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Coefficient of Friction of Sn Separable Interface Applications

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Introduction

Due to legislative pressures, customers are now requesting lead free products. This report presents data comparing the frictional behavior of lead free pure Sn and traditional 93-7 SnPb electrodeposits under conditions typically used in Sn separable interface applications. Friction impacts insertion/retention forces in separable connector applications.

Test Method:

Coefficient of Friction [COF] values were generated for the different coating combinations by dead weight loading a stationary hemispherical cap against a coupon attached to a DC motor driven reciprocating simple harmonic motion table. The lateral force was dynamically measured and analyzed using a 1000 g (2.2 lb.) load cell and computer data acquisition/analysis programs. Further description of this apparatus can be found in reference 1.[1]

The testing parameters used were:

- Wear track length: 5mm (0.2 in.)
- Three different normal loads were used: 100, 300, and 500g
- At least three cap on flat wear tracks of 10 friction cycles each were tested for all sample combinations evaluated

Each friction cycle consists of a forward and a reverse pass under load due to the reciprocating harmonic motion of the table along the 5 mm (0.2 in.) track. Therefore, each friction cycle has 2 COF values (1 forward and 1 reverse).

Samples:

Typically, the vast majority of Sn based separable interface applications are used in the lubricated state using normal forces in the range of several hundred grams.[2]

Substrates:

0.4 mm (15.7 mil) thick T04 C51100 Phosphor Bronze 12.75 x 25.5 mm (0.5 x 1.0 in.) coupons and 6.35 mm (0.25 in.) radius hemispherical formed caps with no Ni barrier.

Electrodeposits:

Both matte and bright samples of the lead free pure Sn and the 93-7 SnPb electrodeposits were plated in the lab. The combinations tested were:

[1] Friction Behavior of Press-Fit Applications: Test Apparatus, Methodology, and Results, Corman, N., Myers, M., Copper, C., paper accepted for presentation at the 2003 HOLM Conference.
[2] The Tin Commandment, Whitley, J. H., Plating and Surface Finishing October 1981, pp 38-39.

Lead Free	97-3 Sn Pb
Matte cap on Matte flat	Matte cap on Matte flat
Bright cap on Matte flat	Bright cap on Matte flat
Bright cap on Bright flat	Bright cap on Bright flat

Optimal plating parameters specified by the bath suppliers were used to produce deposits with a thickness between 1.0 – 1.5 μm (40 – 60 microinches).

Lubricant:
Tyco Electronics proprietary Sn lubricant PN 1205405-1 was applied by dipping, draining the excess off, followed by hang drying. Similar to what is done in the production environment.

Results:
COF results were calculated as the average Root Mean Square [rms] value. The standard deviation of the average rms COF's was calculated for each direction of travel along the 10 cycle wear tracks.

The data is presented in two formats.

- Table 1 is the average and standard deviation COF values for both the forward and reverse on the 1st friction cycle for three wear tracks. Similar to the first insertion and extraction cycle in a connector.

- Table 2 is the average and standard deviation COF forward and reverse values for all 10 friction cycles for three wear tracks.

Figure 1 is an example of a typical 10 cycle COF data trace from which the data in Tables 1 and 2 are derived (1st cycle, forward, reverse, 10 cycles, etc.).

Conclusions:
COF values are a good guideline for sliding behavior of contact systems. However, COF values are not the only factor influencing insertion and extraction forces. Surface geometry interaction, formed surface features (rolled, formed, sheared, etc.), insertion/extraction dynamics of the designs, and environment are examples of other factors that effect the measured insertion/extraction forces of a contact system.

All the lubricated samples tested exhibited COF values within the range to be expected for lubricated Sn based coating friction testing. COF data for lubricated lead free pure Sn and the 93-7 SnPb electrodeposits tested in the range of a few hundred grams are not statistically different.

The lubricated lead free pure Sn and the 93-7 SnPb electrodeposits performed comparably in sliding Sn based contact applications.

Additional information on our lead free product can be found on our website:
http://www.tycoelectronics.com/leadfree

