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Market Trend Report

Silver in Brazing and Solder Alloy Materials

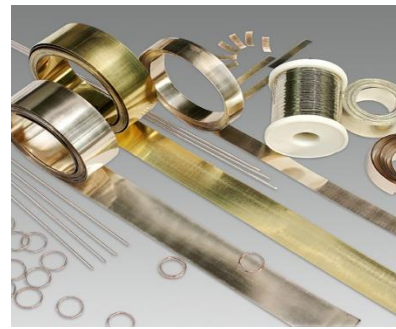


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Executive Summary

For centuries the two most common methods of joining metal tubes and fittings have been brazing and soldering. These tried-and-true methods are in a number of ways similar, yet there are also several distinct differences that set them apart. Solder often uses tin and silver filler materials, while brazing often uses filler metals and alloys such as silver, copper, and zinc.

In 2021, 47.7 million troy ounces (Moz) of silver went to solder and brazing alloy markets, according *World Silver Survey 2022*. According to Precious Metals Commodity Management, that demand is forecast to grow 23% to 58.8 Moz by 2030. This represents a 2% annual compound growth rate (CAGR) for this segment. This forecasted rise in demand is based on projected global infrastructure growth, including increasing plumbing and pipe joining, strong vehicle demand (both internal combustion engine (ICE) and electric vehicles (EV)). Additionally, demand is projected to increase for the electronics market, including light-emitting diodes (LED), printed circuit boards, air heating ventilation, and air conditioning (HVAC) systems. With it, the demand for silver in these brazing and solder alloy markets will also expand.

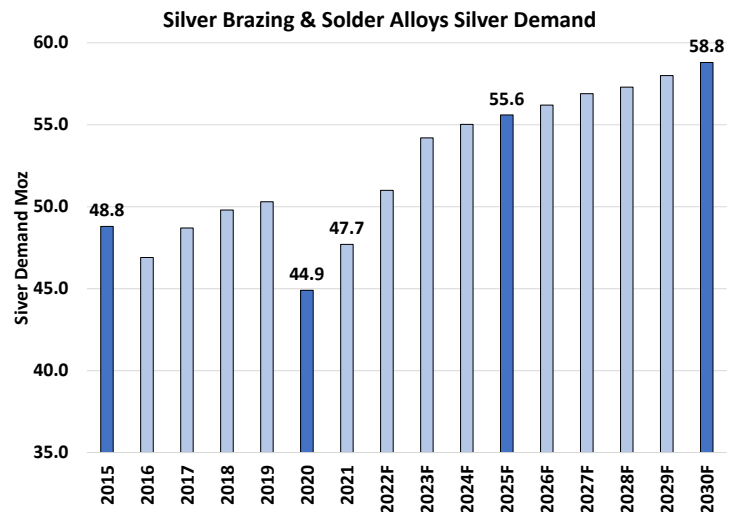


Chart 1: Solder Materials & Brazing Alloys Silver Demand
Source: *World Silver Survey 2022* & Precious Metals Commodity Management LLC

The Fundamentals of Soldering Technology

[The Soldering Handbook, 3rd Edition](#) explains the following:

Welding: When the melting temperature of the substrate material is exceeded, the bond is formed by a fusion joining process, e.g.,



Soldering Basics for RC Planes

welding. In welding, the two substrates are joined by the intermixing of their mutually molten segments. A third material, also referred to as a filler material, may be simultaneously melted and added to the molten base materials.

Soldering versus Brazing: Soldering and brazing are high-temperature filler metal processes that are used in many engineering applications. The difference between soldering and brazing is defined by the melting temperature of the filler metal. These distinguishing temperatures are below the melting point of the metals being joined in both cases. Both soldering alloys and brazing materials typically use significant silver loadings.

- **Solder Material:** A filler metal which has a liquidus temperature below 450°C/842°F is referred to as a solder material, or simply a “solder.”
- **Brazing Material:** A filler metal with a liquidus temperature exceeding 450°C/842°F is a brazing filler metal.

The History of Soldering and Brazing



An Egyptian Goldsmith Working at a Small Furnace

Soldering is a relatively old technology. Shown in Figure 2 is a timeline which illustrates the 6000-year history of soldering. Written details of the earliest uses of soldering are rare.

Archeological evidence of soldering from the earliest periods (4000 to 2000 BCE) is limited to artifacts, primarily jewelry and adornments, constructed with gold (Au)-based solders, since these materials were very resistant to corrosive deterioration. Artifacts having tin (Sn)-based solders, the foundation of today’s soldering technology, are less prevalent, since Sn and Sn-based alloys more readily succumbed to corrosion by rainwater and naturally occurring chemicals in the ground.



