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Thermal Stress analysis of Electronic component in Plastic Moulding Process

Baradeswaran A., Arul Selvi A., Padma Priya R. and Chandra Mohan E.

Madha Engineering College, Kundrathur, Chennai, India

ABSTRACT

As Hardware Technology gets advanced day by day more number of sophisticated methods of fixing the components in the PCB & the way of compacting the electronic system by advance methods like VLSI etc.,. Thus it is necessary that each and every component of an electronic components is of high quality and standards. Each and every component is to be studied for reliability while manufacturing and also while attaching it with the Mating components like PCB's etc.,. The electronic components are subjected to high temperature while operation as well as in the manufacturing cycle. In this process the component is attached with the PCB by plasting moulding process. The objective is to study the stress levels in plastic package after cooling down from 175 ℃ to 25℃. So to study the stresses induced in this process in study state and also in transient thermal analysis. In the first step a Transient thermal analysis is carried out to study the temperature distribution when 350W heat dissipated at top 5 um depth using the loading graph. In the second step Static structural analysis carried out to find the stresses using the transient thermal analysis results as input.

Key words: Tipping: Weld: Microstructure

INTRODUCTION

There are different types of methods are there in fixing the electronic components with the PCB circuit. The latest technology is to imbed the component with the plastic moulding process to get better reliability during operating conditions.

An overview of Component Mounting Techniques in PCB

Vision Assisted Component Placement
The vision system should include as a basis element of the design, an ability to process (establish X/Y/Theta) the component location on the pickup head and match the component to the respective component pads. To achieve the required placement accuracy, the following is necessary:

• Gray scale vision processing.
• Component placement algorithms.
• Fiducial (local and global) camera.
• Component pad/lead recognition camera.

Placement Speed
Although placement speed is typically quoted at approximately 0.1 second per placement, Flip Chip components can take as long as 3.5 to 5.0 seconds per shot (placement). Component placement speed is dependent upon such factors as distance which the placement head must travel between component pick-up and placement location, and the requirement to view the component leads/pads for component-to-pad alignment prior to placement
• Min. 0. 09 sec. per component

• Max. 0. 12 sec. Per component

Placement Accuracy
The accuracy to which the component is aligned and placed on the solder pads is contingent upon several factors, such as use of local fiducial marks; datum point location; size of printed circuit board; flatness of printed circuit board; etc.

• Min. ± 0.025 mm (using local fiducial marks)
• Max. ± 0.1 mm

Component Pick-Up Head Types
The most favored technique of component pick-up is via the vacuum nozzle due to the system's ability to create a negative pressure instantly upon making contact with the top surface of the component with the soft rubber nozzle contact, and then reverse the process by producing a positive pressure to blow [2] the component off the nozzle upon placement. Mechanical chucks, although favored for some time, are expensive to maintain and do present some mechanical difficulties in their operation.

• Vacuums Nozzles
• Mechanical Chucks

Component Placement Pressure Programmable placement pressure can be specified for each component, enabling placement of very delicate parts

Convection Reflow Furnace
Techniques of Solder
Interconnection

Solder interconnection of Through-Hole and Surface Mount components to printed circuit boards may be classified as using the following two (2) categories:

Local Component Heating
Local heating can be divided into the following methods:
• Hot plates with solder paste or flux.
• Hand solder iron with solder and flux.
• Hot bar (pulsed heater) using solder paste or flux.
• Hot air gun using solder paste or flux.
• Directed laser energy using solder paste or flux.

Global Board Heating
Global heating is divided into the following methods:
• Solder submersion.
• Directed IR reflow using solder paste.
• Hot air furnace reflow using solder paste.
• Vapor phase reflow using solder paste.
• Convection furnace reflow using solder paste.

