Influence of electrically conductive adhesive amount on shear strength of glued joints

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Abstract **– This paper deals with the influence of electrically conductive adhesive amount on shear strength of joints glued by EPO-TEK® H20S and MG 8331S. These joints were made by gluing of chip resistors 1206, 0805 and 0603 with two curing profiles for each adhesive. The different thickness of stencils and reductions of the hole in stencils were used. These differences have an effect on the amount of conductive adhesives on the samples. The curing profiles and various amounts of the adhesives have an effect on the mechanical strength of the joint. Samples were measured after curing process by using shear strength test with the device LabTest 3.030.**

Keywords – Electrically conductive adhesive, shear strength test, curing profile

I. Introduction

At present, the most common technology used for conductive connection of components with substrates in electronic devices is soft soldering. In the past lead solder alloys were nearly used only but at present these alloys are almost forbidden by European Directive RoHS (Restriction of Hazardous Substances) and WEEE (Waste Electrical and Electronic Equipment). Therefore electrically conductive adhesives or lead free solder alloys are used. There are some differences in using of these materials. The lead free solder alloys have generally higher melting point than lead solder alloys. The electrically conductive adhesives have usually lower curing temperature than the melting point of the solder alloys. This property is a big advantage of electrically conductive adhesives but these adhesives are hygroscopic and more expensive than solder alloys. These properties are big disadvantages of electrically conductive adhesives.

In the past there were made experiments with shear strength test of electrically conductive adhesives [1], [2], [3]. Textile and flexible substrates are used in practical applications at present. These substrates could change properties of glued joint and shear strength of the joint on flexible substrate could be different in comparison with shear strength of the joint on rigid substrate. This is the reason why the testing of electrically conductive adhesives is still relevant.

Manufacturers produce a huge series of electronic devices for measurement and control and in this process the manufacturers, which use electrically conductive adhesives, consume a big amount of these adhesives. Due to the big consumption of these adhesives, the research of influence of electrically conductive adhesive amount on shear strength of glued joints is important. These adhesives are expensive. Saving of the small amount of adhesive on one joint could significantly reduce the production costs. Costs reducing are the reason for perform of this experiment.

II. Materials

A. PCB

PCBs without surface finish were used for the experiment. PCBs with clean copper surface only and with the size 25 mm x 50 mm were used. The conductive pattern for gluing of ten SMD components was made on one side of the PCB. Three types of samples with different conductive patterns were made. First type of the samples was made for mount components with the size 1206. Second type of the samples was made for mount components with the size 0805 and third type of samples was made for mount components with the size 0603.

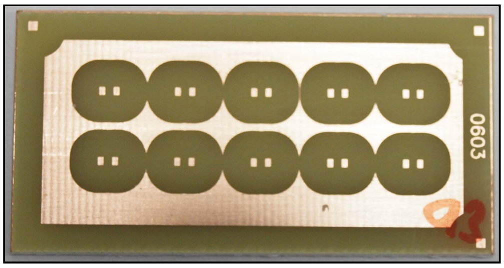

Figure 1. PCB with copper pattern for mount 0603 component.

B. Electrically conductive adhesives

For the experiment two different two-component electrically conductive adhesives with silver flakes were selected. The brand name of the first adhesive is EPO-TEK® H20S and it is produced by the Epoxy technology Inc. This adhesive has the resistivity 0,0005 Ω•cm and the particle size of silver flakes is less than 20 μm. The price of this adhesive is approximately 4,85 € per gram including VAT. That is equal to 11,61 € per cubic centimeter. This adhesive has five recommend curing profiles from 80°C per 90 minutes to 175°C per 45 seconds. The brand name of the second adhesive is 8331S and is produced by the M.G. Chemicals Ltd. This adhesive has the resistivity 0,0060 Ω•cm and the price of this adhesive

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is approximately 1,67 € per gram including VAT. That is equal to 4,06 € per cubic centimeter. This adhesive has four recommend curing profiles from 25°C per 96 hours to 100°C per 50 minutes. The big advantage of these adhesives is storage in room temperature. The storing in freezer is not recommended and it can be opportunity for reduce the costs for adhesive cooling of product manufacturers.

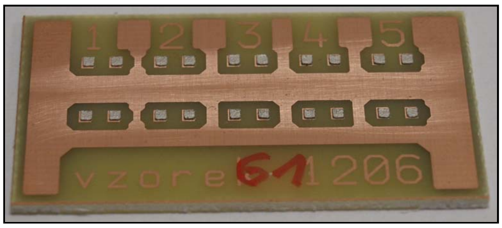

Figure 2. PCB with applied electrically conductive adhesive.

C. *SMD components*

For the experiment three different SMD chip resistors with 0 Ω resistances were used. For the experiment the SMD chip resistors with size 1206, 0805 and 0603 with tin surface finished contacts were used.