Soldering a component to a PCB

Pros and Cons of Soldering

There are many advantages of soldering. These advantages include that this process is simple, low cost, flexible, economical, and user-friendly. Since soldering is done at relatively low temperatures, no metallurgical damage to the base metal occurs. The soft solder jointed can easily be dismantled by simple reheating. Operator fatigue is less compared to the welding process. Another key advantage is that soldering enables dissimilar metals to be joined. Soldering has a very long lifetime, and the process uses only low power for use in heating the soldering iron

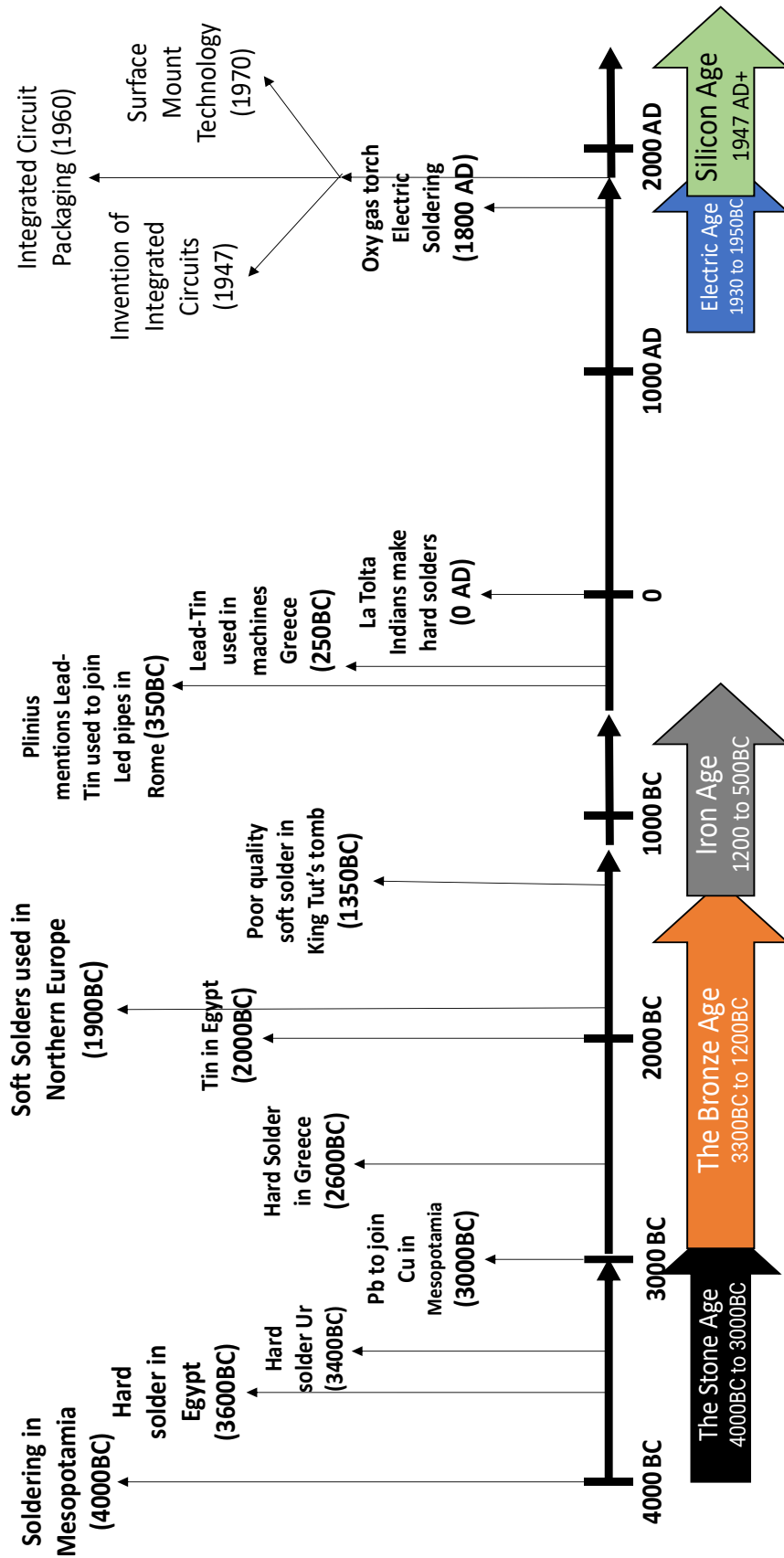


Figure 2

Historical Timeline of Soldering Technology

(Recreated referencing: The Metallurgical Society, TMS. Journal of Metals, Vol. 45, No. 7, "Issues in the Replacement of Lead Bearing Solders," P. Vianco and D. Frear, p. 14, Fig. 1.)

