Drop Impact Reliability Testing for Lead-Free and Leaded Soldered IC Packages

Desmond Y.R. Chong*, Kellin Ng, Jane Y.N. Tan, Patrick T.H. Low
United Test & Assembly Center Ltd (UTAC)
Packaging Analysis & Design Center
5 Serangoon North Ave 5, Singapore, 554916
*Email: desmond_chong@utac.com.sg Tel: 65-65511348

John H.L. Pang[+], F.X. Che, B.S. Xiong, Luhua Xu
School of Mechanical & Aerospace Engineering
Nanyang Technological University
[+]Email: mhlpang@ntu.edu.sg Tel: 65-67905514

Abstract

Portable electronic products such as cellular phones, PDAs, and MP3 units are increasingly designed for accidental drop. Repeated drop events can lead to solder joint failure and malfunction of these products. Hence board-level reliability drop testing is a useful way to characterize the drop durability of the printed circuit board with different soldered assemblies. Lead-free (or Pb-free) solders are replacing lead-based solders. Surface mounted electronic packages are getting smaller and with higher density (I/Os). In this study, Plastic Ball Grid Array (PBGA), Quad Flat No-lead (VQFN) and PQFP solder joint reliability characterization by drop impact testing was investigated for lead-based (62Sn-36Pb-2Ag) and lead-free (Sn-4Ag-0.5Cu) soldered assemblies. The influence of different package types and the impact of PCB surface finishes for OSP and ENIG (electroless nickel immersion gold) were studied. The drop test results showed that lead-free solder joints with ENIG finish have weaker drop reliability performance than the case for OSP surface finish. The different solder alloy-to-surface finish type combination results in different intermetallics formed and contributed to different failure sites and mode of failure. The formation of the brittle intermetallics (Cu-Ni-Sn) for Pb-free solder (Sn-4Ag-0.5Cu) with ENIG pad led to detrimental interfacial fracture of the PBGA solder joints. For both lead-based and Pb-free solders with copper-pad and OSP surface finish, the formation of Cu_6Sn_5 intermetallics resulted in a different failure site and mode. The failures migrated to the PCB copper traces and resin layers. The small size (VQFN) package is most resistant to drop impact failures, due to it's small size, weight and larger solder volume. The compliant leads for the PQFP is more resistant to drop failures compared to the PBGA solder joints.

Introduction

Portable electronic products such as cellular phones, PDAs, and MP3 players are growth areas for the electronics manufacturing industry. The product and packaging design trends continue to push for smaller form factor and increased functionalities. Portable electronic products are prone to accidental drops and can cause internal circuit board damage for example, solder joint failures by brittle fracture at the solder joint intermetallic compound (IMC) interfaces or by impact fatigue in the solder materials. If the solder joint is robust, the failure site can migrate to the board copper traces or even resin cracking. When an electronic product drops on the ground, impact force and deformation is transferred internally to the PCB, solder joints and the Integrated Circuits (IC) packages. The IC packages are susceptible to solder joint cracks, induced by a combination of PCB bending and mechanical shock inertia during the impact event. If a single drop event does not cause failure, repeated drop events and it's frequency can cause impact fatigue or accumulated damage and rupture of interconnection joints and assembly materials. Drop testing provides a useful experimental approach to design for drop reliability. From the physics of failure characterized in the drop test, improved solutions to IC package design can be implemented to avoid such drop related failures in service. Research on drop impact testing and finite element modeling investigations [1-10] are further needed for developing a design-for-reliability (DFR) methodology [5] for drop impact reliability qualification of board-level soldered assemblies. Drop impact responses such as acceleration and strains experienced by the PCB are obtained and studied to investigate the mechanisms of the solder joint failure modes [11-13].

Tin-lead solders (63Sn-37Pb, 60Sn-40Pb, 62Sn-36Pb-2Ag) have been employed in the electronic industry for four decades. Lead-free solders will replace tin-lead solders and the Pb-free solder candidate to replace Sn-Pb is Sn-Ag-Cu (SAC) solder. The tin-silver-copper (Sn-Ag-Cu) alloy is a popular choice for replacement of lead-based solders, but there are concern on its solder joint reliability performance subject to drop impact testing and long-term thermal cycling tests. More experiments and numerical analysis is required for SAC solders in the range of Sn-(3-4)Ag-(0.5-1)Cu.

Studies were already conducted on the effect of PCB surface finish (e.g. electroless-nickel-immersion-gold, ENIG or organic solderability preservative, OSP) on the thermal fatigue reliability performance of SAC solder joints and its underlying failure mechanism. However the influence of surface finish on drop impact reliability has not been readily documented and the failure mechanism need further characterization. The study investigates the effect of drop impact test on the reliability of solder interconnects of lead-based (62Sn-36Pb-2Ag) and lead-free (Sn-4Ag-0.5Cu) solder compositions. Several package types and two different PCB surface finishes of OSP and ENIG were evaluated. Test vehicles used are 35x35mm PBGA, 28x28mm PQFP and 7x7mm VQFN (very-thin profile Quad Flat No-lead) packages with daisy chain interconnects, for continuous monitoring of solder joint resistance during drop impact testing. The failure site, modes and mechanism are reported in this paper.