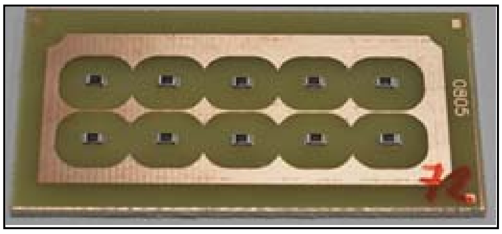

Figure 3. PCB with placed 0805 chip components.

III. Procedures of the Experiment

Description of the experiment was created as a process by using methodology BPMN 2.0 (Business Process Model and Notation). This process is shown in Figure 5.

A. *Amount of adhesives and curing profiles*

For the experiment, two stencils with thickness 120 μm and 80 μm were used. Holes in the stencils were reduced about 5%, 10% and 20% of width and length due to pads in conductive pattern on PCBs. These pads in pattern are normalized. These parameters define the amount of electrically conductive adhesive. The PCBs were weight by the analytical laboratory balances RADWAG XA 52/2X. The weight of one joint was identified by calculation. For the experiment four different curing profiles were used. Curing profiles 120°C / 15 minutes and 135°C / 15 minutes were used for adhesive EPO-TEK® H20S. Curing profiles 100°C / 50 minutes and 130°C / 30 minutes were used for adhesive MG 8331S. The laboratory drying oven Heraeus 5050 was used for curing of the adhesives. The temperature inside the drying oven was measured by thermocouple connected to the measuring device METRAHIT ISO produced by Gossen Metrawatt Company.

B. *Shear strength test*

Mechanical shear strength of glued joint was measured for each sample. The principal of mechanical shear strength test is shown in Figure 4. The thorn pushes on the chip resistor by force until the disruption of the joint and shear off the resistor from the PCB. The shear strength of the joint was not measured directly because surface under load is not known. The maximal force during the test was evaluated. The device LabTest 3.030 was used for recording of force acting on the chip resistor. The settings of the device are as follows: feedrate of shear thorn – 20 mm/min, jaws return 200 mm/min, criterion of test end when reaching 70 % of maximal force (Fmax). There were measured ten values of maximal force for each sample. These values were statistically analyzed.

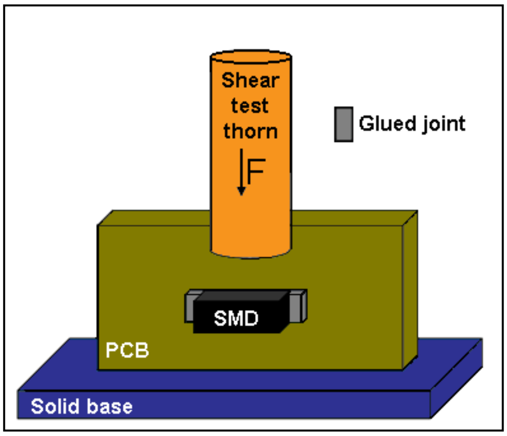

Figure 4. Principle of shear strenght test.

IV. Results

The maximal force to shear off the resistor from the PCB was recorded when the mechanical shear strength test was performed. The recorded values were statistically analyzed and the results of this analyzes can be seen in Figure 6 – 8. In Figure 6, the electrically conductive adhesive EPO-TEK® H20S cured by curing profile 120°C / 15 minutes have larger decrease of maximal forces than the same adhesive cured by curing profile 135°C / 15 minutes. In Figure 7, the electrically conductive adhesive EPO-TEK® H20S cured by curing profile 120°C / 15 minutes have smaller decrease of maximal forces than the same adhesive cured by curing profile 135°C / 15 minutes. In Figure 8, significant influence of electrically conductive adhesive EPO-TEK® H20S amount on maximal force to shear off the component 0603 can be seen only if the adhesive was cured by curing profile 135°C / 15 minutes. Influence of electrically conductive adhesive EPO-TEK® H20S amount on maximal force to shear off the component 0603 cannot be seen if the adhesive was cured by curing profile 120°C / 15 minutes. Sample E is an exception. There is a big decrease of maximal force due to other samples. In Figure 6-8, the values of maximal forces of the electrically conductive adhesive MG 8331S are almost independent on amount of adhesive and curing profile. There are only small irregularities.

