1. General Product Information

- Microalloyed lead free solders
- Good wetting properties
- Smooth and shiny surface
- Reduced copper leaching
- Significantly diminished dross formation

Description

ELSOLD SN100 MA-S solders are designed to replace commercially available tin/lead alloys by lead-free alloys in existing production processes of electronic manufacturing with the pretension to improve properties of lead-free alloys. ELSOLD SN100 MA-solder provide all the advantages of Ni, Ge micro-alloyed solder alloys with the additional benefit of high stability and low dross rates.
SAC305 is the mostly accepted alloy of the SnAgCu group. However, high metal prices have caused introduction and increasingly interest in solders with lower or no silver contents, which provide good results in many applications at lower cost.

Application

As it is the case for lead-free alloys, changes of the temperature profile at the soldering equipment are required for ELSOLD SN100 MA-S solders as well. Typical soldering temperatures are in the range of 255 – 265 °C (up to 320 °C for selective soldering). The quality of the resulting solder joints is in many aspects comparable to traditional SnPb and all conventional lead free solders. In some respect ELSOLD micro alloyed lead free solders exceed quality of SnPb solders.
Physical properties are not changed by the micro-alloy additions. The differences between non-micro-alloyed and ELSOLD SN100 MA-S are as follows:

- Finer grains, resulting in smoother and shinier surface, caused by changed solidification behaviour.
- Reduced copper leaching
- Extended useful life of the solder baths due to reduced copper absorption
- Reduced wear on the soldering equipment
- Much lower cost, significantly diminished dross formation

Storage/Shelf Life

The material can be stored for a minimum of 60 months from the date of manufacturing. Care should be taken, however, to store the material in a clean environment. Using the material beyond the official shelf life is possible without any problem in most cases. However, this should be confirmed by adequate trials before actual usage.

Health and Safety

ELSOLD SN100(Ag) MA-S solder alloys are not considered to be harmful. Information relating to health and safety should be taken from the respective material safety data sheet.

Forms of Supply

ELSOLD SN100 MA-S alloys are available in the form of ingots/bars and solid wires for wave, dip, and selective soldering for manual and automatic soldering processes.

Description	Dimensions [mm]	Weight /Piece
Ingots with suspension eyelets	50 (W) x 18 (H) x 600 (L)	Approx. 4 kg
	50 (W) x 20 (H) x 490 (L)	Approx. 3 kg
1-kg bar	20 (W) x 20 (H) x 335 (L)	1 kg
Triangular bars	8 (W) x 10 (H) x 400 (L)	Approx. 200 g
Clippings	8 (W) x 10 (H) x 30 (L)	Bulk
Solid wires	Various diameters 0.5 – 6	On spools of 500 g, 1 kg, 4 kg, 15 kg

The purity of the alloys meets the requirements of norms EN 61190-1-3 and EN ISO 9453, respectively, with exception of Ni.

Physical properties of ELSOLD SN100 MA-S

Properties	ELSOLD SN100 MA-S SC07
Composition [%]	Sn 99.3 Cu 0.7 ± 0.2 Ni 0.03-0.04 Ge 0.003-0.007 P 0.001-0.005
Melting point [°C]	227
Density [g/cm^3]	7.32

2. Comparison of ISO standard and competitive alloys

	ISO 9453:2014-12 alloy 403	SN100 C Competitive Alloy	SN100 MA-S (Typical Values)
Sn	Remaining	Remaining	Remaining
Pb	<0.07	<0.05	<0.07 (0.03)
Sb	<0.10	<0.05	<0.10 (0.003)
Bi	<0.10	<0.03	<0.10 (0.02)
Cu	0.5-0.9	0.6-0.7	0.5-0.9 (0.7)
Au	<0.05	<0.03	<0.05 (0.001)
In	<0.10	<0.03	<0.10 (0.004)
Ag	<0.10	<0.05	<0.10 (0.02)
Al	<0.001	<0.001	<0.001 (0.0005)
As	<0.03	<0.03	<0.03 (0.01)
Cd	<0.002	<0.002	<0.002 (0.0005)
Fe	<0.02	<0.02	<0.02 (0.002)
Ni	<0.02-0.08	0.04-.006	0.03-0.04 (0.03)
Zn	<0.001	<0.001	<0.001 (0.0005)
Ge	Not specified	0.005-0.007	0.003-0.007 (0.006)
P	Not specified	None	P 0.001-0.005 (0.004)
			Special freshening process, see 4.

