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LÖTTECHNIK

Luxury item SAC305

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Introduction

The price of silver rose sharply at the beginning of 2026 to a historic high, continuing the rally of the previous year. After closing 2025 at around USD 71–72 per ounce, the price rose by over 25% in the first two weeks of 2026 alone. It is currently trading between **USD 110 and over USD 120** (Figure 1). Analysts (including Citi) believe that a further increase is entirely possible. More conservative estimates, such as those from Commerzbank and HSBC, predict an annual average of around USD 68, which is still a historically high level.
In common silver-containing solders (e.g., **SAC305** with 3% silver or **SAC387** with 3.8% silver), the silver content accounts for the lion's share of the metal costs. The tripling of the price of silver within a year has led to a drastic increase in the cost of alloys. To save costs, manufacturers are pushing for a switch to **low-silver solders** or completely **silver-free soft solders.**
Each percentage point reduction in silver content in the solder currently results in a cost reduction of approximately **EUR 35 per kg** of solder. Silver-free SnCu solder alloys such as "Sn100Ni+®" or "Sn100-403C" are available. The addition of nickel and germanium influences the flow behavior, oxide formation, and viscosity of the molten solder. This often requires adjustments to the soldering profile, as silver-free solders usually have a higher melting point. This circumstance brings low-silver soft solders back into focus.

Figure 1: Price chart for silver in euros per troy ounce (1 year)

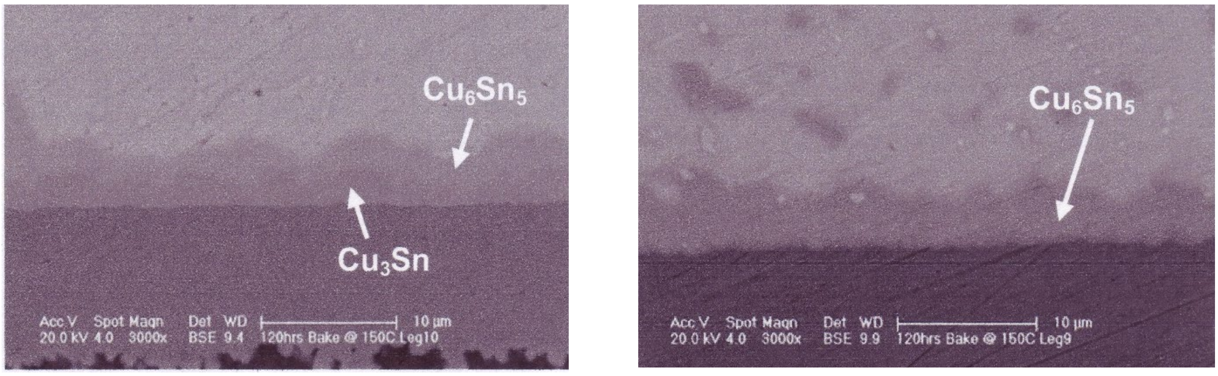
How much silver does the solder need?

The properties of silver-free SnCu and high-silver SAC305 and SAC387 solders have been described extensively in numerous publications since the beginning of the new millennium. At the beginning of 2005, the low-silver, lead-free solder "SACX0307" (SnAg0.3Cu0.7BiX - 217-227°C) was introduced. As early as November 2005, Intel reported in its Technology Journal, Volume 09, Issue 04, CASE STUDY 3: "SAC OPTIMIZATION" [1] on comparative tests between SAC305 (217-220°C) and SAC105 or SAC105Ni (217-226°C). Among other things, this showed that SAC105, with only 1% silver content, had the lowest modulus of elasticity of all the SAC solders tested (Table 1).

Solder alloy	SAC405	SAC305	SAC105	Sn63Pb37
E [GPa]	53.3	51.0	47.0	40.2

Tab 1: Modulus of elasticity of SnPb and various SAC solders (dynamic modulus of elasticity measurement)

In addition, the addition of nickel had a positive effect on the intermetallic phase and suppressed the growth of a brittle phase (Figure 2). This Cu3Sn phase forms during aging or after multiple soldering operations on the copper-side of the Cu6Sn5 phase and is very sensitive to shock. It can therefore be concluded that although a uniform Cu6Sn5 phase is essential for interfacial bonding, the formation of a Cu3Sn phase should be avoided as far as possible in order to optimize the reliability of the solder joint.



