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INFLUENCE OF SOLDERED JOINT GEOMETRY ON MEASUREMENT OF ITS MECHANICAL PROPERTIES

VLIV GEOMETRIE PÁJENÉHO SPOJE NA JEHO MECHANICKÉ VLASTNOSTI

Abstract

This paper deals with influence of soldered joint geometry on measurement of its mechanical properties. Mechanical properties of soldered lap-joints of four lead-free solders with different geometry were measured. In conclusion using of samples with one interface solder – soldered material for measurement of soldered joints mechanical properties is recommended.

Abstrakt

Příspěvek se zabývá vlivem tvaru geometrie pájeného spoje na jeho mechanické vlastnosti. Byly naměřené mechanické vlastnosti přeplátovaných spojů čtyř bezolovnatých pájek S různou geometrií spojů vzorků. V závěru je doporučeno měření mechanických vlastností pájených spojů použitých vzorků S jedním rozhraním pájka – pájený materiál.

1 INTRODUCTION

As it is known there is the Europe Union directive which restricts the use of six hazardous materials (including lead - Pb), in the electrical industry. Restriction of Hazardous Substances (RoHS) took effect on the 1 July 2006 and is required to be enforced and become law in each member state of Europe Union. From that day on electronic manufactures cannot use tin-lead eutectic solders in the electronic assemblies. There has been significant research to improve properties of lead free-solders during last years [1]. At present, much effort is devoted to investigate the relations between microstructure and mechanical properties of these materials and compare new lead free-solders properties with led ones using to recent time and to investigate mechanical properties of soldered joints too [2, 8]. But geometry of soldered joint can affect results of mechanical properties measurement. It is necessary to know degree of influence of soldered joint geometry to these results and so to eliminate possible differences of mechanical properties values between soldered joints with the same properties.

2 EXPERIMENTAL MATERIALS

Soldered joints of two binary lead-free solders Sn3.5Ag and Sn0.7Cu and two ternary lead-free solders Sn3.5Ag0.7Cu and Sn0.3Ag0.7Cu were analysed. Soldered lap-joints were manufactured using these lead-free solder alloys. Copper sheet with purity 99.9% was used. Sheets with size 20 × 10 × 0.8 mm for solder joints were cut. Each Cu sheet was shortly polished on P1200 SiC abrasive paper. To prepare the soldered joints, the solder alloy and the flux (Soldaflux® 7000) were placed between two copper sheets and heated on the hot plate. To limit mobility during the process a facility from aluminium was used (see Fig. 1a|). But due to the sheets were not fully fixed as it is possible

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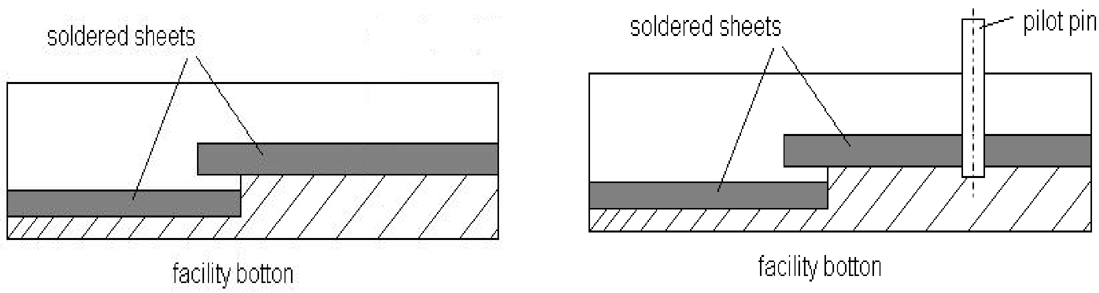
using with modified facility [3] (see Fig. 1b), the geometry of soldered joints were differenced. The joints were created at 270 °C, holding time was 10s. Finished joints were subsequently cooled on a stainless steel pad.



a b

Fig. 1 Joint facilities [3].

Three soldered lap-joints with different chance irregularities were manufactured using each lead-free solder alloys. Examples of lap joints differences are shown in Fig. 2. For comparison, regular lap joint is in Fig. 3 [3].

