THERMAL STRESS IN MULTISUBSTRATE STRUCTURE

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ABSTRACT

The aim of this work is to improve reliability of connecting ceramics – PCB and to increase durability of these structures.

This paper discusses the thermo-mechanical stress rising in solder joints with the using the program ANSYS. It describes the occurrence of stress as a result of thermal expansion coefficient being dependent on temperature. It pays attention especially to examining the stress in solder joining multi-substrate structure ceramics – PCB depending on various geometrical proportions of the sample in the constant temperature. The aim is to define such a shape of the structure, so it is the most reliable considering the rising stress.

1 INTRODUCTION

The surveyed sample is the connection of ceramics (Al2O3) to substrate (FR4) using of a frame (FR4) (Fig.1). The program ANSYS creates geometrical and finite element model and will carry out analysis surveyed stress. Simulation is executed for some different frame dimensions and the connection between a frame and ceramics. The reason is to the find out a geometric dimension where the smallest final stress will be. The interpretations of results are divided into two parts. The first part of evaluation discusses the stress distribution in solder joints. Determining a place in the solder with the maximal stress values and determining the stress is distributed for all shapes are the result of this investigation. The possible danger solder joint crack is in the place with the maximal stress value. The second part of evaluation discusses the maximal stress value in solder joints. Firstly have been change the dimension of frame and secondly the contact dimension between a frame and ceramics. The shape with the smallest stress value which one will be the most reliable regarding stress has been found.

2 MODELING ANALYSIS

Figure 1 shows the full model. Only ¼ ceramics tablet is cut from the model, where is shown the frame between ceramics and substrate. The copper areas are place on the frame and substrate. Between the frame and ceramics is copper area only on the frame. The solder volume is dependence on size of contacts.

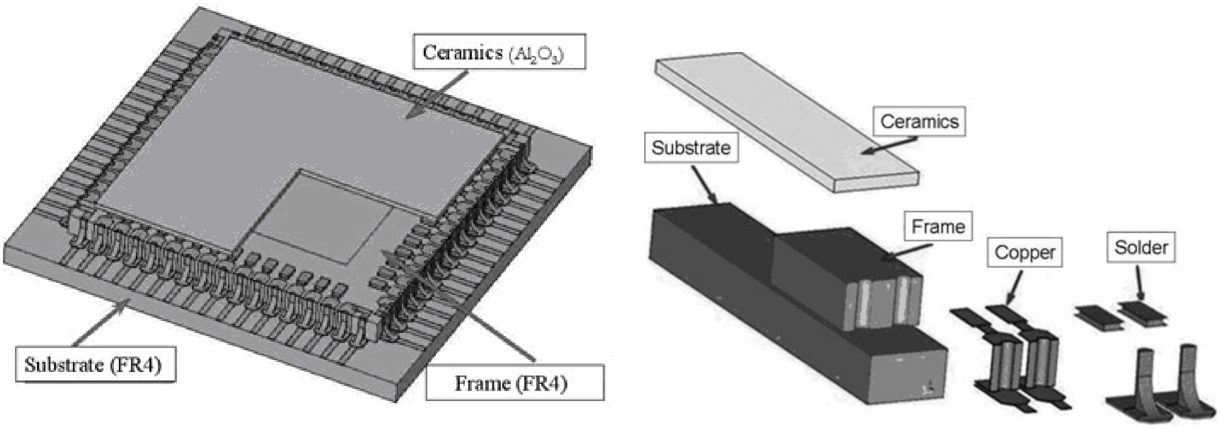

Fig. 1: *Full model*

Simulation is conducted for a few different locations of frame and contact. The reason is to the find out a geometric dimension where the smallest final stress will be. The interpretations of results are divided into two parts:

Frame displacement (A) –

The frame is moved to the right as shown figure 2. The substrate and ceramics stay on the same places. So it means, the frame increase its circumference. The frame is always moved from 0 to 0,5mm with step 0,1mm. Primary frame size is 22,5 x 22,5 mm. The maximum frame size is 23 x 23 mm. The frame width is same for all shapes. New shape of solder joint is created for every displacement of frame. The calculation is done for five different shapes of solder joints between frame and substrate.

Contact displacement (B) –

The contact location is changed for all frame displacement. The frame, substrate and ceramics stay on the same places. The contact is always moved over 0,1 mm from 0 to 0,5 mm.

