WORKING WITH ARGENTIUM® SILVER

By Cynthia Eid--Revised and Updated July 2023

Argentium Silver is a patented and trademarked alloy that is at least 92.5% pure silver. That quality makes it sterling silver. What makes it different from traditional sterling silver is that a small amount of germanium replaces some of the copper that is usually the other 7.5% of sterling silver. Peter Johns, a professor of silversmithing at Middlesex University in England, invented Argentium Silver in 1996. When I heard about this firescale-free sterling silver sheet, I sought out sources. I finally got my hands on it in the year 2000, from a source in Finland. I hoarded whatever I could get, as I fell in love with the material's working properties. By 2005, I realized that I never used traditional sterling silver anymore, and sold all my old supplies of SS.

Today, Argentium Silver Is 94% silver----even more pure than traditional sterling. The alloy contains about 1.2% germanium, and 4.8% copper. As with any sterling alloy, the copper provides strength to the metal. The presence of the germanium stops firescale, as well as providing other advantages.

Argentium Silver

- is highly tarnish-resistant (Neither pure silver, nor any silver alloy is tarnish-proof.)
- has greater ductility and malleability than traditional sterling silver.
- can be precipitation-hardened using a toaster oven.
- fuses, granulates, and welds readily.
- does not firescale.

Argentium 940 and traditional sterling silver have similar melting temperatures.

Argentium 940 melting temperatures:	Sterling Silver melting temperatures:
Liquidus of 1643°F (895°C)	Liquidus of 1650°F (899°C).
Solidus: 1580°F (860°C)	Solidus: 1475°F (802°C)
Melting range : 63°F (35°C)	Melting range: 125°F (97°C)

Argentium 940 was developed to have working properties that are more similar to traditional sterling silver. The shorter melting range makes AS 940 less fragile when red hot. AS 940 can be quenched after annealing or soldering, and moved and poked during soldering. Sterling silver is fragile at the higher temperatures equivalent to fusing, and the same is true for AS 940. When it comes to fusing, which is nearer to melting temperatures, I suggest not moving, poking, or quenching neither AS940 nor sterling.

Despite its many advantages, working with Argentium® Silver is not very different from working with traditional sterling silver. It is useful, though, to know as much as possible about the differences.

SAFETY

If you are like me, you may wonder about the safety of germanium. I know that when I first heard about this sterling alloy, I was quite concerned about its safety. I looked on the web at the MSDS for "germanium metal", as well as those for silver and copper. Since the lists of dangers for silver and copper are longer than the list for germanium, I feel that it is a safe component for sterling silver. Both silver and germanium have anti-bacterial qualities that are used in the medical field.

Naturally, one should always use safe work habits when working with any metal. Wear a dust mask and safety glasses for grinding or polishing. Use good ventilation for soldering, grinding and polishing. Don't eat or drink in the studio. Use common sense and take precautions to take care of your health and safety.

It is interesting to note that using Argentium Silver could make many workplaces safer, since cyanide and/or nitric acids would no longer be needed to deal with the firescale common to traditional sterling silver.

ANNEALING

Argentium® Sterling's annealing and melting temperatures are similar to traditional sterling silver.

The annealing temperature range of Argentium Silver is 1040-1148°F (560-620°C).
The annealing temperature range of sterling silver is 1100-1200°F (593-648°C)

When we work metal by forging or forming, the molecules can get pushed so tightly together that they cannot move---we feel that the metal has gotten stiff. When we anneal, the spacing between molecules relaxes so that the metal can move. When metal is over-heated, the molecules gather into crystalline clusters, which cannot slide around each other as easily as individual molecules, so the metal may develop small little surface cracks, which can turn into larger cracks----we feel that the metal is "brittle" in this case.

For most of us, our intuition is that it is better to get the metal above annealing temperature than to under-heat. And some people say that it is important to quench as quickly as possible after the metal reaches annealing temperature. In my experience, over-annealing by getting the metal too hot, or quenching too soon, can cause cracking in any metal alloy.

Argentium 940 was developed so that it CAN be quenched after annealing or soldering---making it easier for people accustomed to quenching traditional sterling silver to adapt to Argentium Silver.

Argentium® Silver (AS) glows a paler red than traditional Sterling Silver (SS) when heated to the same annealing temperature. Avoid heating AS to a red as deep as what you are accustomed to seeing in SS; that would be too hot. In practice, the glow from the AS can be hard to see, and it is easy to overheat ---especially if we anneal in a lighted room. Another reason that it can be easy to overheat when annealing is that Argentium Silver heats surprisingly quickly, since Argentium Silver does not dissipate the heat as quickly as traditional sterling or copper alloys.

It is ideal to anneal Argentium Silver in a darkened space, watching for a pale glow. When that is not possible, I find that the most accurate and reliable method is to cover the surface with yellow or purple flux (My-T-Flux or Batterns or Ronda's Purple Flux). Heat until the flux separates into droplets. One can also use dabs of paste flux as heat indicators; when the flux is liquid, but bubbly, the silver is annealed. It is also possible to use a black Sharpie Marker as a heat indicator. Scribble all over the surface. Heat until the ink fades to a ghost, and then a bit more. If you usually need to anneal in the light, try to find a time that you can practice annealing in the dark. Apply the flux and/or sharpie. Heat until you see a faint glow, then turn the lights on to see what the flux looks like. Memorize the way the flux looks, so that you can safely anneal in the light. If you are using a Sharpie, watch to see how long before the silver glows, after the Sharpie fades. Remember that it is better to under-anneal than overheat. Severely overheating can cause brittleness and cracking.