- SN100 MA-S fulfills all requirements of ISO 9453:2014-12, which is also used for SN100 C competitive alloys
- Consequently, all physical and mechanical properties and reliability data for SN100 MA-S are same or better than for ISO9453/alloy 403//SN100C
- SN100 MA-S is not affected by the SN100C patent
- Typically level of impurities is significantly lower for SN100 MA-S due to freshening process
- Due to P and special freshening SN100 MA-S offers advantages against SN100C especially with regard to dross formation (see 4. and 5.)

3. Refill & Refill Plus Lowest Dross Formation Even Under Difficult Conditions – Perfect Solutions for all Applications

Due to its unique production process, its very high purity and the micro-alloying elements Ge and P, SN100 MA-S offers a significantly reduced dross formation, a better soldering quality and economic advantages. In combination with tin, Ge and P form a protection layer on the surface of the soldering bath, but, of course, both are slightly consumed by time. For compensation of this, in many applications REFILL alloys with increased Ge and P are used very successfully. In some applications at very high temperatures, very strong and turbulent bath movement or also long power-on times combined with low consumption of solder, the consumption can be further increased and exceed the amount of P and Ge added by REFILL alloy. For such difficult conditions new REFILL Plus alloys offer a reliable solution. They have an even higher amount of Ge and an even higher purity that means a lower level of elements like Fe. This reduces the dross formation and also the consumption of P. Consequently, for all applications, the right solution is available:

	SN100 MA-S	SN100 MA-S REFILL	SN100 MA-S REFILL Plus
Application	For initial filling of machine	For refilling at low/normal thermal/oxidative stress and/or high production volumes	For refilling at high thermal/oxidative stress and/or low production volumes
Sn	99.3 %	99.8 %	99.8 %
Cu	0.7 %	0.2 %	0.2 %
P	10 – 50 ppm	120 – 200 ppm	120 – 200 ppm
Ge	30 – 70 ppm	60 – 100 ppm	250 – 350 ppm

REFILL and REFILL Plus alloys are also available for SN100Ag0.3 MA-S (SAC0307), SN100Ag1 MA-S (SAC107) und SN100Ag3 MA-S. Alloys are available as triangular bars, 1 kg bars and further types on request.

For temporarily increased consumption or as an alternative or addition for regeneration of solder bath Ge and P can also be added by using concentrated alloys with 1000 ppm P/Ge:

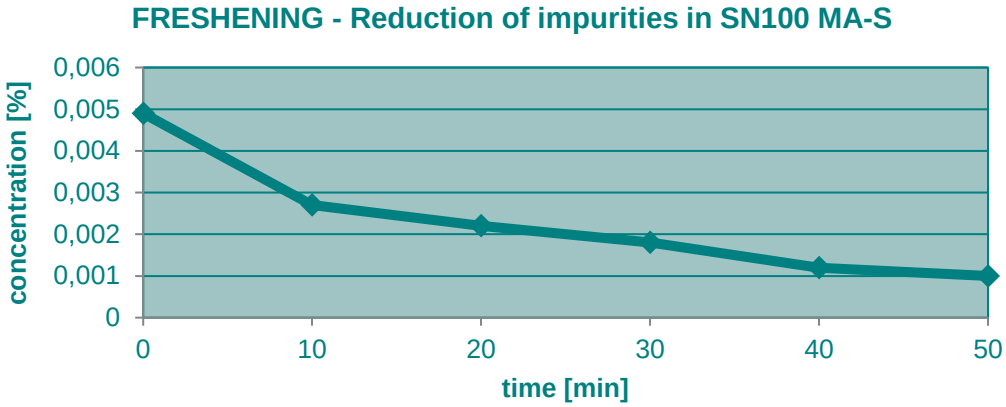
- SnP1 as desoxidation tablets in bottles with 50 or 800 pieces
- SnGe1 as 250 g bars

As a result of solder bath analysis suitable use (incl. right amounts) of REFILL, REFILL Plus or SnP1/SnGe1 will be recommended.

