Dynamic responses of PCB under product/board-level drop impact

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Introduction

When portable electronic products are subject to impact shock, the solder joint stress level is the highest at the moment when PCB has the largest out-of-plane deformation with maximum bending stress.

The out-of-plane deformation of PCB provides us an insight into its dynamic responses under drop impact.

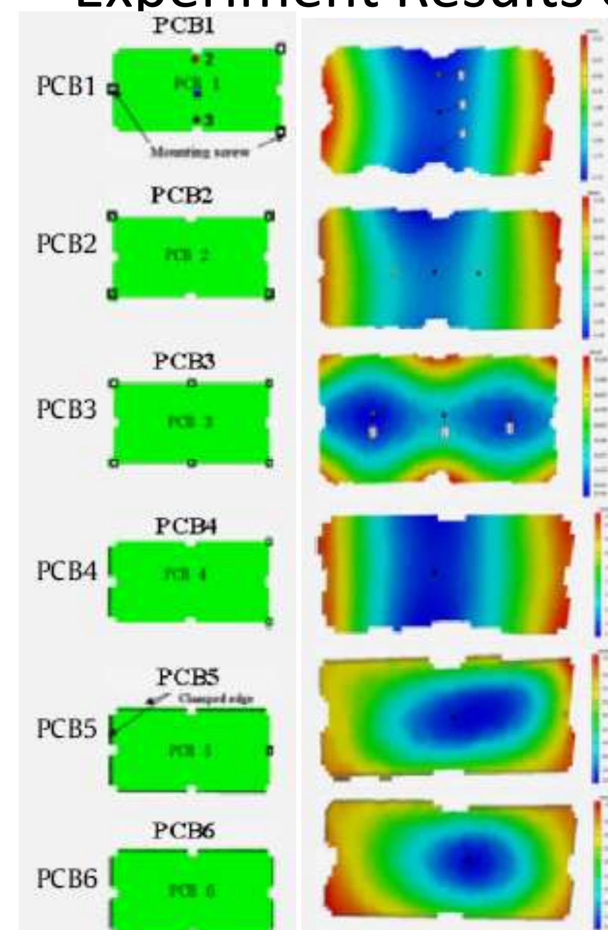
Objective

A new approach of non-contact optical measurement, Digital Image Correlation (DIC), is applied to investigate the dynamic responses of PCB under product/board-level drop test.

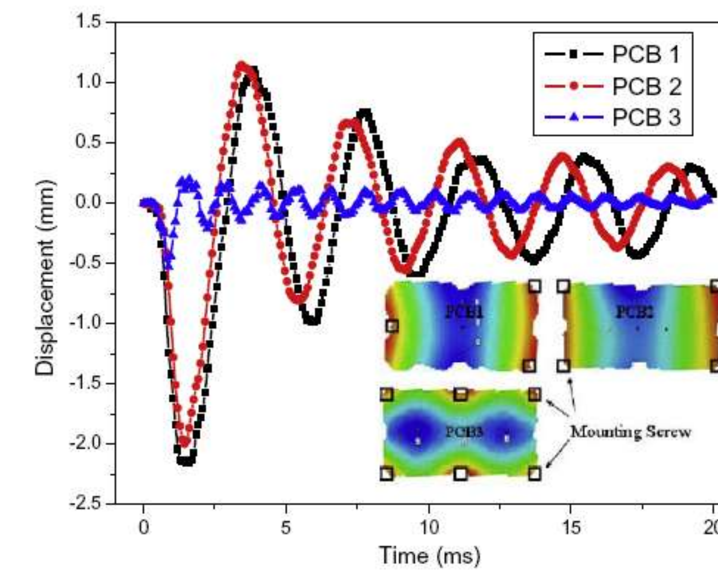
Effect of PCB connection methods is analyzed for product-level free drop test.

