Argentium® Silver is a patented and trademarked alloy that is at least 92.5% pure silver, just like traditional sterling. 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 some in 2000, and then started hoarding all of it I could find, as I fell in love with the material's working properties.

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

Despite its many advantages, working with Argentium® Silver is not very different from working with traditional sterling. It is useful, though, to know as much as possible about the differences.
Annealing
Argentium® Silver has a melting point around 60 degrees lower than traditional sterling. Similarly, it has a lower annealing temperature range of 1050°F to 1150°F. **Argentium® Silver glows a paler red when heated to annealing temperature.**

In practice, I find the paler glow hard to see, and it is easy to overheat—especially if I anneal in a lighted room. Another reason that Argentium® Silver can be easily overheated when annealing is that, because the metal does not dissipate heat as quickly as traditional sterling or copper alloys, it heats very quickly. Annealing in the dark makes it easier to avoid overheating. When that is not practical, I watch for two other signs that the metal is approaching annealing temperature: 1) the ink from a Sharpie® permanent marker fades, and 2) the silver (if it has been brass-brushed or otherwise abraded) turns whitish.

It can also be helpful to use dabs of flux as a heat indicator. The ideal method is to anneal brass-brushed Argentium® Silver in the dark with dabs of flux and a scribble of pen marks; 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 Silver’s annealing temperature, so that you know what to watch for when it is not practical for you to anneal in the darkness.

It is good practice to use a new, clean soldering board for Argentium® Silver 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® Silver having its surface contaminated by oxides in the bricks, which can create stains on the metal or other problems, such as tarnish. I like to use a broad pencil to mark the edges of the board (pencil won’t fade with heat).
Quenching
Argentium® Silver retains heat longer than traditional sterling. 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 slightly 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 completely with no quenching. In fact, it is my general practice to avoid shocking any metal that I am working with—unless it is one of the gold alloys that requires quenching or a steel tool that I am making. On the other hand, note that the sooner the Argentium is quenched after it reaches black heat, the softer it is; therefore, you may choose between metal softness and the risk of shock-cracks or warpage according to the situation and your personal sense of concern about those factors.

Melting Temperatures
Traditional sterling 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® Silver is 1410°F (766°C); the liquidus flow point is 1610°F (877°C). Please Note: Solidus is the temperature at which a metal starts to melt; liquidus is the temperature at which it is fully melted.

Soldering
Because of Argentium® 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 may show signs of having come close to melting. Medium, easy or extra-easy traditional sterling solders are safest.

Germanium-containing Argentium® Silver solders have been developed.
I like their color-match, as well as the fact that they flow well with good capillary action. Since their melting temperatures are similar to those of traditional silver solders, I avoid using Argentium® Hard solder. I use Argentium® Medium as if it is hard. Note that since Argentium Silver does not conduct heat as well as other silver and copper alloys, it is not as necessary to use solders of different melting temperatures; prior joints are not likely to re-melt unless they are adjacent to the new joint.

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

The heat stays where the torch is aimed without dissipating as quickly as do copper alloys and traditional sterling. I therefore approach soldering Argentium® Silver similar 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), and work my way along the seam. I have heard reports from some people that they’ve had difficulty with Argentium solders not melting completely. I think this usually happens because the flame is too small and the person is heating tentatively, resulting in the lowest temperature components of the solder flowing before the entire piece of solder flows. If this happens, it is pointless to keep heating in hopes of having the entire piece of solder flow. Clean up the excess solder and try heating with a larger flame and with more boldness. Please note that this phenomenon can happen with any solder and metal.

Argentium® 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 black-hot. Binding wire or clips to hold things in place for soldering works effectively if this is done before heating the metal. It is NOT recommended to use tweezers or tongs to press or push a hot piece of Argentium® Silver 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 help prevent the metal from sagging during soldering. Lay the Argentium® Silver 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 any case, note that the lower the solder temperature, the less sagging, and that sagging is only a problem with unsupported flat metal. Sagging is not likely to be a problem if Argentium® Medium or Argentium® Easy solder is used. As with any alloy, the thickness of the metal is also a factor in keeping a soldered construction flat. (I have not had any problem with sagging since I generally 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 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 and I both like the way that Rio Grande's MY-T-FLUX™ performs with Argentium® Silver. Prip's Flux and Battern's work well, too. In my experience, paste fluxes can cause firescale (on any sterling); if you are more comfortable working with paste than liquid, try Jel Flux, which works similarly.

