ANALYSIS OF DAM CRACKS AT THE CERAMIC INTERFACE

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ABSTRACT

Dam and Fill is a composite of Epoxy and Silica fillers[1] which is used to protect the wirebonding from shorting. Dam, which is more viscous, is initially dispensed before the fill in order to prevent the scattering of the fill material. Dam crack is often observed near the dam fillet which is a path of moisture ingress to the wirebond pad, thus introduce a potential reliability issue. It has been found out the large filler material occupies greater than 50% of the composite which weakens the mechanical strength of the dam fillet thus resulting to crack.

1. 0 INTRODUCTION

Electronic assembly size is continuously optimized and minimized. One major advantage of having small electronic assembly is the reduced power consumption. A challenge in the miniaturized electronic assembly is the wirebonding wherein the pitch size distance between wires is in the range of micrometer to few millimeters. Thus to protect the integrity of the wirebonds of the electronic package, dam and fill are incorporated. Recent developments in the assembly encountered burnt mark at the dam and fill area of the module after reliability tests. The burnt mark is attributed to shorting. Upon investigation, dam cracks were observed around the periphery of the dam and fill leading to moisture ingress. Shown in Fig. 1 is an illustration of the Ceramic, Dam and Fill and PCB assembly.

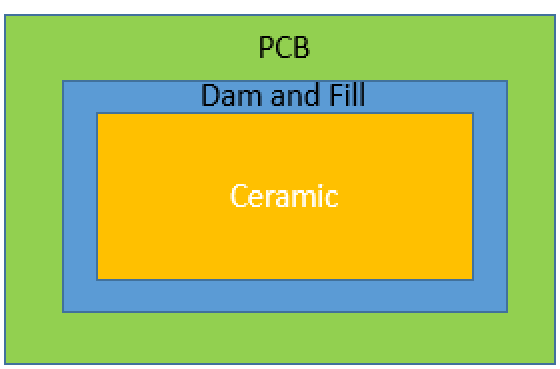

Fig. 1. Illustration of the assembly of the Ceramic, Dam and Fill and PCB.

No crack nor delamination are required for the Dam and Fill to mitigate moisture ingress. Common problem encountered in the process of dam and fill is the formation of cracks and delamination. Cracks manifests at the fillet of the dam. This paper attempts to analyze the crack and suggest probable cause of dam cracks.

The cross-section profile of the dam and fill approximates a half circle with fillet at the ceramic interface as shown in Fig. 2.

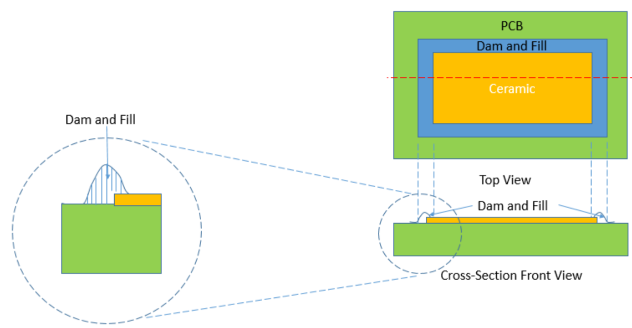

Fig. 2. Illustration of the Dam and Fill profile using the cross-section front view.

The liquid adhesive is dispensed at a specified direction with specific volume to ensure homogeneity in the process. After dispensing, the module is subjected to elevated temperature to initiate the curing process. In theory, the unreacted epoxy monomers and cross-linking agents form small branched molecules then gelation follows wherein giant macromolecules appears. After a period of time the rubbery gel transforms to glassy solid[2] as shown in Fig 3.

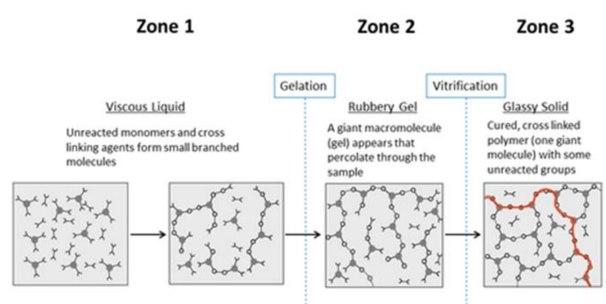

Fig. 3. Viscous liquid adhesive evolves to gelation stage and next to vitrification stage upon application of elevated temperature[2].