Argentium Silver retains the heat where the torch has been, rather than dissipating and transmitting the heat, the way traditional Sterling Silver (SS) and copper alloys do. It is generally best to anneal a large or long piece of AS in sequential areas, rather than trying to "heat the whole thing". For instance, when annealing a large piece of metal, or a long piece of thick wire, work one area at a time, then an adjacent area, then the next area, etc. Do not try to get the whole piece of metal hot at one time, unless it is a small piece (for example, a 1-2 inch / 2.5-5 cm square that is 24 ga/.5 mm thick is small enough that it makes sense to anneal the entire piece of metal at once.)

It is good practice to use a separate soldering surface for Argentium Silver. This avoids the possibility of the Argentium having its surface contaminated, which can affect tarnish-resistance. I like to use a broad pencil to write on the sides of the soldering board, since marker fades with heat.

As with any metal, if you are planning to do a construction in which you want metal to stay flat, I suggest air-cooling completely with no quenching to avoid warpage.

Discoloration: Argentium Silver discolors when heated is if oxygen is missing so that the germanium cannot oxidize. For instance, there is often discoloration on the side of a sheet of Argentium® Sterling which was laying against a soldering pad when heated. This discoloration is only on the surface and is fully removable with pickle.

Annealing a Coil of Thin Wire

Thin wire can be tricky to anneal, since it can be difficult to get all the wire evenly heated to annealing temperature. Thin Argentium Silver wire in a coil can easily fuse together if annealed with a torch. Here is my favorite method:

A great, low-tech way to anneal wire is to put the wire inside of a steel container and heat the container with a torch until the container glows red. I have used the containers that mints and candies often come in, as well as a tuna can (I use a can opener that leaves smooth edges, rather than sharp edges.) Before using a container for annealing, I turn on the ventilation, and heat it to glowing red, to be sure it is made of a material that can withstand the heat, and to burn off any coatings.

QUENCHING

Argentium 940 can be quenched after annealing. Though many jewelers and silversmiths quench silver in water immediately after soldering or annealing, I have developed a different routine, based on my years of teaching silversmithing and personal studio experiences. Years before I began using Argentium Silver, I observed that quenching silver alloys too soon can lead to warpage or cracking.

The Water Droplet Method

Here is the method that I developed, to know when it is safe to move or quench any sterling silver alloy —including Argentium Silver: I dip tweezers into water, and drip a little water onto the metal, or touch the wet tweezers to the hot silver. **If the water dances around on the metal in the form of a droplet, or if the water droplet stays on the tweezers, then the metal is too hot to move or quench. If the water sizzles when it touches the silver, then it is cool enough to quench**.

Note: This is my personal habit, but many people quench without problems.

SOLDERING

Just as one needs to make a mental adjustment about soldering tactics when switching between traditional sterling silver (SS) and gold, platinum, pewter, or steel, it is helpful to use a different approach when soldering Argentium Silver (AS).

SOLDER vs. FUSE

- Since fusing melts the surface of the Argentium Silver (AS), and soldering occurs at lower temperatures without melting the surface, fusing is a higher risk process than soldering. I tend to fuse early in the process of making a piece. The more time and material I have invested, the more likely I am to choose to solder.
- Is it necessary to fuse? No! If you prefer to solder, and do not feel attracted to trying fusing, there is absolutely no need to fuse.

HEAT CONDUCTIVITY

The most important thing to remember with Argentium Silver is to forget about trying to heat a large piece of metal all at once, or trying to have all the solder flow at once. Argentium Silver does not conduct heat in the way of traditional sterling alloys and copper alloys---the heat tends to stay where the torch has been. If you have experience with soldering gold, pewter, or steel, you may find that they conduct the heat similarly. **After giving the entire piece a general heating, I concentrate the heat on the area of the solder joint, and work my way along the seam as the solder flows.**

Solders

- Argentium Silver solders contain germanium, so they are slower to tarnish than traditional silver solders, and whiter in color. Their melting temperatures are approximately equivalent to traditional silver solders. There is no harm in using traditional silver solder with AS---the color match and tarnish resistance simply are not as good.
- In the U.S., Argentium sheet and wire solders are available in Easy and Medium.
- In the UK, Europe, and Australia, Argentium wire solders are available in Easy, Medium, and Hard.
- Argentium paste solder is available in the U.S., the UK, and Europe in Hard, Medium, & Easy. I like to apply paste solder inside hollow forms for a neat, clean seam on the outside.
- Since AS does not transfer heat the way that traditional SS does, it is often not as necessary to use a sequence of different solders, since the previous joint is not likely to re-flow unless it is very close to the next joint.

Soldering Boards/Blocks

I like to use soldering boards that are highly heat reflective, such as Solderite (but not for fusing) and Rio Grande's Ceramic Block for Platinum. Firebricks and honeycomb blocks are also quite heat reflective, but their rough surface can be regrettable if you overheat. Many people prefer charcoal.