Disadvantages of soldering include that the soldering process cannot join heavy sections. Soldering is suitable for small parts only. Also, the solder materials are costlier, and soldering requires proper solder to get strong bonding, using skilled labor.



Brazing Process

Pros and Cons of Brazing

The following are the advantages of brazing:

The key advantage to brazing is that brazed joints are strong and can be reliably used on heavy sections. On non-ferrous metals and steels, the tensile strength of a joint will often exceed that of the metals joined. On stainless steels, it is possible to develop a joint whose tensile strength is 130,000 pounds per square inch. Metals with widely varying melting points can be brazed safely. Another advantage is that a brazed joint is ductile, able to withstand considerable shock and vibration.

The following are the disadvantages of brazing:

Skilled labor is required for brazing and the process often results in lower strength joints compared to welding.

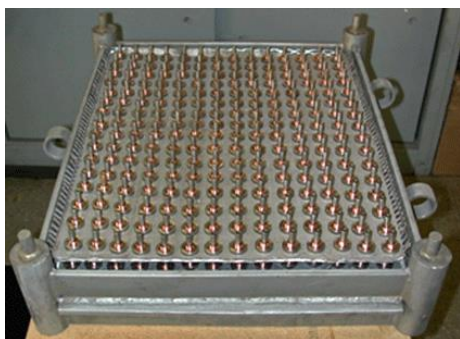


Atmospheric Brazing

Silver Brazing Process

There are six fundamentals of brazing to ensure consistent and repeatable joint quality, strength, hermeticity, and reliability.

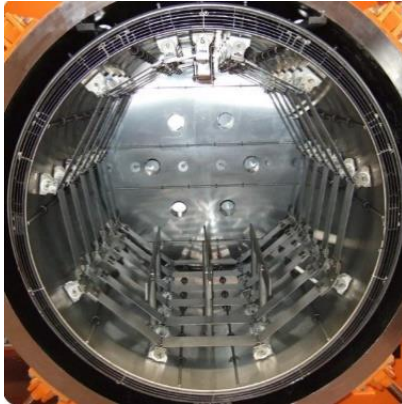
1. **Good Fit and Close Clearance.** Brazing uses the principle of capillary action to distribute the molten filler metal between the surfaces of the base metals. This means, in almost all cases, a close clearance.
2. **Cleaning the Metals:** Capillary action will work properly only when the surfaces of the metals are clean. If they are "contaminated," coated with oil, grease, rust, scale or just plain dirt, those contaminants must be removed. If they remain, they will form a barrier between the base metal surfaces and the brazing materials.
3. **Fluxing the Parts:** Flux is a chemical compound applied to the joint surfaces before brazing. Its use is crucial in the atmospheric brazing process. Heating a metal surface accelerates the formation of oxides, a chemical byproduct of the hot metal and oxygen in the air. If you don't stop these oxides from forming, they'll inhibit the brazing filler metal from wetting and bonding to the surfaces. Applying a coating of flux on the joint area guards the surfaces from the air, preventing oxide formation. It also dissolves and absorbs



Electric Contactors Fixtured Ready for Vacuum Brazing

any oxides that form throughout heating or that were not completely removed in the cleaning process.

4. **Assembly, or Fixturing for Brazing:** Presently, one must hold the parts in position for brazing in the correct alignment during the heating and cooling cycles, so that capillary action can do its job. Some complex multi joint assemblies like radiators require a fixture with clamping to support the brazing process.
5. **Brazing Heating Method Selection:** The fifth step is the actual accomplishment of the brazing joint. It involves heating the assembly to brazing temperature and flowing the filler metal through the joint. There are four main types of brazing heating methods: torch or manual brazing, induction brazing, resistance brazing, and vacuum brazing. The heating method most used in brazing a single assembly is the hand-held torch.
6. **Cleaning the Brazed Joint:** Cleaning is usually a two-step operation. First, removal of the flux residues. Second, pickling to remove any oxide scale formed during the brazing process.



Brazing in Vacuum Furnace

Silver Solder Product Design & Function

Most silver solder products can be categorized by their silver content. The silver content will determine the fluidity and melting temperature -- the more silver, the more fluid and the lower the melting temperature.