As is displayed by the various soldering techniques above, solder paste is the dominant method of attaching electrical components to printed circuit boards. Thermal Processing (Reflow) System In a similar fashion as in the case of the component placement system, the specifications for thermal processing system will be developed based upon the anticipated reflow soldering requirements throughout the life of the oven. This statement is true for not only the type and configuration of the components currently being soldered, but also any adhesive which would require curing. Taken into consideration will be whether the components of a surface mount design are leaded or leadless the physical size and robustness of the component to withstand reflow temperatures. Because most components being designed into today's products are of a reduced mechanical configuration and located in close proximity to each other on smaller printed boards, the selection of the technology used within the reflow system becomes even more critical. Following are only some of the more critical decisions which will be made concerning the more pertinent parameters of the thermal processing system selection:

Techniques of Solder
Interconnection (Continued)

Product Throughput Is the reflow oven sized [2] for the current and anticipated production requirements. This will require not only a determination as to the number of boards the oven will process, but also how the boards will be conveyed through the oven.

Thermal Uniformity and Accuracy
The reflow system should provide a uniform heat transfer from the heating source, distributing it evenly over the product surfaces under process in an accurate manner so that all of the board surfaces receives an equal temperature rise. The same criteria is required for cooling.

Nitrogen Consumption
The infusion of nitrogen immediately prior to and during the solder paste reflow operation is mandated by the process and materials being assembled. Specifically, bare-copper circuit boards, and no-clean solder pastes benefit from the inclusion of the nitrogen atmosphere. Certain No-Clean solder paste with a metal alloy content of greater than 98% will often require the use of Nitrogen because the remaining 2% (by weight) or less will contain an insufficient amount of flux material available to prevent oxidation of the soldered elements if reflowed in an air environment. Should the process and materials being assembled require nitrogen, features within the oven design should be present which minimizes nitrogen consumption during preheat, soak, reflow, and cool.

I**nfrared Radiation (I.R) Reflow Soldering**
Radiant I.R. is a direct, focused heat source and was the initial heating technique used by the electronics industry to reflow solder paste. This technique, when not properly adjusted in relation to the board distance, could allow excessive amounts of directly focused heat to be delivered to the surface of the board producing a scorching effect to the board and the components under reflow. This technique is no longer commercially viable.

Natural Convection Reflow Soldering
Natural convection of the heat required to reflow the solder is normally obtained through the use of a non-focused I.R. source, without the benefit of a forced air circulation. This design is often referred to as non-focused [2], with the efficiency capability rated lower than the forced convection design due to the ability of larger components to shield smaller components from the available heat source.

Forced Convection Reflow Soldering
Heat require to reflow the solder paste is achieved by directing I.R. energy towards a metal or ceramic surface and utilizing the convected (radiated) energy from the opposite surface to produce the reflow. The heat is circulated within the reflow zones by strategically located fans. By use of a non-directed, convected heat circulated via strategically located fans, hot spots on the boards can potentially be eliminated. It is an indigenous invention by the engineers at Fixed Convection Reflow Soldering.Fixed Convection reflow soldering utilizes much of the same technology as Forced Convection with the exception of the use of strategically located fans.

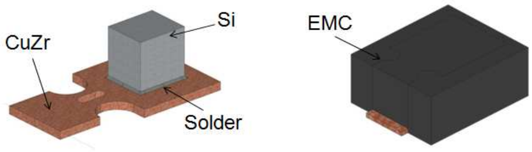
Heating Zones
The number of heating zones required will be determined by current and anticipated product throughput requirements, product size and physical mass, product orientation within the oven while on the conveyor, and requirements dictated by the particular solder paste reflow profile. Reflow ovens are typically offered in ranges from four to 12 heating zones.

Active Cooling Zones
Active cooling zones should be positioned immediately adjacent to the heating zones and should be ideally provided to meet the reflow requirements specified by the solder paste manufacturer. The amount of cooling required may also be dictated by product handling or subsequent assembly operations following reflow. Depending on the system requirements and vendor capability, the number of cooling zones which may be incorporated into the system may range from one to 12.

PROBLEM DEFINITION
Un-averaged Von mises Stresses and Discontinues stresses across the Die-Soldering-Lead frame to be analysed and validated. interface boundary due to the fact that the high difference in material properties such as young's modulus and thermal expansion to be found

EXECUTION PLAN
Problem description
- Mechanical reliability of a semiconductor component after cool-down from mold processing temperature.
- The component consists of a Si die, soldered on top of a CuZr leadframe.

- The assembly is overmolded by a commercial epoxy-molding-compound (EMC) material.
- Overmolding is done at 175°C.
- Stress results are requested after cool-down to 25°C.