4. Technical Information – Dross Formation & Freshening Process

In addition to a complete range of high quality solder alloys, ELSOLD® now offers a world class innovation - the micro-alloys ELSOLD® SN100(Ag) MA and ELSOLD® SN100(Ag) MA-S. These solders are manufactured in a revolutionary process called "Frischen" or "Freshening" which can be described as an ultra-grade cleaning operation. This proprietary technique results in a highly pure and highly stabile solder alloy with a much lower tendency to oxidize during soldering. Typical solder defects such as bridging and solder spikes are almost non-existent. Compared with Sn99.3Cu0.7, our new lead free micro-alloy solder boasts the lowest amount of dross formation while soldering, thereby making it extremely economical!

The special manufacturing process of SN100 MA-S eliminates unwanted impurities leading to a highly pure and stabile alloy which shows a reduced tendency to oxidize. This proprietary manufacturing process guarantees an outstanding level of purity without contamination. Such alloys show a high stability and have a low viscosity thereby reducing typical solder defects such as solder peaks and solder bridging. The soldering results are out-standing and quality fluctuations are kept to an absolute minimum.

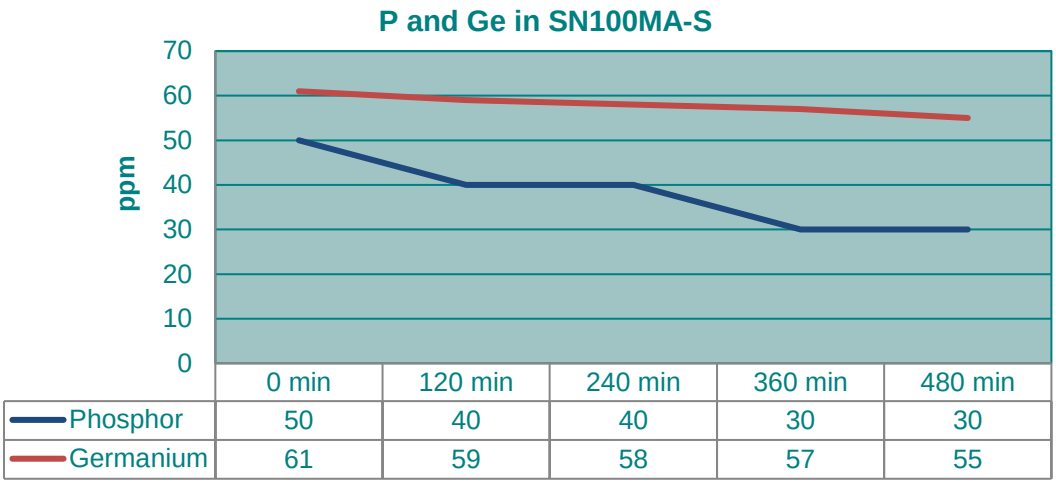


Dross formation in 4 h at 450 °C (static bath)	
SnAg0.3P, "fresh"	2.3 %
SnAg0.3P, non-"fresh"	6.5 %

Dross formation of "fresh" SnAg0.3P compared to a non-"fresh" material at 450 °C (static bath)

One tremendous advantage of "Freshening" can be seen with the stability of the alloys to resist oxidation. Under equivalent conditions, the dross formation of "fresh" SnAg0.3P alloys is a factor of nearly 3 times less than with non-"fresh" SnAg0.3P alloys.

In addition to the well known positive characteristics of SnCu / SnAgCu alloys, it is the outstanding cost / performance ratio that makes SN100 MA-S truly stand out. When using lead free alloys in an open or atmosphere wave solder machine, the dross formation is larger than the required amount of solder in the product. This means that the manufacturing process of a product requires 3 times the amount of solder that ends up being built into the product! With ELSOLD® SN100 MA-S, the dross formation is so reduced that the same product can be manufactured with a far lower solder requirement. This enormous savings has an even greater payoff when using cost intensive silver alloys.



A solder bath analysis will clearly substantiate that the value added outstanding properties ELSOLD® SN100 MA-S remain stable over a very long period of time.