Fusing & Welding
Due to its lower thermal and electrical conductivity, Argentium® Silver fuses and welds very well. My understanding of why Argentium Silver is easier to fuse than fine silver is that because fine silver is a pure metal, it has a very short temperature range at which it melts and fuses. Alloys offer wider temperature ranges, and Argenium has a very wide range. This range makes Argentium® fairly forgiving for fusing, compared to most other silver alloys. Since I was not previously fond of fusing, I was pleasantly surprised to find it easy to fuse links for a chain made of Argentium® Silver. I use liquid flux on the joint and the small, hot flame of my Smith® Little Torch™ on a heat-reflective soldering pad. I focus the heat on the joint rather than the whole link. In my experience, it is possible to fuse without flux, but using flux increases the quality of the resulting joint.

Larry Blackwell is a jeweler who specializes in sterling silver chains. He uses Argentium® Silver 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 alloys makes it difficult to weld. I don't have access to welding machines, but I have seen incredibly complex welded Argentium® Silver 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® 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." Though this should help get you started on fusing Argentium® Silver, I highly recommend also viewing Ronda Coryell's DVDs on this topic.

Summary Of How To Fuse Argentium® Silver:
- Prepare the joint; the metal must be clean and the joint must meet well.
- Flux the joint.
  - My favorite flux for this is Rio Grande’s My-T-FLUX, but Battern’s works too. When I taught in England last summer, I thought that Auflux worked fine.
  - Though it is possible to fuse dirty metal that does not touch well, without flux, those are not ideal conditions for consistent success.
- Use a heat-reflective soldering surface.
  - My favorite is solderite; Ronda’s favorite is charcoal. Honeycomb blocks and firebricks are also quite heat reflective, but their rough surfaces may have an effect on the surface of the Argentium®.
  - It is best to use a block that is used only for Argentium® to avoid contaminating the surface, thus preserving the tarnish-resistance.
- Do what is necessary for you to see the joint well when it flows.
  - I like to set things up so that the joint will be near my eye level. I do this by raising my soldering surface, by lowering my chair, or both.
  - I like to wear a magnifier so that I can see the joint well.
  - Adjust the lighting to the level that works best for you (I like lots of light, Ronda likes to dim the lights).
- Heat the areas adjacent to the joint.
  - Be sure to use a large enough flame. I find that it is better to use a larger flame quickly than a too-small flame for too long.
  - Watch the flux—it is a good indicator of temperature.
  - Here is something I learned from Ronda Coryell: When the flux separates into tiny droplets, then you know that the metal is almost at fusing temperature.
- When the metal fuses, the joint looks to me like it has been soldered—I see 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. The surface of the silver often melts and looks liquid. Some say it looks like mercury.
- Do not be afraid to bring it back to fusing temperature in order to be sure that you have a good joint. If the joint did not fuse well, it is also perfectly okay to re-do the whole thing after pickling and rinsing thoroughly.
- Remember that Argentium® is fragile when red-hot.
  - Allow it to cool to at least black-hot before touching it with tweezers.
  - Both quenching and air-cooling are okay. If you quench, it is okay if the metal sizzles when it hits
the water. If there is a more explosive reaction, then the metal was too hot, which may make the metal more brittle.

Fully air-cooled silver is not much harder than silver that has been quenched at black heat, in my opinion; therefore, I recommend patience before quenching.

- Pickle, rinse well, and finish the piece.

Granulation

It occurred to me that since Argentium® Silver fuses to itself so well, it might well work for granulation. A colleague, Nancy Howland, decided to give it a try, and she made beautiful granulated Argentium Silver jewelry. Unfortunately, Nancy passed away in 2009.

