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High temperature damage and seismic performance analysis of inorganic polymer concrete short columns

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Abstract. For the experiment failure problems caused by the failure of test circuit with high impact of high-range accelerometer in the testing process, this paper uses ANSYS/LS-DYNA to take value simulation for high impact of bonding pad's operation direction (circuit board is perpendicular to chip), vertical (parallel to the chip pin), horizontal (perpendicular to chip pin), analyzes and compares the influence of the impact the PCB pads from different directions on the reliability of circuit board. The results show that the impact resistance is normal, vertical and horizontal when the impact force is the same but in different directions. The results have some reference value for the design of high-range accelerometer and the acceleration circuit with high g value.

Key words. High impact, Finite element software, Bonding pad, Rupture, Geometric modeling.

1. Introduction

High-range accelerometer is data acquisition and recording equipment on the missile weapon system, and can make real-time and reliable records for transient, random and complex dynamic parameters, to provide technical basis for missile system design improvement. It is one of the main means of testing in weapon model development phase [1]. In the process of projectile impact, the tiny solder connection between circuit board and chip becomes the key part that is the most prone to rapture. Research on the mechanical behavior of solder joint in the process of impact becomes important topic in the field of welding circuit reliability. There are usually experimental methods and numerical simulation methods for the reliability of solder joints. [2] But experiments have taken a long time to test, which costs a lot

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of labor and money. Numerical simulation is not only economical and time-saving, but also can provide data that is difficult to measure in the experiment. Numerical analysis is getting more and more attention.

At present, in the penetration acceleration test technology at home and abroad, it more uses ammunition storage test technology [3]. The failure of circuit board research is mainly focused on the structural response under the impact of t circuit board, and the failure of the solder joints under the impact of various directions is ignored. In this paper, with the application of ANSYS/LS-DYNA, numerical modeling studies are taken for the failure mechanism of the bonding pad under different directional impact on tested circuit board.

2. High-impact finite element modeling

By means of the finite element software ANSYS and explicit dynamic analysis software LS-DYNA[10], the simulation analysis of the bonding pad fracture under high impact is carried out, which can easily and quickly evaluate the impact dynamic performance of the welding spot.

Projectile bodies and grid unit of concrete target plate I numerical simulation both adopt 3D Lagrange algorithm provided by ANSYS/LS-DYNA. The algorithm makes the grid unit in adhesion on the material and produce unit deformation with the flow of materials.

When establishing the geometric model of chip and PCB structure, the following assumptions are made in the simulation process [10] :

(1) Both the chip and PCB are considered to be homogeneous and continuous, and both are treated as rigid bodies without initial stress or boundary effect.

(2) The forces acting in all directions are perpendicular to each other, regardless of gravity.

(3) The whole simulation process is adiabatic, regardless of air resistance, and excluding the vibration of chips and PCB plates.

2.1. Geometric modeling of PCB components

Considering the force of the bonding pad in the circuit board under various axial impacts, the finite element model is shown in Fig. 1. The chip of 20mm x 10mm x 1mm is connected to the PCB board (25mm x 13mm x 1mm) by bonding pad (4mm x 2mm x 1mm). The used model takes the circuit board, solder joints, chips and other details into account. In the process of the establishment, only FLASH with a larger chip is considered, and the smaller voltage conversion chip is not considered.

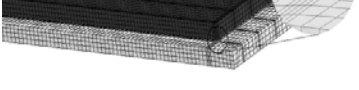

Fig. 1. Three-dimensional finite element model

2.2. Material parameter

The size of mm-g-us is used for modeling. In the numerical simulation, the materials of PCB board are linear elastic orthotropic materials, Orthotropic, and the chip is linear elastic isotropy materials, Isotropic. When electronic components in the process of service receive impact, tiny bonding pad as the key part of components and PCB connection receives the function of mechanical inertia effect to make the solder joints related features of apparent strain rate under impact load. Elastic-plastic material model, Plastic Kinematic, is taken into account, and the equation is as shown in formula 1 [4]:

$$\frac{\sigma}{\sigma_0} = 1 + (\frac{\varepsilon}{C})^{1/p}. \tag{1}$$

Various material parameters are shown in table 1[2,4-6]:

Table 1. Material model parameters

No.		Material model	density /g·cm-3	Young modulus / GPa	Poisson's ratio /PR
1	PCB	Orthotropic	1.910	17.7	0.390
2		Isotropic	2.330	131.0	0.230
3		Plastic Kinematic	1.103	54	1.521

2.3. impact load

In impact experiment simulation, in order to simulate the impact of different directions on circuit board, a mass block of great hardness is established to hit the circuit board at the same speed, respectively from the lateral, longitudinal, and normal direction, to observe the force of solder joint. Fig. 2(a-c) shows the schematic diagram of the mass block impacting the circuit board from different directions.

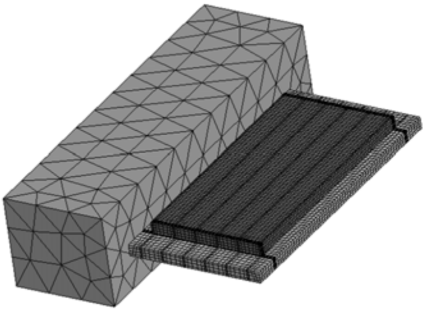

Fig. 2(a) Lateral impact

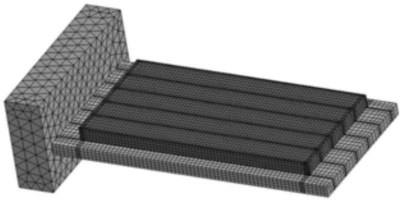

Fig. 2(b) Lateral impact

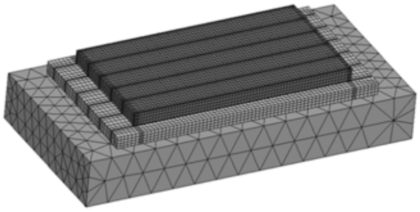

Fig.(c) Normal impact

3. Result discussion and analysis

Fig. 3 (a-c) shows the stress curve of a row (six) of bonding pads when the mass block is impacting the circuit board from different directions. Both lateral and longitudinal impact reach the yield stress (50MPa) [7,8] When the bonding pad breaks, it reaches the peak of yield stress at the first crest. The maximum stress value of pad on normal impact 38.2 MPa does not reach the yield stress. Two kinds of impact before the peak stress impact way are different for shock rise, which is more advantageous for energy to spread evenly from pad to chip.

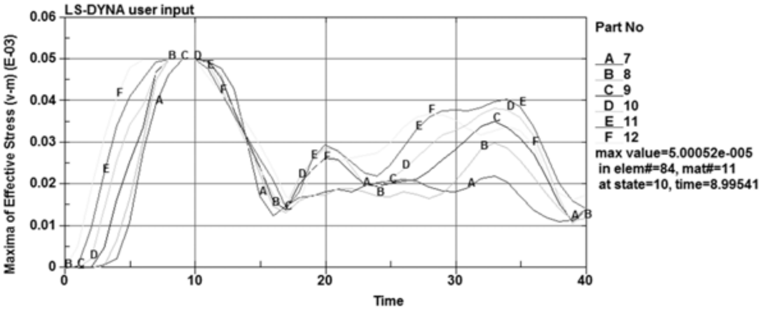

Fig. 3(a) Stress curve of pad on lateral impact

Fig. 4 shows the stress curve of two pads with the largest lateral and longitudinal impact. With comparison, it is found that the total time of yield stress is 5us, and the lateral yield stress time is 7us, which explains the plastic deformation time is longer when the material receives lateral impact, and the bonding pad is easier to fall off.

