Working with Argentium® Sterling Silver—Tips & Procedures

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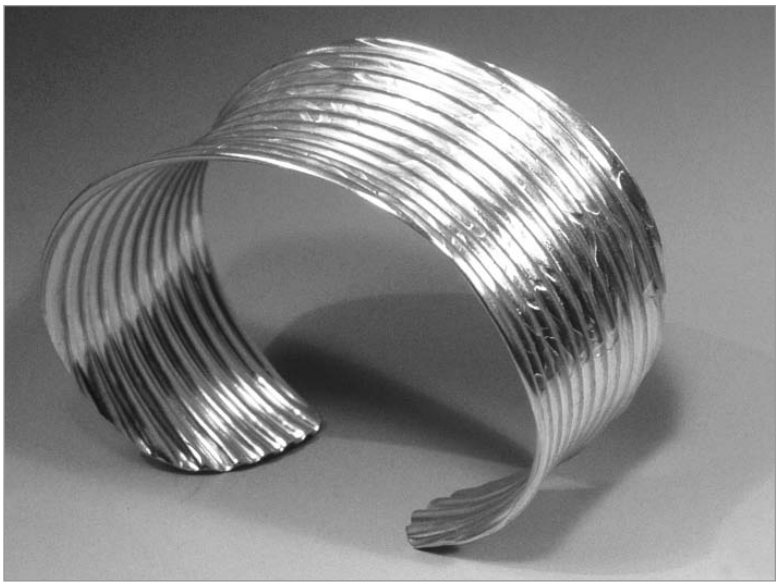


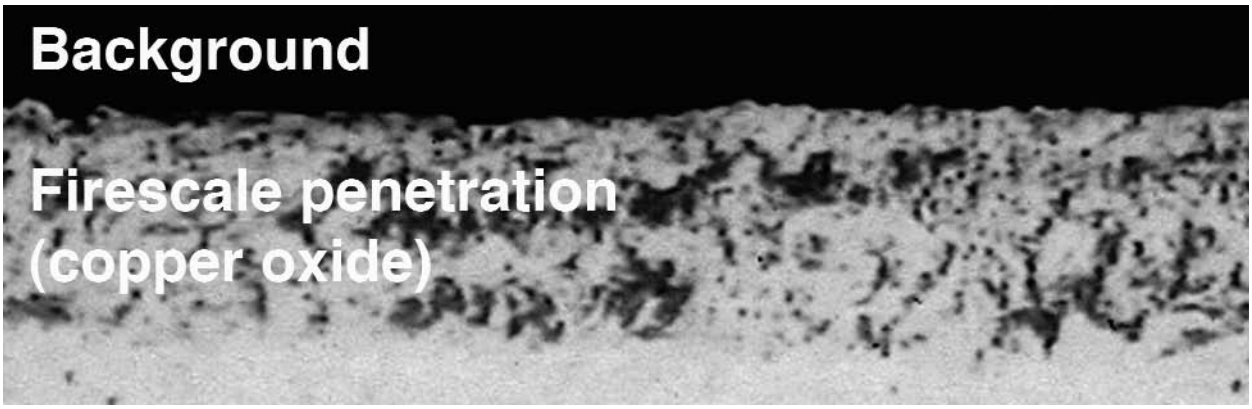
Argentium® Sterling Silver is a patented and trademarked alloy that is at least 92.5% pure silver, just like traditional sterling silver. What makes it different from traditional sterling silver is that a small amount of germanium replaces some of the copper that is usually the other 7.5% of sterling silver. Peter Johns, a professor of silversmithing at Middlesex University in England, invented Argentium® Sterling Silver in 1996. When I heard about this firescale-free sterling silver sheet, I sought out sources. I finally got my hands on some about six years ago and hoarded whatever I could find, as I fell in love with the material's working properties.

Argentium® Sterling Silver

- is highly tarnish-resistant.
- has greater ductility and malleability than traditional sterling silver.
- can be precipitation-hardened using a kitchen oven.
- can be fused and welded.
- does not firescale.

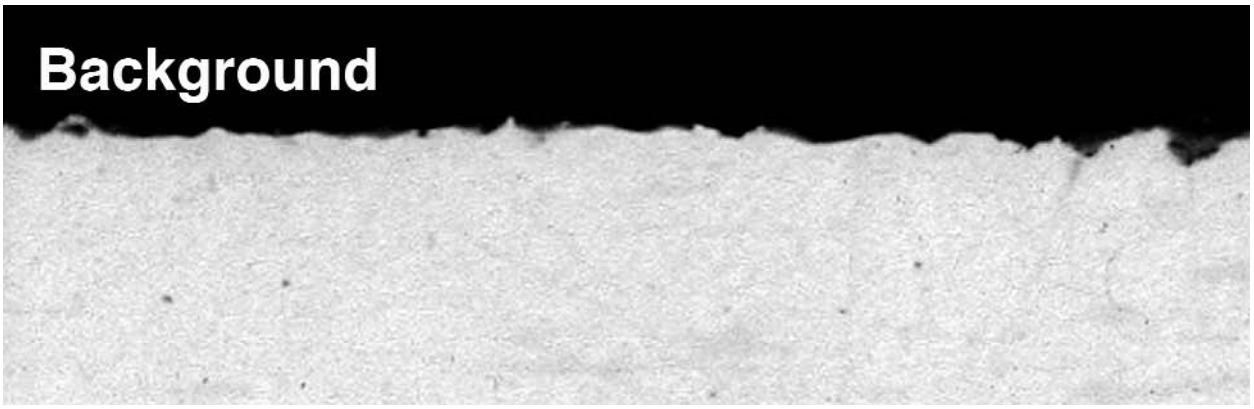
Despite its many advantages, working with Argentium® Sterling Silver is not very different from working with traditional sterling silver. It is useful, though, to know as much as possible about the differences.

