Belt & Re-work Strippers for Lead-free Solders

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There has recently been a worldwide effort to replace lead in electroplating processes. The development of these lead-free electroplating processes, such as tin-bismuth and tin-copper, has led to the need for new post-plating processes. An electrolytic belt stripper and re-work stripper capable of removing lead-free solder deposits are among these processes. The strippers described are capable of removing pure tin, tin-lead, and tin-based lead-free deposits at exceptionally fast rates. A key advantage of the electrolytic belt stripper is the presence of a corrosion inhibitor that protects plating belts and other equipment. A beneficial feature of the re-work stripper is the capability of removing the tin and tin alloy deposits without forming smut on copper-based substrates.

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In the manufacture of semiconductor lead-frames, a strip containing several IC packages is attached to a continuous stainless steel belt by way of clips. This belt transports the frames through a variety of manufacturing processes, including the tin or tin alloy plating solutions. During plating, the belt functions as a cathode, resulting in the buildup of tin or tin alloy deposits on its surface. Such deposits are undesirable on the belt because they may interfere with the mechanical functions of the belt and clips. Therefore, after the plated lead-frames have been unloaded from the belt assembly, the deposits are stripped from the belt and clips with the use of a stripping solution. These stripping processes are typically electrolytic (anodic voltage is applied to the belt) and must work efficiently in order for the belt to reach the beginning of the process with no tin residue where a new set of parts will be loaded. Bleeks[1] has reported that electrolytic stripping processes were among the first utilized by the finishing industry and are regaining popularity over immersion strippers for environmental reasons.

With re-work stripping processes, the defective parts can be re-plated, therefore, reducing manufacturing costs. The re-work stripper needs to efficiently strip these defective deposits from copper-based substrates such as C7025 and C194 without leaving a smutty film that can be difficult to remove[3]. The re-work processes usually operate by immersion. Rosenstein and Hirsch[2] assert that immersion strippers are preferable because complex-shaped parts can be stripped uniformly with less occurrence of passivation.

Even though both the belt and re-work stripping solutions remove tin or tin alloy deposits from a substrate, they cannot be used interchangeably. Each of them is designed to prevent the attack on the substrate after the deposit is dissolved. In the case of the belt stripper, the substrate is stainless steel, and in the case of the re-work stripper, the substrate is a copper alloy. The use of an inappropriate stripping solution may cause process failure.

In this paper, an electrolytic belt stripper and an immersion re-work stripper are investigated.

Experimental Procedure

<u>Electrolytic Belt Stripper</u>

The operating conditions used to strip pure tin, tin-lead, and the lead-free solders are given in Table 1. In addition to a corrosion inhibitor, the solution also contains a surfactant, agglomerating agent and antioxidant.

The surfactant allows for uniform, dendrite-free deposits to be plated onto the cathodes as tin ions accumulate in the solution during the stripping process. This is important to prevent dendrite formation that may lead to bridging between the cathode and anode. The surfactant used in this formulation has a high cloud point, which allows the process to run at temperatures higher than most conventional processes and thus, significantly increasing stripping rates.

The presence of the antioxidant reduces the formation of tin (IV), which eventually precipitates and requires filtration for removal from the solution. The antioxidant used in this formulation is a non-hazardous and non-carcinogenic material, which makes it safe for the environment and the user. The agglomerating agent allows tin (IV) species to coalesce as a coarse precipitate, thereby, assisting in solution filtration during operation. The stainless steel corrosion inhibitor is a novel component of the belt stripping solution and prevents belt degradation after tin stripping has been completed and the belt is exposed to the corrosive solution under anodic current.

Table 1
Operating Conditions

Parameter	Range	Recommended
Temperature	45 – 55° C	50° C
Voltage	1.2 – 1.4 Volts	1.4 Volts
Agitation		Vigorous

The plating and stripping cycle consists of the following steps:

- Load parts on the belt
- Deflash
- Rinse
- Electroclean
- Rinse
- Descale
- Rinse
- Acid Pre-dip
- Electroplate
- Rinse, Dry
- Unload plated parts
- Electrolytic Stripping
- Rinse

Stripping rates were determined for pure-tin, tin-lead, tin-bismuth, and tin-copper deposited on to 316 stainless steel. After a coupon was plated, deposit thickness was measured by the X-Ray Fluorescence method. The coupon was then placed in the stripping solution, and a voltage of +1.4V was applied. When the current reached zero Amps, the stripping was considered complete and the time was recorded. Based on this information, the stripping rates were calculated. Deposit stripping was performed utilizing the recommended operating conditions.