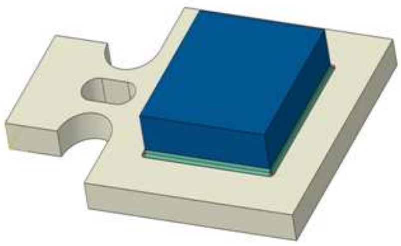


Objective

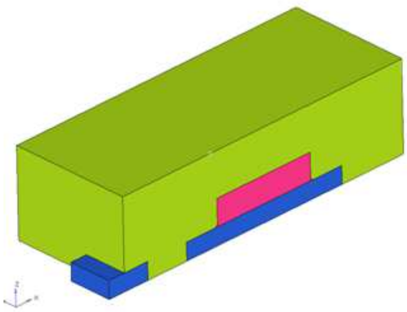
The objective of the analysis is to study the Temperature distribution and stress levels in plastic package when the power is dissipated at top 5 um of the die.

Plan

- The Analysis carried out in ANSYS 11.0 in two steps
- In the first step a Transient thermal analysis is carried out to study the temperature distribution when 300W heat dissipated at top 5 um depth using the loading graph
- In the second step Static structural analysis carried out to find the stresses using the transient thermal analysis results as input
- The complete package is meshed with solid elements (Hex & Penta)
- The Contact between Die, Lead frame, Soldering & Over mold is modeled as Bonded Contact
- The Model statically determinate (Sufficiently constrained to avoid the rigid body motion)
- Since the model is symmetric about its length, a Half symmetry model is considered for the simulation
- At the molding the package components are assumed to be stress free
- Temperature distribution and Vonmises stresses reported as output from 0 to 3.2e-5 sec

