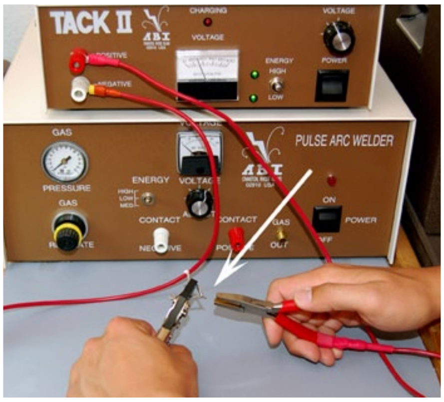
- The equipment settings were 290 volts, 10ms, 1.3HZ with a beam or focus of 15.
- 99% pure argon was dispensed about 1cm away from ring.
- An angled groove was filed around each side of the joint.
- A small piece of the same palladium alloy as the ring was rolled out to 0.1mm and wedged into the joint.
- Pulse shaping techniques were used.
- The ring was polished and inspected under

  10x magnification. There were no visible cracks, porosity or other irregularities found.

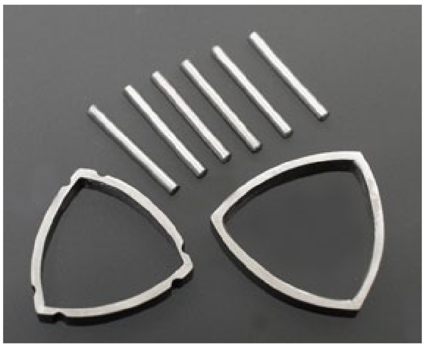
Tack Welding

Tack-welding provides a useful way to position palladium parts prior to soldering. Tack-welding is a temporary joint. Shown in this image is an ABI Tack II unit for tack- and

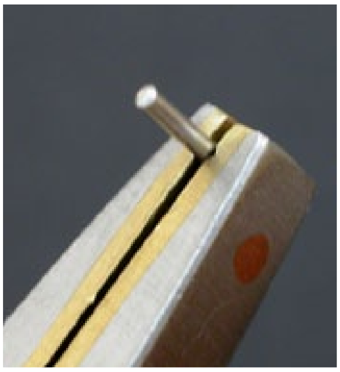
Tech Note: The MS setting was put on 'High' to spread the energy throughout the metal, discouraging excessive heat in a concentrated area, which would make the metal brittle. Use of the pulse shaping technique caused the metal to appear brighter and it was more fluid. During the process, the ring became hot to hold.



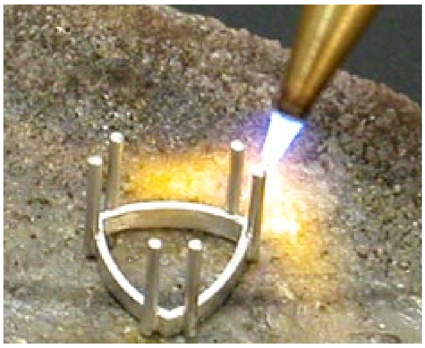
fusion-welding. It is stacked above the ABI Pulse-arc-Welding unit. However any Micro-TIG Welding unit such as the PUK-Welder could also be used to achieve a similar result.



Tack-welding will be used to pre-position parts for a multiple claw double gallery wire setting in palladium. The gallery wires were formed with the lower gallery wire slightly smaller in size (to achieve a tapered setting). The lower gallery wire is notched where the claws will be tacked in place.



The claw wires were tacked lightly in place. A pliers lead was used to hold one part of the assembly, and another pliers lead was used to hold the other part. The machine settings were adjusted, and with one laser pulse the individual claws were tacked in place. Tacking allows for claws to be easily removed if misaligned, and then re-tacked.

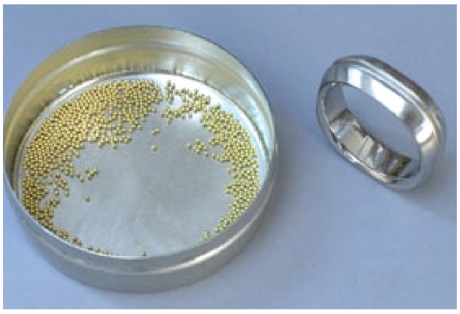


Once all of the claws are properly positioned, the unit is ready for soldering. Solder is placed at each of the joints (no flux or firecoating needed) and then soldered using easy palladium solder.

Fusion-Welding

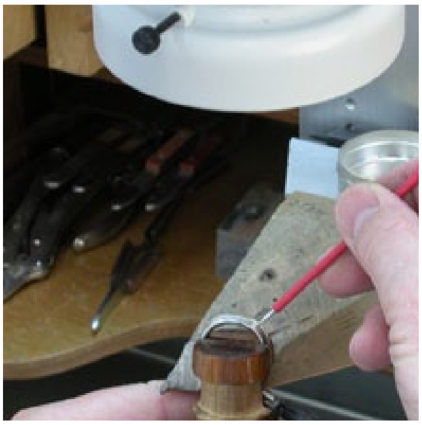
Fusion-welding provides a useful way to permanently weld parts. In this example, 22ct yellow gold beads were permanently attached to this palladium wedding ring.

The palladium wedding band was pre-finished. The groove where the beads will be fusion-welded in place was polished.

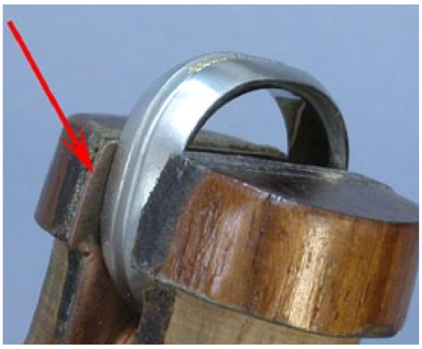


The beads are 22ct, spherical, and uniformly sized.

The leads for fusion-welding were attached to the ABI Tack II and the settings were established.



Next, a small bead was picked up using the vacuum attachment lead with a sterling silver tip. The bead was then placed in its position and a single pulse of energy was released via the foot control to permanently attach it to the palladium band.



The ring was held in a ring clamp which has a copper plate (red arrow) attached to the welding unit.

The fusion welding was completed and the ring finished. The size, number of beads, and their placement was determined in the design beforehand.

Finishing

Pre-finishing Techniques

Pre-finishing is the reduction of coarse surfaces and the removal of undesirable sharp edges and imperfections on a piece, in preparation for polishing and buffing. Palladium is most efficiently polished when pre-finishing is done to very fine and smooth levels.

Casting palladium requires high-heat casting materials and the equipment used is the same as for casting platinum. The surfaces of palladium castings are characteristically coarser than those of gold, due to the different nature of the materials used in each process.

The process of preparing palladium for polishing and buffing can be made more efficient by using clean and well organised materials and work areas. Use clean, new abrasive materials whenever possible. Properly store materials used for pre-finishing.

Here are a few tips:

- Place progressive abrasives in individual plastic bags, containers or bench top sorting trays, and label according to grit.
- Keep files clean and free of build-up and store them so their surfaces do not come in contact with one another.
- Organise materials and group them by procedure. For example, store abrasive tools separately from polishing materials.
- Label abrasive materials you plan to re-use. Place in a sealed bag or container and mark with the the alloy for which it was previously used.

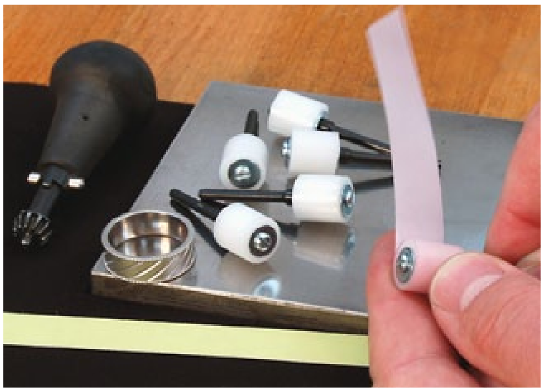
For palladium castings, number 4 files are suitable to begin the smoothing process, progressing to number 6 cut files. This progressive filing makes it easier to achieve the finest polish for palladium.

PROJECT:
Pre-finishing a Patterned Wedding Band

Here's an overview of a few palladium pre-finishing applications:

This palladium wedding band above was produced using CAD/CAM design and model making technology and features high millegrained edges, textured diagonal grooves and a highly polished central flat surface. The ring was finished from a rough casting using a progressive abrasive system and limited standard polishing techniques.

The model for this ring was milled in carving wax and then cast in palladium. The sprues made in preparation for the casting process were attached to the inside of the ring shank, and ground away after separating them from the model. The granular surface seen on this rough casting is the result of the investment moulding and casting process.