Fluxes for Soldering

- Most fluxes work fine for soldering AS 940, so use whatever you are accustomed to. I suggest avoiding paste flux with hard solder---at that temperature, paste flux tends to burn out, and cause firescale/firestain in both AS 940 and traditional SS. My personal preference is for Rio Grande's My-T-Flux or Ronda's Purple Flux. If you are in the UK or Europe, I suggest Argentium Flux from Cookson.
- **Flux only the seam when soldering.** It is undesirable to flux all the surfaces, since that prevents formation of germanium oxide. By only fluxing the seam, the germanium oxide will grow thicker, making the Argentium Silver more tarnish resistant.

SOLDERING PROCESS

Cleanliness

I find it helpful to clean both the metal at the joint, and the solder. I like using 3M's Scotch Brite pads, but pumice with water, scrapers, Penny Brite, and sandpaper also work. Being methodical and thoughtful leads to more consistent success in soldering.

Application of Flux

Use a brush to flux the seam, then heat the flux *gently* to dry it to a white powder. If this does not create a white coating along the seam, dab more flux on the bare areas, and gently heat again. Don't let the brush be *too* wet, or it can liquefy all the dried flux. Ideally, the metal is hot enough that the flux dries immediately upon touching the metal. Very brief applications of heat alternating with dabs of flux works best. If the metal discolors, that indicates that you are overheating. Continue to alternate between applying flux and heat until the seam has a white coating. Natural bristles tolerate heat better than plastic bristles.

Solder Placement

- I put the pallions of solder into a little dish (yogurt lid, pill box, etc.) and flux the solder. I feel that the flux protects the surface--If the solder oxidizes, the solder has a higher melting temperature.
- I prefer to use a few large pieces of solder rather than many small pieces---less time placing them, and fewer places that might need clean up. However, I do not recommend trying to flow solder across VERY large distances, since we don't use the "heat the whole thing" strategy with Argentium Silver.

Torch Heat

- Though it is helpful to not try to "heat the whole thing" when working on a large piece of AS, do remember that the metal melts the solder, so the objective is to get both pieces of metal to the same temperature. If one part is larger or thicker, put the torch heat on that part more. Use the condition of the flux on the two sides of the seam as a temperature guide. It may be helpful to put a few dabs of flux a half-inch or so away from the seam as additional temperature indicators.
- After a bit of overall heat, I start at one end, and heat along the seam sequentially. Keep the torch moving in a back and forth or circular movement with the torch over a small area. When the solder flows in that area, move the torch flame to the adjacent area and heat until that flows, then move to the next area, etc. The first area takes the most time, and then each subsequent area takes less time. With a 1" diameter bead, I find that the solder flows as fast as I can turn the soldering turntable. A larger piece heats more slowly.
- TIP: If the solder melts into a ball, that is an indication that the heat is being focused too much on the solder, and not enough on the metal around it.

Argentium 935 was fragile when red-hot, and one had to be careful not to move or nudge the silver while soldering. Argentium 940 is much "sturdier" when red hot. It can be handled similarly to SS when soldering.

Solder Melt and Flow

Sometimes, solder does not melt completely, even though the solder has flowed along the seam. This is a phenomenon that can happen with any silver solder; the term for the partially melted pallion of solder is a "skeleton". This usually happens because the person is heating tentatively, resulting in the lowest temperature components of the solder flowing before the entire piece of solder flows. If this occurs, do not keep heating in hopes of having the entire piece of solder flow. Clean up the excess solder and heat with a larger flame and/or more boldness next time.

Flat Constructions

Sagging was a problem with Argentium 935. Argentium 940 behaves more like SS, with less sagging during soldering.
Note: During fusing, the metal partially melts, so it is important that the metal be well-supported.

Quenching

- Argentium 940 can be quenched after soldering, just like SS. Personally, though, I like to let it cool a bit, and then use the "Water Droplet Method" that is described under Annealing.
- As with all metals, I air-cool flat pieces completely because quenching warps flat metal. It is beneficial to cool flat pieces on a flat surface (I often slide flat pieces onto a steel plate to cool).

Pickle Pickle and rinse to remove any oxides, just as you would any other metal after silver soldering.

PICKLE

- Use whatever pickle you are accustomed to. My preference is for sodium bisulfate, which is commonly available as a swimming pool chemical and commercial jewelry pickle. Some people like to use citric acid, or vinegar and salt.
- In my studio, I use one pickle pot for all metals—silver, copper and gold—and have had no trouble. Blue pickle has a lot of copper in the solution, but still can work very well. As always, it is important to remember to keep iron (tongs, tweezers, and steel wool) out of the pickle pot, as that can cause the copper that is in the pickle solution to plate onto the silver. If you ever do get copper plating on your silver, you can use abrasives or hydrogen peroxide pickle to remove the copper from the surface.

MELTING THE END OF A PIECE OF ARGENTIUM SILVER WIRE INTO A BALL

The ball that is created by melting an end of Argentium Silver is generally smoother than the typical ball melted on the end of a traditional sterling wire. Most people have no difficulty transferring their technique of melting a ball on the end of a wire to Argentium® Silver. Here are a few tips you can try if you have difficulties:

• Clean the wire to remove any oil left from drawing down. I like to use Scotch-Brite™ pads. (Don't use steel wool, which has oil to keep the iron from rusting.)