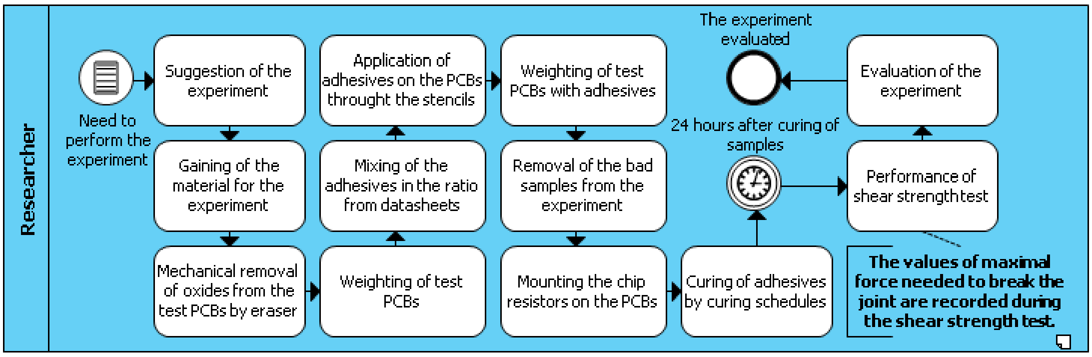

Figure 5. Description of the experiment.

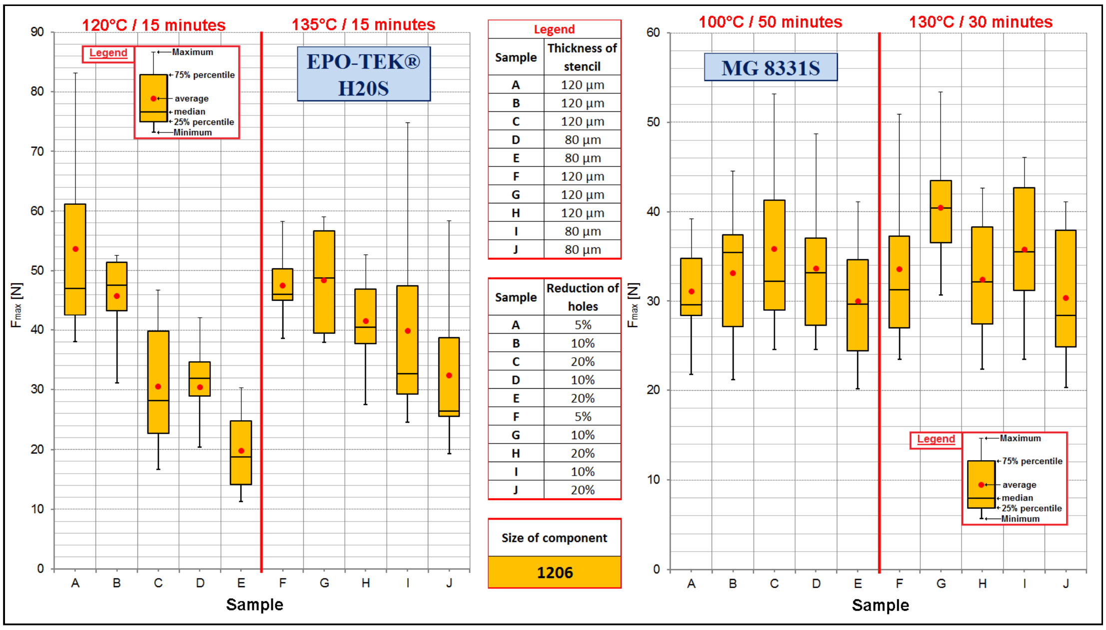

Figure 6. Boxplot of maximal force when shearing-off 1206 components.

