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OPTIMIZATION OF APERTURES SHAPES IN STENCIL FOR ECA PRINTING TO CONNECTING OF SMD COMPONENTS ON PCBS

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Anotace:
Tento článek se zabývá testováním vlivu různých otvorů v šabloně na mechanickou pevnost, elektrický odpor a izolační vzdálenost. V rámci experimentu byly použity SMD součástky o velikosti pouzdra 0805, které byly osazeny na flexibilní substrát za pomoci elektricky vodivého lepidla (MG 8331S, CA 3150). V rámci experimentu bylo testováno šest různých tvarů otvorů v šabloně. Změna tvaru má vliv na množství použitého lepidla a také na izolační vzdálenost mezi vývody. V rámci experimentu byla druhá polovina vzorků podrobena zrychlenému stárnutí (85°C/85%RH/16hrs) a poté testována stejným způsobem jako první polovina. Výsledky ukazují, že je vhodné zvolit jiný tvar otvorů v šabloně než je standardní obdélníkový tvar.

Abstract:
This paper deals with the influence of different apertures shape in stencil on mechanical shear strength, electrical resistance and insulation distance. In the experiment, the SMD chip components 0805 were assembled on flexible substrate by electrically conductive adhesives (MG 8331S, CA 3150). Six different shapes of apertures in stencil were used for this experiment. These differences have an effect on the quantity of conductive adhesives which is used on the samples and an effect on the insulation distance between pads. The half of samples was measured directly (electrical resistance, mechanical strength and insulation distance) and second half of samples was submitted to the accelerated ageing test (85°C/85%RH/16hrs) and then tested the same way. The results shows that it is appropriate to choose other aperture shape in stencil than standard rectangular shape.

INTRODUCTION

The electrically conductive adhesives are most common technology used to connection of components onto substrates when the soldering is not possible even though ECA has disadvantages in compare with soldering [1]–[3]. For application of these adhesives on substrates is possible to use dispensing or stencil printing. Commonly, the rectangular apertures in stencil are used. To achieve the best properties (mechanical strength, electrical joint resistance, insulation distance between pads) can be find the better shapes of apertures. The change of the aperture shape can improve one property of joint but can also worsen other properties. It follows that the compromise has to be found. Also the quantity of adhesive used is important due to the high price of the electrically conductive adhesives (very often filled by silver). This quantity can be also reduced by suitable choice of aperture shape. The initial design and testing of the apertures shapes was realized in past [4]. The results of this previous experiment were used as a basis for our deeper experiment.

MATERIALS AND PROCEDURES

The flexible printed circuit board DuPont Pyralux with 18 µm thick copper conductive pattern was used in our deeper experiment. The nine SMD chip components with the size 0805 with tin contacts were used for each sample. The electrically conductive adhesive MG 8331S from the MG Chemicals company was used. This adhesive was cure by the curing profile 130°C per 30 minutes in oven. Also the electrically conductive adhesive Hysol CA 3150 from Henkel company was used. This adhesive was cured by curing profile 100°C per 93 second.

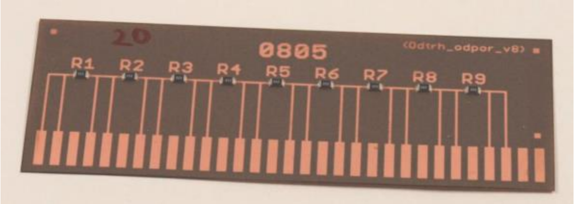

Fig. 1: The flexible substrate Pyralux with mounted chip componets used for the experiment.

The five different shapes of apertures was designed, see figure 2. These shapes were designed due to the standard IPC-7525A [5] with some modifications. Sixth shape was rectangular shape and was used for the comparison as a common shape. For all shapes the standard stencil with the thickness of 120 µm was used.