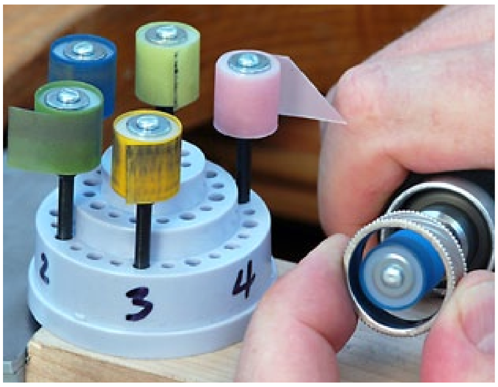
To begin the process of pre-finishing, sanding drums were made using a drum mandrel with an overlay of abrasive lapping film. The lapping film is supplied in adhesive backed sheets. The drum portion of the mandrel measures 13mm in length by 12.5mm, in diameter and is made of hard Teflon®-like material. The shanks are available in two sizes, $\frac{1}{8}$ or $\frac{1}{32}$ inches in diameter. To make the drums, the lapping film was cut into 13mm strips and the backing removed. The abrasive film was simply wrapped around the drum of the mandrel as shown.

> **Tech Note:** abrasive lapping film can be used wet or dry. It features micro-grain particles of high grade aluminium oxide that is applied through a special coating process. The result is a fine, consistently distributed abrasive surface that leaves an almost burnished look on the metal, rather than the deep lines and indentations characteristic of typical abrasive papers

There are six grits of abrasives in this progressive system. They range from 320 to 8000 grit. The blue 320 grit shown in this image has removed the majority of grinding marks left by the coarse removal of the casting sprues. The abrasive technique requires light pressure between the ring shank and the drum mandrel while using a rounding, back-and-forth motion.

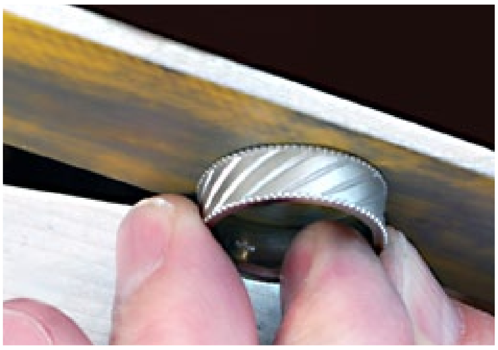
Tech Note: When using a progressive abrasive technique, the best results are achieved by using all grits in the system. Doing so will not only shorten the time required to complete the overall process, but will prolong the life of the abrasive film.

After the blue 320 grit, the green 400 grit was used as the second step. Next, the yellow 650 grit was used leaving an even, semi-lustrous surface inside the shank.



A 1200 grit drum was used in this step. The abrasive drums are stored in a bur holder making them easily accessible. The holder is numbered correspondingly with the grits, helping to keep them in progressive order.

Step 5 and 6 (pink 4000 and lime green 8000 grits) were completed, leaving the inside of the shank smooth, with a high lustre. No polishing compound was used prior to this final pre-finishing step, and only the use of rouge will be required to complete the process.



The same progressive procedure will be used for the sides of the band (around the finger hole). The abrasive film was cut to fit a standard size sanding stick, the backing removed and the film applied to the stick.

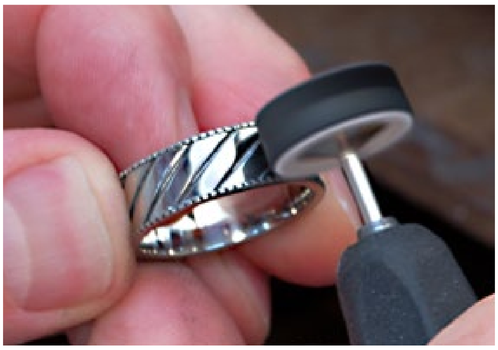
Tech Note: Use cross-sanding techniques – hold the ring so the sanding can be accomplished in one direction and then turn the ring and sand so that your strokes are at 90° to the previous direction. Cross-sanding ensures flatter, more consistent surfaces.

7. The outer surface of the band was next to be filed. This part of the process began with burnish filing. A fine cut file (a No. 6 barrette in this case) was used with a back-and-forth motion.

Tech Note: Usually, filing is done only in the forward direction to cut and remove metal; but by dragging the file backwards, the metal is burnished making it smoother.

The width of the ring between the raised millegrain borders is 8mm. A sanding stick was custom cut to an 8mm width and abrasive film was applied.

The pink (4000 grit) begins to yield a flat, smooth surface. There would be one more step prior to polishing.



The pre-finishing was completed with the six-step abrasive film and the process has taken the palladium surface from granular to a flat lustre. The band was then polished with Hyfin, followed by 8000 grit white rouge. Ring polishing mops were used for polishing the inside the finger hole, a medium felt lap was used for the sides and a medium/ hard felt lap was used for the top flat surface between the raised millegrain edges. A loose stitched mop was used to give the palladium its final, bright white lustre.

PROJECT:
Pre-finishing Necklace Parts

The three-piece grouping of cast palladium will become a necklace while the two mirror-image pieces are marked for earrings to compliment.

Notice the surface finish of the rough palladium cast piece. Even though the wax was perfectly smooth, the surface of the casting has a granular appearance. First, the remaining sprues were filed away with a number four cut file.

The bottoms are dead flat and sanded using the benchtop polishing motor with a flat disc and 3M Diamond Polishing Cloth Discs®. These discs are supplied in

several abrasive grits and three steps were used to refine the finish and bring the bottom surfaces to dead flat.

To smooth the granular surface of the cast palladium pieces, coarse rubberised abrasives were used.
For the rubberised abrasive process, a bench-mounted dust collector was used the capture the debris.

Tech Note: A dust collection unit not only guards the health and comfort of the operator but also improves his viewing perspective of a project by pulling the debris away from the work area. At the same time, it serves as an efficient recovery system for precious metals.

To further refine the curved surfaces of the individual pieces, radial bristle discs were used mounted on the bench lathe. The individual pieces are now ready for polishing.

Tech Note: Radial bristle disc components are used in groups – threaded onto a hub by the user – to achieve various widths of polishing surface. For most projects, threading six individual disc components on one hub is sufficient. Fewer may be used for smaller objects. It is important to note that the burnishing of the metal is accomplished with only the very ends of the bristles. For best results and long life for the bristle discs, do not push or otherwise force parts deeper into the wheels for pre-finishing.

PROJECT:
Pre-finishing Two Rings

The two cast[5] rings used for this demonstration require a variety of pre-finishing and polishing methods.

Tech Note: Both rings have four substantial sprues attached to the inside portion of each ring shank.

Because the rings were substantially sprued for the casting process, a rotary burr and a number two cut file were used to remove the excess metal. After the remaining sprue metal was removed, the rings were rounded on a mandrel using a rawhide mallet. In the next step the inside shank areas were brought to a smoother surface. For the smaller ring, an abrasive band of 400 and 800 grit were used in the first phase of progressive finishing.

For the larger ring, a 120 grit abrasive band was used mounted in a small bench rotary machine. This method of reduction is faster than filing with a #2 cut file. The rings were again placed on a ring mandrel and rounded.

The next step was to further reduce the inside of the shank. This could be done with finer files, sanding abrasives or rubberised abrasive wheels. Here, abrasive lapping film was used to further refine the inside surface. The inside of the ring was reduced to a consistently flat, fine grade semi-polished surface. The last grit used was 1200.

Sanding sticks were used to smooth the outside surfaces of each ring. Grits were used progressively, ranging from 200 to 1200.

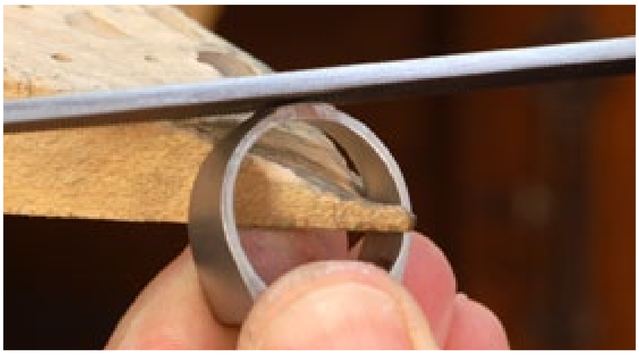
Abrasive strips were cut from abrasive lapping film for the purpose of thrumming (sanding or polishing in tight areas with strips or string embedded with polishing compound) between the upper and lower galleries of the smaller ring. Three progressively finer grits were used.

Small mounted rubberised abrasive points were used to refine recessed areas of the heavier ring. Three grits were again used ranging from 400 to 1000.

The outside shank of the larger ring is reduced using rubberised wheels which contain ceramic abrasives. Three progressive grits were used ranging from 400 to 1200. Sanding sticks and fine files would also work well to achieve the same finish. The rings were then processed in a magnetic finishing unit, which enabled finishing in the tightest areas of the rings.