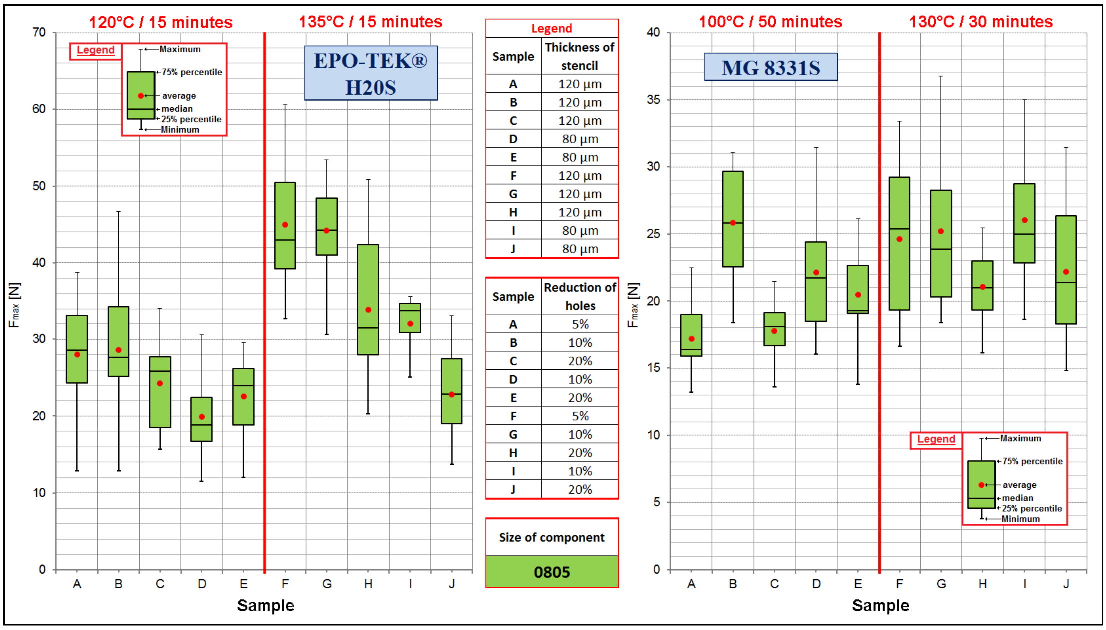

Figure 7. Boxplot of maximal force when shearing-off 0805 components.

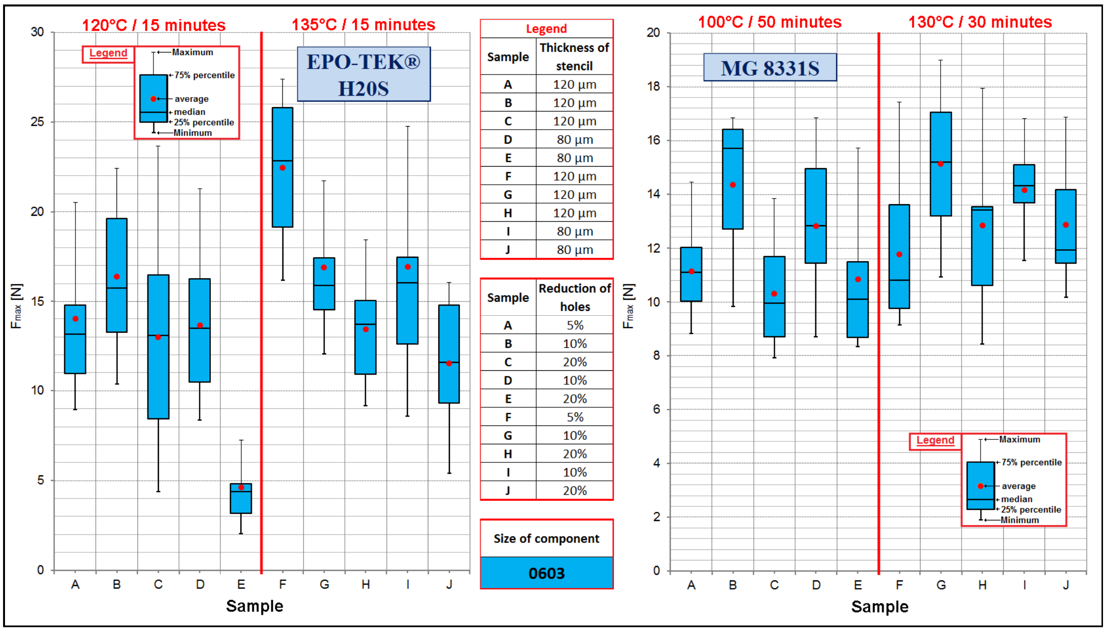

Figure 8. Boxplot of maximal force when shearing-off 0603 components.

V. Discusion

The results shows that the electrically conductive adhesive EPO-TEK® H20S has better mechanical shear strength than the adhesive 8331S for basic samples with 5% reduction of hole in stencil and thickness of stencil 120µm (sample A and F). For the components with size 1206 can be seen that the reduction of the adhesive EPO-TEK® H20S has a big influence on mechanical shear strength. But the adhesive EPO-TEK® H20S has the same or worse mechanical shear strength than the adhesive 8331S for samples with 20% reduction of hole in stencil and thickness of stencil 80µm (sample E and J). If we consider that the price of the adhesive EPO-TEK® H20S is three times higher than the adhesive 8331S, we could recommend using of adhesive 8331S with 20% reduction of hole in stencil and thickness of stencil 120µm. The similar recommendation could be done for the components with size 0805 and 0603. If we compare using of curing profiles of adhesive 8331S, it depends what is required. If manufacturers require less time for curing, the profile 130°C / 30 minutes could be recommended. If manufacturers require lower temperature for curing, the profile 100°C / 50 minutes could be recommended.

VI. Conclusion

The experiment proved the recommendation for using of electrically conductive adhesive and influence of type of the adhesive and adhesive amount on shear strength test. In general the adhesive 8331S could be recommended from economical aspect. The investigation of influence of the adhesive amount on quality of glued joint will be continued.

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