Most common are 33% silver (around 720°C), 40% silver (around 675°C) and 55% silver (around 650°C). Also available are silver bearing copper phosphorus alloys (CoPhos). These are available with either 2% or 5% silver and are used primarily for joining copper to copper, where, if the metal is clean, no flux need be used.

Silver solder can be used to join most common metals, including mild steel, stainless steel, copper, brass, cast iron and dissimilar metals.

Solder Alloy and Brazing Market Segments – Breaking It Down

Solder and Brazing materials are prevalent in a number of markets including:

- **Household, businesses, infrastructure, appliances, and hardware markets:** Brazing and solder alloys are commonly used on sealing and connecting pipes and plumbing.
- **HVAC - heating, ventilation, and air conditioning systems:** HVAC uses solder and brazing to ensure proper seals, especially with sealed systems under pressure. Radiators are another application requiring a strong seal even under temperature and pressure.
- **Automotive applications:** Many auto applications have very high vibration and temperature exposure requirements that are very specific, and temperature resistant brazing and solder alloys are used.
- **Electronics including printed circuit boards (PCB's):** Solder reflow products conductively connect components, displays, sensors and devices.
- **LED:** Light emitting diodes used in lighting and displays rely on solder alloys and brazing as part of their final assembly.
- **Jewelry:** Requires a wide range of silver solder products.



**Copper to Copper Tube/Pipe
Brazing**

A quick look at these key brazing and solder alloy markets shows projections for substantial growth rates over the remainder of the decade.

Global Infrastructure Including Plumbing and Piping

The [G20 Initiative](#) models the infrastructure investment current and forecast needs. To keep up with world growth and development, more construction projects will be called for each year. In fact, the world will need to spend an estimated \$94 trillion on infrastructure by 2040 to keep pace with demand. Global infrastructure spend is expected to grow at a modest 1.2% annual growth rate.



Copper Brazing

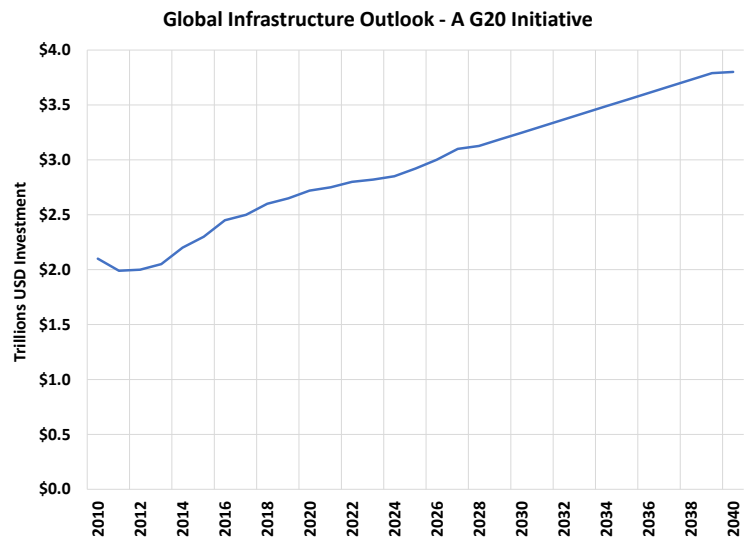
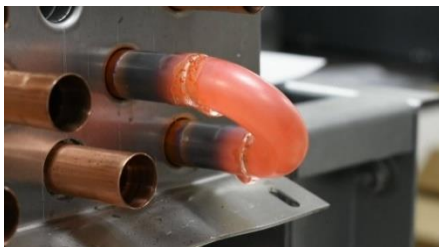


Chart 3 – Global Infrastructure Outlook



Brazed Components - Air Conditioning System



Automated Induction Brazing of Heat Exchangers



Brazing Aluminum Curved Motorcycle Radiator

Global Heating, Ventilation and Air Conditioning (HVAC) Market Trend

The Heating, Ventilation and Air Conditioning market is projected to be one of the fastest growing markets globally at a 7.3% compound annual growth rate (CAGR) between now and 2030. The silver alloys and brazing materials market will grow in kind.