650X magnification



A microscopic cross-section of traditional sterling silver that has been annealed in a kiln at 1076°F (580°C) for one hour. In this sample, firescale (cuprous oxide) penetrated 20–26 microns. There is also a surface layer of black cupric oxide. 650X

650X magnification



The Argentium® Sterling Silver sample was exposed to the same heat and temperature as the traditional sterling silver above. The cross-section shows that there is no firescale, only a cupric oxide (black) layer on the surface, 1–2 microns in depth, which can be removed by pickling.

Annealing

Argentium® Sterling Silver has a melting point around 60 degrees lower than traditional sterling silver. Similarly, it has a lower annealing temperature range of 1050°F to 1150°F.

Argentium® Sterling Silver glows a paler red when heated to annealing temperature. In practice, I find the glow hard to see, and it is easy to overheat if I anneal in a lighted room.

Annealing and soldering in the dark make it easier to avoid overheating. When that is not practical, I use dabs of paste flux as a temperature indicator; when the flux is fluid, but still a bit bubbly (not yet as runny as it looks when silver solder is ready to flow) I figure the Argentium is annealed. It's nice to have as many clues to watch for as possible. Two more signs that the metal is approaching annealing temperature are: the ink from a permanent marker fades, and the silver (if it has been brass-brushed or otherwise abraded) turns whitish. The ideal method is to anneal brass-brushed Argentium Sterling in the dark with dabs of flux and a few pen marks, and then turn on the lights and take a look; this way, you'll have your own visual references of what your flux, ink and metal look like at Argentium's annealing temperature, so that you know what to watch for when annealing in light, if darkness is not practical.

It is good practice to use a new, clean soldering board for Argentium® Sterling and to label it prominently to keep it separate from the surfaces that are used for other metals, especially copper alloys. This avoids the possibility of the Argentium having its surface contaminated by oxides in the bricks, which can create stains on the metal or other problems, such as tarnish.

Quenching

Argentium® Sterling Silver retains heat longer than traditional sterling silver. **Please Note:** It is important to wait for any visible red heat to disappear from the alloy before quenching (this is best judged in a darkened area, of course). In practice, if unable to work in the dark, wait about 10 seconds to quench a small piece or up to a few minutes to quench a large piece. If in doubt, I suggest waiting longer to be safe. The worst that will happen by waiting is that the metal will be less soft. I find that it is still wonderfully ductile and malleable, even if I completely air-cool it without quenching. If I were doing soldered constructions that I did not want to warp, I would air-cool, not quench. In fact, I rarely quench any metal—it is my general practice to avoid shocking any metal that I am working with—unless it is one of the gold alloys that require quenching or a steel tool that I am making. On the other hand, note that the sooner the Argentium is quenched, the softer it is; therefore, you may choose between softness and risk of shock-cracks or warpage according to the situation and your personal sense of concern about those factors.

Melting Temperatures

Traditional sterling silver has a solidus melting temperature of 1475°F (802°C) and a liquidus flow point of 1650°F (899°C). The solidus melting point of Argentium® Sterling Silver is 1410°F (766°C); the liquidus flow point is 1610°F (877°C). (Solidus is the temperature at which a metal starts to melt; liquidus is the temperature at which a metal is fully melted.)

Soldering

Because of Argentium® Sterling Silver's lower melting temperature, hard silver solder is not recommended.

I have found that, when I use hard silver solder, say, for a short seam in a complex construction, the metal usually shows signs of having come close to melting. Medium, easy or extra-easy traditional silver solders are safest.

Germanium-containing Argentium® Sterling Silver solders have been developed.

I like their color-match, as well as the fact that they flow well, with good capillary action. Their melting temperatures are approximately equivalent to medium, easy and extra-easy silver solders. Available as wire and sheet, they are called Argentium® Hard, Argentium® Medium and Argentium® Easy. Argentium Easy melts at 1146°F (619°C) and flows at 1253°F (678°C). Argentium Medium melts at 1237°F (670°C) and flows at 1319°F (715°C). Argentium Hard melts at 1272°F (689°C) and flows at 1355°F (735°C).

The most important thing to remember when soldering Argentium® Sterling Silver is that it does not conduct heat the way that traditional sterling does.

Therefore, I approach soldering Argentium® Sterling similarly to the way I solder gold (or the way a beginner wants to solder!). After giving the entire piece a general heating, I concentrate the heat on the area of the solder joint (on the area that is being soldered—not on the solder itself).

Argentium® Sterling Silver can be fragile when it is red-hot.

Recently, I broke a thin piece of metal in half by moving it while it was still red-hot from soldering rather than waiting a few moments until it was gray-hot. Binding wire or clips to hold things in place for soldering works effectively. It is NOT recommended to use tweezers or tongs to press or push a hot piece of Argentium® Sterling into place during a soldering operation.

Metalsmiths making soldered constructions of flat sheet will want to make sure it is well supported.