Failure Mechanisms of Drop Impact Test

From product level drop test reported by Lim et al [3], it was found that a horizontal drop orientation gives the largest impact responses. Wong et al [2], identified three board-level drop impact characteristics; (a) elongation and bending of interconnection due to differential flexing of PCB and package, (b) inertia force from electronic packages, and (c) longitudinal stress wave from impact. Due to the variation in stiffness of the IC package and the PCB where it is being mounted onto, it results in different flexing of the package and PCB when the board is subjected to a horizontal drop impact. In a package mounted at the centre of the PCB, this differential flexing has caused the corner solder joints to experience a larger tensile stress that leads to detrimental failure.

Inertia force of a body is the second driver for interconnection failure. During free fall, the IC package travels at the same velocity with the PCB mounted onto. Upon horizontal impact, an IC package with a larger size (thus larger mass) will experience a larger inertia force where force = mass x acceleration. As a result, the solder interconnects falls apart when the impact force reaches a threshold limit. The location of the package on a PCB plays a part in the solder interconnect strength as well. The PCB adjacent to the supports could experience up to a thousand times (1000g) acceleration and a package near to it could also experience the same acceleration. For a package at the center on the same PCB, its acceleration could only be in the range of hundreds of gravitational acceleration. Thus given the same mass, interconnects in the package placed near the support will be subjected to a larger tensile stress and eventually more prone to impact failure. Lastly, the high magnitude of longitudinal stress waves transmitted from the support to the adjacent interconnects may induce failure in it.

Experimental Setup for Drop Impact Testing

The Lansmont Model 65/81 drop impact tester (as seen Fig. 1) is used to carry out the board level drop impact test. The samples used in this experiment are 35x35mm PBGA (312 balls), 28x28mm PQFP (208 leads) and 7x7mm VQFN (48L) packages. All units are daisy chained for the purpose of interconnection failure monitoring. These packages assembled on a 150x200mm test board (Fig. 2) were clamped onto an aluminum fixture that is mounted onto the platform of the guided drop impact machine. The solder compositions used in the test are: lead based of 36Pb-62Sn-2Ag for PBGA packages and 15Pb-85Sn for the PQFP/VQFN plating, lead-free of Sn-4Ag-0.5Cu (also known as SAC) for PBGA packages and matte pure tin for the PQFP/VQFN plating. The packages are mounted onto PCBs with two different pad surface finishes of ENIG and OSP with the following breakdown:

i) Leg 1 – Lead-free packages on ENIG pad finish
ii) Leg 2 – Lead-free packages on OSP pad finish
iii) Leg 3 – Lead based packages on OSP pad finish

Fig 1. Lansmont Model 65/81 Drop Impact Tester.

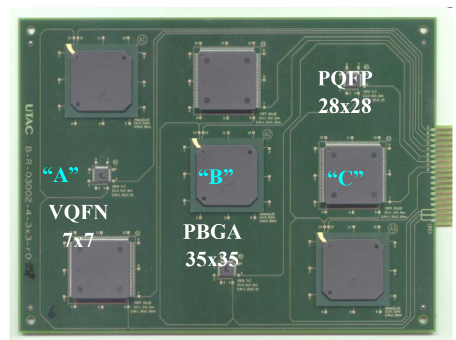


Fig 2. 150x200mm PCB with Drop Test IC Packages.

The drop height was set at 1.0m with the impact surface covered with felt pads. Six boards (sample size) were dropped for each of the three legs. The drop orientation is of horizontal with packages in a face-down position. The PCB is mounted along the length-wise direction in a clamp-clamp position onto the aluminum fixture where it is fixed to the drop table (see Fig. 3).

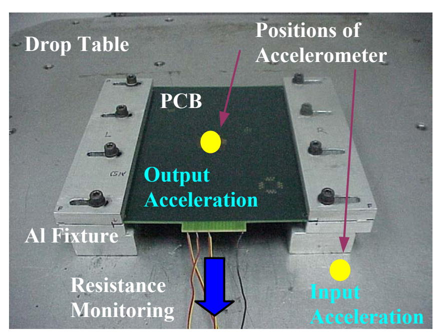


Fig 3. Drop Test Fixture with PCB Mounted onto it.