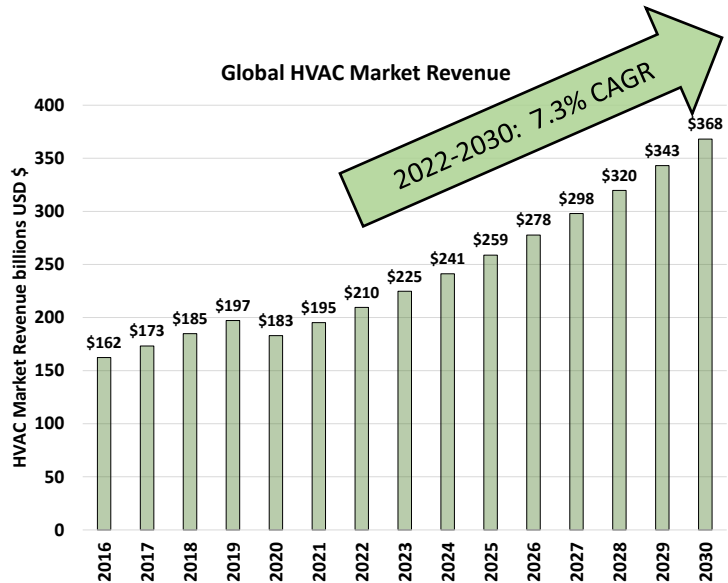


Chart 4 – Global HVAC Market

Precious Metals Commodity Management

Silver Brazing Alloys Process Solutions for Automotive Markets

During automotive assembly, reliability is one of the most important goals for any manufacturer. Components and electronics need to withstand harsh environments including extremely high temperatures, extremely low temperatures, vibrations, and shock. There is a wide range of different requirements for every vehicle, from low weight, low cost in-cabin electronics, to under hood controls that must perform in any condition. This includes Electronic Control Units (ECU's), electronic controls used for steering, emission control systems and sensors, braking and exterior lighting in and around the engine compartment.

Thermal stress and thermal cycling are important factors to consider when assembling electronics that are subject to harsh environments. Under the hood and around the engine bay are areas within automobiles that require high-reliability electronics and controls. Therefore, building these electronics requires a high-reliability silver solder alloy.

Automotive Electronics Market Trends

Automotive electronics are electronic systems used in vehicles, including engine management, emission control systems, transmission, ignition, radio and in-car infotainment systems, body, safety, driver assist, and other sensors and systems.



Auto (ECU) Electronic Control Unit Testing & Hardware Repair

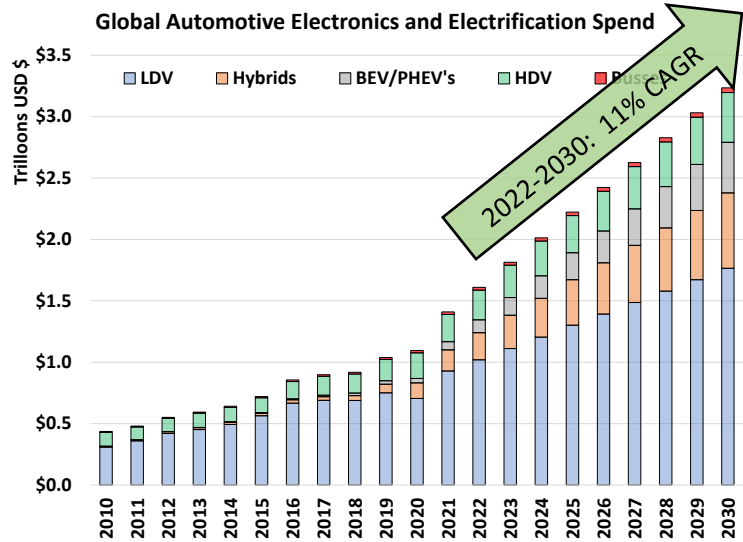
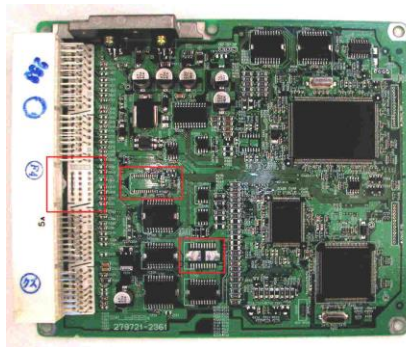


Chart 5 – Automotive Electronics & Electrification
 Source: Precious Metals Commodity Management LLC



Universal Auto Dashboard ICs:

Auto Computer ECU IC, Airbag drive IC, chip tuning IC, engine power driver IC, ECU flash memory chip, SRS ignitors driver chip, car lighting drive chip, car dashboard, car radios drive

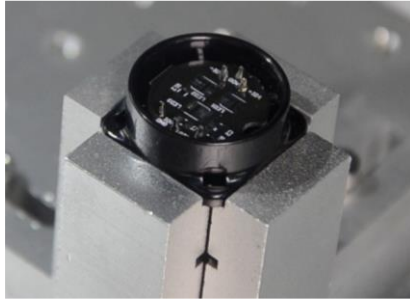
As we migrate into electric vehicles, the electronics loading per vehicle doubles. Growth in automotive electronics is projected to be 11% year over year through 2030.

