International Journal of Scientific Engineering and Applied Science (IJSEAS) - Volume-1, Issue-3, June2015
ISSN: 2395-3470
www.ijseas.com

Thermal Flux assessment and Drop test of a smart phone –A case study

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ABSTRACT

Advancement is the latest technology, smart phones have gained importance in mode of communication due to the fact that they have a huge potential in market. Simulation engineering is adding value to improve its durability, reliability and robustness. The most interesting smart phones are driven by processor with powerful graphics to compute performance of mobile features. The present work concentrated on the study to analyse 3-Dimensional Thermal analysis of a smart mobile phone. Based on the heat flux generated in the silica materiel, an attempt is made to substitute which results in less heat flux. For safe life design of the product, explicit analysis is carried out through drop test, focussing on critical area, where most of the sensitive components are assembled. Modification in design is brought into ensure safety of the components.

Key words - Smart phone, Transient thermal, Drop test, Heat flux, Damper.

1. INTRODUCTION

Smart phones have been endowed with all the features that qualify them as a mini computer. Such handheld compact gadgets offer both communication and computing. The Graphics processing unit(GPU) is responsible for pushing millions of pixels to display and does same to 60 times each second. These high performance tasks will make System on Chip (SoC) burn lot of power ,generate lot of heat.

B.Jayachandraiah 2013, considered on “Modeling and Simulation 3D Heat Conduction for Sony Xperia Tipo Model Mobile Phone”. The paper presents the3D heat conduction along with the Consumers demand in smaller electronics devices with more features and capabilities.[1]

Wei Liu, Hongyi Li considered the impact study of a new cell phone design with split steel bands, focus paid on some key components. The integrity of the split band investigated carefully. The stresses for cover glass and LCD layers were evaluated numerically; and the shock absorbing performance of different visco-elastic pads attached on camera compared in detail.[5]

The present study involves to fill the gaps of above work by conducting Steady state, Transient thermal analysis and a drop test for a smart mobile phone

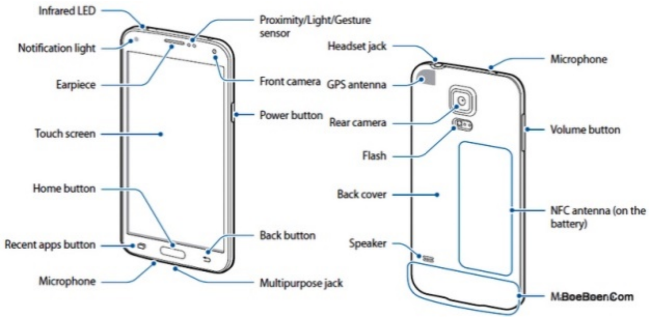

Figure.1-Basic components in Touch screen mobile

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2. OBJECTIVES OF THE PRESENT WORK.

The present work is divided into two parts.

- To identify the possible replacement for silica (base materiel) which results in less amount of heat flux generation.
- To conduct the Explicit analysis through drop test for both Initial and modified mobile phone model and then to compare the performance which results in less deformation.

3. METHODOLOGY

1. Build the CAD model.
2. Finite Element Modelling of the CAD geometry
3. Steady state and transient thermal analysis for different materials.
4. Drop test
5. Design modification.

4. MATERIAL DATA FOR MOBILE.

The materials considered in the present work for mobile.

1. Lithium-Considered for battery.
2. Silicon-Considered for base material (Circuit board).
3. Germanium-Considered as a substitute base material (Circuit board).
4. Thermoplastic Polycarbonate-Considered for mobile casing.

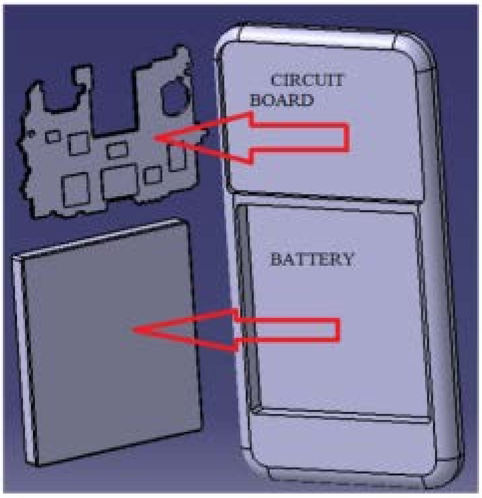


Fig.2 Material idealisation for analysis purpose.