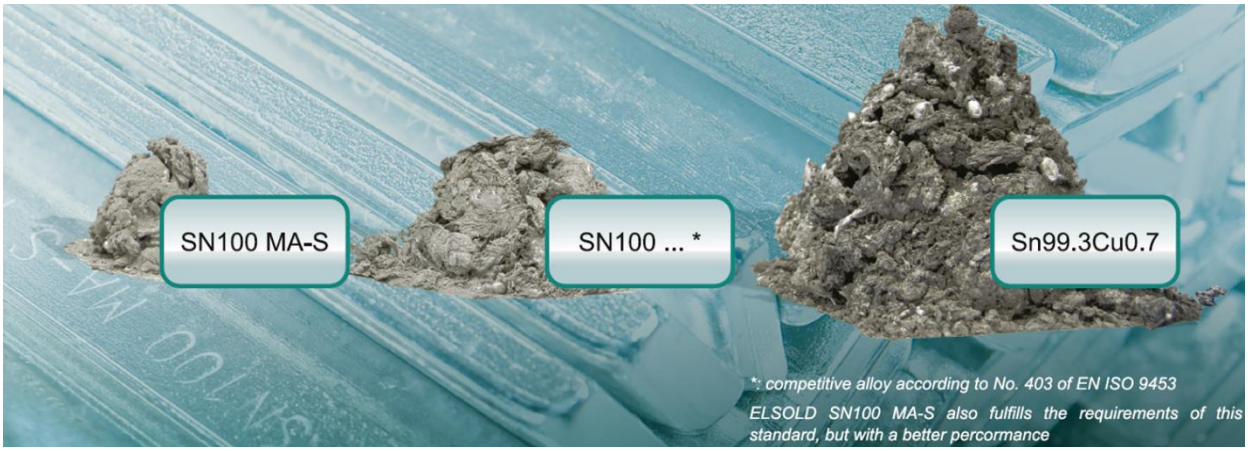
Analysis results of SN100 MA-S dynamic dross test over 8 h at 290 °C

Element symbol	Initial state	Conc. after 2 h	Conc. after 4 h	Conc. after 6 h	Conc. after 8 h
Sn	Rest	Rest	Rest	Rest	Rest
Cu	0.67	0.69	0.,69	0.69	0.70
Ag	0.0002	0.0002	0.0002	0.0002	0.0002
Ni	0.035	0.035	0.035	0.035	0.035
Ge	0.0061	0.0059	0.0058	0.0057	0.0055
P	0.005	0.004	0.004	0.003	0.003
Pb	0.017	0.017	0.017	0.017	0.017
Sb	0.004	0.004	0.004	0.004	0.004
As	0.018	0.018	0.018	0.018	0.018
Fe	<0.001	<0.001	<0.001	<0.001	<0.001
In	0.003	0.003	0.003	0.003	0.003
Bi	0.011	0.011	0.011	0.011	0.011
Cd	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Zn	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Al	0.0001	0.0001	0.0001	0.0001	0.0001
Au	0.0001	0.0001	0.0001	0.0001	0.0001
Co	<0.001	<0.001	<0.001	<0.001	<0.001

The solder bath remains stable. The concentration of all elements remain stable in the observed period of time. Actually, only a very slight amount of Germanium (6 ppm) and Phosphor (20 ppm) could be observed.

The tremendous advantage of SN100 MA-S can best be seen in a dynamic wave soldering process. At 290 °C the dross formation on the wave can be reduced by a factor of 15! This means not only fantastic savings due to using less expensive solder, but also savings due to a reduced service requirement of the wave soldering machine!

Based on the positive effects of “Freshening” and the influence of the micro-alloy additives, dross formation with SN100 MA-S is up to 93 % reduced compared to non- "freshening" SnCu0.7 alloys without micro-additives.



Dross formation of SN100 MA-S in comparison to SnCu0.7 at 290 °C in a **dynamic** solder bath (8 h).