Automotive electronics can be subjected to, and are therefore rated at, more extreme temperature ranges than commercial and consumer electronics.

Global LED Solder Assembly Market

Light Emitting Diodes (LED's) are among the most widely used of all the different types of semiconductor diodes available today and are commonly used in TV's and color displays

Silver in Brazing and Solder Alloy Materials



Automated LED Soldering

[FCT Solder](#), based in Windsor, Colorado, describes how their LED soldering materials are designed with high-speed productivity in mind, to allow manufacturers maximized throughput. With the ability to print at up to 150mm/sec, their no-clean, lead-free solder pastes have become the standard for LED applications.

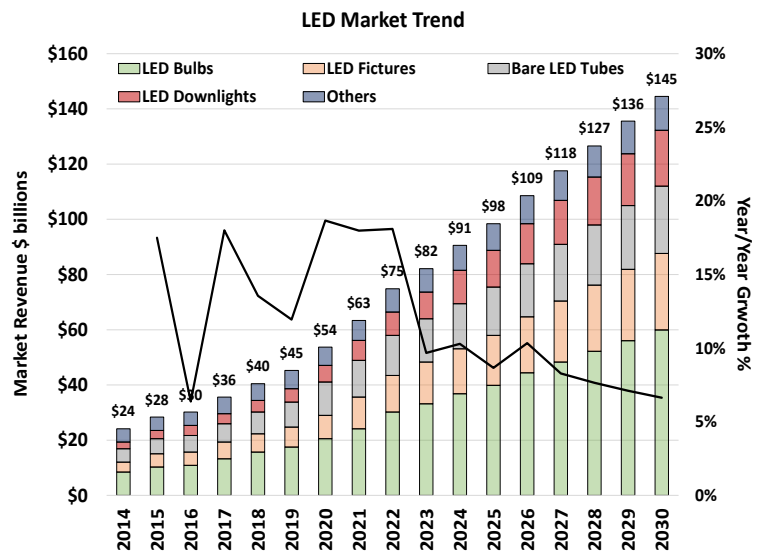
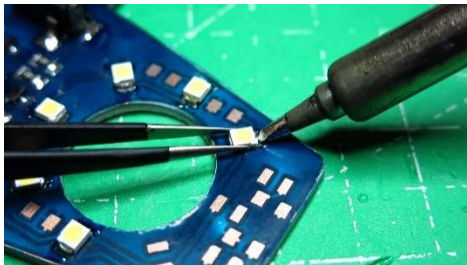


Chart 6 – LED Market Trend

Source: Precious Metals Commodity Management LLC



Soldering SMD LED Diodes

Jewelry Silver Solder Market

The global jewelry market size (including diamonds and gems) was valued at \$278.5 billion in 2018 and is anticipated to witness approximately 3% annual growth rate.

Silver solders with silver content ranging from 50 to 75% are quite popular. The highest silver content produces a very hard solder joint.

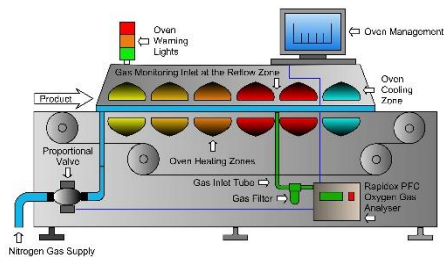


Silver Solder in Jewelry

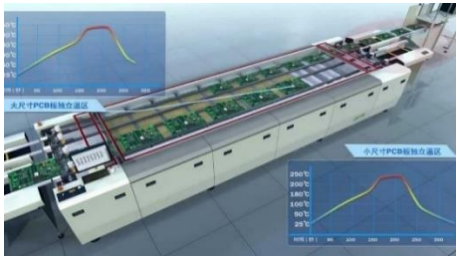
The trend for jewelry revenue and cost of precious metals sold is increasing, although the precious metals troy ounce volume is relatively small. Silver consumption for solder materials in jewelry is therefore expected to remain flat.