Dam cracking is observed to happen after the composite reaches the solid state.

2. 0 REVIEW OF RELATED WORK

Not Applicable

3.0 METHODOLOGY

Different curing time are applied to the assembled parts. Assembled parts are subjected to SEM inspection. The focus of the SEM inspection is the dam-ceramic interface and the dam PCB interface. After SEM inspection, the dam material is scraped from the assembly. The collected dam sample is tested in DSC. Other assembled module is subjected to micro-sectioning.

The table top Scanning Electron Microscope (SEM) is used to obtain magnified images up to several thousands. For this particular analysis, magnification of less than 1000x is applicable.

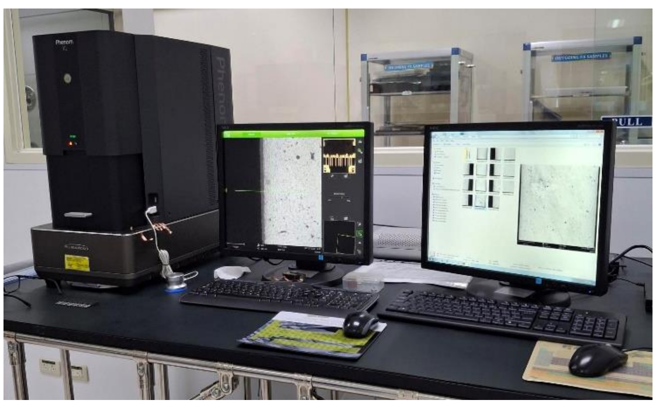

Fig. 4. Scanning Electron Microscopy can provide the magnified dam-ceramic, dam-PCB interfaces and the dam and fill micro-section.

Scraped adhesive dam samples are used in the differential scanning calorimeter (DSC) to determine its curing percentage.

Fig. 5. Differential Scanning Calorimetry is used to determine the curing percentage of the adhesive.

4.0 RESULTS AND DISCUSSION

Representative SEM images of the dam-ceramic interface and dam-PCB interfaces are shown in Figures 6 and 7. The light rendered spots in the dam are the fillers.

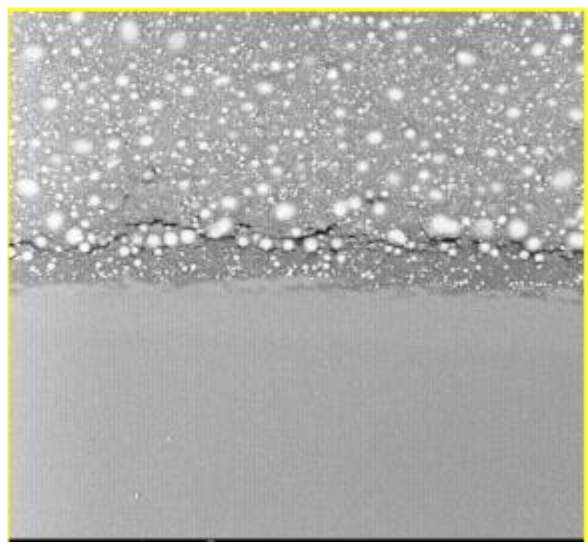

Fig. 6. SEM image show dam crack. Dam at the upper part of the image while the lower part is the ceramic area[3].