During the test, the drop table is raised and dropped from a desired height along the two guiding rods of the drop tester onto a rigid base covered with one layer of felt. Upon impact, the drop responses of interest are the shock level experienced by the PCB and the IC packages, the strains experienced at the center of the PCB, and the static and dynamic resistances of daisy-chained solder joints in real-time. As the PCB is experiencing maximum bending at the center during drop, only packages labeled “A”, “B” and “C” along the centerline of the board will be monitored for drop impact reliability. The experiment was performed with an input shock pulse of about 600g at the drop table. Referring to Fig. 3, an accelerometer is mounted on the drop table near to the fixture to measure the input acceleration. Another accelerometer is mounted at the center of the PCB (reverse side of the IC package) to characterize the output acceleration response of the PCB. The accelerometers are connected to charge amplifiers and a data acquisition system with TP3 software to monitor the acceleration readings. Strain gauges were mounted on the PCB at the opposite side of the center PBGA package to measure the bending strain experienced during drop impact. A data acquisition setup was used for strain measurements. It consisted of strain gauges arranged in a Wheatstone bridge circuit of a half bridge connection, a dynamic strain meter (TML DC-92D) and a digital oscilloscope (Yokogawa DL-1540). The signals from strain meters are linked to the oscilloscope. For drop test consistency and repeatability, drop responses of input/output acceleration and PCB strain were monitored for one board from each leg. Both the acceleration and strain values were found to be reproducible.

In many cases, event detectors are recommended for continuous monitoring and detection of the solder interconnects connectivity failure. However event detectors setup is expensive and with its ability of registering only an event (eg failure with resistance reaches 300Ω or more), it may not be able to capture the continuous intermittent failure occurring in a solder joint. The dynamic resistance of daisy-chained solder joints in real-time during drop impact is used [6]. According to his method, a resistor, *Ro*, is placed in series with the daisy chain solder joints and connected to a DC power supply. The dynamic resistance of solder joints, *Rx*, can be described by,

$$R_x = \frac{R_0 V}{E - V} = \frac{R_0}{E/V - 1} \qquad (1)$$

where E is the voltage (1.8 volt) of the DC power supply, and V is the dynamic voltage of daisy chain that changes with the dynamic resistance of the daisy chain,. In this way, the voltage is monitored instead of the resistance using an oscilloscope. When $V \rightarrow E$, $Rx \rightarrow \infty$ (which implies an open circuit), it indicates the critical solder joint has failed with crack opening. *Ro* of 10Ω was used in this test.

Results and Discussion

The current test vehicles and PCBs have undergone board level thermal cycling test of –40°C to +125°C (1 cph) for joints’ integrity assessment under thermo-mechanical loading. All three legs had survived 1000 cycles of thermal loading, thus implying that the component mounting reflow profile was optimized for reliable solder joints formation. A total of 50 drops was conducted for every PCB, with the solder joints resistance of packages positioned at A, B and C being monitored. The failure due to opening of solder joints is observed through the change in the dynamic resistance reflected on the oscilloscope. Before drop, the solder joint resistance was measured by manual probing to ensure that no failure in the interconnection was observed. In a drop test, it is common to observe that the solder joint crack opens up resulting in a resistance discontinuity during drop impact and closes back to resume electrical continuity after the flexing of the board has ended. This observation is due to the upward/downward flexing of the PCB leading to the opening/closing mode of the crack. This is known as an *intermittent* solder joint failure where static resistance measurement by manual probing is not able to register any discontinuity. When the crack becomes larger and cannot be closed back even after the impact test, a *permanent* solder joint failure will be resulted (open circuit registered with static resistance measurement). In the current test, the *permanent* solder joint failure is identified as the failure criteria.

Dynamic Responses of Drop Impact

The dynamic resistance of the daisy-chained solder joints in real-time during drop impact is represented by a voltage reading on the oscilloscope. In any drop, the solder joints resistance (or “voltage”) for three packages (PBGA, PQFP and VQFN) and the PCB bending strain were captured. A typical curve response is showed in Fig. 4 where it can be divided into two regions, before impact (static) and after impact (dynamic). Before the impact, the PCB strain is zero while the static solder joint resistance is similar to the value measured by manual probing at the beginning of the test. During the first drop of test board in Leg 1 (Pb-free on ENIG), dynamic strain was recorded due to PCB bending after impact. In channels 1 and 2 for VQFN and PQFP respectively, there was little change in the resistance responses before and after the impact, indicating that no solder joint failure has occurred.

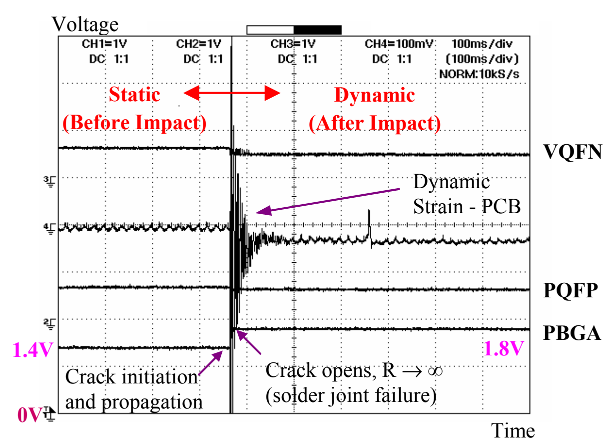


Fig 4. Dynamic Responses for Leg 1 (Pb-free on ENIG) Test Board at 1st Drop.