Effect of shield-can design on the dynamic behaviors of board-level assembly is also investigated

Experiment Results of Product-level Free Drop Test



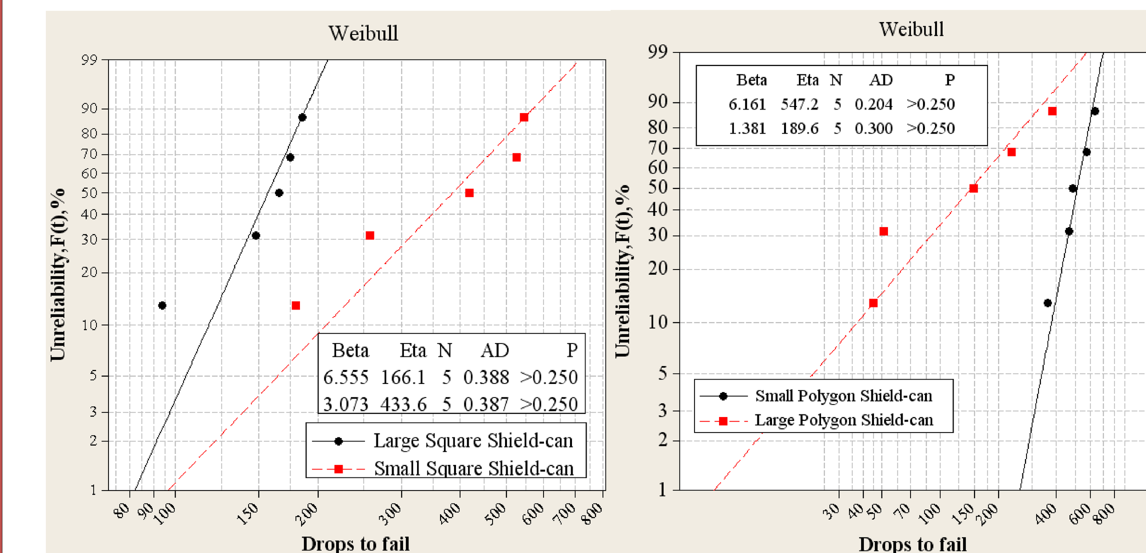
Out-of-plane deformation contour plots for different PCB connection methods



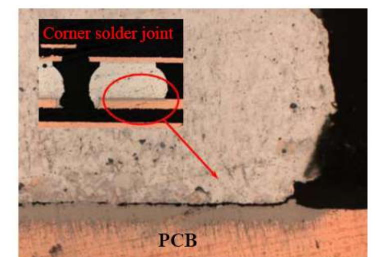
Out-of-plane displacement for different PCBs

- Position and number of mounting-screws connecting PCB with the cell phone case are crucial to the PCB bending modes.
- More constraint reduces the maximum out-of-plane deformation.

Effect of Shield-can Design on Impact Fatigue Life



- It is clearly shown that the small size shield-can increases the reliability of package to the drop impact.
- Polygon shape shield-can is more efficient at increasing the drop reliability.
- The failed sample was found to have crack along the solder/PCB interface at the outermost corner



Cross-section of failed solder joint

Digital Image Correlation & High-speed Cameras

High-speed cameras:

Speckle patterns on the PCB surface are captured by high-speed cameras and digitized into digital image series.

High-speed cameras

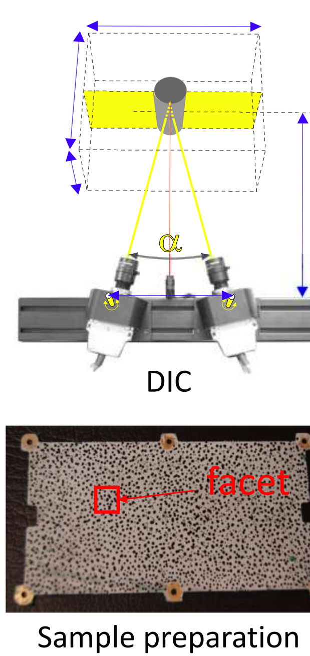
High-Speed Measurement	
Resolution	640 x 352 pixels
Frame rate	12,500 fps

Digital Image Correlation (DIC):

DIC is *a full-field non-contact* optical measurement technique.

In-plane and *out-of-plane deformations* can be computed by comparing the pictures of the target object at initial and deformed stages.