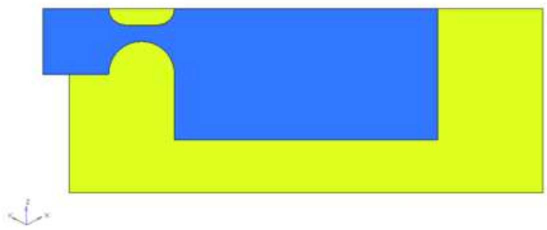


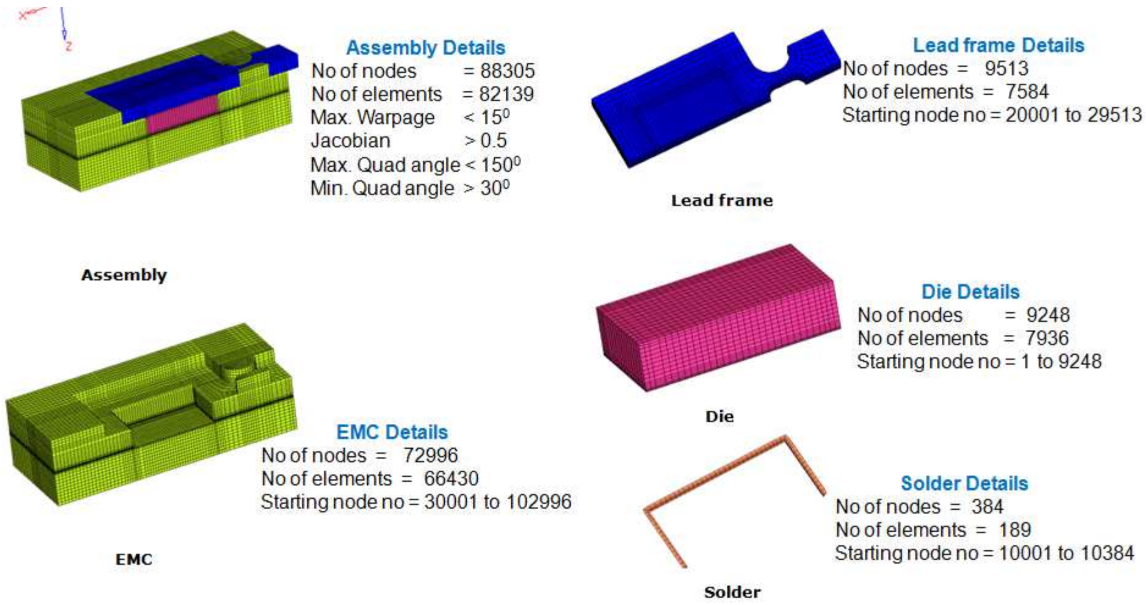
Assembly model



Cross sectional view

Bottom View





Material Properties

Material	Density [kg/m^3]	Thermal conductivity [W/mK]	Heat capacity [J/kg K]	CTE [ppm]	Young's Modulus [MPa]	Poisson's Ratio [-]
CuZr	8890	367	385	17.0	129000	0.3
PbSn5Ag 2.5	11020	300	130	29.0	13800	0.4
Si	2300	124	794	2.5	112400	0.3
EMC	1000	10	900	12	15000	0.35

Unit converted for analysis

Material	Density (Ton/mm3)	Thermal Conductivity(W/mmK)	Heat capacity (mJ/ton.K)	CTE (0K)	Young's Modulus (Mpa)	Poisson ratio
CuZr	8.89E-09	3.67E+02	3.85E+08	1.70E-05	129000	0.3
PbSnAg2.5	1.10E-08	3.00E+02	1.30E+08	2.90E-05	13800	0.4
Si	2.30E-09	1.24E+02	7.94E+08	2.50E-06	112400	0.3
EMC	1.00E-09	1.00E+01	9.00E+08	1.20E-05	15000	0.35

- Natural convection applied on the boundaries using 10W/m2K as film co-efficient 298°K as ambient temperature
- 300W heat is dissipated at top 5 um depth of Die using the loading graph(refer fig
- Uniform temperature of 298°K applied globally

- The following boundary condition used to find the Stresses
  1. Symmetric boundary condition about Y-Axis
  2. A single node is constrained in Z and X – direction as shown in the Picture.
  3. Reference temperature of 298°K applied globally
  4. Transient thermal analysis results used as input for Stress analysis

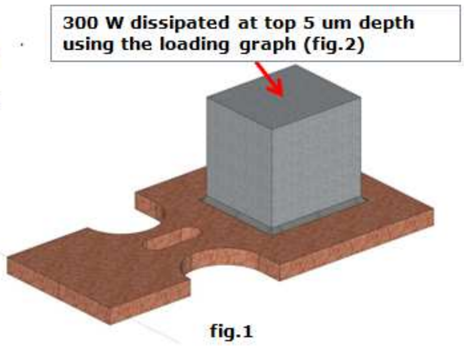
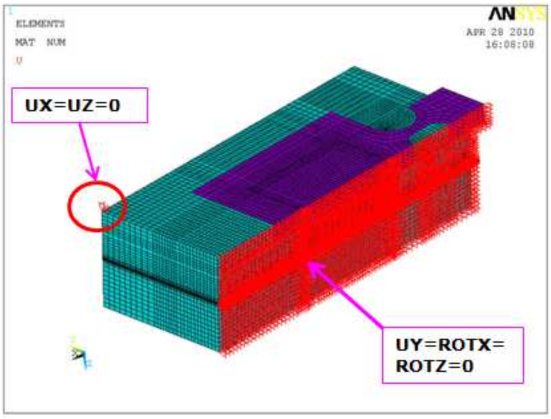


fig.1



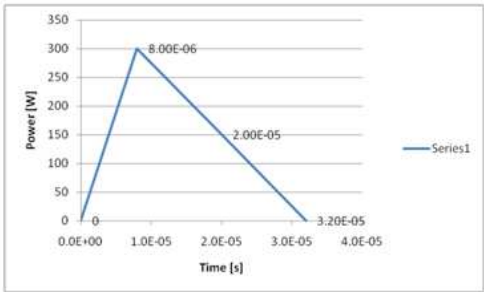
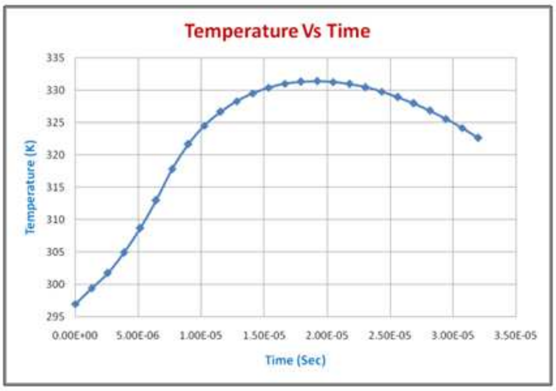


