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MECHANICAL TESTING OF ELECTRONIC PRINTED CIRCUIT BOARDS AND SOLDERING ALLOYS

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Abstract: *According to electronic technology theory, the electronic connection must satisfy electrical, thermal and mechanical functionalities. Is known that the resistance and mechanical integrity of the electronic assembly (composed from: printed circuit boards (PCB), devices/electronic components and electronic component installation on printed circuit boards), is provided by the mechanical function. The goal of the present paper is to describe some mechanical aspects regarding the behaviour of copper layer deposit on the PCB and of the soldering alloys deposit on the copper – PCB assembly used in electronic technology and also we want to determine the abrasion coefficient of those. In order to highlight the mechanical characteristics of tested boards in correlation with different rigid support, there were performed some mechanical tests using a dedicated stand. The tested PCB's is CEM (composite epoxy material) with deposited copper, and the soldering alloy was a lead free one SAC305. Friction forces between sliding surfaces arise due to complex mechanisms and lead to mathematical models which are highly nonlinear, discontinuous and nonsmooth. The novelty of the present paper is given by the materials that are tested and by the fact that this type of mechanical testing was never used in electronic technology, although the subject under discussion has major importance for mechanical integrity of electronic assemblies.*

Keywords: *soldering alloys, printed circuit boards, adhesion, CEM (composite epoxy material).*

1. INTRODUCTION

According to electronic technology theory, the electronic connection must satisfy electrical, thermal and mechanical functionalities. The subject of the present paper is given by the mechanical attachment of electronic assembly.

Is known that the resistance and mechanical integrity of the electronic assembly (composed from: printed circuit boards (PCB), devices/electronic components and electronic component installation on printed circuit boards), is provided by the mechanical function [1].

We want to observe some mechanical aspects regarding the behaviour of copper layer deposit on the PCB and of the soldering alloys deposit on the copper – PCB assembly used in electronic technology at low and very low sliding speeds.

The tested printed board (PCB's) is one of the most frequent and common substrates, with a relatively low-cost, CEM (composite epoxy material) with copper deposited and the soldering alloy is the lead free solder paste, SAC305 (96.5 % Sn / 3.0 % Ag / 0.5 % Cu).

CEM is a composite epoxy material typically made of woven glass fabric surfaces and non-woven glass core combined with epoxy resin.

Copper is the most used non ferrous metal and the sheet of copper, in general used to cover PCB's has thickness between 5 and 100 µm. The common thickness is 35 µm, small thicknesses may not provide sufficient resistance and the biggest are not economic [2].

The tribological tests were made on an installation used for friction and wear study at low and very low sliding speeds.

This paper aims to determine abrasion coefficient and friction coefficient of deposited copper on the rigid support and of the soldering alloy SAC305.

2. EXPERIMENT DESCRIPTION

The results of the previous work [1] and the description of the experiment are highlighted below.

In the previous work [1], the mechanical tests were made by applying a force of 20 N with a sliding speed equal with 0.5 mm/s on the layer of copper deposited on rigid support CEM and on the soldering alloy SAC 305 deposited on the rigid substrates. As an indenter we used a use a steel diamond cone with tip angle of 60° and a radius of 12.5 µm.

Was used an UMT Micro-Scratch Equipment. The schematic of the setup used in this study is shown in Figure 1. It can provide rotational translational or reciprocating motions with speeds ranging from 0.1 µm/s up to 10 m/s. The load is applied to the sample by the carriage using F_z for a close-loop feed-back mechanism for stability and accuracy and can be kept constant or linearly increasing from as low as 0.05 g to as high as 1000 N.

Friction force (F_x), normal load (F_z), penetration deepness and friction coefficient are measured and recorded at a total sampling rate of 20k Hz.

Wear depth electric capacitance and digital camera are also readily available. The configuration below is an example of one of many possible combinations of friction/load sensor lower drive specimen holder and specimens [3].

The results are captured with the help of acquisition system they may be viewed, analyzed and interpreted by using the control unit.

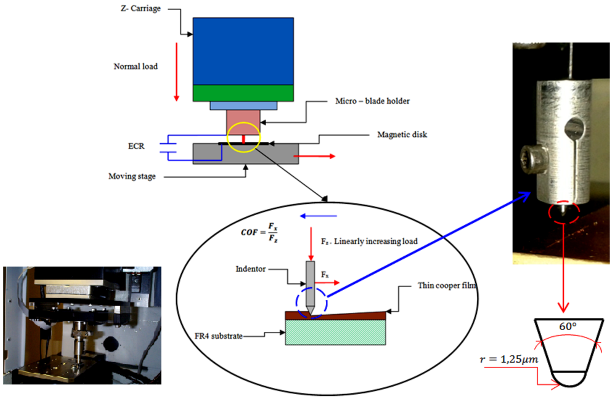

Figure 1. Functional scheme for micro-scratch test equipment

After the micro-scratch test profilometry of the sample was determinate with the help of SJ301 (Mitutoyo, Japan) profilometer the same one we used for our experiment too (Fig. 2). Optical inspection was made with a video system Leica (Condor 70-3 – share test equipment) [1].