If that is not possible, it is helpful to prepare the metal a bit beforehand to prevent the metal from sagging during soldering. Lay the Argentium® Sterling on a flat soldering surface, bring it to annealing temperature (dull red) with a torch flame, keep it at that temperature for about 15 seconds and then allow it to air-cool.

There is disagreement among the experts on just why this sagging occurs and why annealing-then-air-cooling helps prevent sag. It has something to do with crystalline structure, the size of the grain and the rate of cooling. More studies are being conducted; I bet that eventually the manufacturing process will be adjusted and that this is a temporary problem.

In the meantime, note that the lower the solder temperature, the less sagging, and that sagging is only a problem with unsupported flat metal. T. Flory recently ran a set of experiments that expanded on the tests that I have done. They can be seen on his blog at www.touchmetal.com. Based on Mr. Flory's tests, one can conclude that sagging is not likely to be a problem if Argentium® Medium or Argentium® Easy solder is used and that pre-treating the Argentium® Sterling Silver by annealing and air-cooling prevents sagging of flat metal soldered with Argentium® Hard. As with any alloy, the thickness of the metal is also a factor in keeping a soldered construction flat. T. Flory's experiments were run with 24-gauge (.5mm) Argentium® Sterling Silver. (I have not had any problem with sagging

since I always work with metal that has been formed, but I have investigated the problem for the benefit of those who do constructions with flat metal.)

When soldering, it is advisable to flux the solder joint only.

Avoid coating the entire piece with flux (it is not harmful, but it is unnecessary and would prevent the tarnish-preventive germanium oxide from being formed). Peter Johns likes the way that Rio Grande®'s MY-T-FLUX™ performs with Argentium® Sterling Silver. I have not had a chance to try it yet; I've been using Prip's Flux or Battern's for soldering. Paste fluxes work well, too.

Fusing & Welding

Due to its lower thermal and electrical conductivity, Argentium® Sterling can be fused and welded. I have used this property to fuse links for a chain made of Argentium® Sterling Silver and I was pleasantly surprised to find it easy to do. I used liquid flux on the joint and the small, hot flame of my Smith® Little Torch™ on a heat-reflective soldering pad. Since Argentium® Sterling Silver does not conduct heat very well, I focused the heat on the joint rather than the whole link.

Larry Blackwell[1] is a jeweler who specializes in sterling silver chains. He uses Argentium® Sterling wire for his chains and fuses whenever possible since he finds it faster than soldering. He does not usually use flux to fuse, and varies the size of the flame, depending on the gauge of the metal.

The high thermal and electrical conductivity of traditional sterling silver alloys makes it difficult to weld. I don't have access to welding machines, but I have seen incredibly complex welded Argentium® Sterling jewelry made by folks who do have welders.

Murray Ardell Heimbecker tells me, "Welding jump rings is relatively easy. You simply have to be sure you have a machine capable of enough current to handle the gauge metal you are using. I have welded Argentium® Sterling Silver jump rings with a pulse arc welder. The rings weld nicely and the joint is solid. There is very little finishing needed after the weld and they do not need to be pickled, as they would after soldering. I use the Jump Ringer™ to make the jump rings in quantity and the pulse arc to close them."[2]

Granulation

It occurred to me that since Argentium® Sterling Silver fuses to itself so well, it might well work for granulation. A colleague, Nancy Howland, decided to give it a try. When Nancy tried it, she said, "I did not melt any granules, even when the sheet metal looked close to meltdown."

Nancy heated the sheet with a torch until some surface melting occurred, producing a "liquid look." She did not heat for too long, however, just enough for the granules to adhere to the sheet. She even added more granules to the already fused granules, and this also worked well.

Melting the End of a Piece of Argentium® Sterling Silver Wire Into a Ball

The ball that is created by melting an end of Argentium® Sterling Silver is usually 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® Sterling Silver. However, some of us seem to need to alter our technique a bit. When I first tried, I had difficulty. Sometimes the ball fell off, and sometimes the wire next to the ball got thin and scrawny-looking. Here are a few tips you can try:

- Clean the wire with Scotch-Brite™ to remove any oil.[3]
- 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 below the end of the wire, so that it does not affect the wire next to the ball as much, causing it to melt, which can make it thin.
- Although flux is not necessary, it is sometimes helpful.

Pickle

In my studio, I use one pickle pot for all metals—silver, copper and gold—and have had no trouble (yet!). It certainly would be a good idea, however, to avoid any cross-contamination with other alloys by having **a separate pickle pot for Argentium® Sterling Silver**. I recommend a separate pickle pot if you work a lot with copper alloys, or are in a group studio situation, or simply like to be cautious. Note that the reason for being concerned about contamination is the effect that copper deposited on the surface of the silver could have on tarnish-resistance.

Casting

Argentium® Sterling casting grain is at least 93% silver, with the same solidus and liquidus temperatures as Argentium® Sterling Silver sheet and wire. Accurate temperature measurement and control is important in order to avoid overheating when melting Argentium® Sterling casting grain for casting. If a torch must be used, one needs to learn

to recognize the paler color that indicates Argentium® Sterling Silver is melting. When investment casting, cooler pour and flask temperatures should be used than are used with traditional sterling because Argentium® Sterling retains heat longer. A melt/pour temperature between 1725°F and 1780°F (941°C and 971°C) and a flask temperature of 700–1100°F (371–593°C) are recommended. One caster I know uses a melt/pour temperature of 1725°F (941°C) and a flask temperature of 800–900°F (427–482°C).