- Remember to use as small and as hot a flame as possible, as quickly as possible, so that the heat does not have time to travel up the wire.
- For large wires and/or large balls, try holding the torch flame just below the end of the wire---- so that it does not affect the wire next to the ball as much, which can make it thin.
- Although flux is not always necessary, it can be helpful.



FUSING AND GRANULATION WITH ARGENTIUM SILVER

Argentium Silver (AS) is wonderfully easy to fuse. My understanding of why AS is easier to fuse than Fine Silver (FS) is that because FS is a pure metal, it has a specific temperature point at which it melts and fuses. Alloys (a mix of 2 or more metals) have ranges of melting temperatures, and AS has a range of temperatures at which it melts and fuses. This temperature range makes Argentium Silver "forgiving" and relatively easy to fuse.

Fusing is an option with Argentium Silver that many people enjoy, but there is certainly no requirement to fuse AS.

Advantages of Fusing

-After fusing, the two pieces of metal have become one---you don't have to worry about the joint re-melting during the next fusing.
-Fused joints are wonderfully neat ---there is little, or no clean-up needed to a fused joint.
-Fusing can be quick and efficient compared to soldering since the solder does not need to be placed. Soldered joints tend to need more "clean up" than fused joints.

When to Fuse? When to Solder?

Since fusing melts the surface of the metal, and soldering occurs at lower temperatures without melting the surface, fusing is a higher risk process than soldering. I generally fuse early in the process of making a piece. The more time and material I have invested, the more likely I am to choose to solder. **All fusing should be done before soldering**, since fusing is done at temperatures higher than silver solder's melting temperatures.

FUSING PROCESS

Prepare the joint so that the metal is clean and meets well.
The joint does not need to be "perfect", but the better the fit, the easier it is to make a nice smooth joint, which does not show. Metal will not tend to jump across a gap. It is best if the two parts touch.

Use a heat-reflective soldering surface.

- My favorite for fusing is charcoal. Vermiculite, firebricks, and other surfaces work, too.
- Avoid fusing or granulating over Solderite, which tends to cause a rough surface to develop where it melted during fusing.
- It is ideal to use a block that is used only for AS, to avoid contaminating the surface, thus preserving the tarnish-resistance.
- Use a smooth surface, because it is common to have a bit of texture transfer from the soldering board, especially if the metal is over-heated.
- Since the silver is being heated to the point of melting, it may slump if it is not supported.

Torch Fuel

- Avoid using oxy-acetylene or oxy-propane. The high heat tends to cause a rough surface in the fused area.
- Lower temperature flames produced by acetylene-air, propane, and butane leave smoother fused surfaces.

Flux

- Though it is possible to fuse dirty metal that does not touch well, without flux, those are not ideal conditions for consistent success. The purpose of flux is to keep the metal clean, and to help metal flow.
- Jump rings, however, can usually be fused without flux.
- My favorite fluxes for AS are Rio Grande's My-T-Flux and Ronda's Purple Flux, but Batterns and Prip's Flux also work well. For people in the UK or Europe, I recommend Argentium Flux from Cookson.
- You only need to flux the joint. However, I usually flux the entire surface when fusing or granulating, since flux is a good temperature indicator. I watch the flux to help me judge when the silver is near fusing temp.

How to apply liquid flux so that the entire surface is covered:

- Clean the metal. A greasy surface repels liquid. Metal that has been heated, pickled, and rinsed is clean. Heat burns up grease and finger oils. Pickle removes scale and oxides, but not grease. Other ways to clean the surface include: scrub with a scotch brite pad; scrub with pumice and water; scrub with Penny Brite. Metal is grease-free if water "sheets off" the surface, rather than beading up.
- Apply the flux with a brush or sprayer, and then heat the flux *gently, with a soft flame,* to dry it to a white powder. Use a smaller flame than you will use for fusing. If there are bare areas after the flux dries, lightly dab or spray more flux on the bare areas, and gently heat again. Don't let the brush be *too* wet, or it can liquefy all the dried flux. Ideally, the metal is hot enough that the flux dries immediately upon touching the metal. Brief applications of heat alternating with dabs of flux works best. If the metal discolors, that indicates that you are overheating. Continue to alternate between applying flux and heat until the metal has a white coating. Tip: I find that natural bristle brushes handle heat better than plastic bristles.
- It is helpful to flux the entire exposed surface. Two reasons:
  - The flux is a good indicator of the temperature of the metal.
  - Repeated high temperature fusing gives Argentium a crusty surface --- a thick layer of germanium oxide. If the surface is fluxed it stops this from forming and makes fusing easier if you need to fuse on the same surface again.

See The Joint Do what is necessary for you to see the joint(s) when the metal fuses.

- I set things up so that the joint is near my eye level. I do this by raising the soldering surface, lowering the chair, or both.
- I wear a magnifier so that I can see the joint well. I have found that it is not always enough to see the surface liquefy. But, if I see the joint (or some of the joints) flow, then I KNOW that there is a strong fused joint.