To determine the effect of temperature on the stripping rate, stripping was performed at two temperatures for each deposit: 35° C and 50° C.

The corrosion of the belt material was studied using two experimental procedures. The first was a surface study that involved 50 consecutive cycles of plating and stripping the tin deposit. SEM photographs of the belt surface were taken after 50 cycles.

The second study involved two stripping solutions: one with corrosion inhibitor and the other without. This test consisted of 50 cycles of exposing the bare belt material to the stripping solution for three minutes at +1.4 volts and then to air for 30 seconds. The dissolution rate of the belt material was estimated based on the concentration of iron, chromium, and nickel analyzed by ICP in the stripping solution after every 10 cycles.

The stability of the stripping rate over time was studied in the following experiment. A piece of tin metal was anodically dissolved to build up the tin concentration in the stripping solution. Every 10 Amp-hours/Liter, the tin piece was removed and replaced with a plated piece of stainless steel material so the stripping rate could be determined. At the same interval, the tin (II) concentration in the solution was measured by titration.

<u>Re-work Stripper</u>

The solution composition and operating conditions of the re-work stripper are given in Table 2.

Table 2
Operating Conditions

Parameter	Range	Recommended
Temperature	23 – 27° C	25° C
Agitation		Mild

Stripping rates were determined for pure tin, tin-lead, tin-bismuth and tin-copper deposited onto C7025 material.

A smut-test was performed to determine if a black residue was formed on the C7025 material after stripping pure tin and tin alloys. Smut formation can be detected by wiping the surface with a cotton squab after stripping and rinsing. The smut test was also performed on C194 substrates plated with tin-lead for comparison purposes.

A life-study was performed on the stripping solution to monitor stripping rate as a function of total metal buildup. Tin-lead deposits stripped under the standard operating conditions were utilized for this test.

Results

Electrolytic Belt Stripper

Figure 1 illustrates the stripping rates of tin and tin alloys in the modified stripping solution in comparison with a conventional formulation. Tin-lead and tin-bismuth had the fastest rates, followed by pure tin. Although the stripping rate of tin-copper was the slowest of the tin alloys, the rate was still higher from the modified solution than from the conventional one.

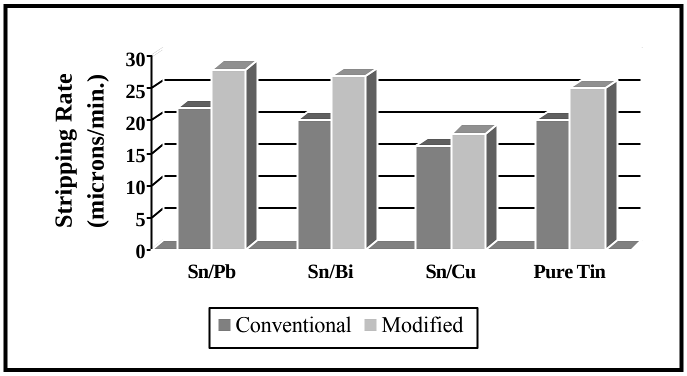

Fig.1- Stripping Rates for various deposits at 50°C.

Figure 2 shows the effect of temperature on the stripping rate. Increasing the solution temperature increased the stripping rate for all deposits.

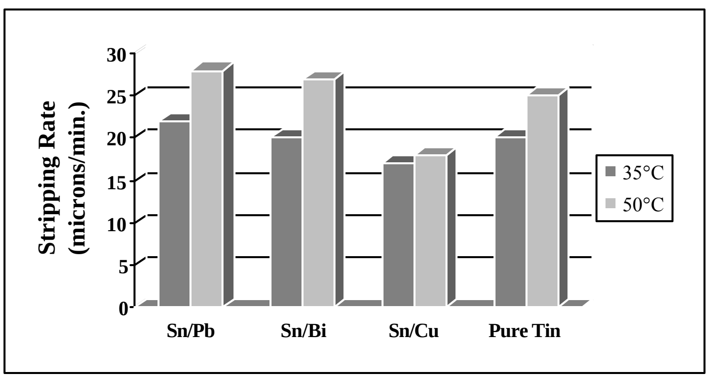

Fig. 2 -Effect of temperature on the stripping rate.

The corrosion test utilizing plating/stripping cycles performed on the belt material did not reveal significant changes in the morphology of the surface. Figure 3 is an SEM photograph of the surface before exposure to the stripping solution. Figure 4 is an SEM photograph of the surface after 50 cycles of plating and stripping the deposit in a solution without the corrosion inhibitor.