For channel 3 (PBGA component), the resistance increased sharply from an initial value of 1.4 volts [*Rx(initial)* = 10/(1.8/1.4 – 1) = 35Ω] to 1.8 volts [*Rx(final)*

= ∞] and remained at that level as seen in the dynamic response curve. This indicates that an open in the connectivity has been detected (probably due to a solder joint crack). The discontinuity was confirmed by manually probing again of the resistance connectivity. An open circuit was measured, thus implying that the joint opening is permanent. It is to note that the failure corresponded with the highest dynamic strain value as shown. The subsequent drop for other test boards in Leg 1 revealed that most of the PBGA joints failed within a maximum of six drops. Failure analysis was done and solder joints cracks were observed by cross sectioning the samples. Details of the failure analysis will be reported in the next section.

The drop dynamic responses for Leg 2 test vehicles (Pb-free on OSP) are illustrated in Fig. 5. With the Pb-free PBGA solder balls mounted onto an OSP pad finish, the first failure was observed at the 15th drop. From the graph, the resistance was again increased from an initial value of 1.4 volts to 1.8 volts after impact. However some differences in the response was noted against Leg 1. In contrast to Leg 1, the dynamic resistance did not reached the 1.8V level immediately but fluctuates for a short period of time before reaching 1.8V permanently. This observation was first postulated that upon impact, a solder joint crack was initiated followed by a rapid crack propagation till total failure (dynamic resistance reaches infinity, $V \rightarrow E$ = 1.8volts). Manual probing after the drop confirmed that the static resistance reached infinity and hence permanent failure was registered. Cross sectioning showed that no solder joint crack was found. Copper trace failure was noted instead. From the dynamic curve response, the copper trace fatigued after 14 impact drops. At the 15th drop, the copper trace tear in a ductile manner and the failure was not immediate. With subsequent PCB flexing, it caused the copper trace to rupture and resulted in a permanent connectivity failure. The above failure mode shows that Pb-free Sn-4Ag-0.5Cu with OSP pad finish gives a much stronger joint durability to drop impact test than the case with ENIG surface finish.

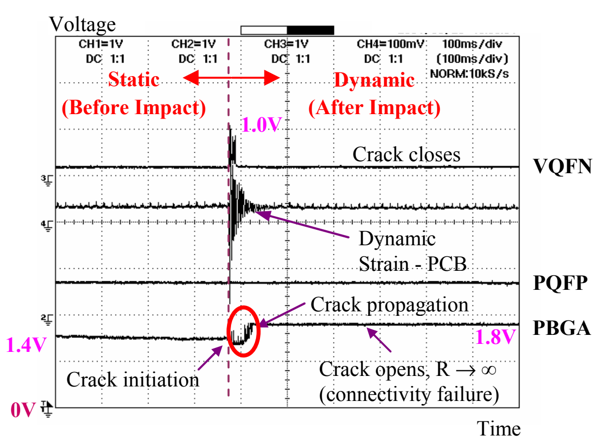


Fig 5. Dynamic Responses for Leg 2 (Pb-free on OSP) Test Board at 15th Drop.

As for the VQFN package, some intermittent failures were observed in the dynamic resistance curve. Crack in the VQFN interconnects has started to initiate and propagate through the joint interface at the 15th drop. However the crack was only partial, hence the resistance peaked to about 1.0 volt (instead of 1.8 volts which indicates total crack opening). When the PCB bends downwards, the outermost solder joints are subjected to tensile stress thus leading to an open mode in the crack. On the other hand when the board bends up, the joints are under compression which helps the crack to close up. Towards the end of a drop, the partial crack would most probably closes up when the flexing of the board is over. At this instance, manual probing after the drop test would not register any failure. As such, no failure was considered for the VQFN package after the 15th drop. When probed manually, the static resistance after drop is 7.1 Ω as compared to a static resistance of 5.1 Ω before drop. No change in the resistance response was observed for PQFP after the impact, indicating again that no interconnect failure has occurred.

Failure mode similar to Leg 2 was observed in Leg 3 where 36Pb-62Sn-2Ag solder balls were mounted onto an OSP pad finish. Failure analysis showed that the interconnection failure was due to copper traces breakage and not solder joint crack. Fig. 6 shows some intermittent failures (resistance peaks) were observed for the PBGA package in the dynamic resistance curve at the 39th drop. The copper trace crack was completely opened at the resistance peaks ($V \rightarrow E$ = 1.8volts). However the gap of the crack may be small and the crack surfaces came into contact again after the impact. Manual probing after 39th drop registered good connectivity. At the 40th drop, the PBGA package registered a constant dynamic resistance of V = 1.8volts. Manual probing after the drop confirmed permanent failure. Lastly, no change in the resistance response for VQFN and PQFP indicate that no interconnect failure was recorded after 40 drops.