Putting the Torch Heat on the Argentium Silver
Remember that AS does not conduct heat in the way of traditional sterling alloys and copper alloys---the heat tends to stay where the torch flame has been. If you have experience with soldering gold or pewter or steel, you may find that they conduct the heat similarly. So, whether I am fusing or soldering, I give the metal a bit of overall heat, and then focus on one area at a time. When that area fuses, I move the torch to an adjacent area. Put more heat on the largest piece of metal, since both the large and small pieces of metal need to reach the same temperature, in order to fuse.

Heat the areas adjacent to the joint.

- Take the time to be sure that everything is positioned as you want it. It is not advisable to try to move a piece of AS when it is near the fusing temperature. Since the metal is nearly melting, it is quite fragile.
- All the parts to be joined need to reach the same temperature, so put more heat on the larger parts.
- I don't try to "heat the whole thing" when working with AS. After a bit of overall heat, I start at one end and heat areas sequentially. Keep the torch moving in a back and forth or circular movement with the torch over a small area. When the metals fuse in that area, move the torch flame to the adjacent area and heat until that flows, then move to the next area, etc. The first area takes the most time, and then each subsequent area takes less time. If the metal is not a circle or rectangle, start at the smallest area, and work towards the larger end of the shape.
- Watch the flux---When the flux separates into tiny droplets, then you know that the metal is almost at fusing temperature.
- When fusing, watch the surface of the silver melts and looks liquid. Some people say it looks like mercury.
- When fusing onto sheet, watch the surface of the sheet---it needs to be molten for fusing to happen. It will not fuse if the granules or wires melt, but the sheet does not.
- If the wire or granule melts, but not the surface of the sheet, that means that you need to move the torch more quickly around a larger area of the backing sheet, and avoid putting the heat directly on the smaller part to be fused.
- When the metal fuses, the joint looks like it has been soldered---there is a "fillet" of molten metal at the joint. That is what I watch for, whether I am fusing a joint in a ring, or a granule to sheet.
- If the metal is still clean, and the flux in good condition, you can bring it back to fusing temperature, in order to be sure that you have a good joint. It is also perfectly ok to re-do the whole thing after pickling and rinsing, if the joint did not fuse well.

Since you just melted the surface of the silver, the metal is fragile. Let the metal cool a bit before touching or moving it. It is okay to quench at "black heat" but quenching at red heat may result in cracking or breakage. In practice, it can be difficult to assess when black heat has been achieved. In my experience, it is okay if the water hisses and sizzles when the silver is quenched, but the piece was too hot if the water seems to boil or explode. I use the "Water Droplet Method" described in the annealing section. As with all metals, I air-cool flat pieces completely because quenching warps flat metal. It helps prevent warpage of a flat piece to cool it on a flat surface.

Check the Joint(s). After the metal has cooled a bit, I use tweezers to check whether the granule or joint truly fused. If the flux and metal are still clean, you can re-heat if the parts did not fuse together. Otherwise, pickle, re-flux, and re-fuse.

Test the joints with your fingers. Test granules with a fingernail.

Use Hot Water to Remove Flux if you want to have a perfectly smooth surface. This step is optional. If the flux is uneven on the surface of the silver, the spots of thick flux may act as an etching "resist". The pickle will have more time to work on the bare metal between the thick spots, creating a blotchy, uneven surface. If this happens, use 3M Radial Bristle Discs.

Pickle Surface discoloration is normal. Pickle and rinse well. Re-fuse if necessary.

HARDENING

Hardening is not a requirement for AS. It is an option that makes the metal sturdier, while increasing the tarnish resistance at the same time. Finish all fusing, soldering, and annealing. Clean the AS and avoid touching with fingers before hardening.

- Hardening works on air-cooled silver, or partially work-hardened AS. Though maximal hardening is achieved if the AS is annealed, quenched at black heat (see annealing handout), and then hardened, I do not bother with that step in my own work.
- The hardened Argentium Silver takes a polish better than un-hardened AS.
- Temperatures: toaster oven, oven, or kiln can be used. Normal safety practice suggests that it is best to use a kiln or toaster oven that is not used for food.
  - 400-572°F (205-300°C) for a minimum of 10 minutes. Remove from oven/kiln. Air cool or quench.
  - Temperatures in between work as well.
  - Surprisingly, it may work best to put the AS into the kiln or toaster oven when the oven is already at the correct temperature.
  - Add a bit of time to allow the object to come to temperature. A large object will take more time.
- How to: Do not enclose the Argentium® Sterling when heat-hardening. Exposure to oxygen is needed to create the germanium oxide that prevents tarnish. I usually use a glass baking dish or a clean soldering board. I think that a stainless pan would likely be ok, but I avoid aluminum, since it has potential for contaminating silver.
  - Though an oven does not need to be spotless, it should be fairly clean. If there are food drippings on the bottom of the oven, the smoke resulting from the burning food may discolor the metal.
  - Using a kitchen oven, in which food is also cooked, has no known harmful effects. Nevertheless, it is prudent to use a separate toaster oven or kiln for hardening.
  - Pickle after hardening to remove discoloration (and copper) from the surface.
  - Other metals: The hardening process will not have any harmful effect on fine silver, sterling silver, gold or copper alloys that are used in combination with Argentium Silver. Discoloration is removed with pickle.
- Re-do: Should the need arise, the alloy can be annealed and then re-hardened.

FINISHING

File, sand, and polish, using the usual processes and methods that you are accustomed to.