4.1. Mechanical Properties of considered materials

a .Lithium:

Density in g/cm^3	0.534
Isotropic thermal conductivity in W/mK	85
Specific heat capacity in J/kgK	3560

Table.1-Mechanical Properties of Lithium

b. Silicon:

Density in g/cm^3	2.3296
Isotropic thermal conductivity in W/mK	150
Specific heat capacity in J/kgK	712

Table.2-Mechanical Properties of Silicon

c. Germanium:

Density in g/cm^3	5.323
Isotropic thermal conductivity in W/mK	60
Specific heat capacity in J/kgK	321.4

Table.3- Mechanical Properties of Germanium

d. Thermoplastic Polycarbonate:

Density in g/cm^3	1.2
Isotropic thermal conductivity in W/mK	0.2
Specific heat capacity in KJ/kgK	1.2-1.3
Yong's modulus in pa	$2.4e^{9}$
Poisson's ratio in pa	0.37
Bulk modulus in pa	$3.0769e^{9}$
Shear modulus in pa	$8.7591e^{8}$

Table.4- Mechanical Properties of Thermoplastic Polycarbonate

5. THERMAL ANALYSIS:

In this study, steady state and transient thermal analysis of a base material (chip) of a mobile is carried out with suitable boundary conditions. Mobile phone under high application requires multiprocessors to be operated, As shown in Fig.3 .processer A will be ON in operation for first few minute additional to that processor B will be operated with A as shown in fig. This leads to generation of heat at its max in the base material[3]

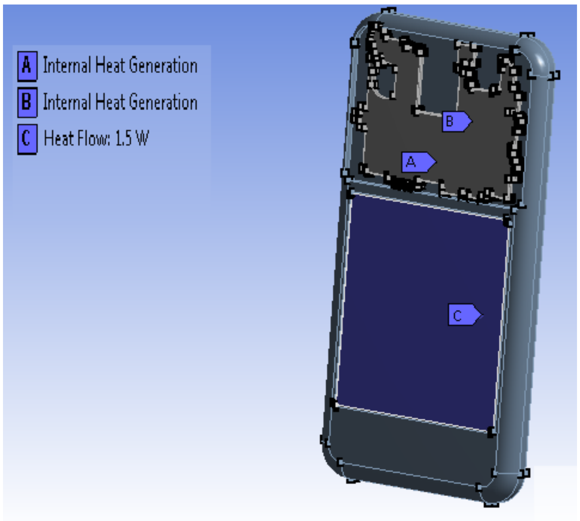
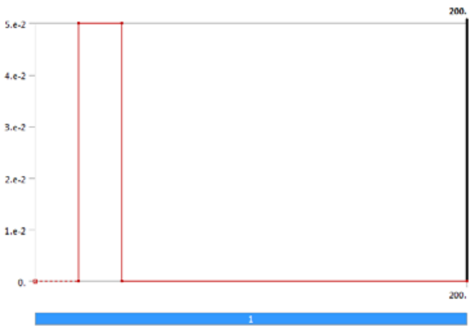


Fig.3-Heat Generation in a mobile body.

5.1 Time versus Heat Generated in Processor A and B



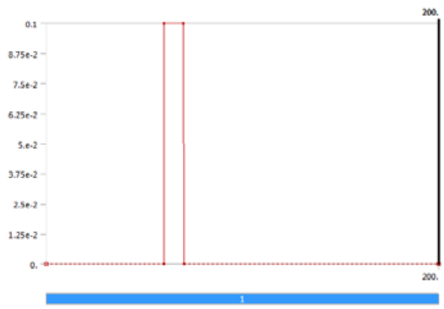


Fig.4Internal Heat generation (Processor A)

Fig.5 Internal Heat generation (Processor B)

Internal Heat Generation

Part	Max. Heat Generation in W/mm^2
Processor A	5e^{-2}
Processor B	0.1

Table.5-Tabulation of results processors A

In the present study base material (chip) is considered as silicon and Germanium. Thermal steady state and transient analysis were carried out; Germanium resulted better compared to silicon. Flow of thermal stresses and heat flux were less compared to silicon as shown in figure.4 and 5.