SAC105 **SAC105Ni0,05**

Figure 2: Intermetallic phases in SAC105 with and without nickel after aging for 120 hours at 150°C.

JEITA-Report: "The 2nd generation lead free wave alloy "

The "Lead-free activity report" [2] published by JEITA (Japan Electronics and Information Technology Industries Association) on February 28, 2007 describes a research project that examined various low-silver, lead-free solders (referred to as "second-generation" lead-free solders) for the following properties. **Wetting, penetration, copper alloying, thermal shock resistance (Table 2), surface tension, creep resistance, spreading.** Here, we will focus exclusively on the results of the thermal shock tests, as they have a particularly significant influence on the final ranking.

Nr.	Legierungsbestandteile					Thermo-Zyklen bis zum Erreichen einer Fehlerrate von 1%
	Sn	Cu	Ag	Bi	Ni	
1	Rest	0,5	3			450
2	Rest	0,7				280
3	Rest	0,7	0,3			320
4	Rest	0,7	0,5			290
5	Rest	0,7	1			400
6	Rest	0,7	1	1		320
7	Rest	0,7	0,3	0,1		250
8	Rest	0,7	0,3	1		320
9	Rest	0,7			0,03	270
10	Rest	0,7			0,05	320

Table 2: Temperature change test, thermal cycle -40°C to +90°C; cycle time 1 hour, dwell time per chamber 30 minutes; max. number of changes: 1000.

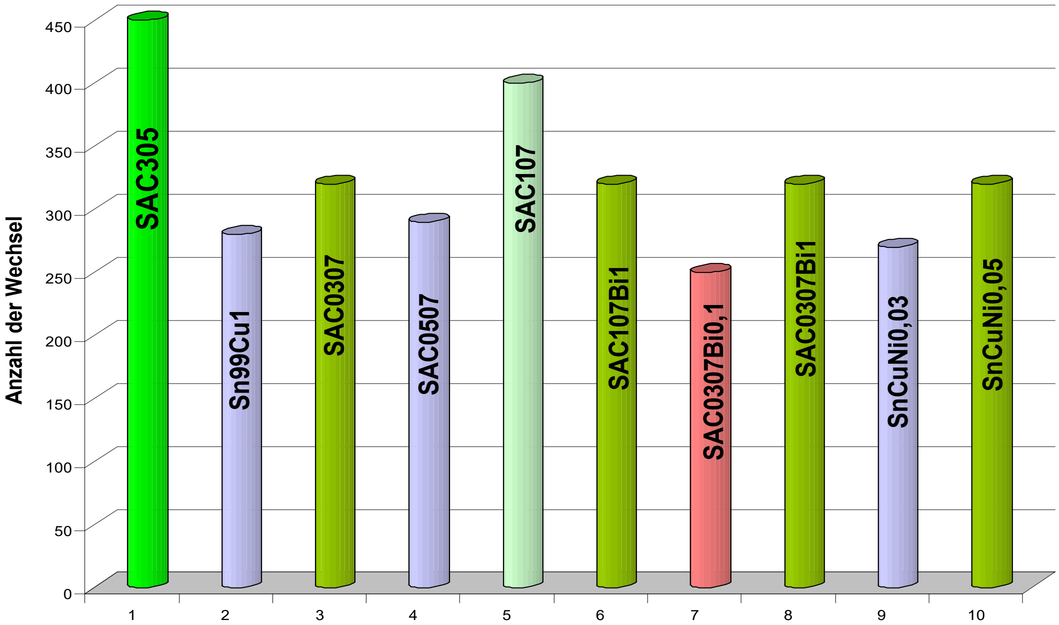


Figure 3: Graphical representation of the results from the temperature change test.

SAC0307: The positive influence of silver on the wetting properties has been confirmed. The apparent reduction in wetting performance of **SAC0307** (compared to SAC305) requires an increased solder bath temperature. The reduced thermal shock resistance must be assessed on a case-by-case basis. Although wetting is measurably better than with SnCu, 100% penetration is only achievable to a limited extent.

SAC107 is almost on par with SAC305 due to its balance of wettability and thermal shock resistance. Minor changes to the soldering parameters (wave height, soldering angle) are required.

Endowments

In addition to assessing the silver content, the effects of doping were also examined.