Take the silver to a rouge finish, if that is your preference. Some good satin finishes: a brass brush or bronze* wool *with soapy water,* or scotch brite, or radial bristle discs. (*I like to use bronze wool, rather than steel wool. Steel wool can cause rust, and can contaminate pickle.)

- If you like a tumbled finish, it has been found that a commercial tumbling solution works better than dishwashing liquid.
- For the best tarnish resistance, keep separate finishing tools for AS if that tool could smear the prior metal onto the surface of the Argentium Silver. In my studio, that means that I keep **separate buffs for Argentium Silver**, and another set of buffs for gold.
- **Remove all traces of grease after polishing, for tarnish-resistance. Greases are organic substances that break down with time and discolor the silver.**
  - Metal is grease free when water "sheets" off after cleaning, rather than beading up on the greasy surface.
  - Consider using one of the new water-soluble polishing compounds, which may be easier to remove, and less greasy.

Ultrasonic If you use an ultrasonic, use a good commercial solution rather than soap and ammonia. Solutions should be neutral in pH (pH6–pH8) for any sterling silver, whether traditional or Argentium®, since high-alkaline liquids attack all sterling alloys. The metal can look etched or discolored, especially if the ultrasonic is run very hot (over 120°F/49°C). Solutions labeled as neutral are not necessarily so. Use your own pH test strips to check the pH. (Disposable paper strips are available at pharmacies and aquarium/pet stores, as well as on the web.)

- Avoid de-ionized water, which can yellow the surface of the silver. Most tap waters are fine.
- I have also been told that an ultrasonic, if run with too much force, can attack any metal's surface. A good practice is to soak a piece in the ultrasonic for a few minutes before turning the machine on. This loosens the polishing compound or dirt so that the metal needs less time exposed to the ultrasound.

- **Tips for finishing fused work:**
  - Cup burs can round off a granule that is not as spherical as desired.
  - Radial bristle discs are excellent for smoothing around fused wires or granules and getting an even finish.
  - If you plan a polished finish, use radial bristle discs after each fusing and pickling, to keep the metal smooth.

HEAT TO INCREASE THE TARNISH RESISTANCE (Optional) Neither pure silver, nor any silver alloy is tarnish-proof. With heat however, we can make Argentium Silver highly tarnish resistant. At temperatures over freezing, the Germanium atoms get excited, and grab oxygen, creating a layer of germanium oxide on the surface. Germanium oxide is invisible to the naked eye. GeO_2 prevents oxygen from passing through silver, thus preventing tarnish and firescale.

- Heating for 2-4 hours at 212°F (100°C) after all finishing increases the tarnish resistance without discoloring the metal.
- Do not enclose the Argentium® Sterling when heating. Exposure to oxygen is needed to create the germanium oxide that prevents tarnish. I usually use a glass baking dish or a clean soldering board. I think that a stainless pan would likely be ok, but I avoid aluminum, since it has potential for contaminating silver.

***ADD THIOL* to the surface for additional tarnish resistance (Optional)**

- Thiol is in Argentium Silver Care Cloth, Goddards Long Shine Silver Cloth and polishes, and Tiffany mitts.

This chemical seems to bond with AS, to prevent tarnish, and resists abrasion.

Silver Glory (optional) is another product that can be added for extra tarnish resistance (available from RioGrande.com). Be sure that the metal is grease-free first. I find that it works best to use rubbing alcohol rather than water when making the solution. Silver Glory is not wear resistant; it is ideal for when when an object will be on display for a lenthy time.



PATINAS Any chemical normally used to darken silver will work on Argentium Silver. Use your normal procedures. It might take longer than traditional SS, or need a slightly stronger solution.

HALLMARKING & TRADEMARKS IN THE U.S.A.

- When marking a piece made with Argentium Silver in the U.S., the only legal requirement is to stamp it as "925" or "sterling silver," since Argentium is sterling silver.
- Many people choose to mark it "940"; 940 stamps are available from Rio Grande. If you hand-engrave your marks, you might choose to mark your work "A940" or "Argentium Silver".
- If you want to use a flying unicorn, which is the logo for Argentium, you need to register with Argentium International. There is no charge for registering. Here is the link to the trademark registration page on the Argentium Silver web site: http://www.argentiumsilver.com/brand-and-tm-licence... /react-text . Registration is required because Argentium International has to show they are protecting their brand. If they do not do this they risk losing control of the brand at some future time.
- Large manufacturers may wish to contact Argentium® International Ltd. about their partner program, for access to the artwork for the logo for laser marking, co-advertising, etc.

In the UK, 940 Argentium is marked 925. Usually, the trademark of the flying unicorn is added.

SETTING STONES

- If the stone is a synthetic or diamond, you can generally set the stone(s) and finish completely before heating for hardening and/or tarnish resistance
- For other stones, you might choose to harden before setting. Argentium prongs and bezels are not brittle from hardening. They are stiffer than annealed AS, but softer than 14KYG.
- Fine silver and 22K gold bezels are still soft after the hardening process.