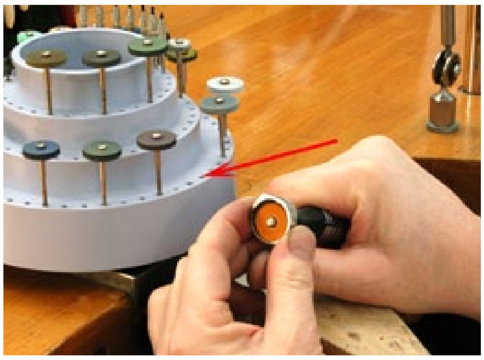
PROJECT:

Pre-finishing a Men's Ring



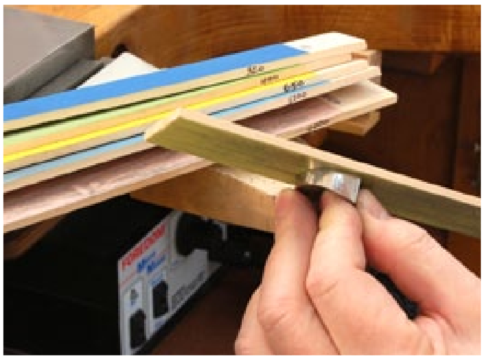
This palladium ring had a single oversized heavy inlet or sprue placed at the bottom of the ring.

A coarse number two cut flat file was used to remove the remainder of the sprue.



The inside of the ring was then made smoother using fine rubberised wheels containing a ceramic grit.

The ring was rounded on a steel ring mandrel with a rawhide mallet and then sanded on the inside using a series of progressive one inch abrasive grit bands mounted on a variable speed bench lathe.



The sides and top were sanded using abrasive lapping film attached to sanding sticks. Four grits were used in preparing the ring for polishing.

PROJECT:
Pre-finishing Inside a Solitaire Ring

This ring was small and smooth. After removing the sprues, the ring was rounded.

Four grits of rubberised wheels were used to smooth and semi-polish inside the ring shank prior to hallmarking.

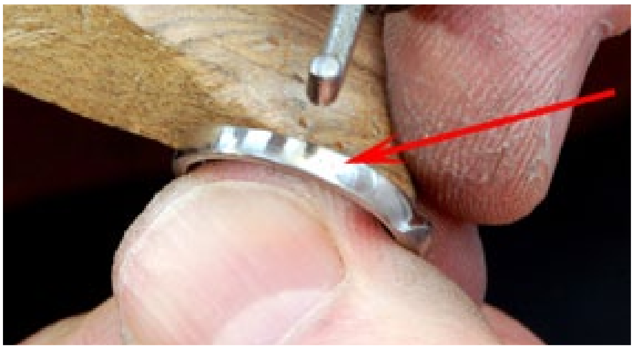
PROJECT:
Pre-finishing a Wide Flat Ladies' Tapered Ring

This wide, flat, tapered band has a flat to rounded surface. Polishing wheels are ideal for efficiently smoothing this transition of form. These wheels come in six grits, are quickly changed on the small motor and work much faster than hand filing and sanding. The last wheel used in preparation for polishing is 3000 grit. The wheels worked well on the top and side profiles of this ring as shown in the images.

PROJECT:
Burnishing Small Imperfections

After soldering the setting into this shank, porosity was revealed at the joint. A small tungsten carbide concentric burnisher was used to blend them.

A small, extra-fine rubberised diamond abrasive wheel was used to smooth the burnishing marks prior to polishing.



This burnisher was made from the shank of an old polishing brush (3/32 inch in diameter). The end is bent at a right angle to the shaft, to resemble the letter "L". Then the end is rounded. When mounted in a flexible shaft, the bent end "hammers" with each rotation, moving and compressing the surface metal to create larger flatter areas, diminishing the porosity.

Magnetic Finishing

Centrifugal magnetic finishing (tumbling) is an automated process which aids in the clean-up, burnishing and polishing of intricate and detailed parts. With media as small as 0.01mm in diameter and 0.25mm in length, these stainless steel pins are able to work in undercuts, recesses, slots and other tight areas.

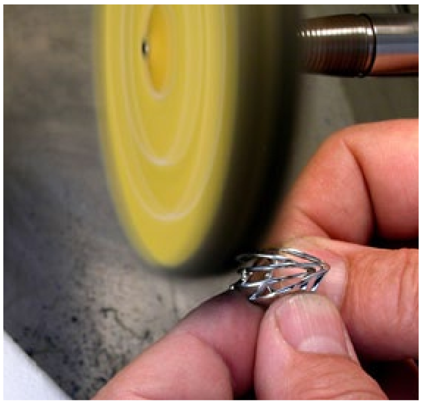
With palladium, the finishing cycle can be as short as twenty minutes. This alone assures fast turnaround time on parts when compared to other methods. It should be noted that on large, smooth or flat surfaces the finish will appear frosted and a slight buffing is recommended. Depending upon the alloy and the structure of the design, there may be slight percussion marks evident which are easily removed through rouge polishing. The image above shows the process in action on the left and the burnishing compound on the right.

These pendant pieces were placed in the tumbler after filing and pre-finishing. Water was added to the level indicated, and about twelve drops of burnishing compound were added to the barrel before starting the cycle.

Magnetic finishing has brightened this assembly leaving only minute percussion marks on the metal. They are easily removed in the polishing process. This image shows the results immediately after the magnetic finishing process and prior to polishing. The gemstones were placed in their bezels after tumbling.

Here is an image of another ring after magnetic finishing. The pins easily accessed the narrow space between the inner and outer shank surfaces. Notice the very faint percussion marks on the surface of the palladium. They were easily polished away using Hyfin.

Buffing and Polishing

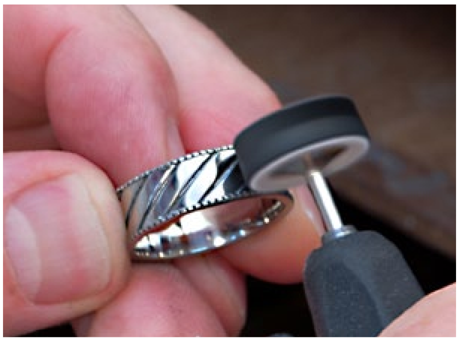


Polishing is the use of abrasive wheels and compounds to improve the general surface finish. *Buffing* produces the final high lustre finish. For palladium, assuming the pre-finishing is done to a fine, smooth level, both procedures require two steps to accomplish a commercially satisfactory, bright, white lustre that will not require rhodium plating.

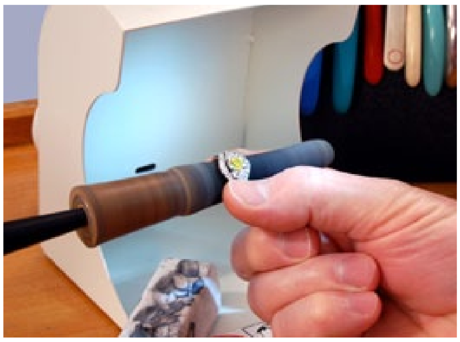
Polishing Techniques

For palladium items that are roughly pre-finished, (i.e. grits used for pre-finishing did not go above 600) and still retain tool marks, a two-step polishing process is used. For the first step, a stitched yellow buff is used with platinum Tripoli®. The best polishing compound for the second step with palladium is Hyfin and a stitched yellow buff. For items that are finely pre-finished, a one-step polishing process using Hyfin is all that is required.

Polishing brushes charged with platinum Tripoli®, and then with Hyfin work well in detailed and intricate areas. For polishing larger flat and or rounded surfaces, a standard yellow stitched buff is used with Tripoli® followed by Hyfin. It is essential to clean the piece between each pre-finishing and polishing step. For the best results, use palladium dedicated and grit specific pre-finishing materials and polishing wheels.



Lapping wheels charged with either platinum Tripoli® or Hyfin work well with palladium—depending upon the quality of the pre-finishing. Here a small, hard, felt wheel is used to polish a dead flat surface between raised millegrain edges.



With a finely pre-finished palladium ring, the next step is to use white Hyfin on a polishing stick. This step will brighten the colour and remove all undesirable abrasive marks.

For polishing in areas where it is necessary to maintain detailed curved surfaces, Robinson polishing brushes charged with platinum blue polishing compound work well. To apply the final finish, a loose stitched muslin mop charged with 8000 grit white rouge brings out the final colour and lustre.

Hyfin is ideal for palladium. For pieces that are finely pre-finished, this one compound used with a yellow stitch mop produces a high white lustre. For the finest lustre and colour, follow with 8000 grit white rouge used with a stitched or loose muslin mop.