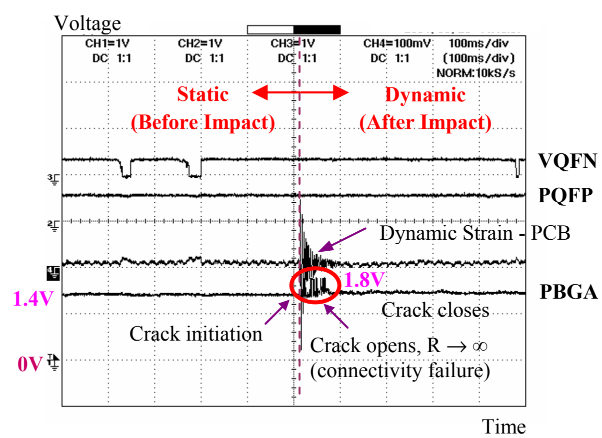


Fig 6. Dynamic Responses for Leg 3 (Leaded on OSP) Test Board at 39th Drop.

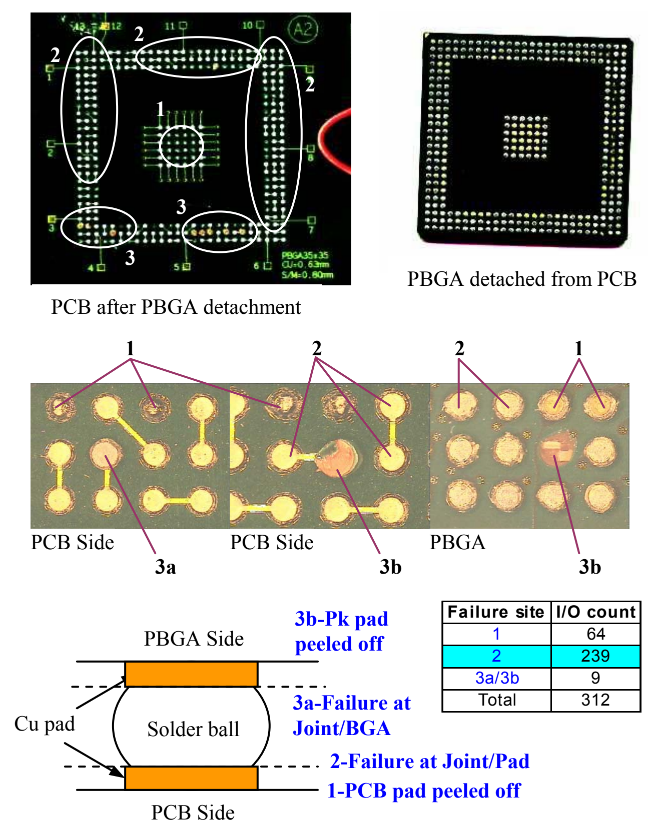
Test Results

With a drop of 50 times conducted for every test board, the summary of the impact test results is given in Table 1. The sample size is 6 for each of the test package in each leg.

Table 1. Drop Impact Test Results and Summary

Test Leg	Frequency of Failure	Number of Drops to Failure**
PBGA:		
Leg 1*	6/6	1/50[1,4], 1/50[4], 1/50[4], 2/50[4], 6/50[4], 24/50[5]
Leg 2*	5/6[6]	15/50[2], 15/50, 19/50, 28/50, 47/50
Leg 3*	3/6[6]	12/50, 24/50, 40/50[3]
PQFP:		
Leg 1	2/6[7]	44/50, 45/50
Leg 2	2/6[7]	16/50, 29/50
Leg 3	0/6	-
VQFN:		
Leg 1	0/6	-
Leg 2	0/6	-
Leg 3	0/6	-

* Leg 1=Pb-free on ENIG, Leg 2=Pb-free on OSP, Leg 3=Leaded on OSP.
** A total of 50 drops were conducted.
'1'=Illustrated by Fig. 4, '2'=Illustrated by Fig. 5, '3'=Illustrated by Fig. 6.
'4' – PBGA units detached away from PCB after drop impact.
'5' – Solder ball joint cracks found, component still intact on test board.
'6' – Failure due to copper trace breakage.
'7' – Failure not due to solder joint crack but component failure.



Failure site	I/O count
1	64
2	239
3a/3b	9
Total	312

Fig 7. Failure Sites for the PBGA Packages that Detached from the PCB after Drop Impact (Leg 1).

Failure sites for each of the test legs will be discussed before analysis of the results and failure trend obtained. In Leg 1 of the PBGA package with most failures occurred in less than 6 drops, five out of six failed units were detached away from the PCB. Possible failure sites of the PBGA solder joint were illustrated in Fig. 7. By examining the PCB where the PBGA detached from, solder ball to copper pad interface failure was found to be of majority. Clear solder joint cracks at the board side were found in the last remaining unit. Similar failure site was reported by Tee et al [10] in their test for a fine-pitch BGA package of size 6.39x6.37mm.