To avoid contamination from other metals, use a separate crucible. A protective atmosphere, borax, boric acid flux or graphite powder are all effective.

After casting the metal, a minimum of 15 minutes of air-cooling is needed before quenching. (Naturally, the time should be adjusted according to the size of the flask. Quenching too soon can crack the casting.) Note that castings will be much harder if they are completely air-cooled rather than quenched. The casters at New England Sterling like to let their castings cool overnight. Since they have a pneumatic investment remover, this is not a problem for them. No fire-dipping or or stripping with cyanide is necessary since there is no firescale.

As with most metals, it is important to pay attention to the ratio of scrap to new alloy for the melt. Re-melting too much scrap may result in poor-quality castings. The ratio of new to re-used material can vary depending on the equipment being used. The ratio may also vary depending on what is being cast and how it is processed and used.[4]

Precipitation/Heat-Hardening Argentium® Sterling Silver

Heat at 580°F (304°C) for 45 to 60 minutes, and then air-cool to room temperature.

Unlike many other alloys, Argentium® Sterling Silver does not need to be quenched in order to be hardened. Argentium® Sterling will harden very well after a slow air-cool, a method which is preferred by many metalsmiths, since quenching can warp or shock metal. The following method does not require quenching and will achieve a hardness of approximately 110HV/DPH.

1. After annealing or soldering, allow the alloy to air-cool to room temperature.
2. Heat the alloy in a kiln or oven at 580°F (304°C) for approximately 45 to 60 minutes, and then air-cool to room temperature.

Annealing and then quenching prior to oven hardening will achieve a greater hardness of approximately 120HV/DPH. To achieve maximum hardness:

1. Heat the Argentium® Sterling to a pale red annealing temperature, wait until any visible red heat has disappeared, and then quench in water. If using a kiln, the recommended temperature is 1050°F (565°C).
2. Heat the silver in a kiln or oven at 580°F (300°C) for approximately 45 to 60 minutes, and then air-cool to room temperature.

Other Helpful Tips

- Ovens/furnaces and supports should be pre-heated to the required temperatures before commencing the heat treatment for the specified times.
- Heat treatment time will vary, depending upon the size of the Argentium® Sterling piece. In other words, a larger piece will require longer heat treatment.
- The alloy will not lose its hardness if left in the oven longer. (Since my oven goes only to 550°F/288°C, I usually heat it for an hour or two at 550°F/288°C.)
- Lower temperatures can be used for hardening if the time is increased (365°F/220°C is the minimum). For instance, at 365°F (220°C) Argentium® Sterling Silver needs to be heat treated for approximately 2 hours.
- Avoid contamination and minimize discoloration by placing the Argentium® Sterling Silver on a clean soldering pad or a clean Pyrex® dish. It is not recommended to use a metal rack or a metal pan.
- A slight discoloration may occur during the hardening cycle which can be easily removed with pickle. (Then, if necessary, I suggest using a Goddard's™ Long Shine Silver Cloth or a brass brush lubricated with soapy water to refresh the shine.)
- Though the 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.
- Do not enclose the Argentium® Sterling when heat-hardening. The insulation slows down the heating process and prevents oxygen from reaching the metal; the oxygen is needed to create the germanium oxide that prevents tarnish.
- The hardening process will not have any negative effect on fine silver, sterling silver, gold or copper alloys that are used in combination with Argentium® Sterling Silver.
- Should the need arise, the alloy can be softened by conventional annealing and then hardened again.

Reticulation

Noticing the texture Argentium® Sterling Silver gets when close to melting, I have tried to reticulate it. Since reticulation works on the principle of the interior melting at a lower temperature than the exterior skin, I put a few pieces of 24-gauge and 18-gauge Argentium® Sterling sheet into a kiln for 45 minutes at 1050°F (5660°C) to build up a skin of oxides (which have a higher melting temperature than Argentium® Sterling). I managed to get a few areas of lovely ripples, but nothing consistent.

Enameling

There have been experiments with enameling on Argentium® Sterling Silver, but I don't know of anyone who has had consistent success. It seems that it would be worth investigation, since Argentium® Sterling is sturdier than fine silver, and the temperature required for hardening should not damage enamel. Peter Johns and Stern-Leach are currently working on an alloy formulation that will be more suitable to enameling.

Antiquing

When I want to darken the recesses in my work made of Argentium® Sterling Silver, I use a commercial acidic solution, such as Griffith Silver Black or Midas® Black Max. I usually apply it with a brush or cotton swab, but if the piece is very small, I dip the silver into the acid. These acid types of "antiquing" patinas are ready to use—no mixing or heating is required—and they don't deteriorate like liver of sulfur, which has a short shelf-life. I like to use liver of sulfur for copper and brass alloys because of the beautiful range of colors and the depth of the colors; however, for antiquing silver, when I just want the recesses to have a black patina, the acid solutions seem quicker and easier. Also, liver of sulfur seems to take longer to work on Argentium® Sterling than on traditional sterling.

Of course, it is important, as with any chemical, to be very careful. Read and follow the instructions and precautions on the bottle's label, and use common sense! Have adequate ventilation, use gloves and eye protection, etc. Make sure to read the MSDS.