Solder bath surface after 8 hours and before dross removal

SN100 MA-S

SnCu0.7

Solder bath surface after 8 hours and after dross removal

SN100 MA-S

SnCu0.7

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5. Scientific Studies on Ni and P

Microalloyed Solder Alloys – Content Does Matter

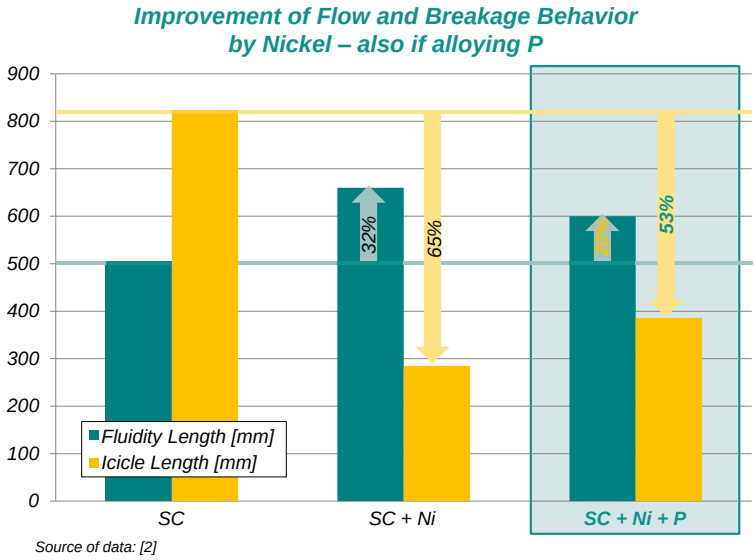
Improving the properties of lead-free solder has been in focus of research and development for several years, whereby microalloying is one of the most important approaches [e.g. 1]. A detailed analysis of a recent research work [2] confirms that due to possible interactions between the alloying elements like nickel or phosphor especially their exact content matters.

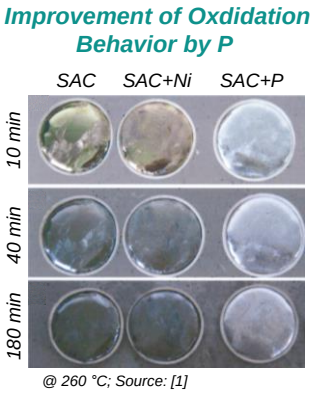
So, in ELSOLD SN100(Ag) MA-S solders the phosphor content is typically adjusted to about 40 ppm and lies in that range, which enables to use the positive effects of phosphor concerning oxidation and dross generation and also the advantages of nickel with regard to microstructure, fluidity, breakage behavior and risk of bridging. Finally, the analysis of the recent research studies confirms the development results by ELSOLD and the positive experience by numerous customers.

- **Influence on Microstructure**
  Alloying Ni improves and homogenizes the microstructure of the solder. Typical primary dendrites disappear. Consequently mechanical properties are increased and risk of crack formation is reduced [1, 2].
  Even though phosphor reduces this positive effect, at phosphor contents, which are typical for MA-S alloys, a clear advantage remains. Only at 800 ppm P and more, that means factor 20 compared to MA-S, no improvement of microstructure is possible any more. [2]
- **Fluidity, Breakage Behavior and Risk of Bridging**
  Similar to the influence on microstructure, nickel has a very positive effect on flow and breakage behavior, which is only slightly reduced by phosphor. Icicle length and consequently the risk of bridging is reduced by 65% by adding Ni, and still by 53%, if Ni and P are combined. Fluidity is improved by 32% by Ni. Adding small phosphor contents, which are typical for MA-S alloys, an improvement by 20% remains. Only at high phosphor contents (> 200 ppm) the improvement is reduced to 8%.
- **Binding of Nickel by Phosphor**
  Investigations described in [3] approve that the positive effects of Ni are eliminated only by very high phosphor contents. They show a reduction of effective Ni content only at more than 500 ppm P. At lower values (about 50 ppm) a constant Ni value was detected.
- **Reduction of Oxidation and Dross Generation**
  In contrast to nickel, which has no strong influence on oxidation behavior, phosphor offers important advantages in this regard. Probably by the formation of complex tin phosphor mixed oxides a protective layer on the surface prevents the solder from further oxidation and dross generation [1]. But also here, the content matters. At too high phosphor contents > 700 ppm the formation of intermediate Sn-P-phases was detected, which would damage this protection layer [4]. At lower contents of about 40 ppm, typical for MA-S solder, phosphor – combined with the similar, supporting effect of germanium and the high purity due to the special manufacturing process – creates the well-known very low dross generation of MA-S solders.