However for the PBGA package in Legs 2 & 3, PCB copper traces breakage and resin cracks were the contributing factor for connectivity failure (see Fig. 8). Lall et al [8] also reported PCB resin cracks in the drop test of a 8x8mm chip scale package. As for the PQFP packages where failures were also recorded, they were not due to solder joint crack but component failure instead. In Fig. 9, the lead fingers were found to broke off from the mold compound due to the large impact force during drop. All the lead fingers are still intact properly to the test board. Being the smallest in size and lightest in weight, the VQFN packages are the most resistant against impact forces among the three components.

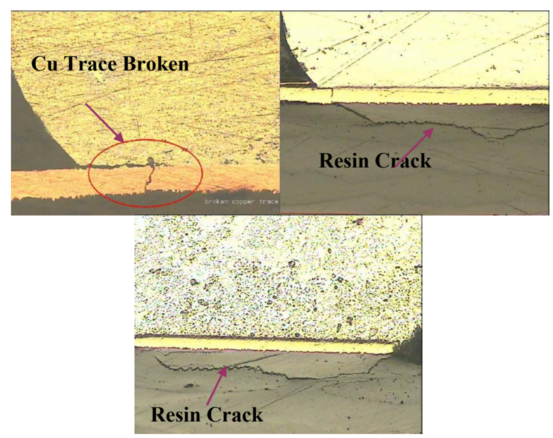


Fig 8. Failure Sites for the PBGA Packages in Legs 2 & 3.

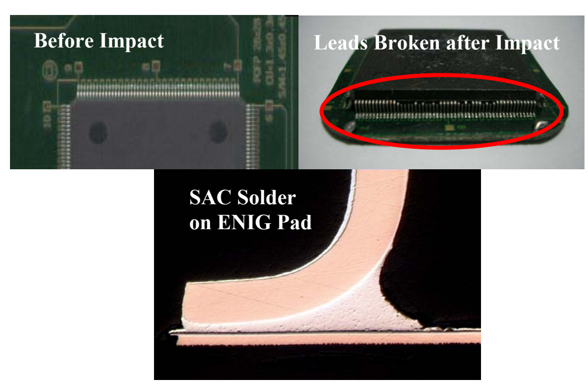


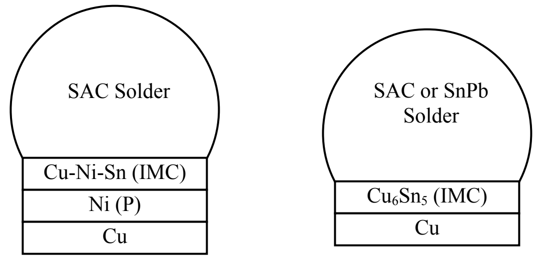
Fig 9. Failure Observations for the PQFP Packages with Good Solder Joints Intact.

From the above observations, it can been seen that the type of surface finishes (i.e. ENIG vs OSP) does have a significant effect on the solder joint reliability between a package and the board. Interconnection between solder joints and board with Pb-free/ENIG configuration proved to be the weakest where failure had occurred between the joint and copper pad. But as for the Pb-free/OSP and leaded/OSP configurations, solder joint strength proved to be stronger due to the different intermetallic compound layer formed (to be elaborated more in the next section). With the stronger intermetallic adhesion strength, the failure site is being migrated to the copper traces and resin layers. This phenomenon has highlighted the importance of the quality of PCB as well (copper traces, resin etc) in determining drop impact reliability.

Since no solder joint failure was found in the Pb-free/OSP and leaded/OSP legs up to 50 drops, solder joint reliability of Pb-free versus leaded solder balls on the OSP pad finish cannot be readily characterized. With the compliant gull-wing leads, the PQFP package outperforms the PBGA in drop impact reliability where the solder balls are more rigid. Being smallest in size and with the center pad holding the entire body firmly onto the PCB, the VQFN package proves to be most robust under drop test.

Failure Modes and Mechanism Investigation of the PBGA Solder Joints

Under high strain rate test situations, brittle fracture is promoted through the suppression of plastic deformation [14]. Thus drop test for soldered assemblies can cause brittle failure in the intermetallic compound (IMC) layer instead of ductile failure in the solder. In the current drop test study, only solder joints of the PBGA packages in Leg 1 (Pb-free on ENIG) was observed. And cracks were observed at the joint to copper pad interface. For Pb-free (and PbSn) solder joints mounted on OSP coated copper pads, no joint interface failure was found. Hence different IMC layers formed with different surface finish can contribute to different failure modes. When Sn-Ag-Cu (SAC) solder reflowed on the ENIG finish of copper pad, the gold plating (usually < 1um) dissolved rapidly into the solder and the nickel barrier layer forms a ternary intermetallic of Cu-Ni-Sn [13,15-16]. For SAC or leaded solder reflowed over an OSP copper pad, the OSP coating is evaporated and allows the interaction of the solder with copper to form a binary intermetallic of Cu_6Sn_5 [17-18]. The different layers of IMC formed in Leg 1 and Legs 2-3 are illustrated in Fig. 10. With ENIG process, phosphorous (P) present in the nickel plating bath generates a brittle Ni-P intermetallic compound segregating between the Cu-Ni-Sn intermetallic and the Ni(P) layer [19-20]. Mei et al [20] showed that this Ni-P intermetallic is detrimental and leads to brittle interfacial fracture of BGAs solder joints.