fig.2

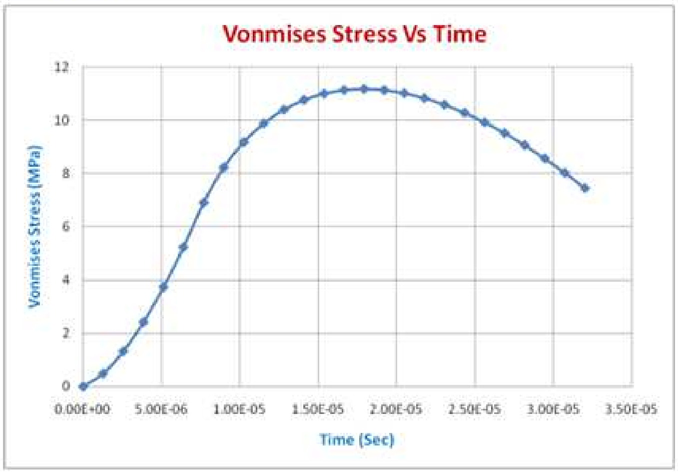
- Temperature distribution and Von mises Stress plots has been reported
- Maximum Temperature and Stresses are observed in the Overmold-Die interface region
- The maximum rise in temperature observed due to 300W heat is (298~322) = 24 degree
- The maximum temperature and stresses for the assembly model are observed at 2e-5 sec

Time	Temperature Distribution (∘ K)
8e-6	321
2e-5	331
3.2e-5	322



Note : Graph plotted for node number 46324

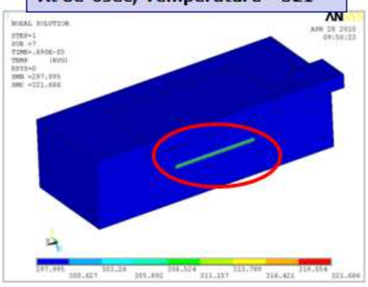
	Vonmiese Stress (Mpa)		
Time (Sec)	8.00E-06	2.00E-05	3.20E-05
Die	8.22	11	7.8
EMC	4.16	6.9	5.7
Lead Frame	0.48	1.2	1.47
Solder	0.19	0.49	0.59



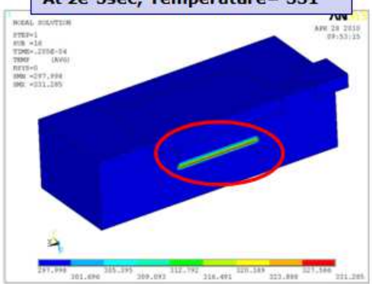
Notes : Graph plotted for node number 30972

TEMPERATURE DISTRIBUTION PLOTS
(Maximum Temperature observed in the Mold and Die interface region)
Results – Vonmises Stress for Assembly model