Polishing, Finishing & Tarnish Resistance

Just as it is important to keep buffs used for steel tools separate from buffs that are used for precious metals, it is good practice to **use separate polishing wheels for Argentium® Sterling Silver** to avoid contamination from other alloys (residues left on the buff from another metal could be transferred onto the surface of the Argentium® Sterling and could cause tarnish). If separate buffs are not possible, thoroughly rake the buffing wheels to clean them before using them to buff Argentium® Sterling. Of course, like the soldering boards, these separate buffs should be labeled and stored separately from buffs used for other metals.

For my own work, I usually like the soft sheen of a brass-brushed finish. It is important to use soapy water as a lubricant when brass-brushing so that the brass (which is a copper alloy) does not rub onto the silver, which would cause contamination and tarnish.

Similarly, take care that any tool used on Argentium® Sterling Silver (such as grinding wheels, files, sandpaper, etc.) does not apply other metals to the surface of the silver, causing contamination which could cause tarnish.

Ultrasonic 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). Peter Johns learned the hard way that 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.)

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.

The protective germanium oxide layer forms at room temperature. Heating applications such as soldering and precipitation/heat hardening accelerate the process of germanium oxide formation. If hardening is not required or if the work has been abraded or polished after hardening, then items can be placed in an oven for 10–20 minutes at 250°F (121°C) to speed up the oxide formation.

Like glass or any other metal, Argentium® Sterling Silver can show fingerprints; however, I have noticed that the pieces on which I have used Goddard's™ Long Shine Silver Cloth (or Liquid) have stayed cleanest and are more fingerprint-resistant. It seems that the chemicals in the cloth affect Argentium® Sterling, enhancing the non-tarnishing properties—though I do not notice a film nor any visible difference other than the polishing action. Another reason why I like to use Goddard's Long Shine Silver Cloth is that it helps wipe away contaminants or water spots from the surface.

For optimal tarnish resistance, it is best to make sure that after the last abrasive process, the Argentium® Sterling Silver has been exposed to oxygen in a heated environment. Use of Goddard's™ Long Shine Silver Cloth or Liquid can be extra assurance.

Working Procedures & Sequences

Depending on what finish you like and how you usually work, a few small adjustments in your procedures may be necessary in order to work efficiently and achieve hardness and tarnish resistance. To help with planning, here are two typical work sequences:

A possible work sequence for an object with a Scotch-Brite™ or satin finish:

- Saw and drill
- Solder on the finding
- Pickle and rinse
- Scotch-Brite™
- Harden (simultaneously increasing the germanium oxide protective layer on the surface)
- Pickle and rinse
- Brass brush with soapy water and/or rub with a Goddard's™ Long Shine Silver Cloth

A possible work sequence for a polished piece:

- Saw and form the metal
- Solder and pickle
- Polish
- Harden in the oven (simultaneously increasing the germanium oxide protective layer on the surface)
- Pickle and rinse
- Use Goddard's™ for added protection and to bring back any shine that was lost due to heating and pickling

Another possible work sequence for a polished piece:

- Saw, drill and/or form the metal
- Solder and pickle
- Harden in an oven or kiln
- Pickle and rinse
- Polish and clean
- Heat at 250°F (121°C) for 10–20 minutes to optimize the tarnish resistance. Pickle if necessary.
- Use Goddard's™ for added protection and to bring back any shine that was lost due to heating

Scrap

If you generally send your scrap to a refiner, it is not necessary at this time to keep Argentium® Sterling Silver scrap separate from traditional sterling scrap. (It won't be detrimental to traditional sterling.) If Argentium® Sterling is mixed with traditional sterling, the sterling's properties won't alter until the percentages of the alloys become similar to those of Argentium® Sterling Silver.

Hallmarking

License application forms for use of the Argentium® Sterling Silver mark may be downloaded at www.argentiumsilver.com. Since Argentium® Sterling is sterling silver, the only legal requirement is to stamp it as "925" or "sterling silver." However, as the marketing program of the Argentium Silver Co. progresses, licensees of the Argentium® Sterling Silver mark will benefit from the brand values of Argentium® Sterling Silver, as the mark may be sought out by consumers as proof of quality and tarnish resistance. Also, the Argentium Silver Co. promises that all Argentium® Sterling Silver mark users will be promoted on its website. The company plans to feature work made with Argentium® Sterling Silver in the website's gallery with contact info and brief resumes. Additionally, the Argentium Silver Co. is committed to protecting Argentium® Sterling Silver mark users from unauthorized use of the mark. The Argentium Silver Co. has responded to the issue of price and accessibility for independent designer-jewelers and silversmiths and has a sliding scale for licensees according to the size of their businesses.

Differentiating Argentium® Sterling Silver from Traditional Sterling Silver

At this time, there is no foolproof way for a metalsmith without access to analysis equipment to figure out whether a piece of metal is traditional sterling silver or Argentium® Sterling Silver, so it is important to stay very organized if you have both Argentium® Sterling Silver and traditional sterling silver in your studio. Below are a few things you can try if you find yourself feeling unsure about which alloy a piece of silver is.

My preferred method:

1) Abrade the surface of the metal—with a Scotch-Brite™ wheel, for instance—to remove any grease, dirt, germanium oxide or fine silver.
2) Heat it *lightly* with a torch. Argentium® Sterling Silver will usually stay silvery; traditional sterling usually darkens. Ideally, when you do this, you do it alongside a piece of metal that you *know* is Argentium® Sterling Silver as well as a piece that you *know* is traditional sterling, for comparison.