PROJECT:
Polishing a Gold and Palladium Pendant

The polishing process for this two-tone pendant began with using the small bench top lathe and radial bristle discs. Radial bristle discs come in several colour-coded grits ranging from semi-coarse to ultra fine. Only the finer grits are used as this piece is already smooth and bright. No polishing compound is used with bristle discs, so the process is clean. Using a bench top motor saves a trip to the polishing machine, and requires less time than using a flexible shaft with smaller bristle discs for the same process. Since negligible debris is generated in this process, dust collection or a hood is not necessary.

Fine abrasive compound was used with a small treated yellow stitched mop. A bench top dust collection hood and vacuum was used to collect waste and to keep debris from the operator's face.

Small horsehair bristle brushes charged with the same abrasive compound were also used in the small tight areas. The combination of these two wheels and this compound prepared the two-tone piece for its final polish which was done with 8000 white rouge.

Since palladium will not tarnish or turn yellow with wear, rhodium plating on palladium jewellery is optional. It is not required for any reason other than colour preference, as rhodium plating is slightly whiter in tone than palladium.

Texturing and Other Finishes

Applying textures to palladium is no different than with other precious metals. The hardness of the individual palladium alloy will reflect how well the texture holds up during normal wear. Generally, moderately or heavily applied textures are best as these will tend to camouflage typically encountered stress marks during normal wear.

Novell Design Studio

This extruded, seamless and machined wedding band was designed by Novell Design Studio for palladium. The central honeycomb pattern is textured and raised over the highly polished edges of the band. This design will hold up well under everyday wear.

Novell Design Studio

This ring features a triple linear raised pattern with medium texture and a triple recessed polished finish. Recessing the polished finish provides a stunning contrast and will protect the polished areas during normal wear.

Jewellery by Venetti

This band features polished bevelled edges and a large flat surface with a medium stone or brush texture. This texture was applied by hand using a rotary motor and an abrasive wheel and will not show the stress of typical daily wear.

Mokume-gane by James Binnion, James Binnion Metal Arts

The mokume-gane wedding band is made by diffusion bonding palladium and silver under pressure and heat. Over the diffusion bonded pattern of the two alloys is a medium stipple finish, which helps form a contrast between the metal colours. Stippling is an excellent choice for a finish that will not yield to the stress of most daily activities when worn, and it is simple to reapply. The stippling on this ring was done using a magnetic finisher. When being finished in this way, pieces are tumbled along with stainless steel pins which provide the stippled appearance. A stippled finish can also be done by hand using a rotary motor with a hammer handpiece attached holding a sharply pointed tool. The reciprocation or pulsating action lightly "pounds" the surface. You can use a coarse, medium or fine point to achieve different stipple effects.

This ring features a deeply cut hand engraved pattern. This kind of deep engraving will hold up well during normal wear and can be refinished without losing the design.

Setting

General Overview

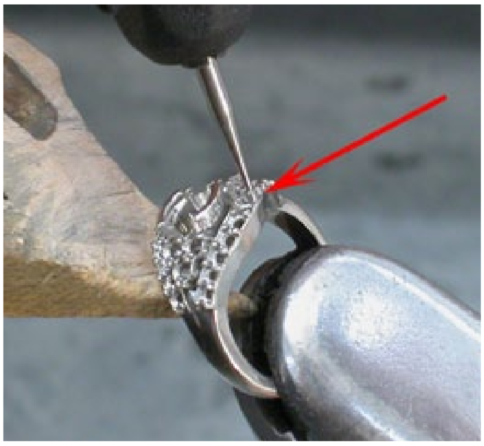
With the proper design, palladium's metallurgical properties are similar to platinum and ideal for gemstone setting. Both platinum and palladium have little or no memory as opposed to gold alloys, which often causes claws and channel walls to spring back after forming. Because of palladium's highly malleable and ductile properties, designs incorporating shorter and heavier claws will hold up better during normal wear, as opposed to thin claws with tall profiles and no gallery wire supports.

The burrs and tools required for setting in palladium are similar to those used for gold and platinum. However, due to palladium's inherent properties, thicker claws, grains, and setting edges are needed to ensure that the stones stay tightly in place, and that the setting keeps its shape under normal wear. When creating bearings in palladium, it is generally expected that about 35% to 45% of the claw or wall thickness is removed, as opposed to gold, where about 45% to 55% is removed. The added thickness of the grains, claws, and setting edges is not a hindrance for the setter, due to palladium's excellent malleability and ductility.

PROJECT:

Setting Round Brilliant Cut Gemstones in Claws and Partial Bezel

This ring was designed using CAD jewellery design software. The customer wanted the stones set closely together, with visible metal kept to a minimum. The 6mm centre stone is surrounded by round brilliant diamonds ranging from 1.75mm to 2.7mm. This ring is an excellent example of the gemstone setting and working characteristics of palladium. Alloy properties such as malleability and overall strength provide for secure setting.



In preparation for gemstone setting, this rough casting was pre-finished, then polished with grey platinum Tripoli® followed by Hyfin. The first gemstones to be set were the rows of diamonds on each side of the centre grouping. The small claws were shortened slightly by filing, then rounding using a cup burr of slightly larger diameter (arrow).

Tech Note: Prior to polishing, the pre-finishing process included tumbling the ring for 30 minutes in a magnetic finisher with stainless steel micro pins. This process provided a semi-polish to the 950 palladium ring, including the hard-to-reach areas.

A setting burr was selected to create the bearings for the diamonds in the shared claws (arrow). There are six diamonds on each side measuring exactly 1.90mm. The setting burr measured 1.80 mm. While burring the depth of the bearing, pressure was applied from side to side to slightly enlarge the bearing to accommodate the 1.90 mm diamonds.

Tech Note: When creating the bearings or seats in palladium jewellery, use lubrication such as oil of wintergreen, standard machine oil or burr lubricants with the setting burr. This helps to maintain the sharpness of the burr as well as ensuring a precise bearing is cut. The lubricant also reduces the friction that causes overheating.

A brass pusher was used to pick up and place the diamonds in their bearings. The brass pusher is made from 3mm brass brazing rod and a wooden handle. The end of the brass rod is tapered. The end should be slightly smaller than the outside diameter of the diamond being set. A thin smear of beeswax is used to make the end of the brass rod tacky enough to pick up a diamond from the pre-assigned layout and position it in its bearing.

Tech Note: These diamonds matched in diameter and proportions. If the diamonds are not matched, care must be taken when creating the bearings so the tables of the stones are level and aligned when setting is complete.

After placing the diamonds in their bearings and making sure their face-up orientation was consistent with the curve of the setting, a grain tool was used to seat and secure the diamonds in their bearings. Select a grain tool with a cup size slightly larger than the claw diameter to shape and form the claws. The same procedure is used to set the 1.75mm diamonds–four on each side–using a 1.65mm setting burr and smaller grain tool.

Tech Note: : Lightly secure the diamonds in place, pushing the claws only part way, and working opposing points of contact. This will allow you to make final alignment adjustments as the diamonds are secured in their settings.

With the 1.90mm and 1.75mm diamonds set, the diamonds immediately adjacent to the centre stone were next. There are four 2.70mm diamonds and two 2.50mm diamonds to be set. For this, setting burrs slightly smaller than the stone diameter were used to create the bearings. About 20% of the claw diameter was removed during the burring process from each side of the claws.

All six diamonds were seated in their bearings using a brass pusher. The claws have been pre-shaped and, as with the smaller diamonds, a grain tool was used both to secure the stones in the bearings and to shape the claw tips.

The diamonds were checked for consistent orientation and alignment of the tables to ensure that they faced up evenly before finally securing the stones in their settings.

All stones were set, and the shared claws ready for final shaping. For this step, a grain tool (cup size slightly larger than the claw diameter) was shortened and fitted into the pendant motor hand-piece. The unit was set at low impact and adjusted so the foot pedal would control the speed of the hand-piece. The tool was placed over individual claws to quickly and consistently shape the claw tops and to do the final compression of the metal over the diamonds.

To create the bearing for the centre stone, a 3mm 90° bearing burr was selected. The bearing was created using CAD software (arrow), with particular care taken to create a precise shape. The fit of the centre stone was checked throughout the burring process.

After seating the centre stone, the ring was placed onto a ring holding device for setting. The central portion of the holder expands to firmly hold the ring in place for hammering. The stone was first partially set on one side of the bezel, then the other. The setting punch was placed over the midpoint of the bezel and was lightly hammered with a chasing hammer, partially bending the metal over the stone. This procedure was continued from the midpoint outward on each half of the bezel.

With the centre stone secured, the ring was then placed on a steel ring mandrel. The mandrel was positioned into the bench slot created for it. A smaller setting punch and chasing hammer were used to perform the final bending of the bezel.

PROJECT:

Setting Cabochons in Palladium Bezels

This tourmaline and cultured freshwater pearl pendant is made in palladium and yellow gold.

For convenience during the setting process, the pendant was held in a thermoplastic compound. The compound was heated with warm water to make it pliable. When the compound cooled, it firmly held the piece for setting. The bezel was trued and fit to the centre stone using a small inverted cone burr and a wheel burr.