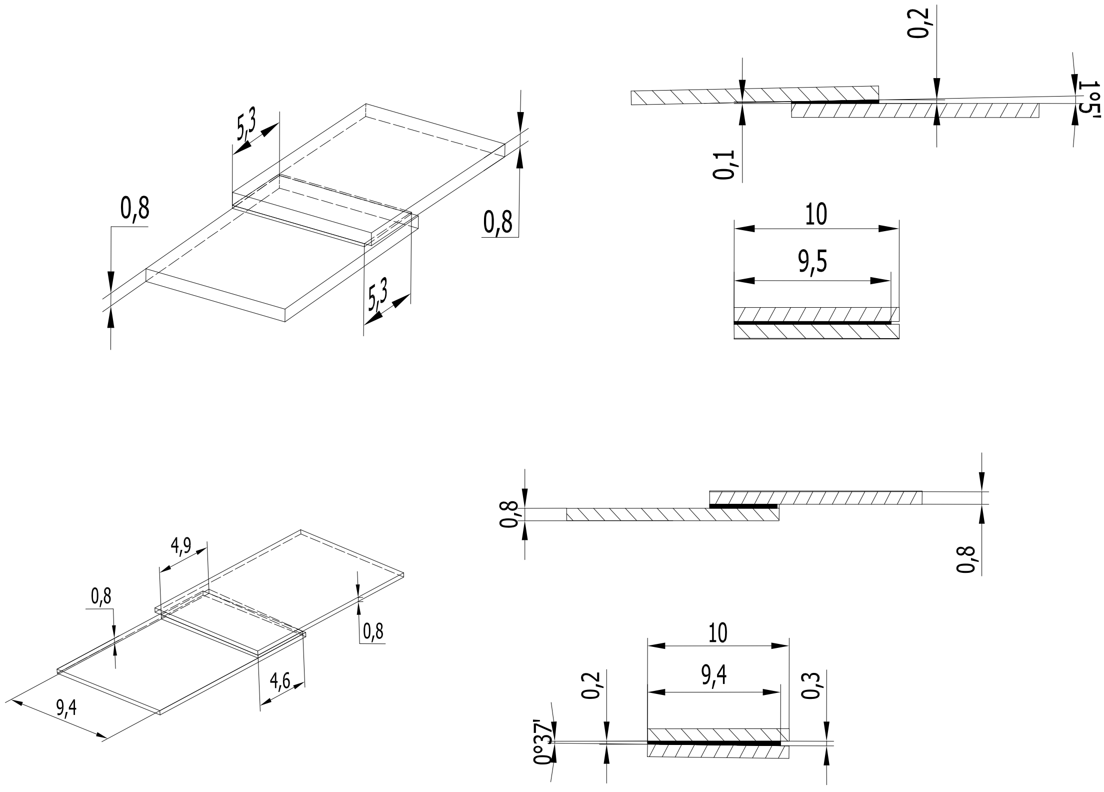


Fig. 2 Examples of lap joints differences.

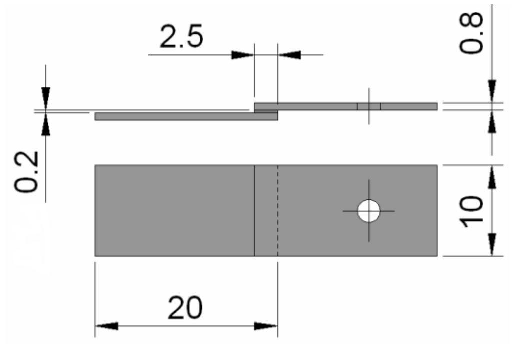


Fig. 3 Regular lap joint [3]

3 RESULTS

For measurement of mechanical properties of soldered joints FPZ 100/1 universal testing machine was used. Deformation rate was 2 $mm \cdot min^{-1}$. Shear strength of joints were measured. The shear strength of solder lap-joints was determined by dividing the maximum load by the area of the solder lap-joint [4, 7]. The measured value of lap-joint areas S, maximum loads F_m and calculated shear strength τ are in Table 1.

Tab. 1 Measured value and calculated shear strength of lap-joints.

Joint	Solder	S [mm^2]	F_m [N]	τ [MPa]
I-I	Sn99Cu0.7Ag0.3	32.760	820	25.031
I-II	Sn99Cu0.7Ag0.3	44.652	860	19.260
I-III	Sn99Cu0.7Ag0.3	35.040	850	24.258
II-I	SnAg3.5Cu0.7	58.590	1210	20.652
II-II	SnAg3.5Cu0.7	75.440	1630	21.607
II-III	SnAg3.5Cu0.7	31.960	400	12.516
III-I	SnAg3.5	33.600	770	22.917
III-II	SnAg3.5	29.240	720	24.624
II-III	SnAg3.5	66.500	1,060	15.940
IV-I	SnCu0.7	57.000	590	10.351
IV-II	SnCu0.7	57.000	480	8.422
IV-III	SnCu0.7	50.350	750	14.896

4 DISCUSSION

The results showed, that a small irregularities of solder joints geometry lead to relative great differences of their mechanical properties. In comparison with regular joints prepared by using modified facility [3] (Fig. 1b) and the same solders at the same conditions mechanical properties rapidly decreased. For comparison, shear strength of regular lap joint by using Sn99Cu0.7Ag0.3 solder was 38.8MPa, SnAg3.5Cu0.7 49.9MPa, SnAg3.5 47.1MPa, SnCu0.7 41.7MPa and data dispersion was very small [5]. Preparation of these types of soldered joints is relatively work intensive and time consumption. The main problem is saving precision common position of soldered sheets.

5 CONCLUSIONS

This measurement method of mechanical properties of soldered joints can be used for a lot of experiments, but it is necessary to precisely keep geometry of soldered joint, which is in some cases very difficult, in some times even impossible. But exist another way, which eliminates common position of soldered parts. This way goes out definition of soldered joint structure – joint material, reemelted solder and interlayer solder-material [6]. It is solder feed on joint material pad prepared for instance on a hot plate at appropriate technological conditions using special facility. Not only shear strength of solder-pad interface can be measured, but toughness –fracture energy can be calculated from area under the curve in force- displacement diagram [3]. In comparison with soldered lap joint, this method until now publicised indications seems very simple without any problems of soldered joint geometry.

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