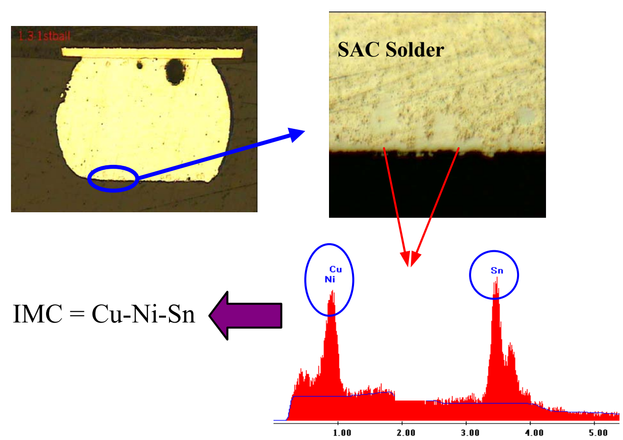


a) ENIG Pad Finish (Leg 1)

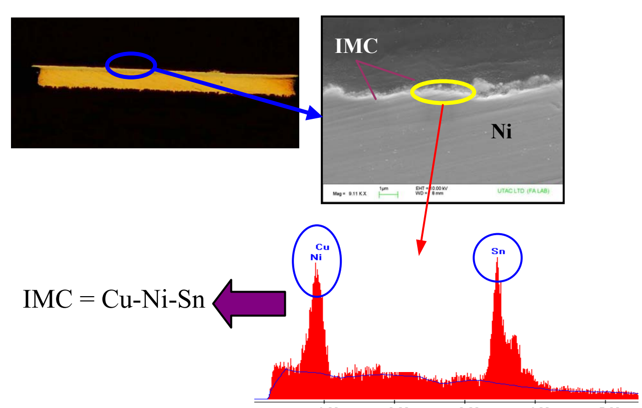
b) OSP Pad Finish (Legs 2 & 3)

Fig 10. Intermetallic Layers Formation for Legs 1-3.

Fig. 11 shows the cross-sectioning picture of a PBGA solder joint where the unit was detached away from the PCB after drop impact (Leg 1). EDX analysis at the failure interfaces found that IMC of Cu-Ni-Sn were present at both the BGA and copper pad interfaces. Fig. 12 shows another cross-sectioning picture of a Leg 1 PBGA solder joint where the unit remained intact on the PCB after drop impact. Referring to Fig. 12b, an IMC layer of Cu-Ni-Sn was present between the nickel plating and Pb-free solder ball. Solder joint crack was found to break through the interface of the solder to copper pad in Fig. 12a. A closer examination of the failure mode found that it actually cracked through the IMC layer. EDX showed evidence that IMC of Cu-Ni-Sn were found at both the solder and copper pad interfaces.

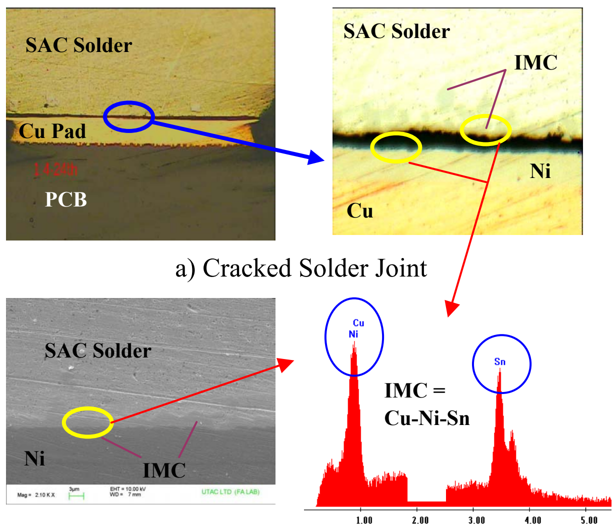


a) PBGA Solder Ball



b) PCB Copper Pad

Fig 11. Interfaces of a PBGA Detachment Joint (Leg 1).



b) Good Solder Joint

Fig 12. Cross-sectioning and EDX of a Failed Solder Joint – Pb-free on ENIG Surface (Leg 1).