With the seat prepared, the centre stone was set using a pendant motor with a reciprocating handpiece and a polished, flat chisel point. The hammer was adjusted for light impact.

Tech Note: The setting edges around the corner curves of the gemstone were lightly hammered to begin the process. Then the edges between the curves were hammered. Applying impact from the top completed the process of securing the gemstone. Palladium facilitates setting as the alloy is malleable and has no memory (does not spring back). Because little pressure was required in the setting process, risk of damage to the centre stone was minimised.

After setting both cabochons, the thermoplastic compound was removed from the holding device. The assembly with the pendant pieces was placed into warm water for about ten minutes, and then the pieces were removed.

PROJECT:

Setting a 5-Stone Palladium Ring[8]

Design by Lainie Mann[1]

The centre stone is an aquamarine coloured Montana sapphire in a four claw setting. The pear shaped side stones are tourmalines set in a "v" claw and partial bezels. The small round brilliants are diamonds and set in the side bezels.

Setters comments: "I have been a stone setter for over 15 years specialising in all setting styles. I enjoy setting in palladium because it is a tough metal that is not hard and springy. It is malleable and workable taking forms and shapes with ease. The metal is easy to cut with standard gemstone setting burrs of all shapes and gravers. Forming the bezels, claws and partial bezels is easy. The metal formed and shaped without springing back."

Designer and shop owner[6] comments: "Designs for palladium must be considerate toward its metallurgical characteristics. Because of its desirable malleability, claws should be heavier than when made in white gold so they will hold up and retain their shape during normal wear."

PROJECT:

Grain Setting Small Diamonds in Palladium[3]

Design by Tom McLaughlin, Lennon's Jewelers

The top portion of these 950 palladium earrings is grain set with small round brilliant diamonds on one side. When worn, the bottom portion swivels and is grain set with small round brilliant diamonds on both sides. The two sides of the bottom portion are separated by 18ct yellow gold spacers. The diamonds on each side of the bottom portion accent the round Tahitian cultured pearls, as they swivel when worn.

The first step in the setting procedure was to cut the bearings for the small diamonds. Each diamond is secured by shared claws. The spacing between the diamonds is minimal, so precise cutting of the claws was essential. A 1.2mm 90° bearing burr was used to cut the claws individually. The size of the burr dictates the depth of the cut into the claw, with an experienced diamond and gemstone setter gauging the height of the bearing by eye on each claw.

These stones were set three at a time. With each of the three diamonds placed in their seats, a flat bottom graver was used to push the outside claw toward the centre, while applying pressure from the top and slightly bending it. This procedure provided the final security for adjacent diamonds. After all of the diamonds were set, a grain tool was used to shape the tops of each of the claws.

Tech Note: The size of the concave cup in the grain tool is slightly larger than the top of each claw. The grain tool is placed on the top of the claw and moved in a small circular motion while applying downward pressure. 950 palladium is malleable and workable so only moderate pressure is required.

PROJECT:

Channel Setting in Palladium[10]

Design by Barney Jette,
Barney Jette Jewellery Design[10]

This palladium ring features five 0.25ct diamonds channel set around the radius of the top design element.

The bearings were cut individually for the diamonds using a 70° bearing burr.

The diamonds were also placed and pre-set individually, starting at the top of the ring. For pre-setting, a reciprocating hammer was used to lightly tap the metal on each side of the bearing.

The setting was inspected and another diamond seated into its bearing.

After all of the diamonds were seated, the reciprocating hammer was used again to finally seat and secure the diamonds. Channel setting in palladium is ideal, given its strength and malleability.

Unusual Setting Styles

Palladium's malleability, lack of spring-back (memory) and capability of being formed smoothly makes it an ideal metal for setting gemstones, including those with unusual shapes, angles and features. Given palladium's mechanical properties and assuming proper alloy selection, design, engineering, setting preparation and execution, a gemstone will not become loosened during normal wear.

Jewellery by Thomas Dailing, Image by Azad Photo

The fancy cut diamond centre stone and round diamond side stones in this three-stone ring are securely set by using opposing bars that conform to the diamonds' outside shape.

Jewellery by Nina Basharova

The cabochon is securely held in this palladium ring by a full bezel. Palladium at the thickness and height of this bezel easily conforms to the shape of the stone. Hammer setting followed by use of a burnisher securely locks this gem in place.

This centre stone is a rounded triangular brilliant cut. Its unique shape is securely set in opposing walls, one formed to the rounded side of the gemstone and the other cradling the pointed corner. Palladium's malleability eased the stress of fashioning the setting for this unusual style.

Jewellery by Thomas Dailing, Image by Azad Photo

Machining

Image Courtesy of Novell

Image Courtesy of Lieberfarb

These wedding bands are seamless and made from 950 palladium-ruthenium extruded tubing. The extrusion process forms tubes of metal through applied pressure which forces the metal through a die, resulting in a very fine grained structure and increased Vickers hardness ranging between 150HV and 170HV. Machined products will retain this increased hardness unless the item is exposed to heat when soldering or annealing. The annealed hardness of 950 palladium-ruthenium alloy ranges between 120 and 130HV. Typically, machined bands can be expanded and contracted up to 2 sizes using commercial ring stretchers without annealing. If larger sizes are required, it is advisable to have another ring made in the desired size. Using a torch to solder in a piece of stock to increase the size will return the ring's "work hardened" Vickers hardness value to its lesser "annealed hardness" value.

Extruded Tube Production

950 palladium-ruthenium alloy is melted and poured into a large ingot or billet weighing between 100 and 200 ounces (3.1-6.2 kg) for each pour. Melting is done inside a sealed chamber where the atmosphere is first removed by vacuum, and then back-filled with a cover gas prior to melting. Different cover gases used for this process include argon, nitrogen and carbon monoxide. Induction heating is used to melt the alloy and, when molten, it is poured into an ingot mould and allowed to solidify in the chamber under the protective cover gas. The cylindrical billet (ingot) is machined on a CNC machine, and the core drilled out whilst being flooded with machining coolant. The extrusion process forces the billet under significant heat and pressure through forming dies to achieve specified dimensions. This causes the microstructure to be refined and the subsequent cold drawing makes the metal harder with each pass.

Machining Process

The tubing is then cut into workable sections and blanks cut from the sections of tubing on a CNC machine, dependent upon the dimensions of the bands.

Polycrystalline diamond (PCD) cutting tools which consist of a layer of diamond integrally bonded to a carbide substrate are typically used. The diamond layer provides high hardness and abrasion resistance, and the carbide substrate improves the toughness. For certain applications, tungsten carbide tooling is used.

Palladium has a tendency to build up on tool cutting faces and this build up reduces the ability of the cutter to accurately perform. Palladium's low thermal conductivity also causes the heat generated to concentrate at the surface interface between the tool and the metal. Using water soluble machine coolant reduces this build up and increases lubrication in the process. The depth of the cut, the speed at which the metal is being turned, and the sharpness of the tool all contribute to the efficiency of machining.

The swarf (metal cuttings discarded during machining) that is generated comes off in coils or flakes. This depends on the cutting application, cutting tool, shape or rake of the cutting surface and the amount of palladium being removed in the process. Because the coolant is water soluble, the swarf can easily be cleaned and reused. If the machinist is not careful with the settings or generally unfamiliar with the nature of the process, certain tools can

Image Courtesy of Lieberfarb

overheat and chip off. If tools have deteriorated in this fashion during the process, the swarf must be recycled or refined to remove the foreign metals.

Image Courtesy of Novell

Blanks are mounted onto a turning arbour and the outside shape such as a half-round or flat surface is created. Machining coolant is introduced to lubricate and to prevent the tools and the jewellery from overheating.

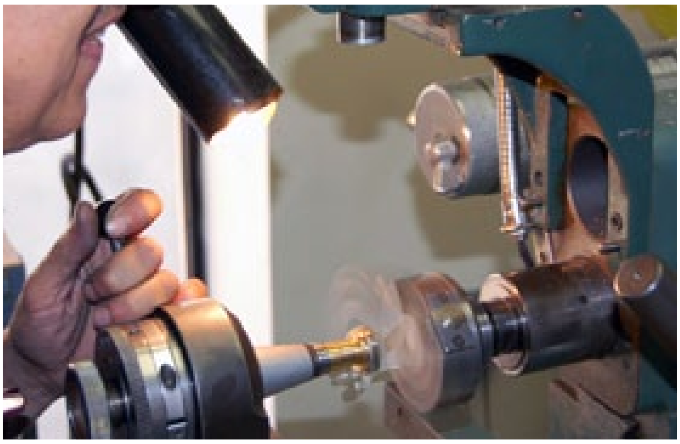


Image Courtesy of Novell

For cutting a precise court shape inside the machined band, a heavy-duty lathe equipped with a carbide steel cutter is used. The band is securely held by an

Image Courtesy of Novell

expandable rotating mandrel and the court is created by the stationary cutter on the right. After cutting one side, the ring is removed from the mandrel and the opposite side is cut.