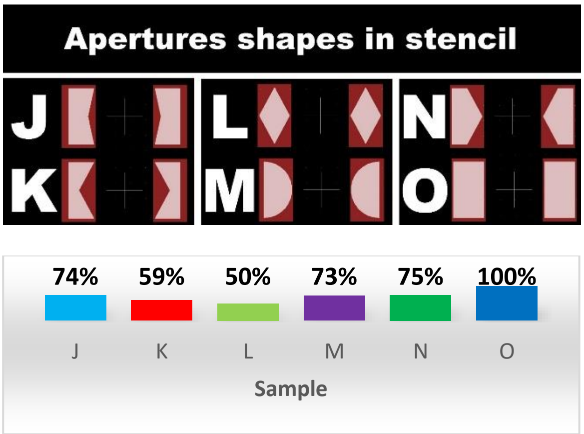

Fig. 2: Designed aperture shapes for the experiment with calculated ECA amount for each shape relative to the common shape “O”.

Firstly, the electrical resistance of glued joints was measured by four-point probe method. Each sample was connected to the Keithley 2701 device. Then the mechanical shear strength test was realized for half of the samples by the device LabTest 3.030. The hexagonal thorn pushes by force onto the component until the disruption of the joint appears. The flexible substrates had to be attached to the rigid PCB before testing because the samples (due their flexibility) could not be tested without reinforcement. The shear strength of the joint was not measured directly because the surface under load is not known. The maximal force required to shear off glued component from the substrate was recorded when the mechanical shear strength test was performed.

After the shear strength test, the microscopic observation with measurement of insulation distance between pads was done. The second half of the samples was subjected to accelerated ageing in climatic chamber immediately after the resistance measurement. The setup of the chamber was 85°C / 85% RH / 168 hours. After the climatic ageing, the measurement of these samples was same as previous samples (resistance, maximal strength, insulation distance).

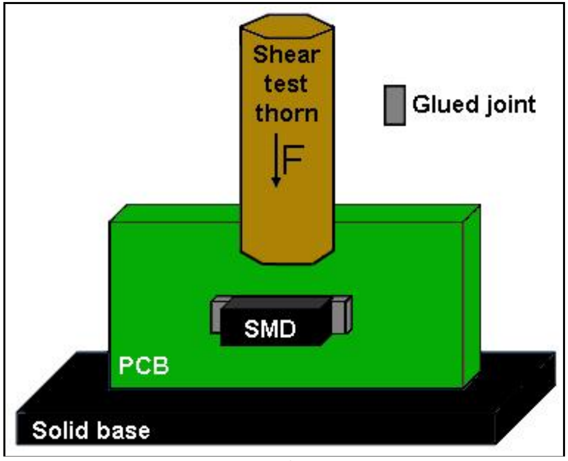

Fig. 3: The principle of the shear strength test.

RESULTS AND DISCUSSION

All values were statistically analyzed and the results can be seen in Figure 4, 6, 8. The results of the experiment were also analyzed by factor analysis (e.g. [6], [7]). This method is often used for the detection of more and less significant factors. The results of this analysis can be seen in Figure 5, 7, 9.