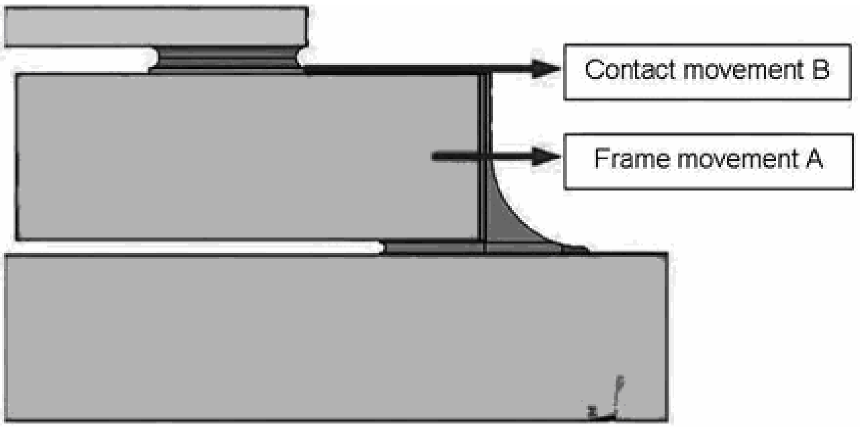

Fig. 2: *The contact and frame movement*

The material properties which are used for simulation are written in table 1.

Materiál	**E**	μ	**TCE**	**G**
	[MPa]	[-]	[ppm/K]	[MPa]
63Sn37Pb	30 642	0,35	24,5	-
FR4	**$E_x = E_y$**	$\mu_{\zeta\xi} = \mu_{\zeta\psi}$	$\alpha_\xi = \alpha_\psi$	**$G_x = G_y$**
	16 850	0,29	14,5	2 570
	E_z	$\mu_{\psi\xi}$	α_ζ	**G_z**
	7 376	0,11	67,2	1 690
Al_2O_3	303 000	0,21	23,4	-
Cu	129 000	0,344	16,61	-

Tab. 1: *Material properties*

3 RESULTS

Table 2 shows calculated stress values for each displacement A and B.

B	A = 0,1	A = 0,2	A = 0,3	A = 0,4	A = 0,5
[mm]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]
0	189	201	196	242	213
0,1	177	201	198	252	216
0,2	209	202	194	239	217
0,3	209	201	215	230	214
0,4	209	197	190	202	212
0,5	195	189	189	203	208

Tab. 2: *Calculated stress values*

There is calculated value of stress in dependence on frame displacement (A) on figure 3. Individually solder joints shapes rise from frame displacement. The first value on graph show frame position, where frame is location exactly in half length of contact between frame and substrate. The length of contact is 2,032 mm. The first shape is placed 1,016 mm from the left contact ledge (fig. 2). Moving the frame is possible conduct only to right side as that is shown on figure 2. It is by reason of mounting ceramics to frame. The curve presents stress modification in dependence on moving of frame to the right side. The maximal stress value is calculated for displacement A = 0,3 mm and minimal stress value is for A = 0,1 mm. Difference between maximal and minimal stress value is cca 30 %.

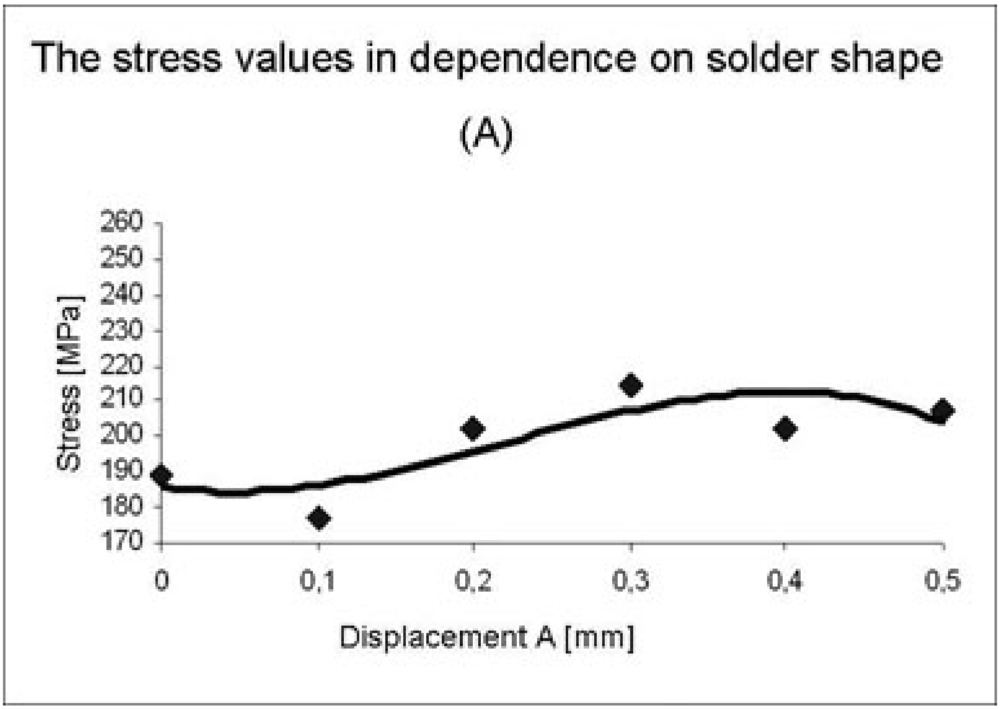

Fig. 3: *Stress values*

There is stress value in dependence on displacement of frame and contact on figure 4. The separately curves show displacement (A). Displacement (B) is brought up on axis X. The minimal stress value rise from solder shape where A = 0,1 mm and contact displacement B = 0,1 mm. The maximal stress value rise from solder join shape where A = 0,4 mm and contact displacement B = 0,1 mm. This values results from graph.