The next step involves exterior surface embellishment, which is done by a Swiss cutting machine, creating a precise and highly polished groove.

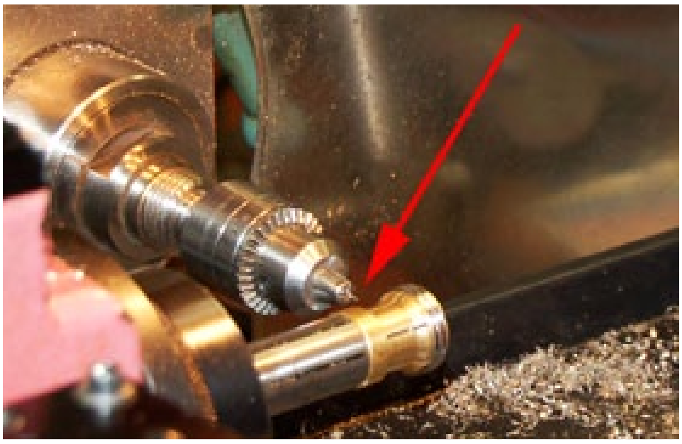


Image Courtesy of Novell

The Swiss cutting machine creates a highly polished groove. The machine operates at high speed and uses a diamond cutting tool. The ring is mounted on an expandable holding mandrel, and the cutting is monitored through high powered magnification.Holes for decorative features or stone setting are systematically drilled using this machine. It is indexed and calibrated by the specialist, and then used to drill the holes around the band with a minimum amount of operator attention.

Image Courtesy of Lieberfarb

Much of the finish work for machined bands, such as diamond setting or final polishing, is done by hand. Here diamond setters are pavé setting the side of a wedding band.

Image Courtesy of Lieberfarb

Examples:

This 950 palladium wedding band features four rows of mille graining, a highly polished diagonal diamond pattern and other surface treatments, which have all been machined. Hand polishing for this band was strictly limited to the inside and sides of the band.

Image Courtesy of Novell

This 950 palladium wedding band has two cut grooves into which pink gold is mechanically applied. In the next step a machined millegrain effect was applied. The recessed areas for the princess cut diamonds were also machined into the band, and then the setting was done by hand.

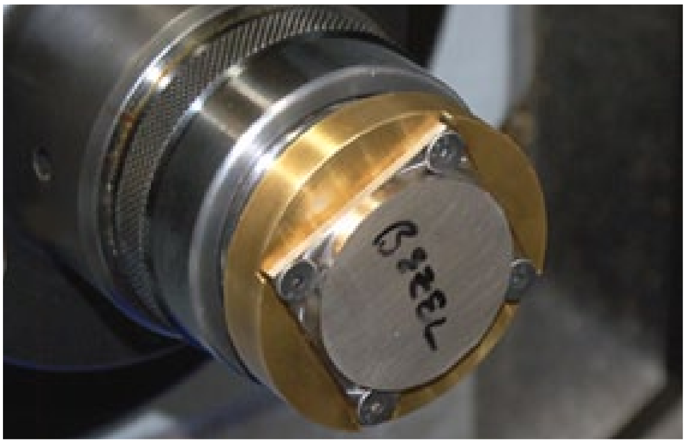
Image Courtesy of Novell

These 950 palladium wedding bands feature mechanically drilled holes. The CNC machine is programmed to control the spacing and depth of cut. The grains and recessed areas where the diamonds are set were also done by machine. All diamond setting was done by hand.

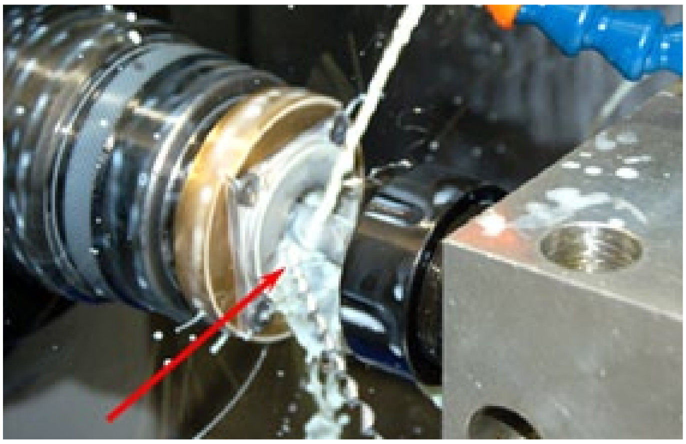
Image Courtesy of the Machine Shop at Montana Watch Company

Machining Watch Cases

Palladium is used by an American watch manufacturing company to make cases. A block made of palladium-ruthenium alloy is machined and formed into watch cases. The initial step in the machining process is completed and the finished unit is ready for the next step. This image shows the milled palladium part and two 950 palladium blocks ready for similar processing.



Next the block is mounted with set screws on the computer aided lathe. This step will remove the inner portion of the watch case bezel.



With the palladium case mounted, the machine settings are adjusted and the coolant dispensers fixed so they will dispense water soluble coolant on the piece while it is being turned. Notice the long spiral of palladium swarf that is being cut away (indicated by the red arrow). The final step will cut threads in this half of the bezel. After threading both halves, they will precisely screw together and be ready for hand finishing and assembly.

This image shows the finished palladium watch done by Montana Watch Company.

Die Striking (Stamping)

Die striking is a process used to form jewellery parts and findings. It is done by pressing or blanking sheet metal alloy between two dies using great force. The resulting compressed metal piece is finely detailed, hardened and shaped. There may be additional forming and production soldering methods used after the initial blanking, to complete jewellery components.

It is critical when die striking or blanking parts in palladium to consider its unique metallurgical characteristics such as hardness, malleability and ductility. These features, along with the intended use of the component (e.g. a setting, mechanical device, or bail) call for specific and unique engineering parameters of the parts to be made.

For example, many of the parts die struck for jewellery use are bezels for gemstones. These are typically four or six claw bezels. After die striking, shaping and assembly, these units are sold to jewellers, who subsequently assemble, then set the components. If not properly designed, these bezels can fail under the stress of normal wear. A costly example would be the twisting and deforming of a die struck bezel during daily wear, causing the gemstone to become dislodged.

Die Striking for Palladium

Settings:

Here is a listing of considerations that are important when designing dies for striking palladium settings:

- Claw Thickness – The thickness of the claws must be adequate to hold a gemstone under the stress of normal wear. Palladium claws must be thicker than those in white gold, due to the lower hardness and higher malleability of palladium.

- Total Height of the Setting – The height of settings should be proportional to the thickness of the claws. If thin claws are desired in a particular design style, lowering the setting height would help compensate for the thinner metal. Thicker claws can be made taller without compromising structural support.

- Tapered Settings – The taper from the base of a setting to its top should be moderate. Avoid settings that taper significantly, e.g. claws with very wide tips and narrow bases. Although this is a common die struck design for white gold parts, it may fail if attempted in palladium, due to the metal's malleability.

Earring Posts:

Here are some important considerations when designing dies for striking palladium earring posts:

- Post Diameter – the diameter of a palladium post must be greater than typically required for gold earring posts. This is due to the lower hardness and higher malleability of palladium compared to white gold alloys.

- Palladium Hardness – The hardness of palladium after die striking is substantially greater than when cast. However, soldering will soften or anneal the metal. In die-struck parts that serve a structural or mechanical role in finished jewellery, it is advisable to use palladium alloys that possess greater hardness values than those typically used for casting and other manufacturing procedures.

These die striking conventions apply for all palladium applications.

Refining

Refining Palladium:
The Six "C's" Bring Best Return

Scrap Metal Retrieval Techniques

The following bench practices are suggested for the most efficient retrieval of metal from palladium jewellery manufacturing processes. Palladium scrap can be even more complex and costly to refine than platinum, so for maximum returns, the process must begin long before you 'box up' the metal to send to the refiner.

Collect metals separately

Collect like metals separately. Do NOT mix palladium scrap with gold, silver, base metals, or even platinum - your return will be far greater with palladium-only submissions to your refiner. In addition, collect until you have a sufficient quantity to make refining cost effective according to your refiner's terms. Screen investment waste from any casting processes for hard metallic scrap.

Categorise your scrap

Keep separate:

- Hard metallic scrap - worn rings, failed castings, buttons and pieces from fabrication
- Filings - bench filings, grinding scrap, machining swarf
- Polishing sweeps - dust from polishing machine and debris from dedicated pre-finishing stations

Cleanliness = better returns

When beginning a palladium project at the bench, clean away the debris from previous projects. This will help you to avoid contamination and increase your palladium return on filings and hard metallic scrap.