An oxidation test:

> From T. Flory, a tip given on www.orchid.com and his blog at www.touchmetal.com: "Here's a technique I've used: torch it, but good. You can often tell from the way it heats up but, if not, just quench, dip it briefly (a couple of seconds) in pickle and have a look at the scale on it. If you've got any reddish scale at all then it's traditional sterling (unfortunately, that means that it is now fire-stained). If all you get is a little bit of sooty black oxide and nothing else, then it's probably Argentium® Sterling Silver."

A heat treatment test:

> More from T. Flory: Another idea is to apply a precipitation/heat-treatment procedure as described on page 5. If the alloy becomes nice and hard, it's Argentium® Sterling Silver; if it only hardens a little, it's traditional sterling.

In any comparison test, it is best if both silver samples have been cleaned and treated the same way and have the same surface finish. It is also preferable to have a known sample of each alloy with the same finish as the piece(s) that you are testing.

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 (since I knew *nothing* about germanium!) I looked on the web at the MSDS for germanium, 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. My recent research for this article led me to this interesting statement: "Certain germanium compounds have a low mammalian toxicity, but a clear activity against certain bacteria, which makes them of interest as chemotherapeutic agents."[5]

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® Sterling 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.

MORE ABOUT ARGENTIUM® STERLING SILVER: TECHNICAL & HISTORICAL INFORMATION

Argentium® Sterling Silver is Highly Tarnish Resistant.

When I initially heard this claim, I was skeptical. I have noticed, however, that when I receive work back from an exhibition or gallery, the metalwork made with Argentium® Sterling Silver looks fine, though the work made with traditional sterling silver is often tarnished, despite my habit of applying a coat of Renaissance Wax to work made with traditional sterling when it is going to an exhibition. Recently, I borrowed a bowl I made in Argentium® Sterling Silver for the Silver Triennial exhibition in Europe. The owner apologized that she had not had time to polish it before returning it, and that it had been sitting out on her dining room buffet for a year. I was therefore surprised to open the box and see that it looked nearly pristine.

CATRA (Cutlery and Allied Trades Research Association) is an independent testing laboratory in the United Kingdom. They performed tests comparing the tarnish resistance of traditional sterling silver and Argentium® Sterling Silver. Here is a quote from their report: "Photographic records were used to visually document the tarnishing behaviour of the two alloys when exposed to the accelerated tarnish test procedures over set periods of time. In both the BS EN ISO 4538: 1995 Thioacetamide test and the Ammonium Polysulphide test, Standard Sterling developed severe dark discolouration. In comparison, Argentium® Sterling remained clean and bright."
You can see the full report with photos of the samples at http://www.landellflutes.com/-Products/Assets/argreport.pdf.

Argentium® Sterling Silver has Greater Ductility and Malleability Than Traditional Sterling Silver

Ductility is the ability of a metal to be stretched or elongated. Malleability is the ability of the metal to be transformed—e.g., bent, formed, forged, etc.—without breaking. A metal can have one property without the other; lead, for instance, is malleable but not ductile.[6] I realized this the first time I formed Argentium® Sterling Silver in a hydraulic press with a matrix die. When I used the amount of force I expected to need for traditional sterling silver, the entire flange was pulled into the negative space of the die! Since it was a large piece of Argentium® Sterling, which was hard to obtain at the time, I had to re-work the form for the teapot by hammering. I enjoy this greater ductility and malleability when I do fold forming, forging, die forming, anticlastic and synclastic forming, raising and knitted chains. I have not tried chasing with it yet, but I expect that it will be a delight to chasers. To me, Argentium® Sterling is softer after annealing than traditional sterling, and can be worked longer and further before it needs re-annealing than traditional sterling.

Argentium® Sterling Silver Can Be Precipitation-Hardened Using a Kitchen Oven.

The SNAG Lifetime Achievement Award made by Cynthia Eid

Consequently, an Argentium® Sterling Silver piece is sturdier and more dent-resistant. I appreciated this feature when I made the Society of North American Goldsmiths (SNAG), Lifetime Achievement Award (SNAG gives one at each annual conference). The textured part of the bowl is made of thin (about 26-gauge) Argentium® Sterling in order to achieve the depth of the texture. The structure of the corrugation and cross-corrugation makes it very strong; however, I value being able to further harden the metal in my oven so that I can really feel confident about the award surviving being shipped across the country to the SNAG director, then schlepped to a SNAG conference, handed to a worthy recipient and finally taken to a home.

Tiffany is utilizing this property to make money clips. After soldering (which anneals the metal, as with any silver alloy) the Argentium® Sterling Silver money clips are being heat-hardened.

What is Germanium?

Germanium (Ge) is an element, named for its discovery in Germany in 1886. Its atomic number is 32, its atomic weight is 72.64 and it is located below silicon on the Periodic Table. It is chemically similar to tin. Germanium is not found as a free element in nature. Germanium is found in zinc ores, coal, germanite and argyrodite. In researching this article, I have been intrigued to see that germanium is not listed in charts comparing metals and their characteristics in any of the jewelry or silversmithing books in my studio.

Germanium is a metalloid, as are silicon, manganese, boron and sulfur. These elements are on the border between the metallic elements of the periodic table and the non-metallic elements. 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. (Conduction: the result of collisions between molecules; when one end of an object is heated, the molecules vibrate faster and the energy is transferred to their neighbors.[7]) Because germanium is less conductive than many other metals, Argentium® Sterling Silver can be fused and welded.

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.

What Else is Germanium Used For?