Figure 2. Profilometer SJ301

The profilometry result are presented in Figure 2.

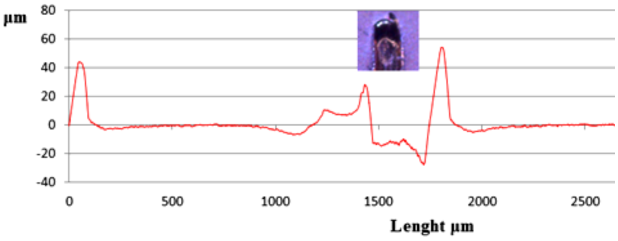

Figure 3. CEM profilometry

In Table 1 we find the results of the abrasivity factor for the rigid support CEM with deposited copper for one scratch.

For the experiment of this paper we utilised an installation used for friction and wear study at low and very low sliding speeds (Fig. 4). The schematic of the setup used in this study is shown below. It can provide motions with speeds ranging from 0 up to 15 mm/min. The load is constant values from 10 to 150 N.

Table 1. Geometrical form of scratch wear and abrasivity factor

Material	A_1 [μm^2]	A_2 [μm^2]	A_v [μm^2]	f_{ab}
CEM-Copper				
End	2845.85	3275.619	-4104.0	-0.491
Middle	1020.4	11716.2	-2184.9	-0.003
Start	628.569	866.223	-697.62	-1.142

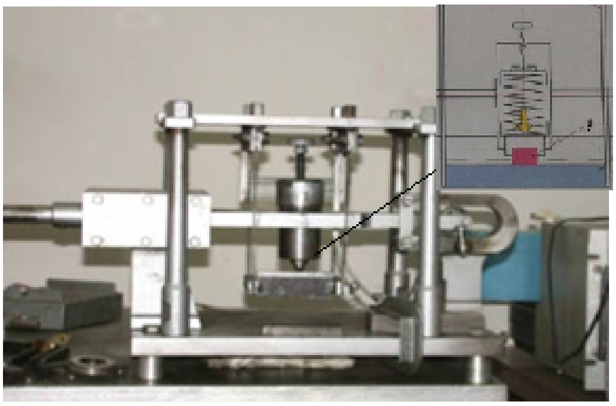

Figure 4. Installation used for friction and wear study at low and very low sliding speeds

The friction and wear test depends on measuring the amount of deformation caused when the indenter 1 is pressed in to the surface with a fixed force and the sliding movement.

The disadvantage is that that although hardness of material depends on the plastic properties, the stress-strain relation cannot be obtained [4].

The experiment consists in a progressive scratch with a length of 35 mm, the indenter will move with a speed of 0.032 mm/s. As an indenter we used a steel cone with a spherical top. The geometry of this intender is characterized by the radius r = 0.1 mm and the angle f = 120° (Fig. 5).

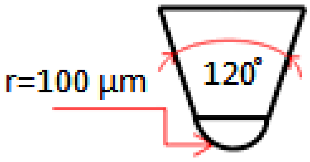

Figure 5. The geometry of the cone

Test samples were cleaned with isopropyl alcohol for removing the oxides deposited on the surface of the copper layer.

The profilometry result are presented in Figures 6 and 7.