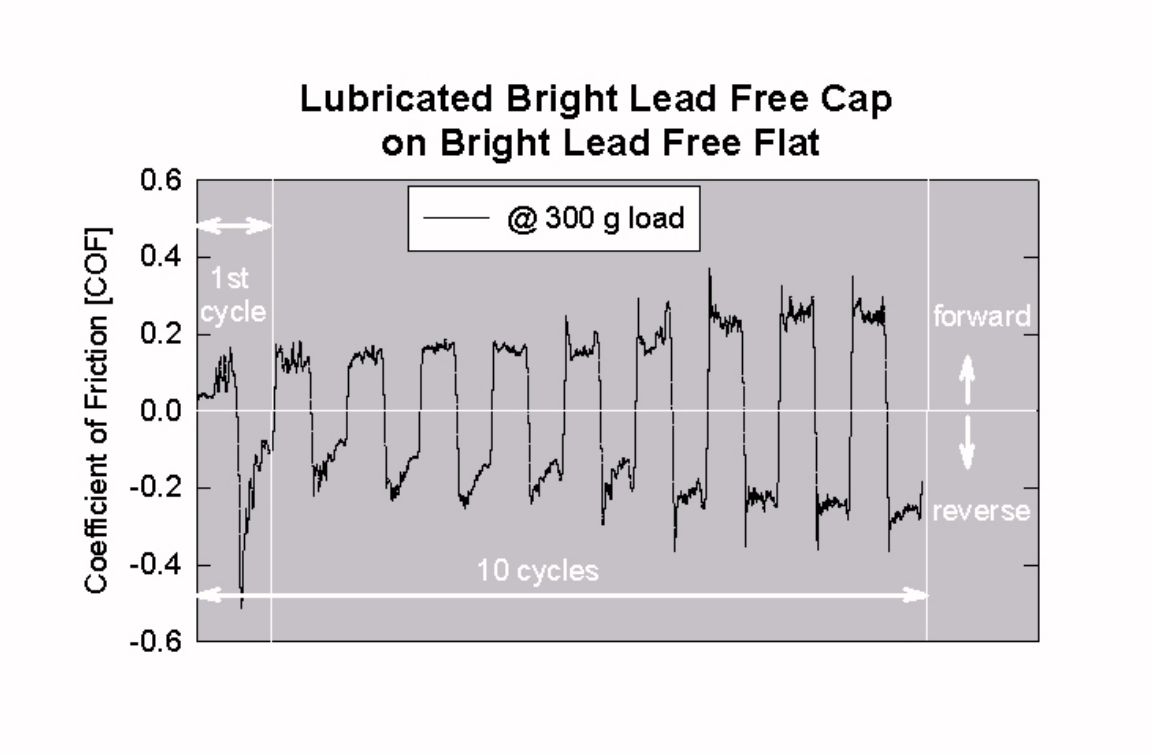

Figure 1: Example of 10 cycle COF data trace

Table 1: Lubricated 1st cycle rms COF data

MATTE cap on MATTE flat					
		lead free		SnPb	
	1st cycle	average	standard deviation	average	standard deviation
100g load	forward	**0.10**	0.01	**0.32**	0.10
	reverse	**0.23**	0.01	**0.37**	0.03
300 g load	forward	**0.11**	0.02	**0.18**	0.00
	reverse	**0.20**	0.02	**0.27**	0.01
500 g load	forward	**0.08**	0.02	**0.21**	0.14
	reverse	**0.17**	0.07	**0.19**	0.12
BRIGHT cap on MATTE flat					
		lead free		SnPb	
	1st cycle	average	standard deviation	average	standard deviation
100g load	forward	**0.26**	0.11	**0.32**	0.22
	reverse	**0.48**	0.08	**0.39**	0.15
300 g load	forward	**0.21**	0.07	**0.21**	0.03
	reverse	**0.29**	0.04	**0.37**	0.04
500 g load	forward	**0.30**	0.03	**0.35**	0.04
	reverse	**0.30**	0.04	**0.28**	0.05
BRIGHT cap on BRIGHT flat					
		lead free		SnPb	
	1st cycle	average	standard deviation	average	standard deviation
100g load	forward	**0.15**	0.02	**0.09**	0.01
	reverse	**0.31**	0.03	**0.18**	0.02
300 g load	forward	**0.06**	0.02	**0.09**	0.05
	reverse	**0.19**	0.03	**0.16**	0.08
500 g load	forward	**0.08**	0.02	**0.12**	0.01
	reverse	**0.15**	0.04	**0.18**	0.01

Table 2: Lubricated 10 cycle rms COF data

Matte cap on Matte flat						
	100 g load		300g load		500g load	
	average	standard deviation	average	standard deviation	average	standard deviation
leadfree	**0.29**	0.13	**0.15**	0.06	**0.16**	0.10
SnPb	**0.33**	0.05	**0.27**	0.05	**0.17**	0.06
Bright cap on Matte flat						
	100 g load		300g load		500g load	
	average	standard deviation	average	standard deviation	average	standard deviation
leadfree	**0.33**	0.11	**0.23**	0.06	**0.25**	0.05
SnPb	**0.30**	0.08	**0.29**	0.07	**0.17**	0.06
Bright cap on Bright flat						
	100 g load		300g load		500g load	
	average	standard deviation	average	standard deviation	average	standard deviation
leadfree	**0.24**	0.05	**0.21**	0.05	**0.26**	0.08
SnPb	**0.29**	0.08	**0.23**	0.07	**0.24**	0.08