Ronda Coryell, an expert in granulation, is now an expert in granulating Argentium® Silver. Her DVDs and classes on the subject are invaluable.

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 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 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 to remove any oil left from drawing down. I like to use Scotch-Brite™ pads.
- 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 always necessary, it can be 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® 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 on tarnish-resistance that any copper deposited on the surface of the silver could have.

Casting

Argentium® Silver casting grain is at least 93% silver, with the same solidus and liquidus temperatures as Argentium Silver sheet and wire. Accurate temperature measurement and control is important in order to avoid overheating when melting Argentium Silver casting grain for casting. If a torch must be used, one needs to learn to recognize the paler color that indicates Argentium Silver is melting. When investment casting, cooler pour and flask temperatures should be used than are used with traditional sterling because Argentium Silver 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 to prevent contamination. 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 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.

Precipitation/Age-Hardening Argentium® Silver

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

Precipitation/age-hardening is a heat treatment process used to harden a metal. Argentium® Silver does not need to be quenched in order to be hardened. Argentium Silver 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. Lower temperatures can be used (365°F/220°C is the minimum) for hardening if the time is increased. For instance, at 365°F (220°C) Argentium Silver needs to be heat treated for approximately 2 hours.

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 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® Silver piece. In other words, a thicker piece will require longer heat treatment.
- The alloy will not appreciably lose hardness if left in the oven longer—say an hour or so. (Since my oven goes only to 550°F/288°C, I usually heat it for an hour or two at 550°F/288°C.)
- Avoid contamination and minimize discoloration by placing the Argentium® 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® Silver when age-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® Silver.
- Should the need arise, the alloy can be softened by conventional annealing and then hardened again.

Reticulation

Noticing the texture Argentium® 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® Silver 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). I managed to get a few areas of lovely ripples, but nothing consistent.

Enameling

Argentium® Silver can be enameled. Opaques don’t seem to present many problems. The best success with transparents has been found by using the lowest possible melting temperature listed for an enamel for several minutes over a clear flux.

Keum-Boo

I use the same techniques to do keum-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 adequate to heat and pickle the Argentium once before applying gold foil.

Antiquing

When I want to darken the recesses in my work made of Argentium® Silver, I use a commercial 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 types of “antiquing” patinas are ready to use—no mixing or heating is required—and they have a long 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. All the patina chemicals seem to need to be a bit stronger to work on Argentium 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® Silver to avoid contamination from other alloys (residues left on the buff from another metal could be transferred onto the surface of the Argentium® Silver).
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® Silver. 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 burnishes the silver and does not rub onto the silver, which would cause contamination and tarnish.

Similarly, take care that any tool used on Argentium® Silver (such as grinding wheels, rubber abrasives, etc.) does not smear other metals onto 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 solution is run very hot (more than 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® 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. The chemicals (called Thiols) in the Long Shine products enhance the non-tarnishing properties—though I do not notice a film nor any visible difference other than the polishing action.

For optimal tarnish resistance, it is best to make sure that after the last abrasive process, the Argentium® 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 some 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, or use it for casting, it is not necessary at this time to keep Argentium® Silver scrap separate from traditional sterling scrap (it won’t be detrimental to traditional sterling).

**Hallmarking**

The official Argentium® Silver “Flying Unicorn” logo is available on high quality stamps from Rio Grande. This mark is legally registered to indicate both that the metal is
Argentium Silver and that it is sterling silver—a separate sterling mark is not legally required. In the United States, this mark must also be accompanied by a quality stamp (“925” or “Sterling”) indicating it is no less than .925 sterling silver.

Large manufacturers may wish to contact Argentium® International Ltd. and ask about their partner program for access to the artwork of the logo for laser marking, co-advertising, and other opportunities.

Differentiating Argentium® 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 or Argentium® Silver, so it is important to be organized if you have both Argentium® Silver and traditional sterling in your studio.