The intermetallic compound layers for SAC and leaded solders mounted onto an OSP copper pad (Legs 2 & 3) are showed in Fig. 13. From the EDX image, a binary IMC of Cu_6Sn_5 formation is evident.

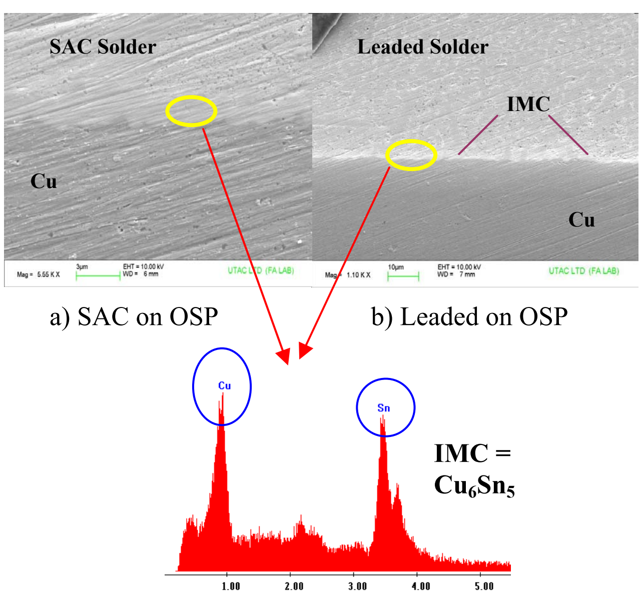


Fig 13. Cross-sectioning and EDX of Joints' Interface in Legs 2 & 3 after Drop Impact (OSP Surface).

Based on the hardness test performed by Lee et al [17], intermetallic of Cu-Ni-Sn (hardness=6.9 GPa) has a higher hardness than Cu_6Sn_5 (hardness=5.8 GPa), thus more prone to brittle fracture. Frear et al [21] further determined that IMC of composition Ni_3Sn_4 is very brittle by hardness and fracture toughness tests. Studies by Mei et al [20] and Bradley et al [22] also revealed stronger adhesion strength of Cu_6Sn_5 intermetallic than Ni-Sn (due to the formation of Ni-P intermetallic layer). The above provides two explanations of the solder joints failure occurred in Leg 1 (Pb-free on ENIG) but not in Legs 2 &3. Firstly, the joints have failed in the brittle Cu-Ni-Sn layer, whereas the Cu_6Sn_5 layer is more impact resistant. Secondly, interfacial cracks could initiate at the weak interface of Ni-P and Cu-Ni-Sn intermetallics and propagate through the Cu-Ni-Sn IMC layer. In Legs 2 & 3 where the solder ball is adhering to a larger surface of copper pad, the thin copper trace where it is experiencing much higher stress intensity due to drop impact failed instead. PCB resin cracks were found in all three test legs.

Five out of six PBGA units in Leg 1 were detached away from the PCB after the impact test. The detachment could be due to the large inertia force of the 35x35mm package size and weight. A smaller BGA package (<15x15mm) may not detached from the board, but cracks in the solder joints should be anticipated at the Cu-Ni-Sn intermetallic layers.

Drop testing with smaller BGA components (eg 15x15mm fine-pitch BGA) and the investigation of different solder compositions (such as SnAg) and other surface finishes (eg immersion silver or immersion tin) are considered for further investigation.

Conclusions

The drop impact reliability performance of the leaded and Pb-free solders IC packages has been assessed with two different surface finishes of ENIG and OSP. A new and simple dynamic resistance monitoring method demonstrated to be capable of capturing instantaneous drop impact failure and the explanation of interconnection failure process. The failure modes and mechanism of the solder ball joints have been analyzed. The following conclusions can be drawn:

i) *Permanent* joint failure is usually followed by 1-2 drops after *intermittent* failure.
ii) The type of surface finishes (i.e. ENIG vs OSP) has a significant effect on the solder joint reliability between a package and the board.
iii) Interconnection between solder ball joints and board of Sn-4Ag-0.5Cu/ENIG configuration (intermetallic of Cu-Ni-Sn) showed to be weaker than the Sn-4Ag-0.5Cu/OSP and 36Pb-62Sn-2Ag/OSP configurations (Cu_6Sn_5 intermetallic). The latter surface finish forms a much stronger joint integrity thus better survivability in drop impact test.
iv) Comparable drop reliability performance in terms of joint's strength for Sn-4Ag-0.5Cu/OSP and 36Pb-62Sn-2Ag/OSP configurations up to a drop of 50 times.
v) The quality of PCB constituent materials such as copper traces, vias and resin etc are equally important in determining drop impact reliability performance.
vi) No failure observed in the PQFP packages, implying that the gull-wing lead fingers are shock compliant and are able to absorb shock pulses resulted from drop impact.
vii) Being smallest in size and with the center pad holding the entire body firmly onto the PCB, the VQFN package proves to be most robust under drop test.

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