- As a transistor element. Its application as a semiconductor provides the largest use for germanium.
- As a phosphor in fluorescent lamps.
- Infrared spectroscopes (heavily used in the Cold War!).
- Lenses. Germanium oxide's index of refraction and dispersion properties make it useful in camera and microscope lenses.
- 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.
- Germanium transistors are still used in stompboxes by musicians who wish to reproduce the distinctive character of fuzzboxes from the early Rock & Roll era.

How Did Germanium Come To Be Alloyed With Silver?

Metaleurop, whose primary product was zinc, found that they had a lot of germanium on hand as a by-product of refining zinc ore. In an effort to find or create a market for this germanium, Metaleurop sent samples and inquiries to people with many different types of expertise, asking for ideas and advice for its use. One of these was Peter Johns at Middlesex University, UK. 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. Soon after noticing this phenomenon, Peter Johns was explaining firescale to a student and he began to wonder if germanium could be used to prevent firescale. Months of experimentation produced Argentium® Sterling Silver.

Why does Argentium® Sterling Silver Precipitation-Harden So Well?

Until now, I had always thought of precipitation as simply the phenomenon we see when a solid settles out to the bottom of a container of a liquid solution, as happens when we make Prip's Flux or put sugar in water. Here is a definition of precipitation, used in chemistry, that helps me understand how germanium can precipitate in a solid: To cause (a solid substance) to be separated from a solution.[8]

Because germanium is a metalloid rather than a true metal, germanium atoms tend to "float" around within the silver/copper alloy relatively unimpeded. When Argentium® Sterling Silver is heated, the germanium precipitates out of the alloy and forms its own crystal structure. Because the germanium crystal structure has a different geometry than the silver/copper crystal structure, the two structures interlock, thus making the metal harder.

What is Firescale? Why Doesn't Argentium® Sterling Silver Get Firescale?

When heated, traditional sterling silver forms cuprous oxide (Cu_2O), known as firescale or firestain, that annoying purplish layer that lurks under the surface of traditional sterling silver after annealing or soldering. Firescale needs to be removed via abrasives or chemicals, covered with electroplating or covered by depleting the copper from the surface through repeated heating and pickling (often called "bringing up the fine silver" or depletion gilding). Though Argentium® Sterling Silver may oxidize when heated, the oxide is cupric oxide (CuO). This is a surface oxide that pickle removes completely; there is no underlying cuprous oxide firescale.

An unusual property of the element silver (Ag) is that it allows oxygen to penetrate through its surface, and into the interior of the metal. That is why the Cu_2O/firescale is able to form under the surface of traditional sterling silver. The addition of germanium to the sterling silver alloy stops the penetration of oxygen past the surface.

How Does Germanium Stop Firescale and Tarnish?

Germanium, being a "mobile" metalloid, readily migrates to the surface. In this context, the word mobility describes the movement of the electrons within a solid. Germanium constantly diffuses to the surface where it combines with oxygen and forms a thin layer of germanium oxide (GeO_2). This thin, nearly transparent layer of germanium oxide is impervious to oxygen, and thus prevents cuprous oxide (Cu_2O/firescale/firestain) from forming in the interior layers of metal. (Firescale forms when oxygen penetrates the sterling and combines with copper.)

Germanium oxide is preferential—the germanium oxide forms so readily and easily that it forms *before* the copper and silver are able to oxidize. Germanium is highly reactive. In chemistry and physics, the definition of reactive is: Tending to participate readily in reactions. This makes sense when we remember that germanium is not found as a separate element in nature. Even the surface of pure germanium has a very thin layer of germanium dioxide.

The only time Argentium® Sterling Silver discolors when heated is if oxygen is missing so that the germanium cannot oxidize. (For instance, I'll notice a discoloration on the side of a sheet of Argentium® Sterling laid against a soldering pad when heated.) This discoloration is only on the surface and is fully removeable with pickle.

Germanium stops the oxygen from penetrating—without oxygen inside, there is no firescale inside the metal. (Silver is one of the few metals to allow oxygen to penetrate.) Germanium on the surface of the metal combines with oxygen to form a protective barrier layer of germanium dioxide.

Some people like to say that Argentium® Sterling Silver is "self-healing" in its tarnish-resistance, because this germanium oxide layer will naturally grow over time. Heating speeds this process, so, if finishing a piece has abraded the surface, heating the Argentium® Sterling Silver will re-build the tarnish-resistant layer of germanium oxide more quickly. The other day, as I was trying to reticulate some Argentium® Sterling that was discolored from being in a kiln with the door closed for 45 minutes at 1050°F (566°C), I was intrigued to see that the longer I heated it with the torch, the *whiter* the silver became!

Some Background About Oxides, Tarnish & Firescale

- 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 gray or black 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. When it forms on the surface of Argentium® Sterling Silver, it prevents tarnish.
- Tarnish is not 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.

How is Argentium® Sterling Silver Different From "Deox" Alloys?

Most "deox" alloys include zinc, replacing some of the copper. The zinc/silver alloys have been used as casting alloys for a number of years.

Who Else Has Been Using Argentium® Sterling Silver?

Some large jewelry manufacturers, including Tiffany, Jacmel and New England Sterling, as well as Magic Novelty (headpins, ear wires, jump rings and eye pins) and Hallmark Sweet (beads) are selling products made in Argentium® Sterling Silver. The World Poker Tour Invitational tournament trophy was made from Argentium® Sterling Silver.[10]

The Future?