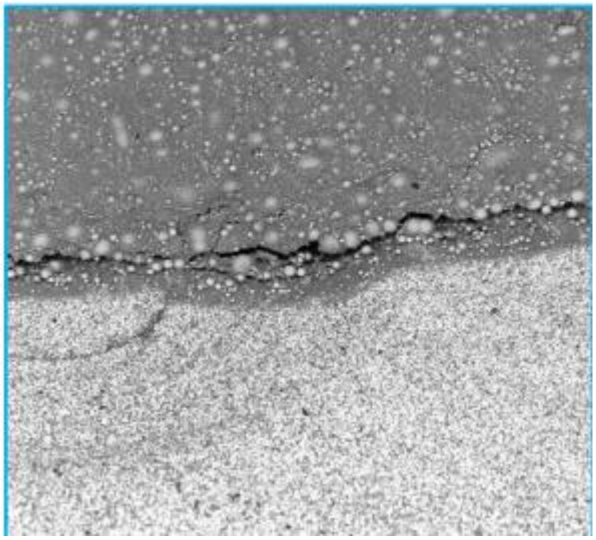

Fig. 7. SEM image show dam crack. Dam at upper part of the image while the lower part is the PCB area[3].

Representative micro-section of the Dam and Fill-Ceramic assembly show crack at the fillet area as shown in Fig. 8. Fillet occupancy of the composite is greater than 50%.

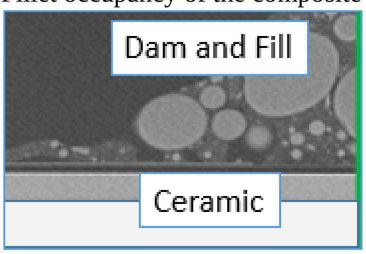

Fig. 8. SEM image of the Dam and Fill-Ceramic assembly micro-section.

Dam cracks were observed on all the evaluated curing time.

Curing % based on different curing times show % Cure greater than 90% which is commonly accepted. Based on Table 1, dam cracks are still present under different curing time. It can be deduced that the curing time is not a factor in mitigating dam crack.

Table 1. Curing Time versus % Cure and Dam

Curing Time, t (hr)	Weight (mg)	% Cure	Dam Crack
t	7.8	97.56	Present
t + 0.5 hr	8.5	91.00	Present
t + 1.0 hr	7.5	94.15	Present
t + 1.5 hr	9.5	97.14	Present
t + 2.5 hr	6.9	98.48	Present

Remarks: Curing Temperature is greater than 100°C.

Referring to Fig. 8, the crack is observed at the fillet of the dam indicating the weakness at that point. Figure 9 shows shear forces F and f. Shear force F is attributed to the bulk material while the shear force f is attributed to the fillet material

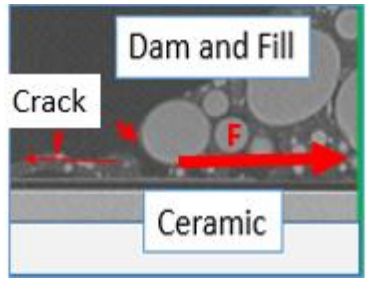

Fig. 9. Illustration of the interacting shear forces that resulted to the dam crack[4].

As the composite solidifies, shrinking happens and the shear forces builds up. After reaching the solid state, the bulk material exerts larger shear force F than the fillet force f that resulted to the dam crack. The fillet's weak point is attributed to less epoxy material volume thus less mechanical strength. Moreover, the uneven distribution of the filler material in the adhesive causes mechanical weakness at the fillet area.

5.0 CONCLUSION

Fillet formation of the dam at the ceramic or the PCB area is the weak point due to the less volume of epoxy material. The dam-ceramic and the dam-PCB crack is not correlated to curing time.

6.0 RECOMMENDATIONS

Since fillet formation is the cause of crack, the recommended course of action are the following:

1. Reducing the fillet formation,
2. Reduce the shear force difference between the bulk and the fillet;
3. Reduce the filler sizes.

Gelation is first recommended to be done after dam dispense. Gelation increase the viscosity of the adhesive liquid thus reducing the fillet formation.

Second recommendation is to dispense the smallest dam volume. The small dam volume can reduce the opposing shear forces thus reducing the possibility of crack.

Third recommendation is to reduce the filler sizes to homogenize the distribution of filler thus strengthening the mechanical strength weakness at the fillet area.

In terms of timeliness and economy, the gelation process and dam fill volume reduction are highly suggested.

7.0 ACKNOWLEDGMENT

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8.0 REFERENCES

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10.0 APPENDIX

Not Applicable