Check your refiner's terms

Understand refiners' submission policies, pricing schedule and procedure for settlement, which should be clearly published, and follow their instructions carefully. You can maximise returns simply by following their guidelines (e.g. submitting sufficient quantity of scrap to avoid minimum handling costs). Check that they are following their published handling procedures, especially turnaround times and how you receive out-turns. If your palladium alloys contain other platinum group metals, ask your refiner for return on this metal too.

Careful packing and shipping

Pack your scrap carefully in tamper-proof sealed containers and include instructions to your refiner to notify you if the seal is broken. Use containers with friction lids and smooth rims, Waste metal can "hang back" in containers with screw-top threading and get trapped in the tracks of the seal in plastic interlock-top bags. Ensure your shipment for the anticipated value of your return, record details and retain all transaction records.

Communicate with your refiner

Be clear about how you wish to have your return processed. Most refiners offer choices such as receiving a credit on future purchases of metal or cash settlements. This gives you the opportunity to select the best option for your business model.

Glossary

Annealing
The process of heating work-hardened metals to a specific temperature, causing recrystallisation, which renders the metal soft and malleable.

Alloy
A mixture of two or more metals. Combinations of metals in calculated quantities result in alloys with qualities suitable for specific uses in manufacturing.

Assay
The testing and marking of jewellery and silverware to guarantee the precious metal content.

Baguette
A small rectangular shaped diamond or other gemstone with parallel facets and a pavilion culminating in a keel.

Bearing
A seat or supporting structure for a gemstone.

Bezel Setting
A type of setting in which the gemstone is seated in a frame that conforms to its shape, and secured by the thinner upper walls of the setting, which are pushed down around the perimeter of the gem's crown. It is also referred to as a box setting for square and other geometric shaped stones.

Bullion
Precious metal in the form of bars or ingots.

Burnishing
Making a smooth, highly polished surface by rubbing metal with a polished steel burnishing tool. This process 'moves' metal rather than removing it. The technique is also used in setting to work metal over the edge of gemstones, creating a lip to hold them in place.

Cabochon
A gem cutting style that produces single surface with no facets. There is no pavilion on a cabochon; the underside tends to be flat, depending on the gem material.

Carat or ct
The carat is a unit of mass used for measuring gemstones and pearls equal to 200 milligrams. In the UK it is also a unit for describing the gold content in gold jewellery (24ct is pure gold).

Carborundum
Silicon carbide (SiC), is made by fusing sand and coke in an electric furnace, grinding and grading. It possesses 9.5 hardness on the Mohs scale, and is used as an abrasive material in granular form, for making grinding wheels and stones.

Castability
The ability of an alloy to be melted and poured into a mould, while retaining sufficient fluidity to take up an accurate detailed impression of the mould cavity and be extracted without cracking.

Casting Grain
Metals, usually alloys, prepared for melting to cast. Small grain sizes allow for more efficient weighing of metal and for faster, more even melting

Casting Temperature
The temperature at which a flask is held before casting. This hold temperature is determined by several factors, including: mass; dimensions; detail and structure of the mould; single or multiple pieces being cast; and the casting alloy.

Claw Setting
Precision cast or fabricated setting with claws that vary in shape depending on the shape of the gem (round, bar, corner, V-shape, etc.) and are strategically positioned for holding gemstones.

Cold-Worked
Reduced (by rolling, forging or drawing) or worked (by bending or embossing) sufficiently below annealing temperature to cause strain-hardening.

Collet
The enclosing metal structure within which a gemstone is set. A collet may take the form of an open-ended cylinder or truncated cone.

Corundum
Alumina (Al203), used finely ground as an abrasive/ polishing compound, and also as a refractory.

Crown / Crown Facets
The upper part of a faceted gemstone (above the girdle), which includes the table and surrounding facets.

Crown Height
The vertical distance between the girdle and the table of a gemstone.

Crucible
A vessel made of refractory material, used for melting alloys at high temperatures.

Culet
The small facet at the base of the pavilion parallel to the table, usually of a brilliant cut stone.

Cure Time
The period of time required for the investment slurry to dry or harden after a flask has been prepared and set aside. Cure time is determined by a number of factors which include flask size, mould volume and wax devesting method.

Doming
Hammering metal sheet or a pre-cut circle with a spherical-ended punch, into a corresponding hemispherical hollow in a block to form a dome. Also called 'dapping', various degrees of convexity may be achieved through a series of punches and hollows.

Diamond Burr
Abrasive hand tools, including burs, wheels and drills, made with embedded diamond grains mounted on metal.

Diamond File
A copper filing tool into which diamond powder has been hammered.

Diamond Lap
Abrasive wheel or file, usually made of copper or other soft metal, and charged with pulverized diamond.

Ductile (ductility)
Capable of being drawn (usually cold) into wire or tube, hammered, rolled or die struck without fracture. Ductility is usually measured by the elongation and reduction in cross-sectional area in a tensile test.

Die Struck
Produced by pressing or striking alloys in solid form between two matching dies using great pressure. The compressed metal piece is finely detailed, hardened and stronger.

Emery
An impure granular form of natural corundum used for centuries as an abrasive material. Consisting of a mixture of corundum and magnetite or hematite, emery has been largely superseded by synthetic alumina (corundum) for more controlled grinding.

Emissivity
The rate of loss of heat from unit area in unit time at a given temperature (usually in the context of the surface of a melt). Very dependent on the principal wavelengths radiated, and the character of the surface.

Feeding
The process of passing molten metal through sprues and into castings, to compensate for contraction as castings solidify. Can be gravity or otherwise pressurised.

Fineness
Precious metal content expressed in parts per thousand (ppt).

Flask
The external, open-ended, metal cylindrical container of an investment casting mould that is used throughout the investment process, until the retrieval of the finished casting.

Fluidity
The ability of molten alloy to flow into and take up an accurate impression of a mould cavity before solidifying.

Flush Setting
A specific style of burnish setting in which the tables of the gemstones are flush (on the same plane) with the background surface. The gemstone is set by burnishing metal around the edge(s) of the crown and usually accented by a bright-cut around the perimeter.

Flux
Inorganic mixture fusing at a lower temperature than melting/soldering/welding an alloy. Flux cleans exposed surfaces and protects against reactions such as oxidation that impair the melt or joint.

Fusing Point
The temperature at which metal begins to melt.

Sprue
An opening in a mould to permit entry of molten alloy into the casting cavity.

Girdle
The outermost series of flat perpendicular planes around the perimeter of a cut gemstone. The girdle divides the crown from the pavilion, and provides the surfaces by which the stone is held in a setting.

Grains
A decorative effect usually achieved by fusing tiny scraps of metal to form spheres by way of surface tension. Also called granules.

Grain Setting
A setting method in which gemstones are set so that their girdles sit flush with the metal surface, and are secured by raising small grains from the surrounding metal with a graver, and pushing them over the crown of the stones.

Granulation
Decoration created by attaching tiny sphere-like granules in various lines, patterns and shapes by fusing them to a surface.

Graver
A cutting tool used for engraving metal.

Green Gold
An alloy containing a high proportion of silver with a greenish-yellow hue.

Hallmarking
Applicable only to gold, silver, platinum, and, from January 2010, palladium goods tested and marked by a UK Assay Office e.g. Assay Office London, as conforming to the UK Hallmarking Act – but often applied unofficially to marking in other countries as well.

Hydrochloric Acid
An aqueous solution of hydrogen chloride gas.

Induction Melting
Heating to above melting point by generating eddy currents within a conducting material surrounded by a water-cooled copper coil, carrying an alternating current at low (<150Hz), medium (>150Hz) or high (>1kHz) frequency. Also creates an electromagnetic stirring effect in the melt.

Investment
A refractory material composed of a mixture of crystobalite, silica and modifying agents with a bonding agent such as gypsum or phosphoric acid. It is mixed with water to form a slurry, that is poured into a flask containing wax or plastic models. It is then vacuumed to remove trapped air, and allowed to set around the models forming a mould.

Jeweller's Rouge
A polishing medium for jewellery metals made of finely ground red to purple ferric oxide, often bonded with wax. It tends to burnish rather than cut.

Joint
The area where two fitted ends or separate metal components align are soldered or lasered together.

Keel / keel line
The long facet junction at the base of the pavilion of a (usually) step-cut stone, parallel to the table.

Laser
Light amplification by stimulated emission of radiation results in brilliant beam of monochromatic light that is highly directional, has high energy and may be focused to provide a fine heat source.

Laser Pulsing
The operating parameters of a laser machine are effectively controlled by the intensity, duration, and frequency of repetition of pulses. Intensity is controlled by energising voltage.

Laser Welding
The light beam emitted by a laser is focused on a small area to generate heat at megawatts/cm with rapid pulsing. The focused energy is sufficient to cause welding (not necessarily needing to melt the metal) of thin sections.