- Argentium® Sterling Silver has been thoroughly tested. I am sure, however, that small improvements will be made. I was very impressed with the combination of technology and craftsmanship at Stern-Leach when I toured the facility. I observed an incredible amount of money, technology and time spent on quality control of the metals made there—dimensions, finish and purity are frequently checked.
- Research on the ability to bend and form Argentium® Sterling with lasers was presented at the 2005 Santa Fe Symposium® by Dr. Sarah Silve, a Research Fellow at Brunel University in England. As a confirmed "hammer-head," this sounds pretty amazing to me!
- I intend to do some more experiments with fusing Argentium® Sterling Silver—it seems to me that there are interesting possibilities for fusing sheet—as one does with pewter—for seamless-looking constructions.
- Could this begin a "renaissance" for silver? I think that the tarnish-resistance will be very attractive to consumers.
- To me, most recent innovations in jewelry and metalsmithing have involved rather expensive investments, and/or fairly large learning curves (e.g. laser welding, CAD-CAM, all-in-one casting machines, etc.). I think it is fabulous that this invention has such far-reaching implications of labor and cost-savings, with such little up-front cost to the jeweler.

Here are some possible implications that Argentium® Sterling Silver could have for silver jewelry and hollowware makers:

- The ability to harden Argentium® Sterling Silver makes some designs possible that were not practical with traditional sterling silver.
- Some people who were unable to wear traditional sterling silver jewelry because of skin reactions find that they are able to wear Argentium® Sterling Silver without any problems.
- Reduced costs due to:

  No cyanide needed for stripping.
  - Cost of cyanide.
  - Cost of managing the toxic waste of the cyanide processes.

  Less deep polishing needed.

  No need for plating or lacquering to prevent tarnish.

  Less labor costs associated with reduced finishing and polishing times—thus increased profitability for silver products.
- Less toxic waste, such as cyanide, is good for the environment.
- Better health for workers as well as neighbors

Argentium® Silver Co.

Argentium® Silver Co. is a spinout from Middlesex University. It is based in London, UK. Argentium Silver Co. has partnered with Stern-Leach (a U.S. division of Cookson, which is based in the U.K.) to make the alloy available. Argentium® Sterling Silver sheet, wire, solder, tubing and casting grain are currently being made by Stern-Leach. Rio Grande® is a distributor.

Technical assistance is available via e-mail at info@argentiumsilver.com (which will probably get you an answer from Peter Johns. If he wants another opinion, he may forward it to me or another artist who works with Argentium® Sterling). You can also ask questions of the Engineering Department at Stern-Leach by phone 508.222.7400 or e-mail at argentiuminfo@sternleach.com.

I would love to hear about any innovations or discoveries made about Argentium® Sterling Silver and/or its use! I can be contacted by email at ceid@cynthiaeid.com.

Legal Notice of Disclaimer

Working with metal and tools is potentially hazardous; users must take responsibility. It is each person's responsibility to use common sense and appropriate safety precautions. The user is also responsible for his own personal safety and the safety of any others on or about his premises. Professional training is recommended. The author, the contributors, Rio Grande, SNAG and their staffs, directors, officers and employees specifically disclaim any responsibility or liability for any damages or injury resulting from any activity undertaken through use of any information presented in this article. The use of any printed information is solely at the user's risk. Any and all information is provided without warranty, implied or otherwise, nor is it warranted for suitability or fitness for any purpose other than to educate and enlighten the user.

Footnotes

1. www.twistedelegancejewelry.com
2. Murray Ardell Heimbecker of A&A Products Ltd. and Creations by Ardell
3. Larry Blackwell figured this out. Thanks, Larry!
4. Since I don't do my own casting, the casting information is gleaned from experts such as Tim Jacobs and Bill Birch at Masters of Design, Sam Davis, and Peter Johns.
5. www.webelements.com/webelements/element/text/Ge/key.html
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- Orchid posts, and the Orchid archives, at www.ganoksin.com
- Conversations with:
  - Peter Johns, inventor of Argentium® Sterling Silver
  - Richard Carrano, metallurgist at Stern-Leach
  - Sam Davis, chemical and mechanical engineer at Stern-Leach
  - Sean Gilson, Technical Editor of SNAG News

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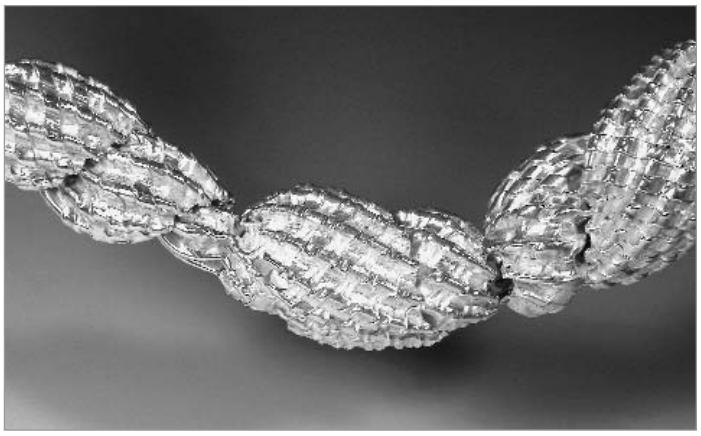
All SNAG members automatically receive the newsletter five times a year. To sign up for membership, go to www.snagmetalsmith.org or call 630.778.6385.

This article is also available online at www.riogrande.com.



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