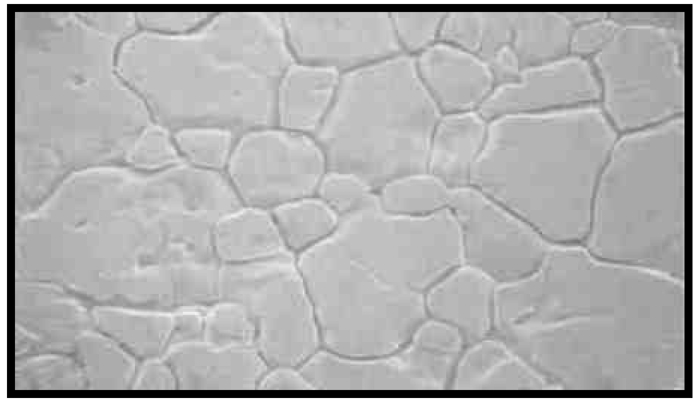

Fig. 3-Belt surface before exposure to stripping solution (Magnification 2000x).

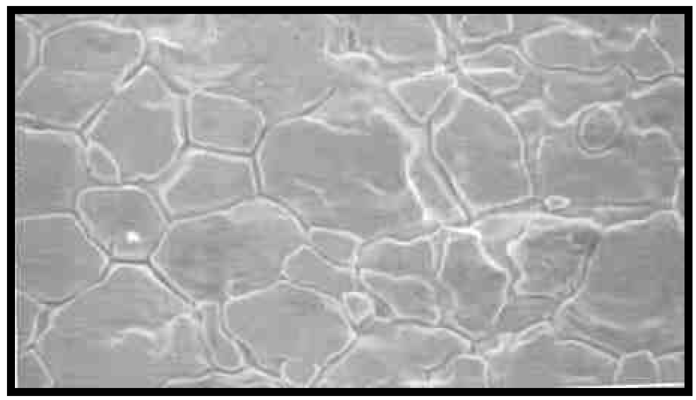

Fig.4-Belt surface after corrosion test in a stripping solution without corrosion inhibitor (Magnification 2000x).

The second corrosion study based on the dissolution of the belt material showed that the presence of the corrosion inhibitor in the stripping solution reduced the attack on the belt. Figure 5 illustrates the amount of chromium, iron, and nickel dissolved from the stainless steel belt after exposure to a stripper solution containing no corrosion inhibitor. Figure 6 shows that significantly less chromium, iron, and nickel are dissolved when the corrosion inhibitor is present in the solution.

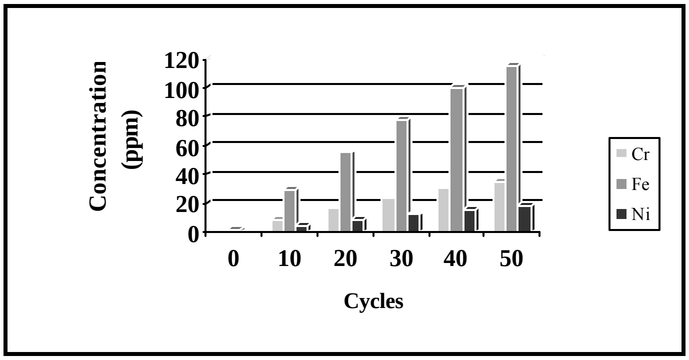

Fig. 5-Amount of chromium, iron, and nickel dissolved from the belt after exposure to a stripping solution without corrosion inhibitor.

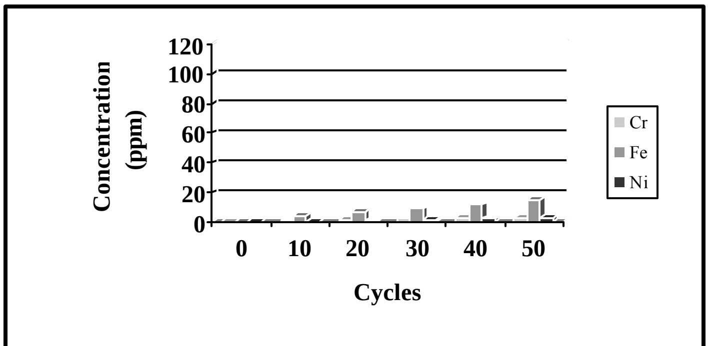

Fig. 6-Amount of chromium, iron, and nickel dissolved from the belt after exposure to a stripping solution containing corrosion inhibitor.

The testing of stripping rate stability over time revealed that as the tin concentration increased in the stripping solution, the stripping rate decreased. However, after 30 Amp-hours/Liter, the stripping rate was still high, as shown in Fig. 7.