6. TEMPERATURE VARIATION

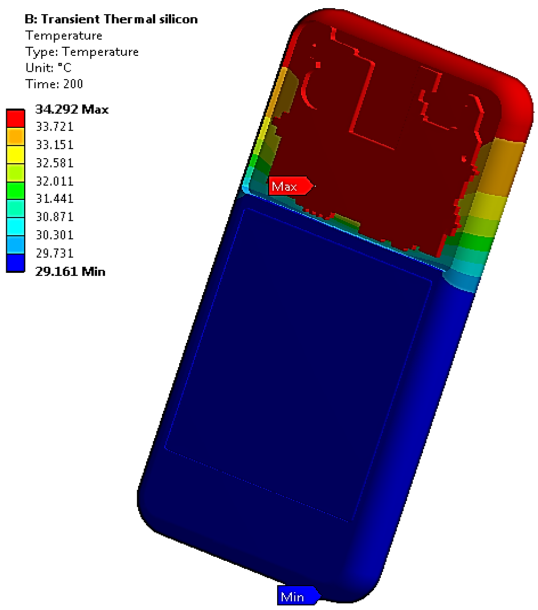


Fig.6Variation of temperature in mobile

6.1 Comparison flow of Transient Thermal Temperature between materials

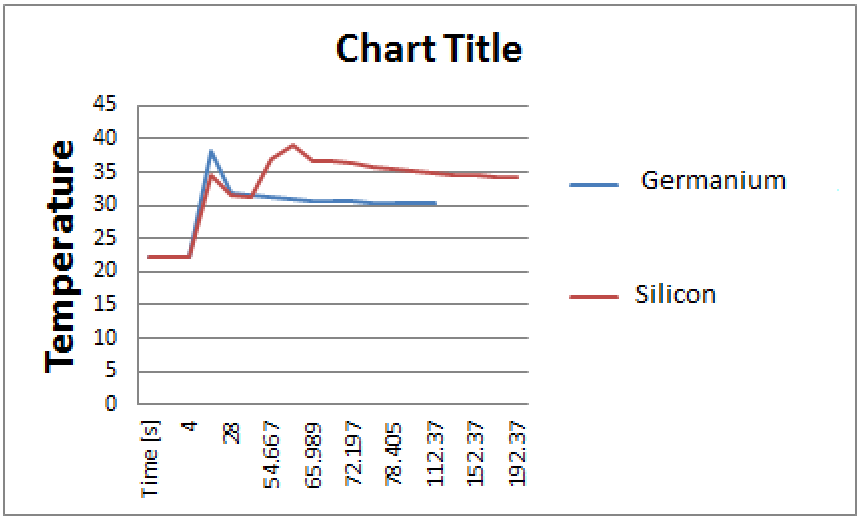


Fig.7Time versus Temperature

Observations- It is evident from the graph the temperature and the intensity of heat carried is more compared to Germanium

6.2. Comparison flow of Heat Flux between materials

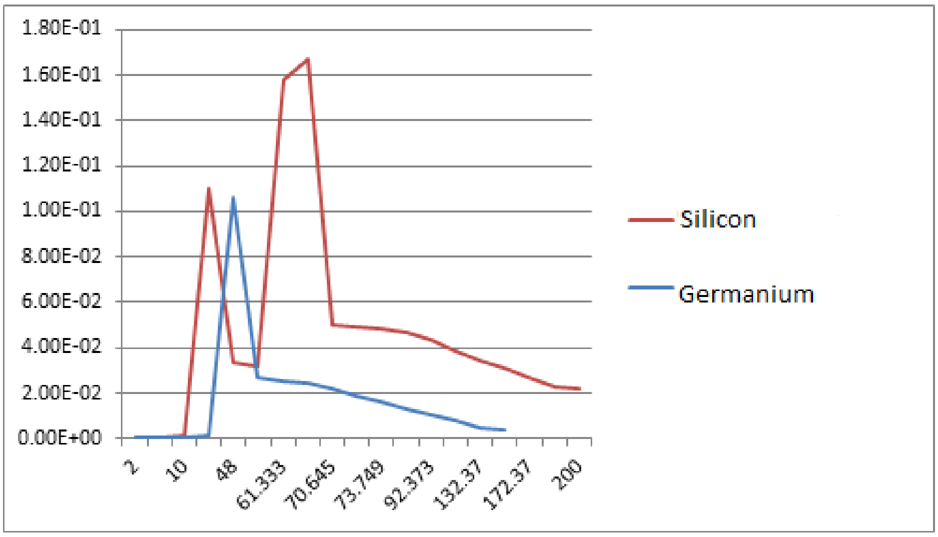


Fig.8 Time versus flux Comparison flow of Heat Flux between materials

Observations–Heat flux generated in silicon is more compared to Germanium

6.3 VALIDATION-for calculating the heat flux by using Newton's law of cooling [6]

Newton's law of cooling is used to express the overall effect of temperature. Heat flux from the hot wall to the cold fluid is considered according to law. In this study Flux from the processor is considered as hot wall the base chip is considered as cold surface. Hence Rate of heat transfer is calculated.