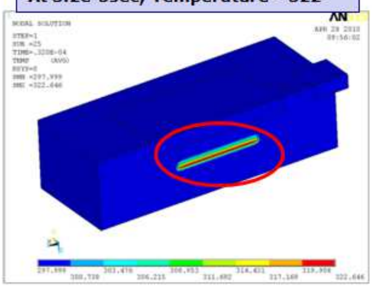
At 8e-6sec, Temperature= 321°

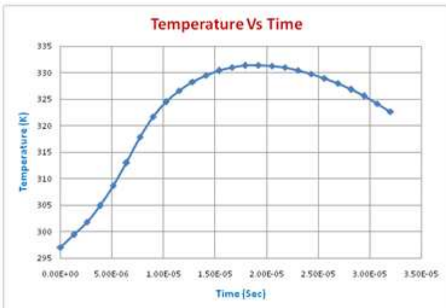


At 2e-5sec, Temperature= 331°



At 3.2e-5sec, Temperature= 322°

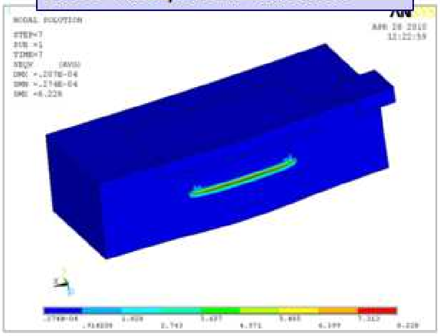




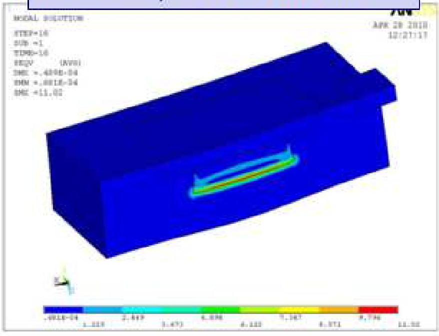
Notes : Graph plotted for node number 46324

STRESS PLOTS
(Maximum Stress observed in the Mold and Die interface region)

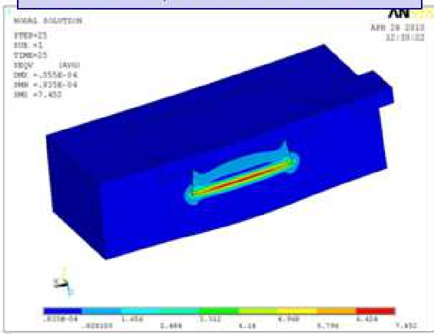
At 8e-6sec ,stress=8.22MPa

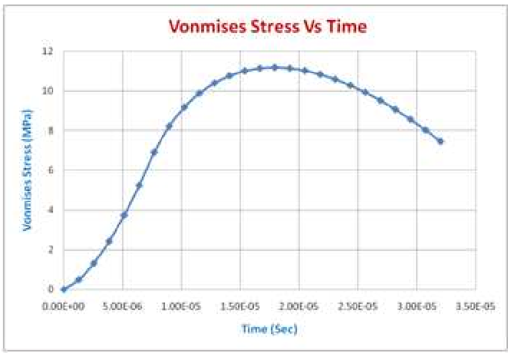


At 2e-5sec , stress=11.02MPa



At 3.2e-5sec, Stress = 7.45MPa

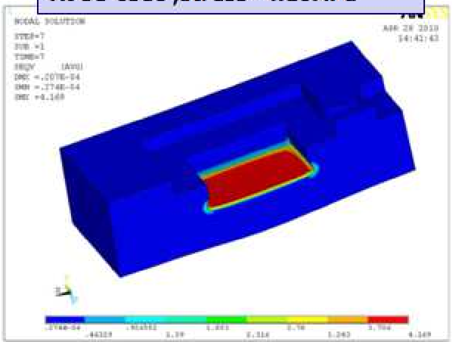




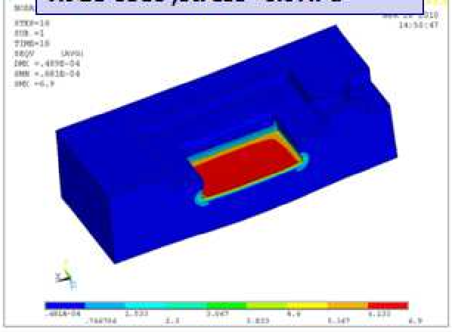
Notes : Graph plotted for node number 30972