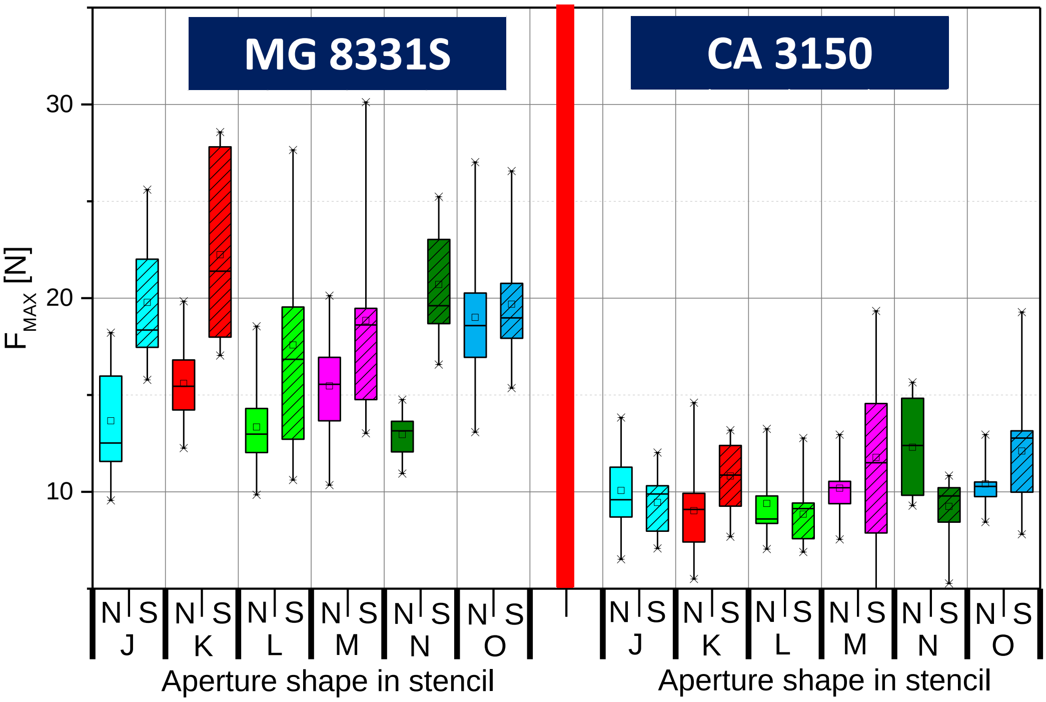

Fig. 4: Boxplot of mechanical shear strength of glued components for different apertures shapes.

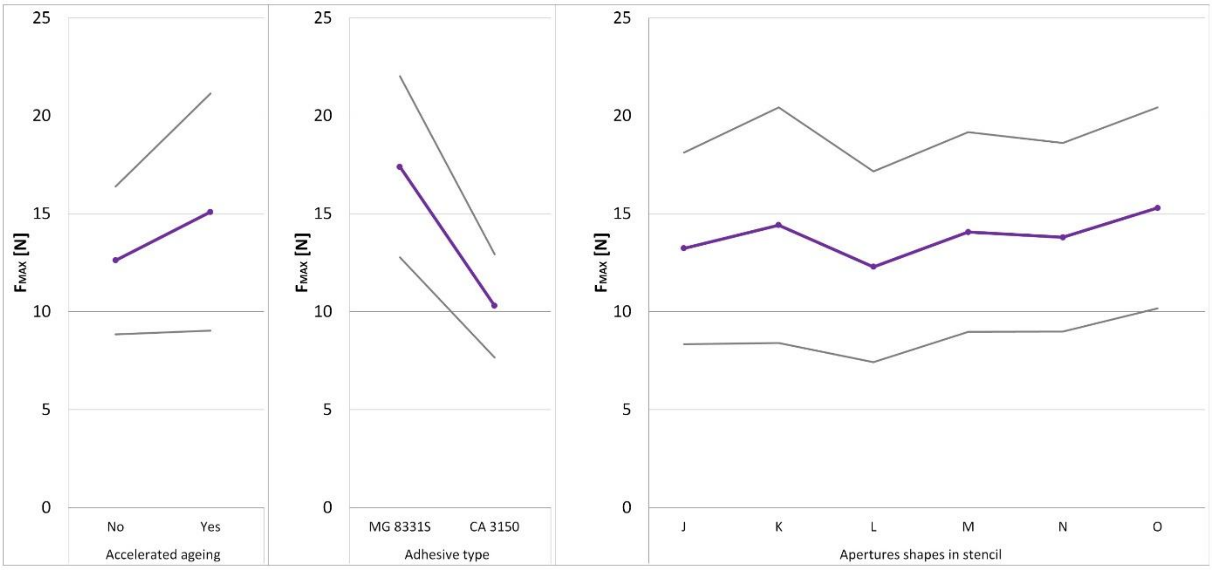

Fig. 5: Influence of factors on the maximal shear strength of glued components from DOE methodology.

The results of mechanical shear strength with MG 8331S adhesive shows that maximal strength has shape “O” and only a little worse strength for other shapes before ageing. After the ageing, the improvement of mechanical strength can be seen. This improvement is cause by fully curing of the adhesive during the ageing. For the adhesive CA 3150, the mechanical shear strength is similar for all shapes.

Influence of mechanical shear strength on adhesive type was the most significant factor. The shape of the apertures and accelerated ageing were not so significant.