If I find myself needing to distinguish between then, my preferred method is to:

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, moving the flame on and off the metal, so that it is exposed to oxygen. Argentium 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® Silver as well as a piece that you know is traditional sterling, for comparison. It is best if all the silver samples have been cleaned and treated the same way and have the same surface finish.

3) If the silver darkens, keep heating lightly, moving the torch on and off the metal. Argentium® will lighten in color as the germanium grabs the oxygen from the copper (traditional sterling will darken further).

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.”

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 ensure 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.

More About Argentium® Silver: Technical & Historical Information

Argentium® 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® Silver looks fine, while the work made with traditional sterling 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. I borrowed back a bowl I made in Argentium Silver for the Silver Triennial exhibition in Europe. The owner apologized that she had not had time to polish it before sending 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 and Argentium® 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® Silver remained clean and bright.” You can download the full report with photos of the samples from the Technical Support area at http://www.argentiumsilver.com.

Argentium® 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. I realized that Argentium® Silver is both malleable and ductile the first time I tried to form the metal in a hydraulic press with a silhouette die. When I used the amount of force I expected to need for traditional sterling, the entire flange was pulled into the negative space of the die! Since it was a large piece of Argentium® Silver, 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. To me, Argentium Silver is softer after annealing than traditional sterling, and can be worked longer and further before it needs re-annealing than traditional sterling. 

**Argentium® Silver Can Be Precipitation-Hardened Using a Kitchen Oven.** 
Consequently, an Argentium® 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 28-gauge) Argentium® Silver 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® Silver money clips are age-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.) 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—allloys 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® 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® Silver. 

**Why does Argentium® 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.® 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® 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® Silver Get It?**
When heated, traditional sterling forms cuprous oxide (Cu₂O), known as firescale or firestain, that annoying purplish layer that lurks under the surface of traditional sterling 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® 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, into and into the interior of the metal. That is why the Cu₂O/firescale is able to form under the surface of traditional sterling. 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 (GeO₂). This thin, nearly transparent layer of germanium oxide is impervious to oxygen, and thus prevents cuprous oxide (Cu₂O/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® 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® Silver 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 oxide.

Some people like to say that Argentium® 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® Silver will re-build the tarnish-resistant layer of germanium oxide more quickly. When I tried to reticulate some Argentium® Silver 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 (Cu₂O), commonly called firescale or firestain, forms within traditional sterling. 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 has.
- Germanium oxide (GeO₂) is somewhat transparent and whitish. When it forms on the surface of Argentium® 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® 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.
The Future?

* Argentium® Silver has been thoroughly tested; nevertheless, improvements continue to be made.
* Research on the ability to bend and form Argentium® Silver 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® 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 flatware, vases and teapots? I think that the tarnish-resistance will be very attractive to consumers.
* Recent innovations in jewelry and metalsmithing seem to 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® Silver could have for silver jewelry and hollowware makers:

* The ability to harden Argentium® Silver makes some designs possible that were not practical with traditional sterling.
* Some people who were unable to wear traditional sterling jewelry because of skin reactions find that they are able to wear Argentium® Silver without any problems.
* Reduced costs due to:
  - No cyanide needed for stripping (cost of cyanide and cost of managing the toxic waste of the cyanide processes).
  - Less deep polishing needed.
  - No need for plating or lacquering to prevent tarnish.
  - Lower labor costs associated with reduced finishing and polishing times, thus increased profitability.
* Less toxic waste, such as cyanide, is good for the environment.
* Better health for workers as well as neighbors

Argentium® International Ltd.

Argentium® International Ltd. is headquartered in the United Kingdom. Technical information, as well as information about the company, is available via e-mail at www.argentiumsilver.com. Technical information 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 of the questions that you may have about Argentium via phone or e-mail.

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 ceid@cynthiaeid.com.

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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
6. My thanks to Jamie Pelissier at pellissiergalleries@mac.com

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• Conversations with:
  – Peter Johns, inventor of Argentium® Silver
  – Richard Carrano, metallurgist at Stern-Leach

– Sam Davis, formerly a 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.

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