Each facet is a measurement point that can be considered of as *an extensometer* or a *virtual strain rosette.*



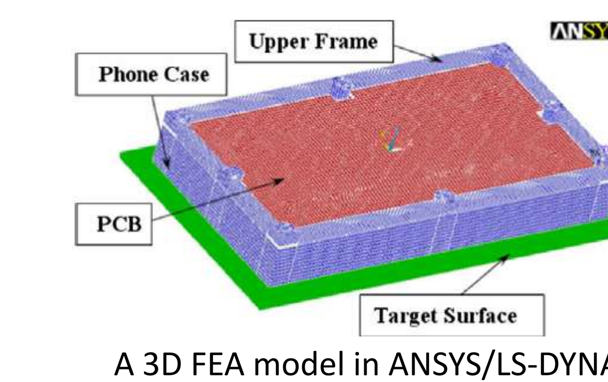
DIC

Sample preparation

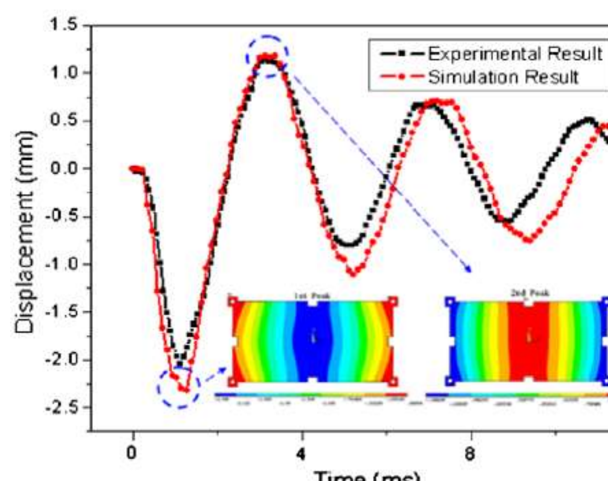
Advantage:

full-field; non-contact; no strain gage is needed

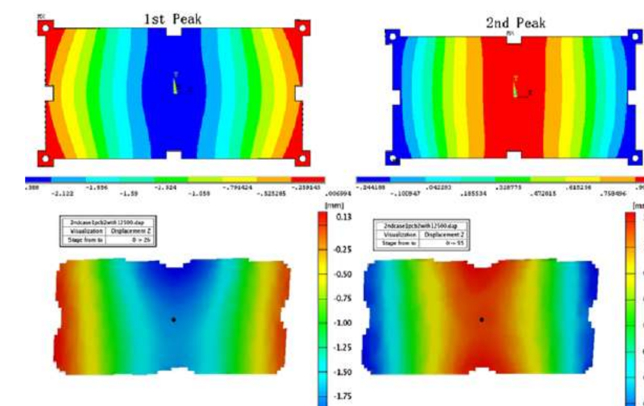
Finite Element Model Validation



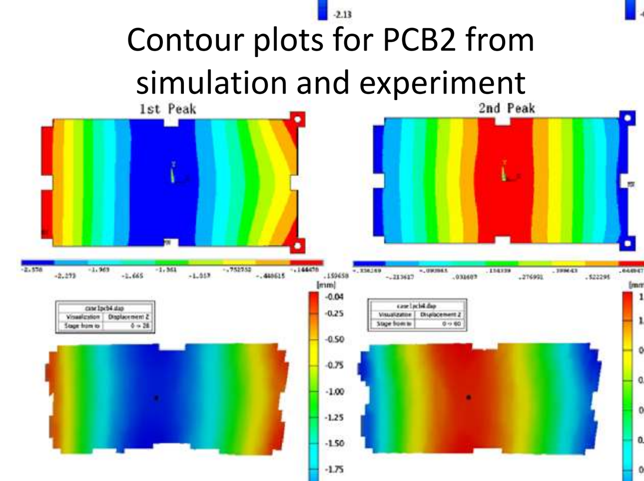
A 3D FEA model in ANSYS/LS-DYNA



Out-of-plane deformation time history data verification

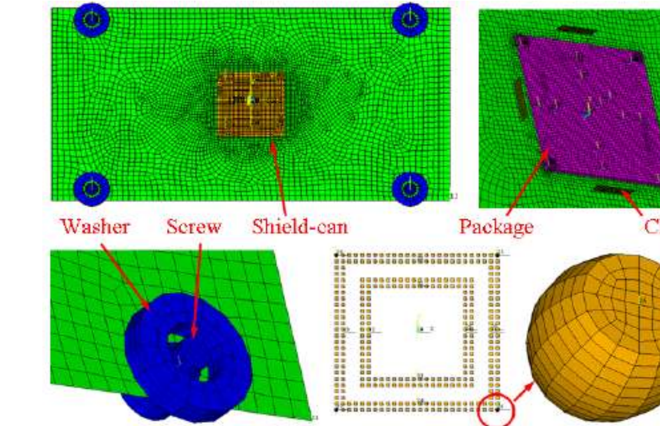


Contour plots for PCB2 from simulation and experiment