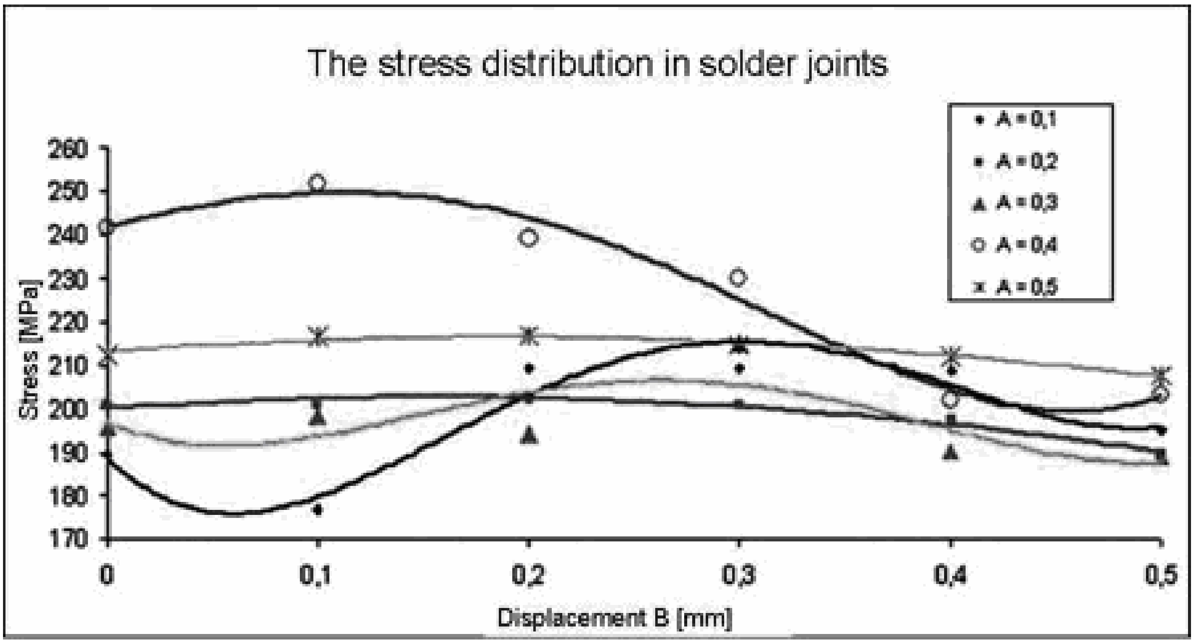

Fig. 4: *Stress distribution*

4 CONCLUSION

After looking into finding shape is possible to say that the place of maximal stress doesn’t depend on move of frame and place of connect. In the respect of stress value is the most critical place of all solder joints in the connecting lower edge of frame and solder. It is caused by spill over into stress, which developed between ceramics, which have higher TCE than the frame and substrate. Ceramics is more distended than frame and its try to move the frame in direction of its. The stress is moved above the frame as far as its lower edge, which have tendency to lift eventually move and its impact to solder and form the finally stress in solder, which connecting substrate and frame. Other strained place is in the top edge of solder connecting substrate and frame. This value is not so conspicuous as in lower side of frame. If it interprets only solder joint connect of frame and ceramics is the maximal value of stress in upper part of solder. That it is taken by the same mechanism, which is described on the top. The value of this stress is 1/3 less than complete maximum. The stress is absorbed by frame, which is formed between ceramics and substrate. In the respect of stress values can be said that the most probably place, where the connecting can be violated is in the solder connecting substrate and frame in the connecting in lower edge frame and solder.

The aim of determined value of stress which rises in solder joint is finding the shape of solder joints where will be the minimal resulting stress. After evaluation all of 25 values workout stress is possible to say that the maximal value of rise stress is for solder shape A = 0,4 mm and place of contact B = 0,1 mm and minimal stress raised during move of frame A = 0,1 mm and place of contact B = 0,1 mm. Difference between maximal and minimal values of stress is about 30 %. The displacement A = 0,1 mm and B = 0,1 mm is the best shape in light of stress values. Size of frame is 22,6 x 22,6 mm and this one is the most reliable considering the rising stress.

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