Results – Vonmises Stress for EMC

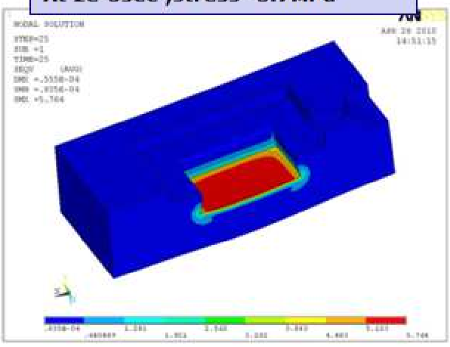
At 8e-6sec ,stress=4.16MPa

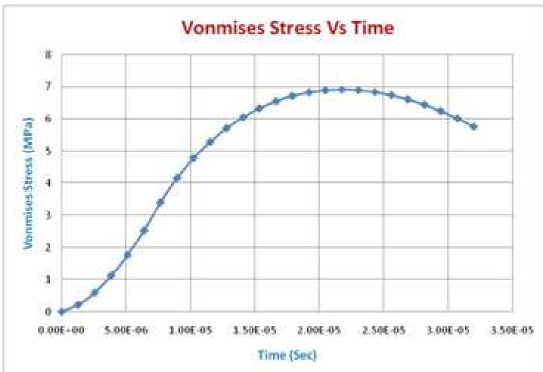


At 2e-5sec ,stress=6.9MPa



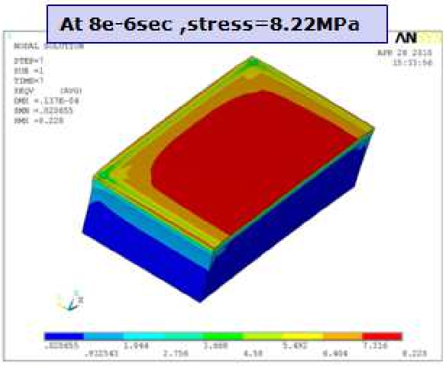
At 2e-5sec ,stress=5.7MPa

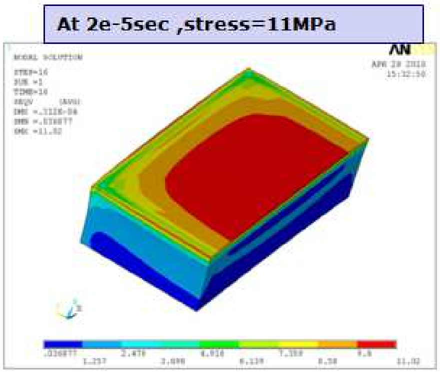


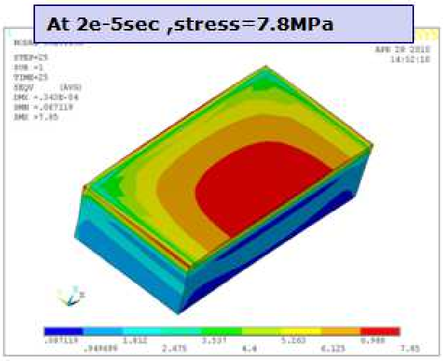


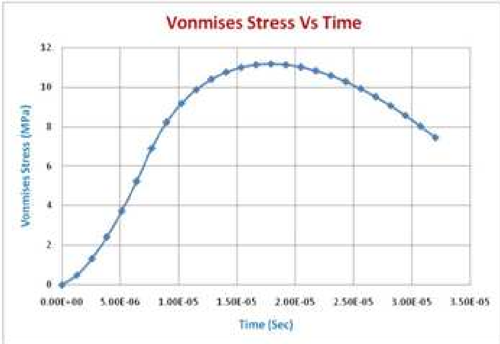
Note : Graph plotted at node number 46995