- Remember that hardening is an option, not a requirement. You can choose to skip hardening, and simply heat gently after all the finishing, to increase tarnish resistance. The optimal temperature for this is 212°F (100°C) for at least two hours.
- If the stone is very heat sensitive, you can choose to use a thiol-containing cloth or liquid (e.g.Goddards) to increase tarnish resistance, and protect the surface. GeO_2 will form underneath the thiol, over time, adding further tarnish resistance.
- **Which stones are heat-tolerant?** Here are two sources with info about stones and heat tolerance:
  - https://studleysjewellers.co.uk/services/gemstone-guide/
  - https://www.gia.edu/gems-gemology/summer-1987-gemstone-durability-martin

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WORKING PROCEDURES/ SEQUENCES

A possible work sequence:

- Saw and form the metal
- Solder and pickle
- Optional: Harden
- Polish or satin finish
- Patina if desired
- Optional: Increase tarnish resistance by heating at 200°F (100°C) for 2-4 hours
- Optional: Use Goddard's™ for added protection and to bring back any shine that was lost due to heating and pickling

A possible work sequence for a piece with a stone:

- Saw, drill and/or form the metal
- Solder and pickle
- Optional: Harden. This may be skipped, if you want to avoid hardening an Argentium bezel or prongs. (Fine silver or gold settings are not affected by the hardening process.)
- Pickle and rinse
- Finish---polish or satin finish
- Patina if desired
- Optional: Increase tarnish resistance by heating at 200°F (100°C) for 2-4 hours (You may choose to do this after setting the stone if the stone can tolerate the heat.)
- Set the stone
- Optional: If the stone can tolerate the heat, consider increasing tarnish resistance by heating at 200°F (100°C) for 2-4 hours
- Optional: Use a thiol-containing cloth or dip added tarnish resistance, such as Goddard's Long Shine Cloth

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RETICULATION

A few people have successfully reticulated, but a reliable protocol has not been established.



KUM BOO

I use the same techniques to do Kum Boo with Argentium Silver that I use for fine silver or traditional silver, with the exception of surface preparation. I find that it is usually desirable to heat and pickle the AS one time before applying gold foil. Though the surface may still darken during application, the bond seems to be fine.


torch fired AS



transparents over opaques and foils---fired in kiln


AS frame, wires, & setting with enamel over fine silver

ENAMELING

Argentium Silver can be enameled. Opaque enamels work just fine. The best success with transparents on AS 935 has been with torch enameling. Kiln enameling on AS 935 tends to reduce the transparency with multiple firings. One way to take advantage of Argentium Silver's advantages is to fuse a frame, then put an opaque down, and use transparents over the opaque, or over foils. Another way I like to use Argentium Silver is to fuse a frame over fine silver, and enamel as usual. AS 960 works well for transparents, but in the US, sheet and wire are not available in 960. Experiments are in process for Argentium 940.

FINDINGS

Findings are available. Here's a link to a list of suppliers in the world: https://www.argentiumsilver.com/artisan-supplies

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CASTING

I don't do my own casting, so I recommend the technical information pdfs at https://www.argentiumsilver.com/user-guides-downloads Note that casting grain is available in 940 and 960. Sheet and wire are referred to as "millforms".

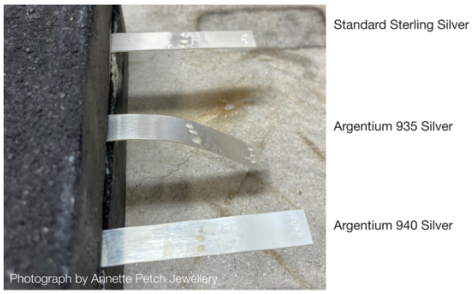
QUESTIONS

Traditional SS? or AS? How can I tell which it is?

First sand, scotchbrite, or otherwise abrade the surface to make sure there isn't a fine-silver or germanium oxide surface coating. Then heat the metal with a SMALL torch flame, being sure to take the flame off the metal occasionally to let oxygen at it. If the metal is traditional sterling, it will turn black and stay black. If the metal is Argentium, it may turn black, but as you keep heating, the germanium and germanium oxide do their thing, and the metal will turn whitish again. Traditional sterling stays black. It can be helpful to test a known piece of each alloy at the same time, to compare results.

Is it Fine Silver? Or is it Argentium Silver?

Clean and heat the metal, as described above. Fine silver does not discolor when annealed or melted.



How can I test whether a piece of Argentium is 935 or 940?

- Method A: Stack two soldering blocks or charcoal blocks. Put a strip of 935 and the mystery AS so that they are as in the above photo. Heat both until the 935 droops. If the mystery metal does not sag, it is AS 940.
- Method B: Cut a piece of AS 935, and a piece of the unknown AS. Put flux on each, and heat until the flux is fluid. Then, test how well each stands up to poking and stressing. Compare. The 940 will be more resilient to poking and pressure.

Scrap?
You don't need to separate AS scrap from traditional SS scrap. It is all sterling. If anything, the Ge will improve the SS. However, separating may get you a better price for the scrap, since AS has more silver.

I've fallen in love with Argentium Silver! What do I do with all the traditional Sterling that I already have?
Option A: Combine it with AS, to use it up. Many people simply solder them together. There will be differences in tarnish resistance, and it could be a little tricky to deal with the way they conduct heat differently, but many people have told me they have no problem with combining the two alloys.
Option B: Sell your traditional SS to someone who does not like AS at a price that is between scrap value and retail. This can make both parties happy.