Silver Soldering and Chain



Inert Gas Blanketing in Solder Reflow Ovens



JUKI | Reflow Soldering Ovens

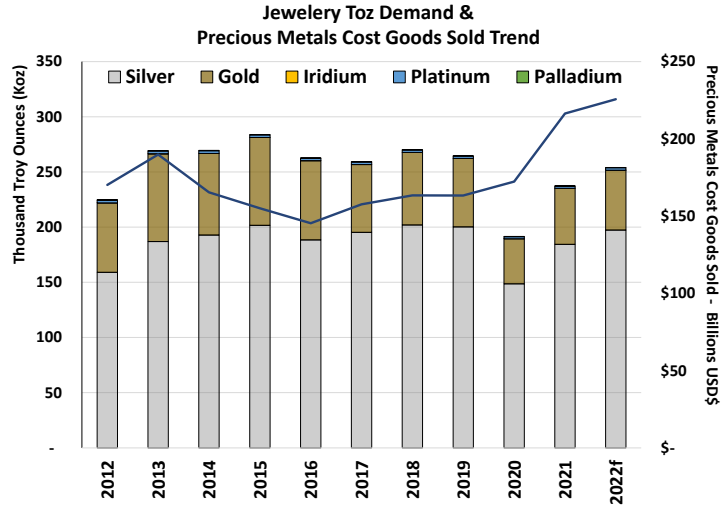


Chart 7 – Jewelry Market Toz & Revenue Trend
Source: Precious Metals Commodity Management LLC

Electronics Including Printed Circuit Boards (PCB's)

Silver solder materials are used in several electronics applications. Here in this segment, the silver serves two key roles. One is as a solder alloy agent, bonding electronic components and surface mounted devices to their substrate, often a printed circuit board, and the other function is to serve as a conductive electrical interconnect.

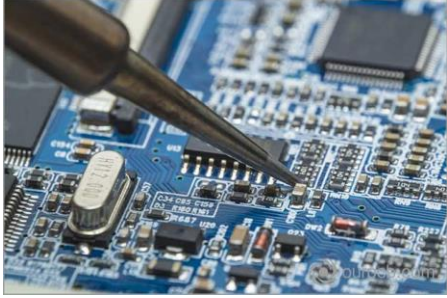
Reflow soldering by infra-red heating, often called infra-red soldering, is used mainly for the soldering of substrates with surface mounted components. Usually, the substrates are conveyed through a machine having a series of heater elements.

Reflow soldering is popular because it is a clean and environmentally friendly method, the heating is contact free and accurate positioning of the product to be soldered is not necessary, and finally the heating power is easy to control.

Printed Circuit Board Market Trends

Printed Circuit Board Market revenue trend cited below illustrates a 4.2% CAGR going forward through 2030. Silver solder reflow demand will follow suit. Taiwan and China are currently forecast to have the greatest future growth, but efforts are underway to repatriate semiconductor production to the EU, USA, and Japan that could alter that future trajectory.

Silver in Brazing and Solder Alloy Materials



Printed Circuit Board Silver Soldering

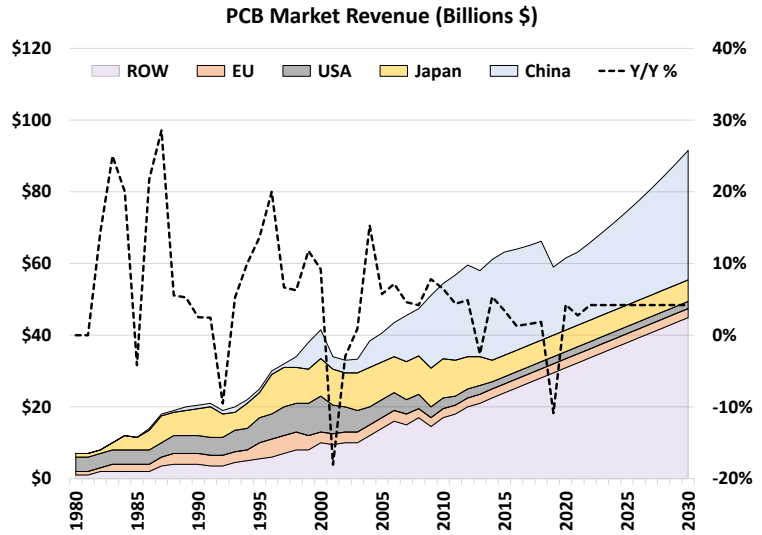


Chart 8 – Printed Circuit Board Market Revenue
Source: Precious Metals Commodity Management LLC

Semiconductor Market Growth Trends

Similarly, the overall semiconductor market is slated to grow at a 6+% annual pace as the trend toward electrification continues. Consumer electronics, personal computing, mobile devices, the Internet of Things (IoT), automotive electronics, and dozens of other market segments are projecting growth in their respective electronics content.