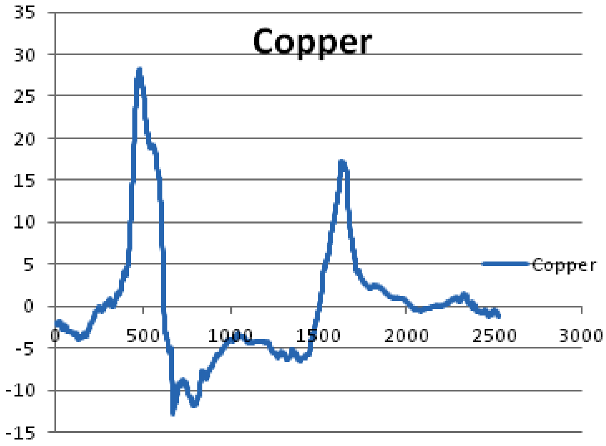

Figure 6. Copper profilometry deposited on the rigid support CEM

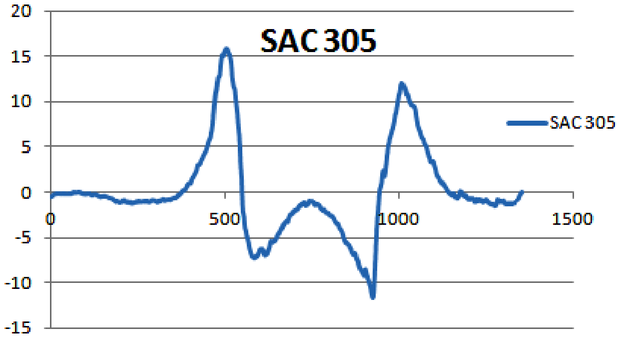

Figure 7. SAC 305 profilometry

As result of micro-scratching test, the surface of the samples has deformed near the contact area between indenter con and rigid surface of the sample. Observing the deformation and by using the profilograms presented above the abrasion factor was determinate as being the ratio of the volume of material displaced in the process and the volume the scratch path. This method was developed by Zum Gahr for scratch profiles in ductile metals [5].

Is define the abrasion factor as:

$$f_{ab} = 1 - \frac{A_1 + A_2}{|A_v|} . \qquad (1)$$

where A_1 and A_2 are the structured surfaces areas situated above the initial axis of the undistorted surface and A_v is the area of the deformed surface structure under the initial axis (Fig. 8).

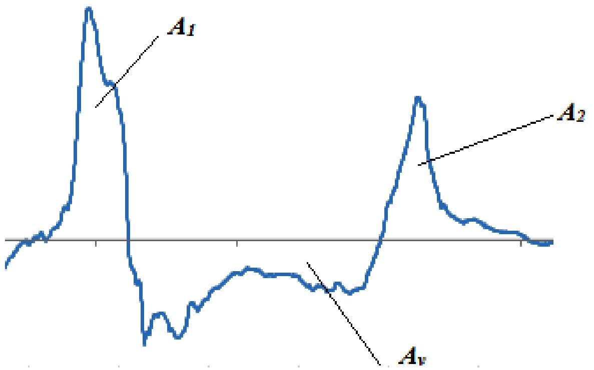

Figure 8. Abrasion model

The values obtained with Equation (1) and the results of the profilometer are presented in the Table 2.

Table 2. Values of the abrasion factor on the samples

Material	A_1 [µm^2]	A_2 [µm^2]	A_v [µm^2]	f_{ab}
CEM-Copper	1990.24	1277.426	-2682.6	-0.2186
SAC 305	1225.56	1120.98	-1830.0	-0.282

The form of the scratch indicates a ductile behaviour because the cone has connected with a sphere on top, the initial deformations were elastic, then plastic. After the move of the top of the cone on the contact surface, the contact surface elastic deformations are cancelled, resulting a jump on the bottom of the scratch. On this phenomenon, we will work a theoretical model in a next paper.

The friction coefficient variation at low speeds is exemplify in Figure 9 for the rigid support CEM with soldering alloy deposited SAC 305.

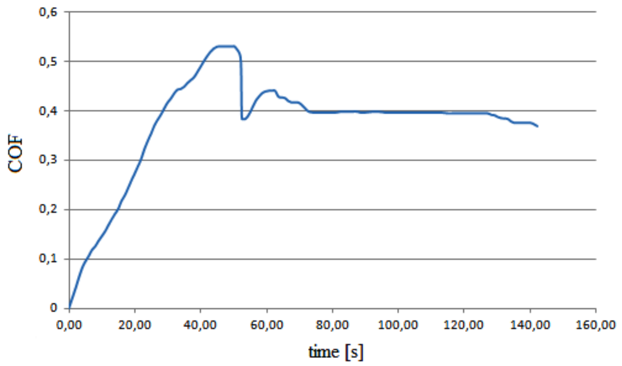

Figure 9. The value of the friction coefficient in time

In Figure 9 we can notice a fast stabilization of the friction coefficient, highlighting that at drive speed 0.032 mm/s and normal force 20 N, the phenomenon of stick-slip does not exist.

3. CONCLUSION

We can see from the profile interpretation that near the indenter, the material deforms. When cone went left behind borders of material, which leads to the idea that the material is ductile.

If we observe the values from Table 2, we can see that the abrasion factor has subunit values, $f_{ab} < 1$. Ductile materials have that characteristic. If we have a material with a hardness above then the abrasion factor also increase.

The value of the abrasion factor (negative) indicates the plastic deformation of the layer with density reduction. This phenomenon of plastic deformation can be explained on the basis of the theory of flow lines Hencky-von Mises.

As we can see from the profilgrams, both sides of the scratch are asymmetrical.

The phenomenon of deformation of the copper layer in the presence of slip includes slipping movement relative.

Material deformed and given to one side denotes a behaviour ductile.

Material removed increasing the volume in the process of dumping.

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