In a nutshell, nickel and phosphor each have their own specific positive effects on the properties of lead-free solders and therefore both are useful as microalloying elements. Because some of these effects are opposing, a very targeted alloying is necessary. But a complete binding of Ni and an elimination of its positive effects only happen at phosphor contents 10 times higher than typical values of SN 100 MA-S solders and no negative synergies between both elements are known. At about 40 ppm phosphor the

advantages of nickel remain to a great extent and are combined optimally with a protection against oxidation and dross generation.





Literature

[1] W Dong, Y Shi, Y Lei, Z Xia, D Guo: Effects of small amounts of Ni/P/Ce element additions on the microstructure and properties of Sn3.0Ag0.5Cu solder alloy, J Mater Sci: Mater Electron (2009) 20:1008-1017

[2] P Corviseri: Das Geheimnis Nickel-dotierter Lote, productronic 07 / 2013, 20-21

[3] Patent EP 2 243 590 A1: Method of regulating nickel concentration in lead-free solder containing nickel, Nihon Superior Sha Co., Ltd Suita-shi Osaka 564-0063 (JP), 2010

[4] AP Xian, GL Gong: Surface oxidation of molten Sn-0.07 wt% P in air at 280 °C, J Mater Res, Vol 23, No 6, 2008, 1532-1536

6. Customer Tests and Reference Lists

Customer Test (EO, Germany)
Machine: Seho 8000
Alloy: SN100 MA-S (vs. SN100C)
Process Parameters: 0.8 mm/min, Preheating 120/200/420 °C, Temperature at PCB surface:116-118°C, Bath temperature: 265°C, delta-wave

Result:
"The solder joints were high-gloss (shinier than e. g. SN100C), the wetting was perfect - even with superimposed boards. No dross was observed in the current wave. According to current knowledge, this alloy is a good alternative."

Reference List SN100 MA-S

OSRAM SpA	Treviso (IT)
S. Siedle & Söhne OHG	Furtwangen
Laryo S.R.L.	Milano (IT)
Otis GmbH & Co. OHG	Berlin
Leesys - Leipzig Electronics Systems GmbH	Leipzig
CML Innovative Technologies GmbH & Co.KG	Bamberg
Pfeifer und Seibel GmbH	Breidenbach
DOKAtec Elektronik GmbH	Sömmerda
Bittorf GmbH & Co. KG Elektrotechnik	Mellrichstadt
ERSA GmbH	Wertheim
Elblinger Elektronik GmbH	Salzgitter
Emil OTTO e.K.	Eltville
SEHO Systems GmbH	Kreuzwertheim
Inertec Löttechnik GmbH	Kreuzwertheim
Tyco Electronics Austria GmbH	Waidhofen (AT)
SMD Leiterplatten Lötservice GmbH	Berlin
Boliden Bergsøe A/S	Glostrup (DK)
Cardin Elettronica SPA	San Vendemian (IT)
ELC.A. scrl	Onè di Fonte (IT)
LAB Electronic GmbH	Minden
ELCON Systemtechnik GmbH	Hartmannsdorf
Tyco Electronics EC Trutnov S.r.o.	Trutnov (CZ)
ZETech C.C.	Blairgowrie (ZA)
IKODA GmbH Innovative Kommunikationstechnik	Dabendorf
Uartronica-Electronica, Lda.	Aveiro (PT)
Mebatron Elektronik GmbH	Brieselang
Watterot electronic GmbH	Leinefelde
BMB Kabeltechnik SRL	Copsa Mica (RO)
Komos GmbH	Bürgel
Avel Electronica Lda.	Trofa (PT)
HFA – Henrique, Fernando & Alves, S.A.	Agueda (PT)
Hans Widmaier	München
Kress Köstl & Rasch Elektronik + Service GmbH	Fraureuth
Bittorf GmbH & Co. KG	Mellrichstadt
A.S.T. Angewandte System-Technik GmbH	Dresden
Alre Regeltechnik GmbH	Berlin
FSG Fernsteuergeräte Meß- u. Regeltechnik GmbH	Königs Wusterhausen