Surface Mount Device Silver Soldering

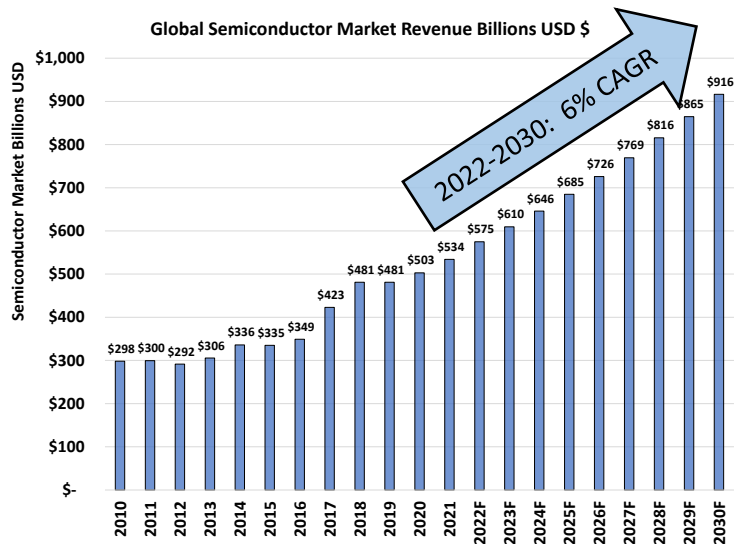


Chart 9 – Semiconductor Market Revenue
Source: Precious Metals Commodity Management LLC

Recall that the number of devices connected to the internet is projected to climb from 1.5+ billion today to over 4 billion no later than 2025. Silver solder alloy products will be used extensively in all those devices to mount components and devices.

YouTube Video Tutorial Overviews

The following are a few short videos that provide overviews of various silver solder and brazing processes. These tutorials are used in both the soldering and brazing process.

- [Silver Soldering Basics and Technique](#)
- [The Basics of Soldering | Jewelry 101](#)
- [How To Silver Solder \(Brazing\) a Copper Pipe \(A/C Line Repair\)](#)
- [Introduction To Silver Solder \(Hard Solder\)](#)

Conclusion

The prospects for growth in the silver brazing and solder alloy market remain strong. Silver will continue to play a vital role in joining technologies, especially in electronics, for decades to come.

Summarizing several of the key silver solder market segments projecting annualized growth rates through 2030, we see the segment growth rates between 0% and 11% CAGR.

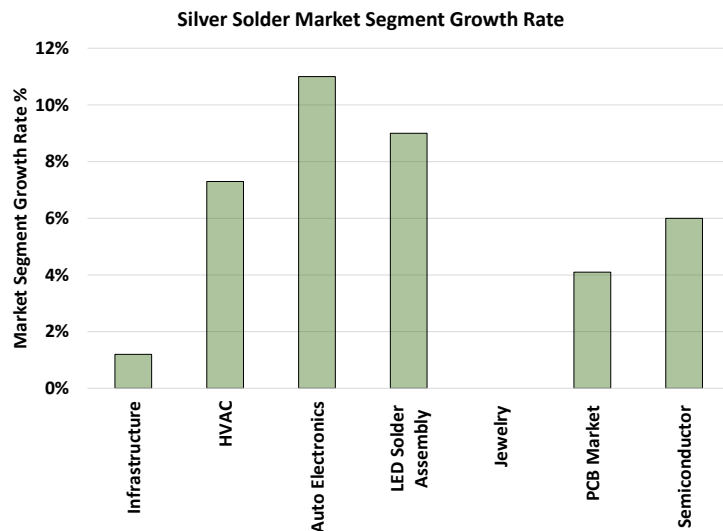


Chart 10 – Silver Brazing & Solder Alloy Market Key Segment Projected Annualized Growth Rate
Source: Precious Metals Commodity Management LLC

Interestingly, automotive electronics have higher temperature and vibration requirements, which motivates the designers to use higher silver content for strength and temperature resistance performance.

With silver demand in the brazing and solder markets forecast to grow 23% to 58.8 Moz by 2030, this category is one of numerous industrial market segments that is looking bright.

Precious Metals Commodities Management LLC



Matt Watson is the Founder and Principal of Precious Metals Commodity Management LLC, based near California's Silicon Valley. Specializing in precious metals markets and its supply chain, Matt assists clients ranging from Mining, Investors, Industrial Precious Metals Users, Processors, and Recyclers and coaching industrial clients how to reduce costs, design thrift, and anticipate market changes. Matt has also worked with the Silver Institute in studying the ever-increasing industrial demands in silver.

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