Liquidus
The temperature above which an alloy is completely molten. Also, on an equilibrium or constitutional diagram (which plots the disposition of phases in an alloy with temperature and composition), shown as a line above which the only stable phase is liquid (molten) metal.

Lost-Wax / Investment Casting
A casting technique adapted from the centuries old method for sculpture, the lost-wax method can produce intricate jewellery castings to close tolerances. Wax models are set up in the investment along with a sprue to the surface through which the melted wax will evacuate, leaving a mould cavity. By various casting processes, molten metal is forced into the mould cavity , cooled and removed from the investment – producing a metal replica of the original model.

Machinability
A qualitative term suggesting the relative ability of a metal to be cut in a machining operation with minimum power, producing a good surface finish, and clearing swarf efficiently, all at maximum speed.

Malleable
Capable of being deformed (e.g. hammered or rolled) extensively without excessive work-hardening and cracking. Malleability usually increases with temperature, except for hot-shortness (brittleness at high temperature during working).

Mandrel Tube-Drawing
Uses a hard straight rod or wire to form the inside cross-section of a tube during cold-drawing through a die, so reducing the wall thickness. Used for short lengths, as opposed to plug-drawing longer tubes.

Millegrain
A setting tool consisting of a fine wheel used to roll a granulated border around the edge of a box or bezel setting of a stone. The tool is also used to produce a decorative edging along bright cutting or to embellish engraved work.

Mokume Gane ("Wood-Eye Metal")
A 17th century technique of Japanese metal smiths who created laminated metal billets consisting of layers of various combinations of alloys, which were then forged, carved and finished to produce uniquely patterned metal stock—resembling a wood grain pattern—for use in adorning samurai swords. A handful of talented craftsmen now employ the traditional methods to create contemporary jewellery which highlights the unique beauty of the 'married metals'.

Paillons
Small pieces of solder clipped from foil, thin strip or sheet. They are ready to use, placed at intervals across the targeted joint zone and progressively flowed by a controlled flame.

Pattern (model)
A master (metal) or consumable (wax) model of a component to be reproduced by casting.

Pavilion (facets)
The lower parts of a faceted gemstone below the girdle, including the culet on brilliant cuts, or the bottom junction called the keel line on step cuts (e.g. the baguette).

Phosphate-Based Investment
Investment with acid-phosphate and magnesia, which first gels silica flour and then bonds it by subsequent dehydration. The working time is rapidly decreased by increasing temperature.

Platinum Group Metals (PGM's)
Platinum is rarely mined pure. It is often found alloyed with iridium, osmium, palladium, rhodium, and/or ruthenium - collectively the platinum group of metals.

Quenching
Rapid cooling in a fluid. This can be a cool air blast, but is more commonly water.

Reducing Flame
A melting, annealing, soldering or welding non-oxidising torch flame with more gas than can combine with the injected oxygen or air.

Refractory (materials)
High melting point materials used for furnace linings, crucibles and moulds. Important considerations for these are a suitable binder to hold the refractory particles together, thermal shock resistance, acidity/basicity and surface finish.

Rolling
The most commonly used cold-working process for jewellery alloys. Uses plain faced polished rolls for sheet and strip; grooved rolls for bar, rod, and simple sections; and patterned rolls for continuous embossing.

Ruthenium
A rare polyvalent metallic element belonging to the platinum group of metals. Symbol - Ru; atomic weight - 101.07; atomic number - 44; specific gravity - 12.2 at 20 °C.

Silica
Silicon dioxide selectively processed to form refractory and abrasive materials. Exits as quartz, tridymite or crystobalite crystalline phases in equilibrium at increasing temperatures.

Soldering
Joining metal or alloy components by fusing together with a further lower melting point alloy known as a solder. Often uses capillary forces to draw the solder into the joint.

Spinning
Forming sheet metal into cups by pushing a smooth-ended tool against the spinning sheet to force it onto a form of the shape required.

Spot Welding
Joining process, usually on overlapping sheet and strip, by a short pulse of electric current led in through copper electrodes with punch pressure applied to weld a spot at the interface heated by local resistance to or near melting point.

Springiness
Having a relatively high elastic limit and Young's modulus. The alloy, usually cold-worked, may be deformed elastically, and springs back to the original shape with little loss of energy.

Sprue
Wax wire feed system in wax models for the casting process. Forms the channel for the melt to be propelled from the central feed via the sprue into the casting cavity.

Stress Relieve
Low temperature heat treatment reducing peak internal stresses (mainly after cold-work), but without causing recrystallisation.

Swarf
An accumulation of metal cut or ground from work by a machine tool or grinder.

Tripoli
A jewellery polishing compound consisting of very fine diatomaceous silica whose texture is porous and absorbent, suspended in a waxy medium and loaded onto the face of a polishing wheel for medium and fine polishing stages.

Wax Models
Wax replicas of a master model or pattern (made by injection of molten wax into rubber or metal moulds).

Welding
Joining process in which no solder is used and the components are joined by mutual fusion with or without flux. A filler metal wire of similar melting point may be used.

Wet and Dry Paper
Waterproof paper coated with carefully graded and oriented silicon carbide particles (carborundum). Used for pre-finishing between the filing and polishing stages.

White Radiation
Mixed wavelength radiation in the visible light range of the spectrum.

Work-Hardened
The increase in hardness which accompanies plastic deformation in a metal. Alloying usually increases the work-hardening rate of a pure metal, and increasing working temperature decreases the hardening rate.

Weights and Measures

Weight

To Convert

Pennyweights to grams	Multiply by	1.55518
Grams to pennyweights	"	0.64301
Ounces troy to grams	"	31.1035
Grams to ounces troy	"	0.0321507
Ounces avoirdupois to grams	"	28.3495
Grams to ounces avoirdupois	"	0.0352740
Ounces troy to ounces avoirdupois	"	1.09714
Ounces avoirdupois to ounces troy	"	0.911458
Pounds avoirdupois to kilograms	"	0.4535924
Kilograms to pounds avoirdupois	"	2.20462
Kilograms to ounces avoirdupois	"	35.2740
Kilograms to ounces troy	"	32.1507

Troy Weight

Used in Weighing the Precious Metals

24 grains	1 pennyweight
20 pennyweights (dwt.)	1 ounce troy
12 ounces	1 pound troy
5760 grams	1 pound troy

The troy ounce is about 10% heavier than the avoirdupois ounce.

31.1035 grams	1 ounce troy
1 gram	15.432 grains troy
1.555 grams	1 pennyweight (dwt)

Avoirdupois Weight

Used in Weighing the Base Metals

16 ounces	1 pound
16 ounces	28.35 grams

The avoirdupois pound is about 21.5% heavier than the troy pound.

700 grains	1 ounce avoirdupois

Carat Weight

Used in Weighing Precious and Semi-Precious Stones

1 carat	0.20 grams
1 gram	5 carats
1 carat	3066 grains troy
1 carat	0.007 ounce avoirdupois

The carat is further divided into points for simple measurement:

1 carat	100 points
1/2 carat	50 points
1/4 carat	25 points
1/8 carat	12.5 points

Temperature

To Convert

°Fahrenheit to °Centigrade (Celsius) = Subtract 32 from degrees Fahrenheit, multiply remainder by 5, divide the product by 9.

°Centigrade to °Fahrenheit = Multiply degrees Fahrenheit by 9, divide product by 5, and add 32.

°Centigrade to °Kelvin: Zero degrees Kelvin equals -273°C and thus add 273 to the Centigrade reading to get Kelvin.

Area and Volume

To Convert

Square inches to square millimetres	Multiply by	645.16
Square inches to square decimetres	"	0.064516
Square decimetres to square inches	"	15.50
Square millimetres to square inches	"	0.00155
Cubic inches to cubic centimetres	"	16.3871
Cubic centimetres to cubic inches	"	0.061024

Length

To Convert

Millimetres to inches	Multiply by	0.0393701
Inches to millimetres	"	25.4
Metres to inches	"	39.3701
Inches to metres	"	0.0254

Linear Measurement

1 decimetre	=	3.937 inches
1 metre	=	39.37 inches
1 metre	=	10 decimetres
1 metre	=	1,000 millimetres
1 inch	=	25.4 millimetres
1 millimetre	=	0.0393 inch
1 micron	=	0.000039 inch
1 metre	=	1,000,000 microns

Fluid Measurement

1 quart = 32 ounces (fluid) = 2 pints
= 1/4 gallon =57 cubic inches

1 gallon = 4 quarts = 128 ounces (fluid)
= 3.78 litre and 231 cubic inches = 0.134 cubic feet

1 litre = 1,000 cc (slightly more than 1 quart U.S.)
= 0.264 U.S. gallons

1 cubic foot = 7.481 U.S. gallons
= 1.728 cubic inches

1 imperial gallon = 1.2 U.S. gallons = 4.59 litre
= 277.27 cubic inches

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