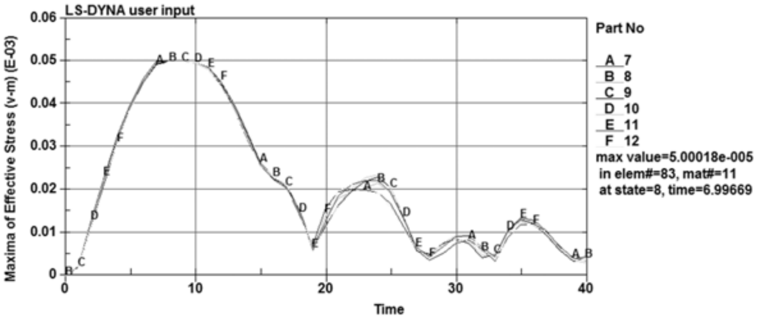

Fig. 3(b) Stress curve of pad on lateral impact

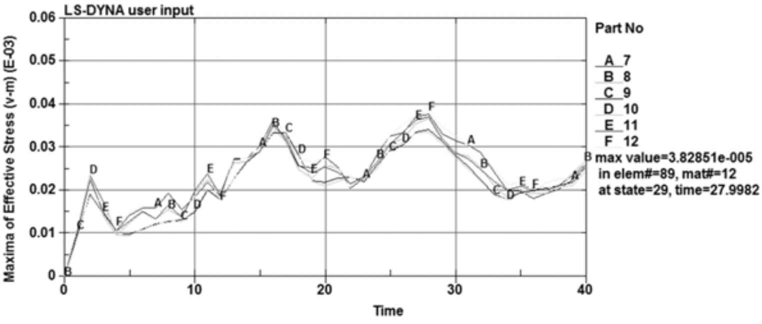

Fig. 3(c) Stress curve of pad on normal impact

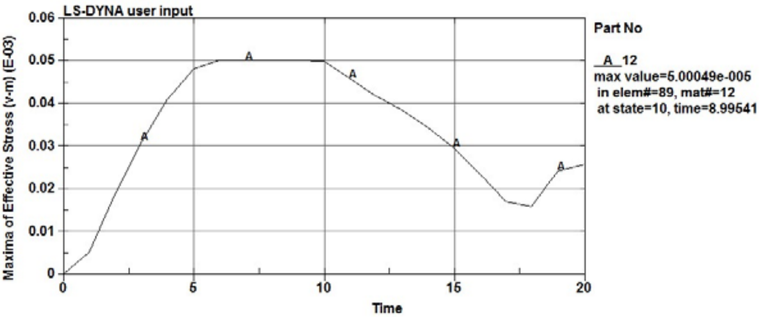

Fig. 4(a) stress curve of pad on lateral impact

4. Conclusion

When the impact force is the same in different directions, the impact resistance is normal, lateral and longitudinal. The results have some reference value for the

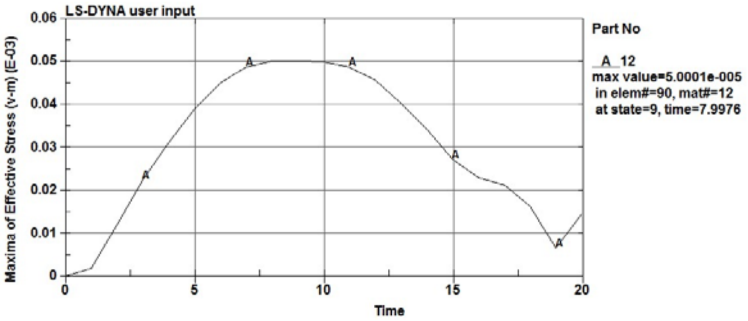

Fig. 4(b) stress curve of pad on lateral impact

design of high-range accelerometer. The direction of the high impact from w the PCB board has a great influence on whether bonding pad is broken. The PCB board can withstand the greater impact from the normal direction to make the bonding pad unbroken, and it can withdraw a small longitudinal and lateral impact. With comparison on lateral and longitudinal, it is found that lateral impact is more likely to cause the bonding pad to fall off. Based on the above factors, it is suggested that the high impact direction should be perpendicular to the plane of circuit board in the design circuit, so as to improve the reliability of the whole test system.

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