Nickel (0.05%) was recommended to reduce copper alloying. Although cobalt also reduced copper alloying, it had a negative effect on wetting and penetration. Figure 4 shows the influence of silver on the wetting time. In these wetting tests, the wetting time between 0% Ag content and 1.2% Ag content was reduced by 50%. Between 1.2% Ag content and 3% Ag content, the reduction factor was still around 7%!

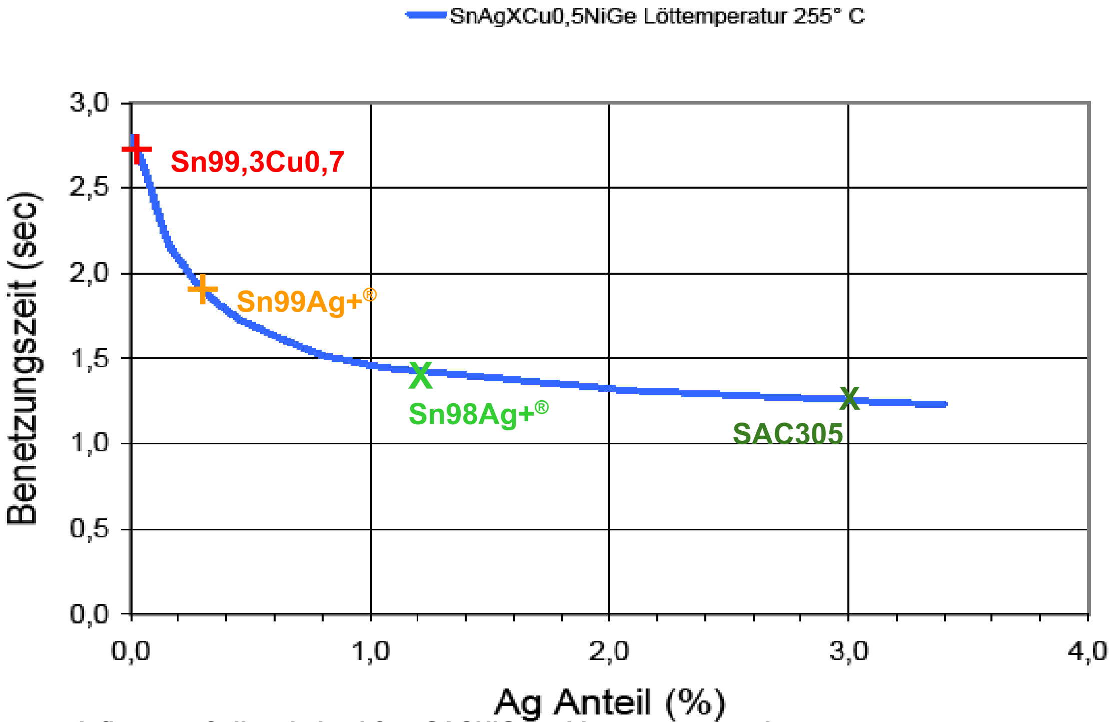


Figure 4: Influence of silver in lead-free SACNiGe solders on wetting time

Wetting time

In a further series of tests, the wetting times of various lead-free solder alloys were investigated. Here, too, the particularly positive effects of **"Sn98Ag+®"** were evident. A direct comparison of "Sn98Ag+®" and SAC305 showed the positive influence of germanium doping on wetting. The wetting curves (Figures 5/6) of both solders are almost identical despite the significantly reduced silver content.