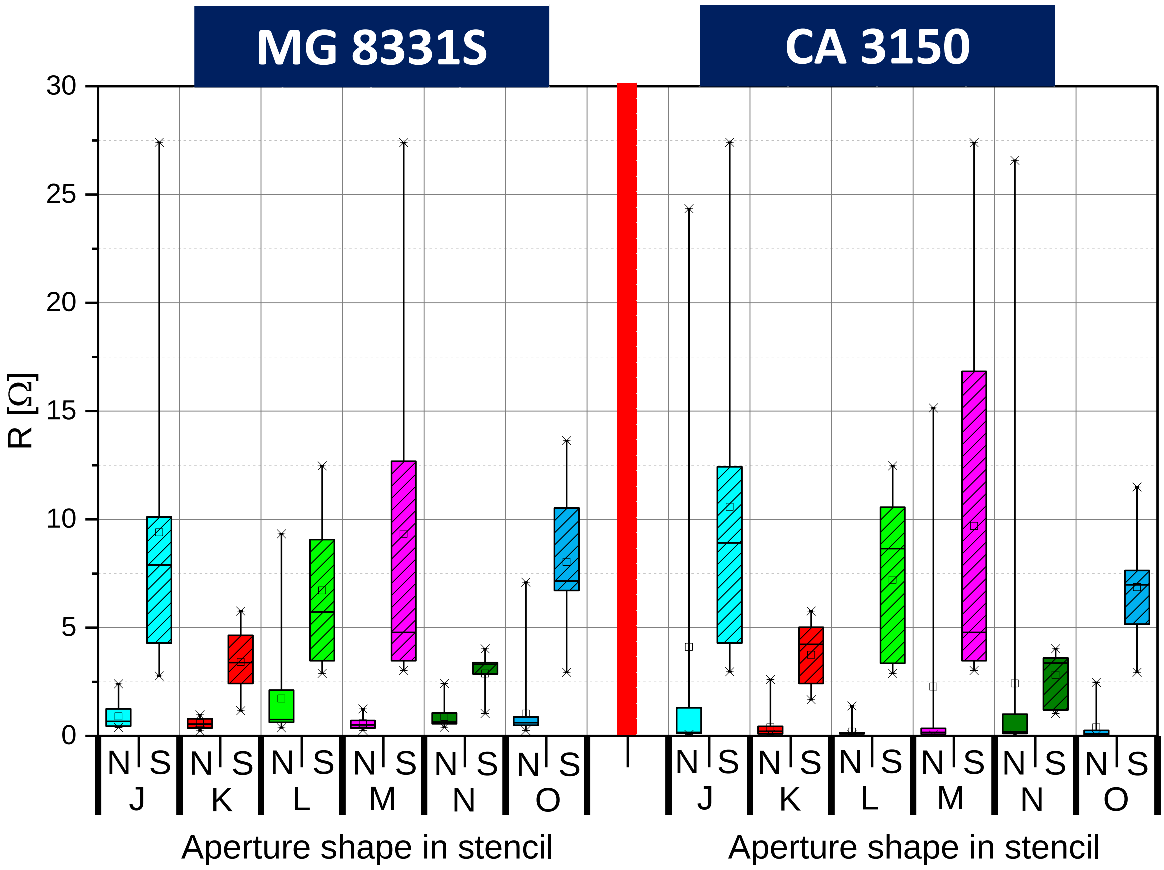

Fig. 6: Boxplot of electrical resistance of glued joint for different apertures shapes.