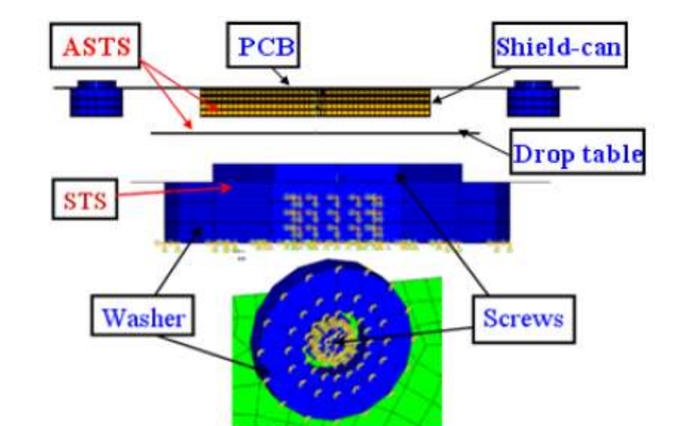


Contour plots for PCB4 from simulation and experiment

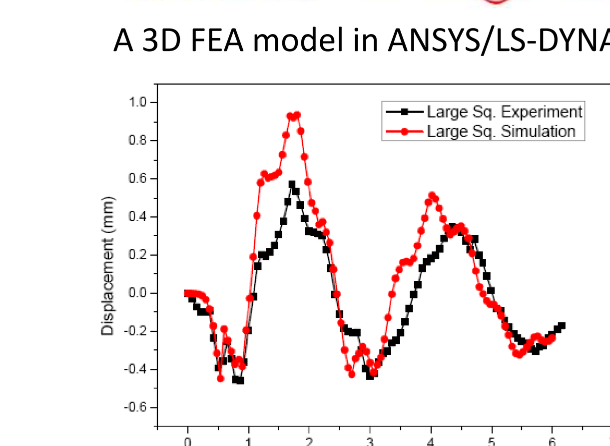
Finite Element Model Validation



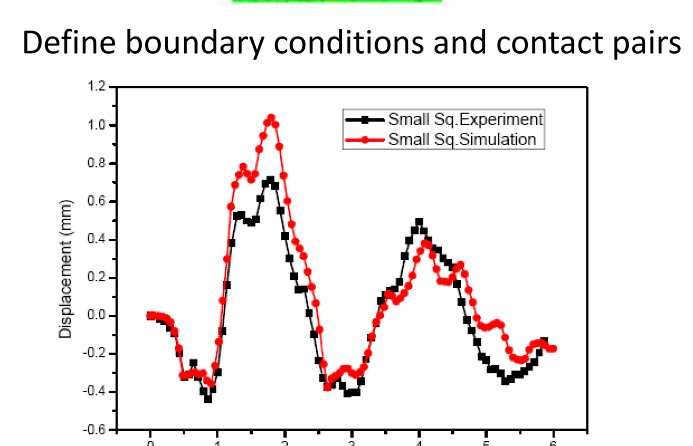
A 3D FEA model in ANSYS/LS-DYNA



Define boundary conditions and contact pairs



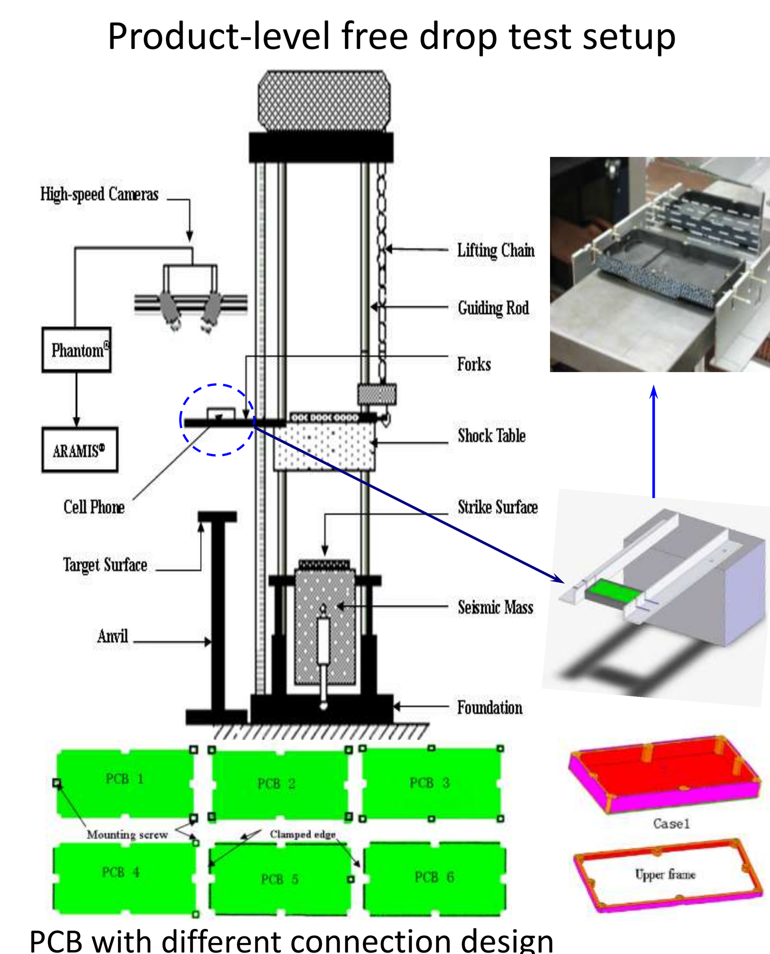
Simulation results for large square shield-can