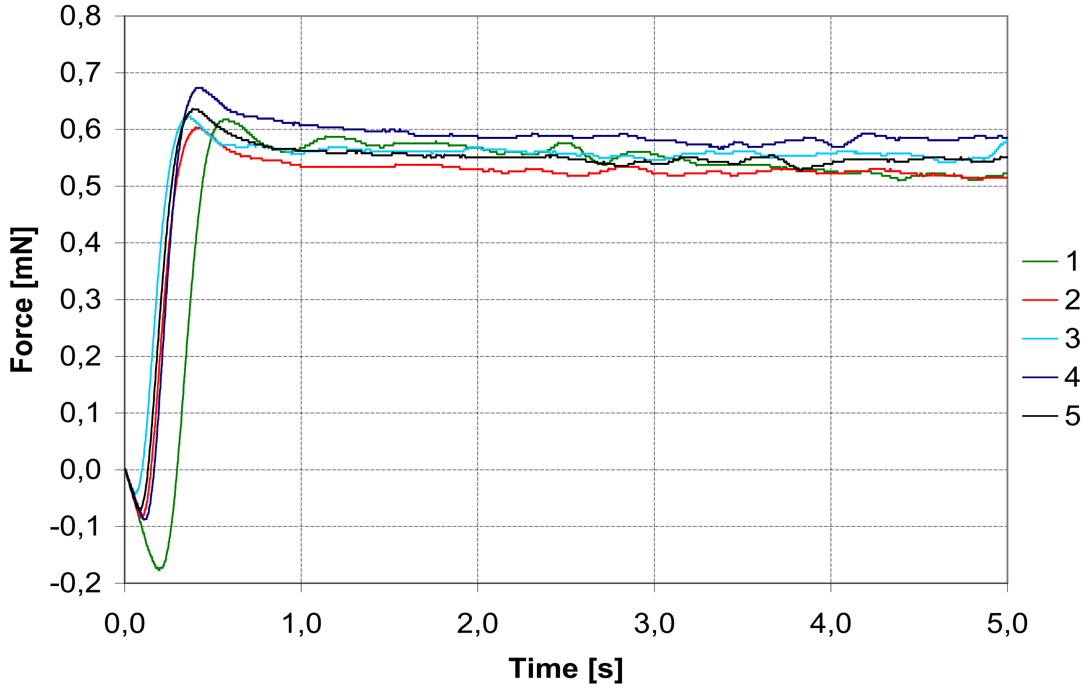


Figure 5: Wetting curve of SAC305

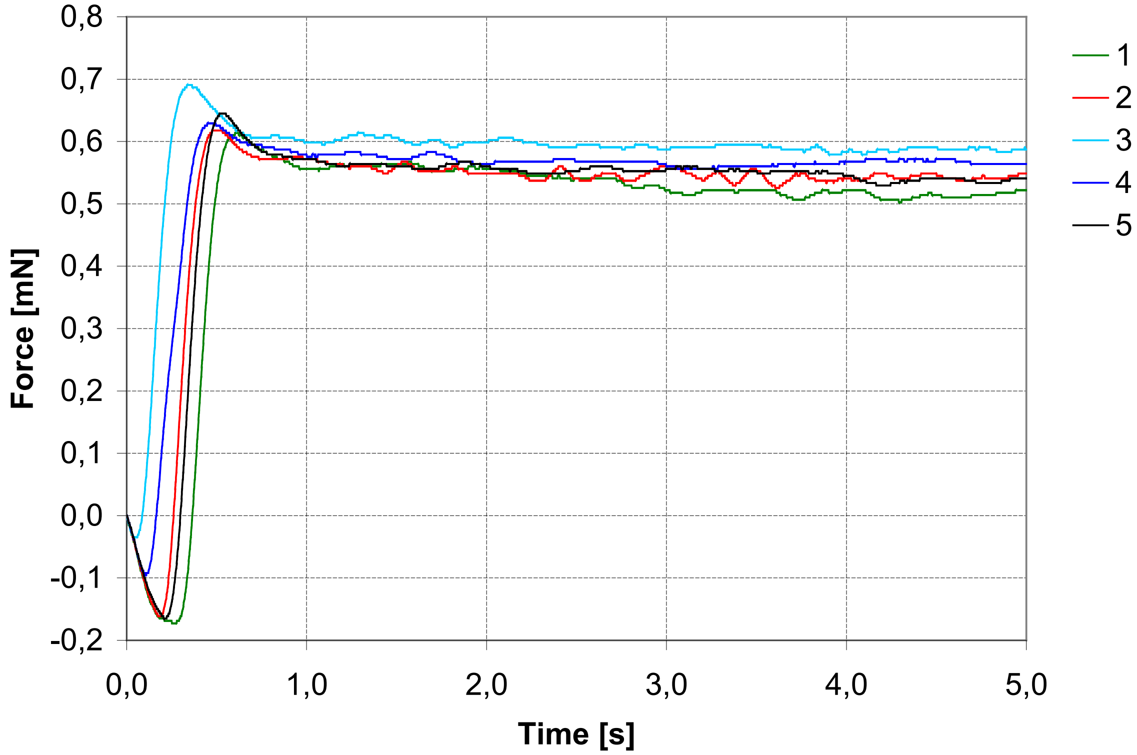


Figure 6: Wetting curve of Sn98Ag+®

Pros and cons

Based on this information and the experience we have gained in recent years in working with various lead-free solder alloys, we have listed the advantages and disadvantages of individual lead-free solders as follows:

Sn99,25Cu0,7Ni0,05(Ge) z.B. Sn100Ni+®, SN100-^{403}C, Tin-copper solders with NiGe doping

Pros	Cons
Inexpensive	Relatively high soldering temperature (up to 275 °C!)
High potential for experience	Limited spread
Low dross formation	Limited penetration
Reduced copper alloying	

Conclusion

Wave soldering temperatures above 270 °C conflict with the maximum thermal load capacities of various electronic components. Although IPC-A-610 classifies fill levels of 75% or higher as acceptable for classes 1-3, in practice it is difficult to determine a fill level of < 75% with any degree of accuracy.

SAC305 / SAC387, Non-alloyed tin-silver-copper solders

Pros	Cons
Low soldering temperature (from 255 °C)	High solder costs (+approx. 40.00 EUR/kg solder per % Ag content)
Good wetting	Protective gas required
Good penetration	High copper removal

Conclusion

High soldering and manufacturing costs are at odds with the prevailing price dumping in electronics manufacturing. In particular, wave soldering processes at soldering temperatures above 350 °C cause greater wear on metallizations such as copper and nickel, which then deposit as impurities in the solder bath. This can only be corrected by regular, cost-intensive solder replacement!

SAC0307NiGe (Sn99Ag+®) SnAg0,3CuNiGe, Doped "Low-SAC" alloy with 0.3% silver content

Pros	Cons
Moderate soldering temperature (260-265°C)	Melting range (10K) 217°C - 227°C
Better penetration than SnCu	Matte solder joints
Protective gas usually not required	
Significant reduction in solder costs	

Conclusion

An inexpensive, lead-free solder with good wetting properties. This solder significantly improves penetration (compared to Sn99.3Cu0.7).

SAC1207NiGe (Sn98Ag+®) SnAg1,2CuNiGe, Doped "low-SAC alloy" with 1.2% silver content

Pros	Cons
Soldering temperature analogous to SAC305	Solder joints slightly matt
Wetting analogous to SAC305	
Penetration up to 100% achievable	
No protective gas required	
Significant reduction in solder costs	

Conclusion

Lead-free solder with excellent value for money! This solder is in no way inferior to the significantly more expensive SAC305/SAC387. On the contrary: the values for wetting, soldering temperature, penetration, and reliability are equivalent and even better!

Conversion of existing solder baths

Switching to a "new" solder naturally involves some practical effort. However, it is not usually necessary to completely replace the solder bath contents. A change from SAC305 to, for example, "SnAg98+® (SnAg1.2CuNiGe)" requires a reduction in the silver content. In this case, only part of the existing solder bath is removed and replaced with special upgrade alloys (effort max. 1/2 working day). A changeover from silver-free alloys (e.g., Sn99Cu1 or Sn100C) to "Sn98Ag+®" or "Sn99Ag+®" is only carried out by adding concentrates and can be done in just a few minutes! A solder bath sample taken prior to the changeover provides information about the actual condition of the alloy. Ag, Ni, and Ge concentrates are then added to the bath based on the bath volume. After a few minutes, the new components have distributed evenly throughout the solder bath while the pumps are running and are effective. To be on the safe side, it is recommended to take another solder bath sample immediately to check the solder changeover.

In accordance with the new alloy, the new parameters such as crucible temperature, transport speed, and pump performance can now be adjusted, and the protective gas supply can be reduced or completely stopped. We would be happy to assist you with this process in person on site.

Summary

The silver market in 2026 is characterized by extreme scarcity. For the electronics industry, this means that silver-containing soft solders will become a luxury item, which will massively accelerate the trend toward substitution with low-silver and silver-free alloys.

Literature

[1] „Technology Journal“, Volume 09, Issue 04, CASE STUDY 3: „SAC OPTIMIZATION“, 09.11.2005, INTEL Corporation.

[2] “Lead-free activity report“, 28.02.2007, JEITA (Japan Electronics and Information Technology Industries Association)