TEMPERATURE

$q= h (T_1-T_2)$ --------------- Equation (1)

Equation (1) indicates Rate of heat transfer of Newton's law of cooling [6]

q –Heat flux in W/mm^3, h - Film Coefficient in W/mm^2

T_1 – temperature of mobile in ^{o}c

T_2 - Ambient Temperature in ^{0}c

$1.3984*E4 = 5*E\text{-}5(T_1-295)$

$T_1 = 297.77$ K or 24.79 ^{o}c

	Ansys	Analytical	% Error
Temperature in ^{o}c	25.578	24.79	3.08

Table.7-Comparision of values obtained between Ansys and Analytical approach

6.4. For Steady State Thermal Analysis-Observations

Materials	Temperature ^{o}c	Total Heat Flux W/mm^2
Silicon	25.578	0.0061928
Germanium	25.578	0.0046386

TABLE.8-Comparision of Values of Temperature and Heat flux obtained from Steady State Thermal Analysis

Materials	Temperature ^{o}c	Total Heat Flux W/mm^2
Silicon	39.035	0.1668

Germanium	38.284	0.10635

6.5. For Transient Thermal Analysis- Observations

TABLE.9-Comparison of Values of Temperature and Heat flux obtained from Transient Thermal Analysis

From the above results it is evident that more Temperature and flux is generated from silicon compared with germanium. Hence germanium can be considered as one of the substitute for silicon in future.

7. DROP TEST

Explicit analysis is done through drop test of incline type .The top face surface both at front and back faces number of components are assembled such as sensors, cameras, infrared device. Display and so on .A drop test conducted targeting these components.[5]

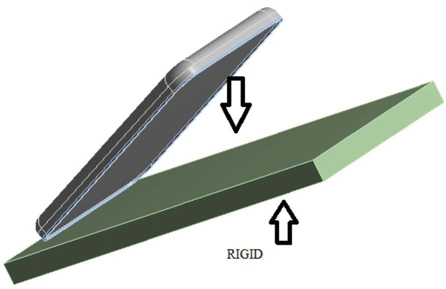


Fig.9- Drop Test of mobile

Through drop test the damage to the component is noticed and hence proper design modification is adapted

Fig.10 Stresses obtained after Drop test.

A damper is extruded 0.1 mm as shown in fig. , same test is carried out, observation are tabulated.

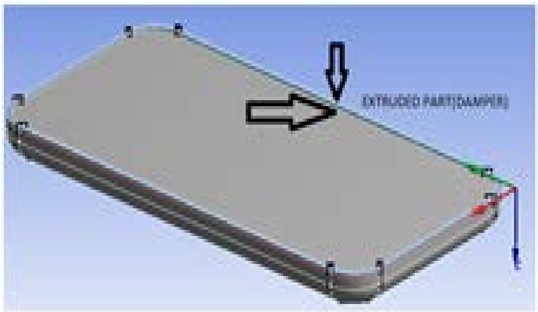


Fig.11 Modified model

Comparisons of Graphs

Before Modification

AfterModification

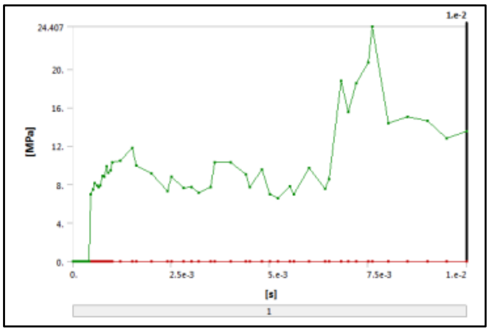


Fig.12 stress v/s time

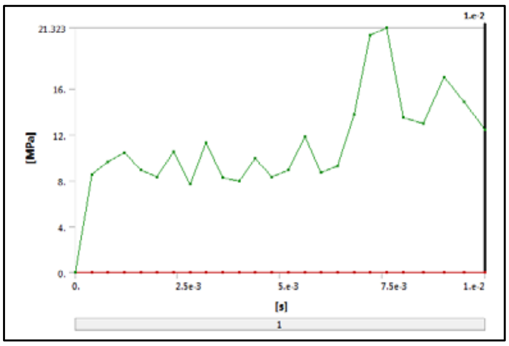


Fig.13 stress v/s time

Observations-From graph it can be concluded that deformation of the mobile is less after modification

Total Deformation in mm	Equivalent Stress in MPa
51.142	24.407

Table.10-Drop Test before Design modification

Total Deformation in mm	Equivalent Stress in MPa
50.567	21.323

Table.11- DropTest before Design Modification

From the above results it is evident that after design modification, stress and deformation level results better. Hence design can be considered.

CONCLUSION

Flux assessment in smart phone with idealization on the regular usage reveals the following observation which further taken forward to improve the performance and integrity. The study reveals the heat flux generated at base line model of system on chip (SoC) needs a replacement both from transient as well as steady state of heat transfer. As a result germanium is an alternative material is employed in the present study which throws a good insight as a substitute from performance point of view as discussed in full length. The drop test reveals geometrical modifications for the safety of display board, camera and sensors.

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