Results – Vonmises Stress for DIE



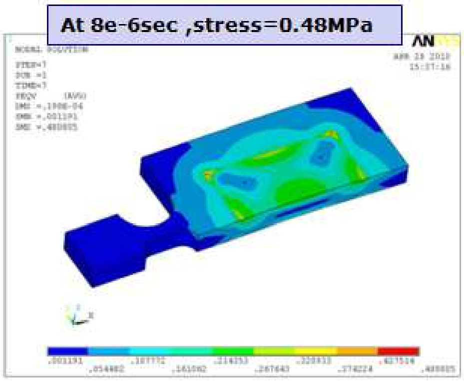


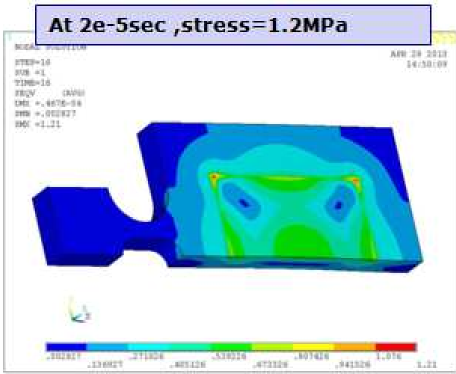


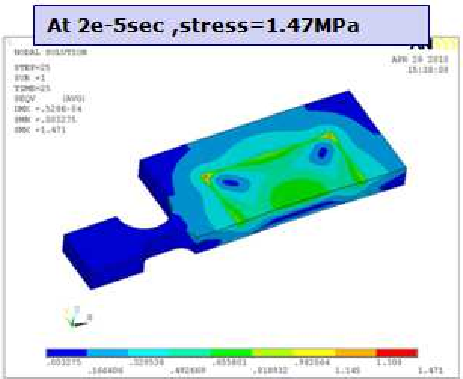


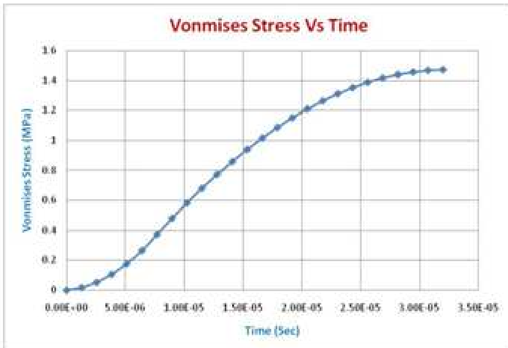
Note : Graph plotted at node number 30972

Results – Vonmises Stress for LEAD FRAME



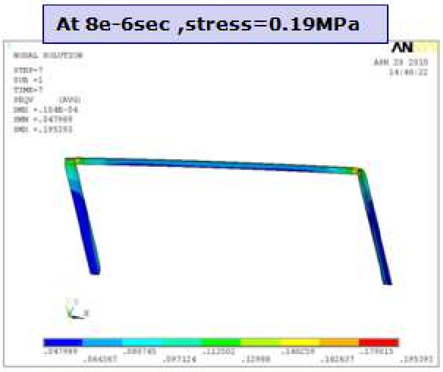


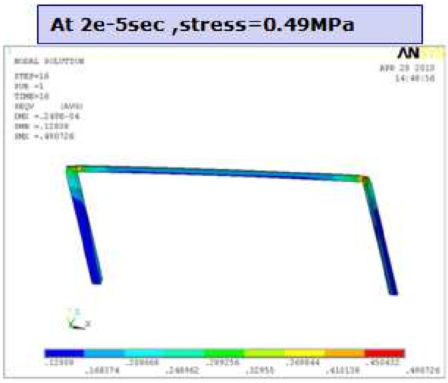


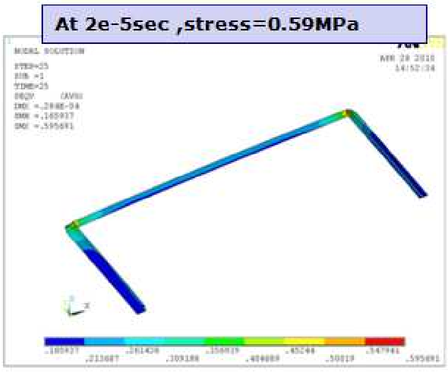


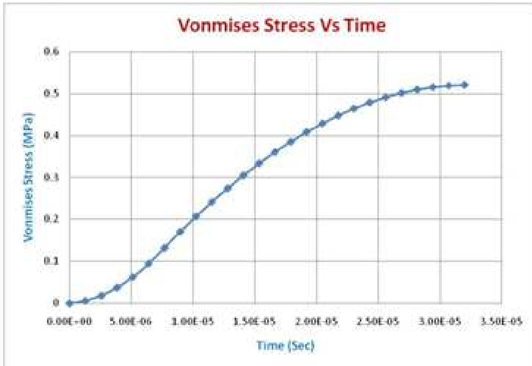
Note : Graph plotted at node number 20205

Results – Vonmises Stress for SOLDER









Note : Graph plotted at node number 10100

CONCLUSION

Thus from the experiments conducted and literature referred it can be concluded that the new technique of PCB mounting is thermally stable and suitable for regular operation.

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