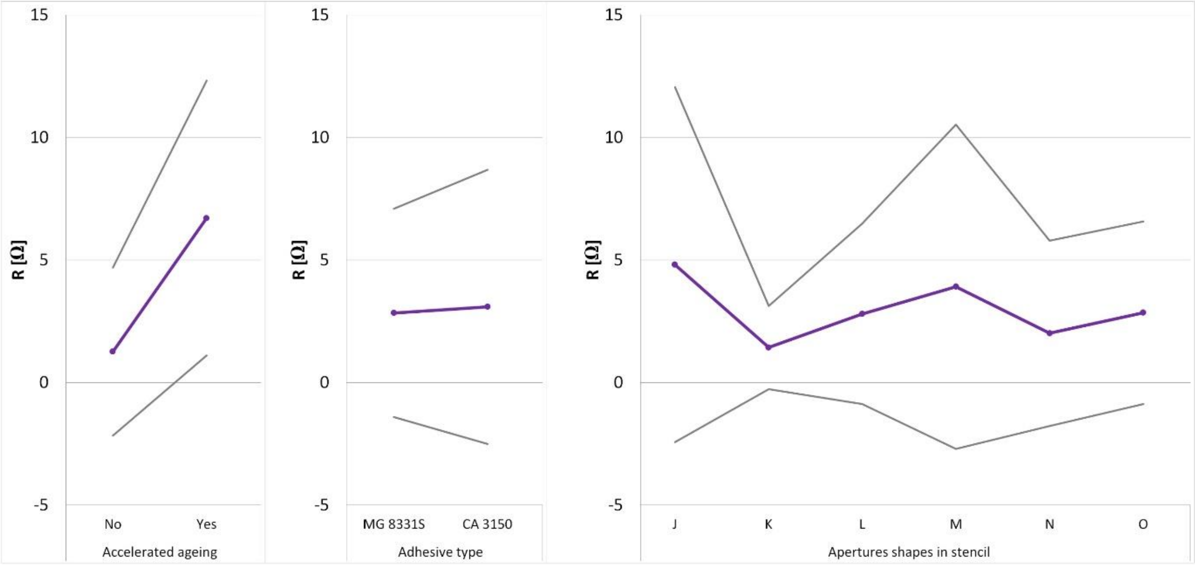

Fig. 7: Influence of factors on the electrical resistance of glued components from DOE methodology.

The results of electrical resistance are very similar for all samples without ageing. The results of samples after the ageing shows increasing of resistance. The significant differences between shapes were not observed.

Influence of electrical resistance on accelerated ageing was the most significant factor. The shape of the apertures and adhesive type were not so significant.

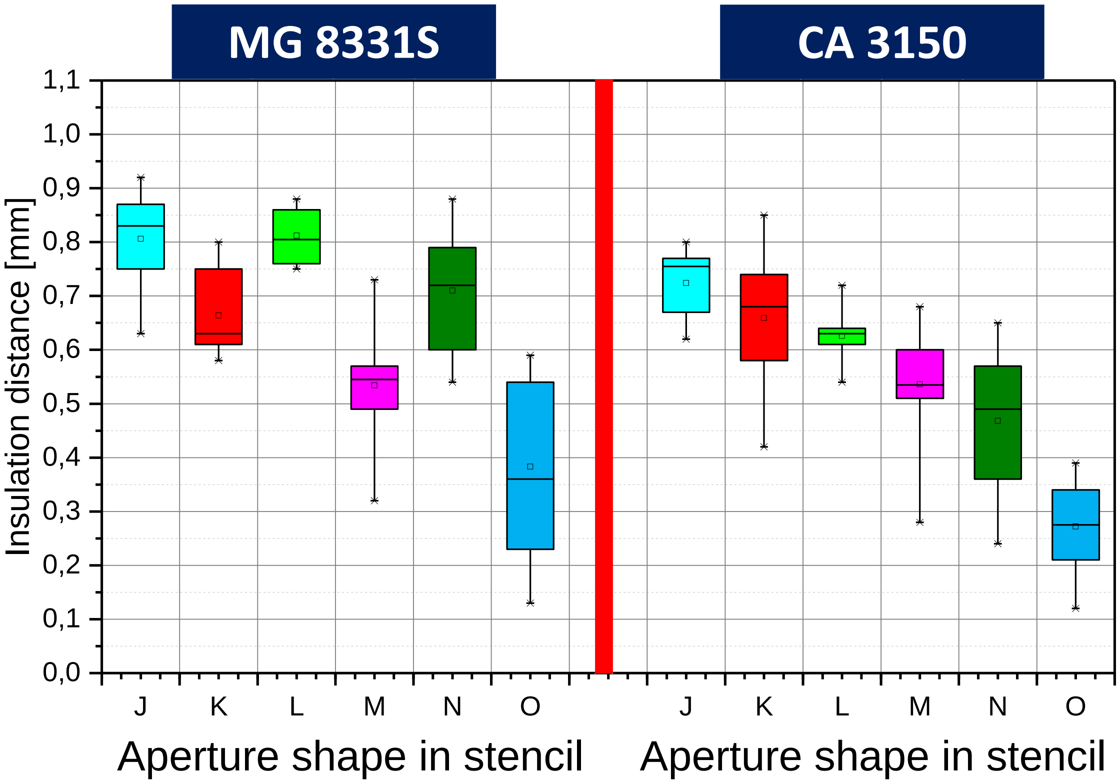

Fig. 8: Boxplot of insulation distance between pads on flexible substrate for different apertures shapes.