Simulation results for small square shield-can

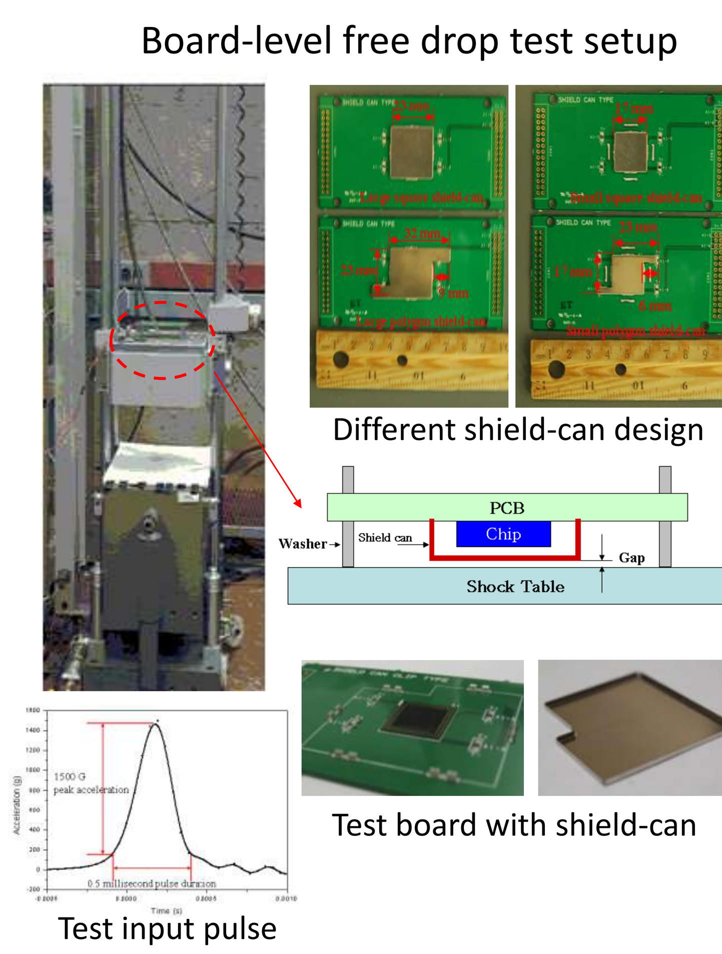
Experiment Setup and Test Vehicle

Product-level free drop test setup



PCB with different connection design

Board-level free drop test setup

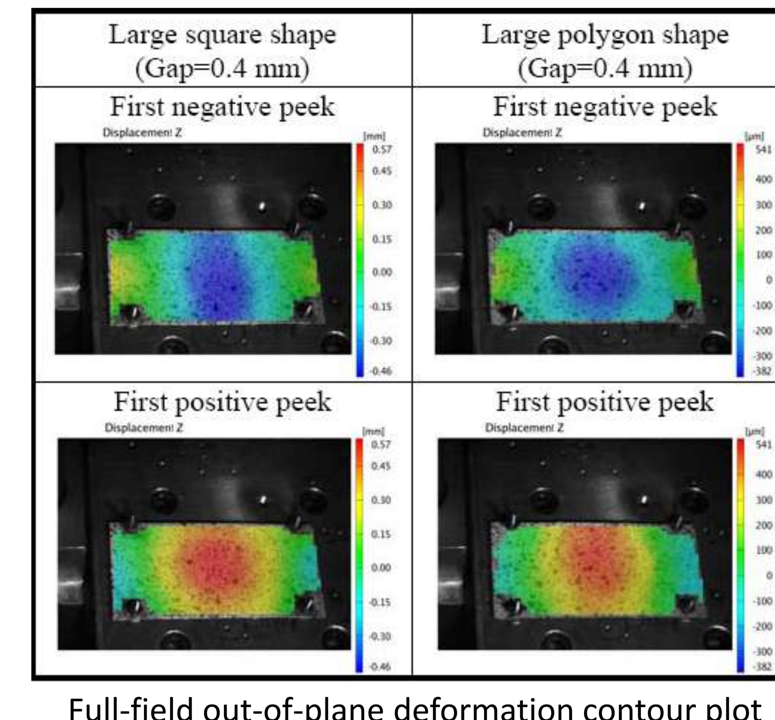


Different shield-can design

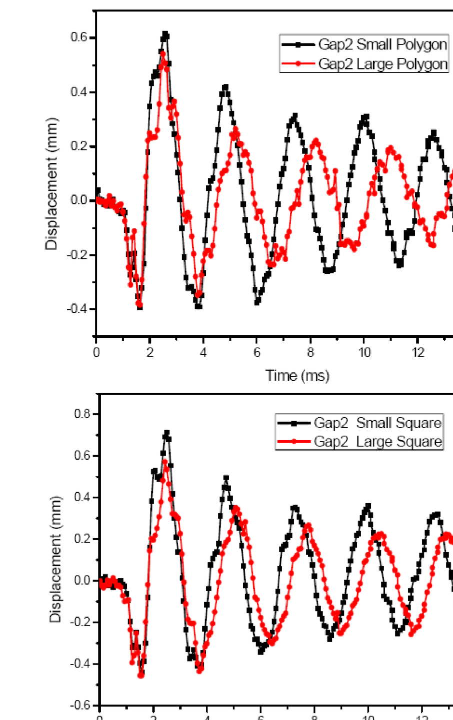
Test input pulse

Test board with shield-can

Experiment Results of Board-level Drop Test



Full-field out-of-plane deformation contour plot



- Bending down process of PCB is limited by the initial gap size.
- The amplitude of the following positive peaks decreases as the shield-can size increases, as the large shield-can will apply more constraint to the PCB during its bouncing-back process.

Conclusions and Future Work

- A new approach of non-contact optical measurement, Digital Image Correlation (DIC), is successfully applied to investigate the dynamic responses of PCB under product/board-level drop test.
- PCB connecting methods are crucial to the PCB bending modes under product-level free drop impact.
- The small size and polygon shape shield-can increases the reliability of package to the drop impact.
- Future work: Perform parametric analysis in FEM to increase the impact life of packages under product/board-level drop impact and optimize their design.

Acknowledgments

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