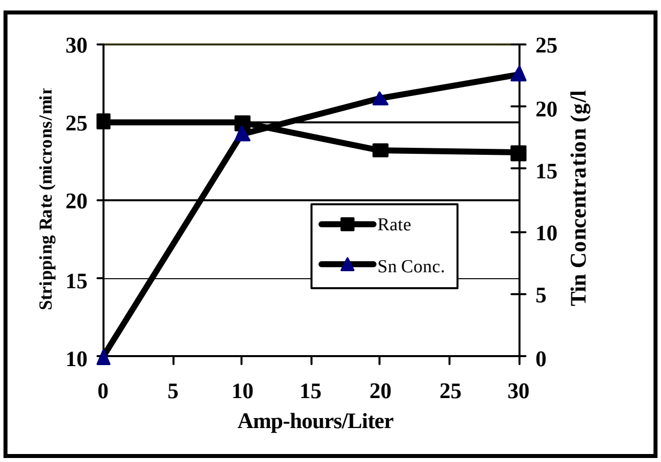

Fig. 7-The stripping rate and tin (II) concentration in solution during electrolysis.

Re-work Stripper

Figure 8 gives the stripping rates for pure-tin and the tin-alloys. The stripping results revealed that the re-work stripper was least effective for tin-bismuth alloys, producing a stripping rate of only two microns/minute. By comparison, tin and tin-lead were stripped at a much higher rate of about 10 microns/minute.

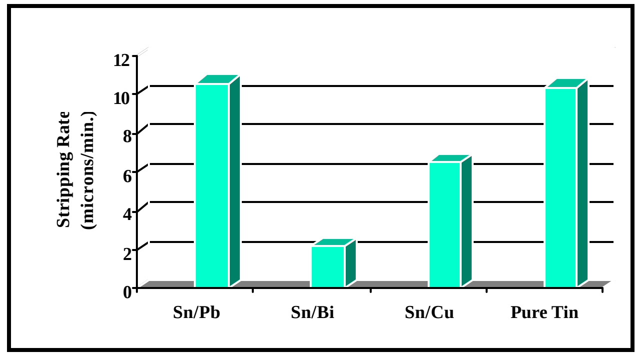

Fig. 8-Stripping rates for tin and tin alloys in the re-work stripper.

The smut-test revealed that an oxide residue did not form after stripping pure-tin, tin-lead, tin-bismuth and tin-copper from a C7025 substrate. The oxide residue also did not appear on C194 substrates after stripping tin-lead.

The life-test performed on the stripping solution showed that as the total metal (tin + lead) in solution increased, the stripping rate decreased. Figure 9 shows the results to this test.

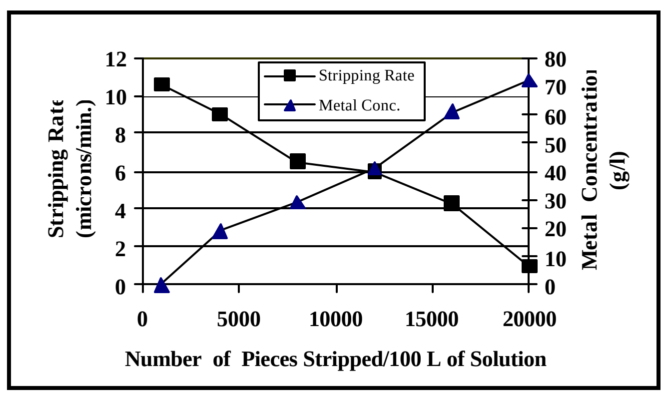

Fig. 9-Life-study on the re-work stripper.

Conclusion

Besides offering a high stripping rate, reduced corrosion and stability, the electrolytic belt stripper described within is environmentally friendly since it contains a biodegradable acid and is free of carcinogenic or cancer-suspect compounds. Another key advantage of the electrolytic belt stripper is that precipitated tin (IV) is easily removed, which results in large cost savings for the user.

In addition to its ability to strip tin and tin alloys completely in an efficient manner, the re-work stripper described within does not contain fluorides, fluoroborate or peroxide. It also fumes very little during operation, and only a small degree of sludge is formed during aging.

References:

1. T.W. Bleeks, *Products Finishing, 1995 Directory and Technology Guide,* **59,** 2-A (1994).

2. C. Rosenstein & S. Hirsch, *Metal Finishing 67th Guidebook and Directory Issue,* **97,** 1 (1999).

3. M.G. Milo, U.S. Patent 2,842,435 (1958).