GERMANIUM AND ARGENTIUM® SILVER

What is germanium?
Germanium (Ge) is an element, named for its discovery in Germany in 1886. It is chemically similar to tin and silicon. Metalloids have both metallic and non-metallic properties. Metalloids tend to be semiconductors rather than conductors. Germanium is a semiconductor, with electrical properties between those of a metal and an insulator. Because germanium is less conductive than many other metals, Argentium Silver can be fused and welded more easily.

Pure germanium is crystalline, gray and lustrous. It is very brittle; it shatters easily with a hammer. Interestingly, it seems to have a bleaching characteristic when alloyed— the alloys made with it look more white and less yellow.

How did germanium come to be alloyed with silver?
A company named Metaleurop, whose primary product was zinc, found that they had a lot of germanium as a by-product of refining zinc ore. In hopes of finding a market for germanium, Metaleurop sent samples and inquiries to people in many different areas of expertise, including Peter Johns at Middlesex University in the United Kingdom.

The germanium that Metaleurop gave Professor Johns to experiment with was mixed with copper. When he melted this alloy, he noticed how cleanly and easily it melted and cast—which is unlike pure copper. From this observation, Peter Johns realized that the germanium was protecting the copper from oxidation.

How does germanium prevent firescale?
Germanium is an "oxygen grabber". Ge is more aggressive about grabbing oxygen than copper. The germanium combines with oxygen, to make Germanium oxide, GeO_2. GeO_2 prevents oxygen from passing through, thus preventing tarnish and firescale. Silver is the only non-ferrous metal that allows oxygen past the surface, so silver alloys are the only metals we use that have oxidized copper under the surface (firescale). Since oxygen cannot get inside the metal, Cu_2O (firescale) cannot form. Argentium may discolor from soldering or annealing, but the discoloration is only on the surface, and it comes off in pickle.

Firescale---what it is, and why it occurs
Silver is one of the few metals that allow oxygen to penetrate the surface. During annealing or soldering, oxygen attaches to the copper under the surface of traditional sterling silver--- this is firescale—also known as firestain (Cu2O, or cuprous oxide). This dark layer is under the surface of regular sterling silver, and does not come off in pickle. Firescale can be *removed* by polishing, strong acid, or electro-stripping. Firescale is often *covered* by plating or by depleting the copper from the surface through repeated heating and pickling (often called "depletion gilding" or "bringing up the fine silver"). Note: The oxide that occurs on the surface of both traditional sterling and Argentium silver after heating, that is removed by pickle, is cupric oxide (CuO).

What Else is Germanium Used For?

• Infrared night vision goggles
- Fiberoptic cable. This application provides the largest use for germanium.
- Lenses. Night vision systems are the second biggest use for Germanium.
- Flutes. Landell Flutes and other flute-makers are now making flutes of Argentium® Sterling Silver. They feel that their projection and tone are better because of the increased hardness, which is similar to an old age-hardened sterling flute.
- As a polymerization catalyst in the making of plastic water bottles. This is the third largest use. It is considered safer than the alternative, antimony trioxide.
- As a phosphor in fluorescent lamps.
- Germanium transistors are still used in stomp-boxes by musicians who wish to reproduce the distinctive character of fuzz boxes from the early Rock & Roll era.
- As a transistor element.

OXIDES AND TARNISH

• Metalsmiths typically think of an oxide as being black, but this is not always the color of an oxide. Glass, for instance, is silicon oxide—it's transparent.
• We rarely see silver oxide. It is a light to medium gray color—it is that pale gray color we see if we use nitric acid to etch or strip sterling silver.
• Sterling silver forms several oxides, including cuprous oxide and cupric oxide. Cuprous oxide (Cu_2O), commonly called firescale or firestain, forms within traditional sterling silver. Cupric oxide (CuO) is the dark surface film that is easily removed by pickle.
• Silver (the element) is unusual in that it lets oxygen in. That is why other metals have a surface oxide only, not the underlying firescale problem that traditional sterling silver has.
• Germanium oxide (GeO_2) is somewhat transparent and whitish.
• Tarnish is not truly an oxide; it is silver and copper sulfide. Tarnish occurs when silver is exposed to sulfur-containing compounds. The sulfur may be in the air or it may be in a chemical that is applied to the silver. There can be many contributing factors that can cause an alloy to tarnish: environmental conditions, perfume, deodorant, chemicals used in manufacture, solder temperature, packaging, skin conditions, water, sulfur or chlorine.

LEARN MORE

- Argentium® International Ltd. Is headquartered in the United Kingdom. Technical information, as well as information about the company are available at https://www.argentiumsilver.com/
- Technical assistance is available via e-mail at info@argentiumsilver.com
- Rio Grande® is a distributor of Argentium Silver. Rio Grande's technical staff can answer many questions that you may have about Argentium Silver via phone or email.
- I would love to hear about any innovations or discoveries made about Argentium Silver and/or its use! I can be contacted by email at cynthiaeidmetalsmith@gmail.com. See my work at www.cynthiaeid.com
- Join the Facebook group Argentium Silver Artists Forum to learn more and ask questions.
- Purchase and watch Ronda Coryell's DVDs. Clips are available on YouTube.com
- Purchase and watch Cynthia Eid's videos from www.interweave.com
- Take a workshop from Cynthia Eid or Ronda Coryell

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