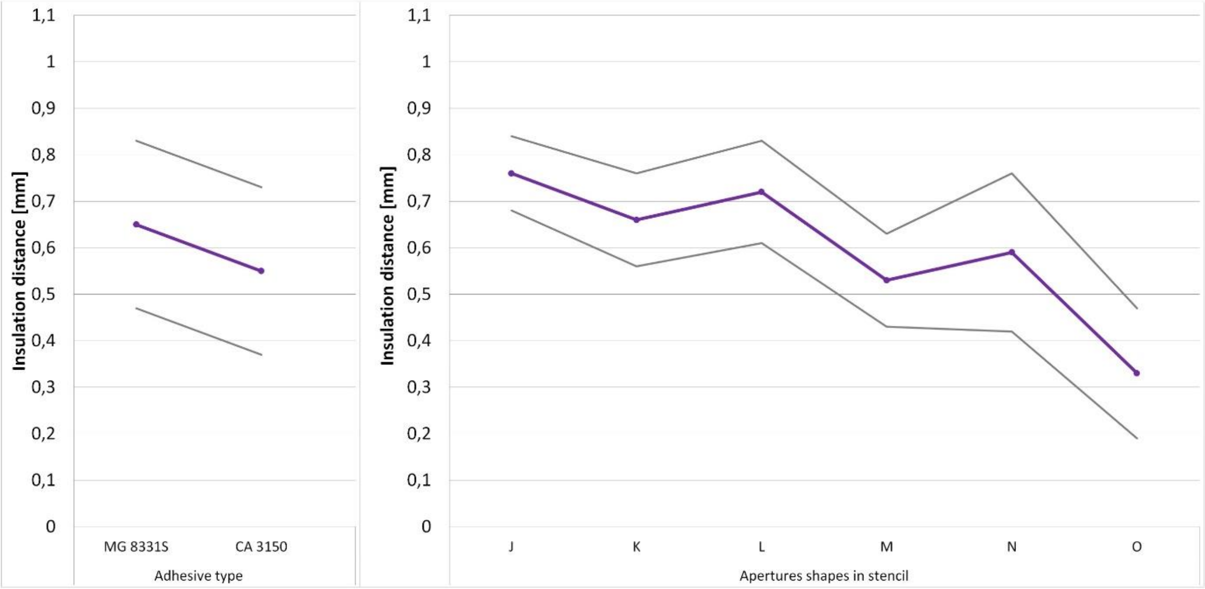

Fig. 9: Influence of factors on the minimal insulation distance of glued components from DOE methodology.

The results of insulation distance for MG 8331S adhesive are best for the shape “J” and “L” and only a little worse for shapes “K” and “N”. In case of the adhesive CA 3150, the best shapes are “J”, “K” and “L” and also acceptable are shapes “M” and “N”. In general, the reference shape “O” has relatively low insulation distance. The rest of shapes have sufficient insulation distance.

Influence of insulation distance on apertures shape was the most significant factor. The adhesive type was not so significant.

CONCLUSION

The experiment provided proof that changes of aperture shapes in stencil have minimal effect on mechanical shear strength and electrical resistance of joints (in case of our shapes). The experiment also shows that changes of apertures shapes have significant effect on insulation distance between pads. With considering of all tested parameters, the using of standard “O” shape cannot be recommended. The all other tested shapes are better and could be recommended but the shapes “K” or “L” seems to be the best choice due to the economic reasons (their lower adhesive amount – only 59% or 50% of amount needed to the “O” shape). The cleaning of these new shapes after the stencil printing process was also studied. The apertures with acute angles (lower then 90°) is difficult to clean. In the experiment, the apertures were optimized by edge rounding of acute angles which was much better to cleaning and it is recommended for another shape difference experiments.

ACKOWLEDGEMENTS

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