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HVQFN Onemap Process Robustification through Mold Compound Size Optimization

Ernani Padilla[1], Lester Belalo[2]
[1, 2]Back-End Manufacturing & Technology, STMicroelectronics, Inc., Calamba City, Laguna, Philippines 4027

Abstract— *In a bold effort to have major breakthrough in cost saving single map leadframe or onemap for HVQFN (Heat sink Very Thin Quad Flat No Leads) was conceptualize and was implemented using HVQFN40-01 as the pilot packages. This includes major change in the mold process both tooling and materials. Several learnings was realized at mold on issues such as incomplete fill/voids, crumpled leadframe and package crack as it was intermittently encountered specially during project fan-out on other packages. Key item considered is the response of the compound weight to different packages.*

This technical paper will be tackling all areas to consider in finalizing the desired mold compound weight for one map leadframe design based from mold compound supplier capability and the effects of silicon die sizes, leadframe design and mold tooling tolerances against the mold compound size or weight. By the end of this report we will be able to identify the required mold compound weight for one map leadframe across all HVQFN packages.

Keywords— *QFN ONEMAP.*

I. INTRODUCTION

Onemap increases strip unit density by converting current five panel or map leadframe design to a one panel leadframe design or one map. At mold, new set of mold tool was purchased for onemap

Also mold compound was changed from its current pellet size of 16mm diameter by 11grams for five maps to 16mm diameter by 12grams to compensate for the additional compound volumetric requirement.

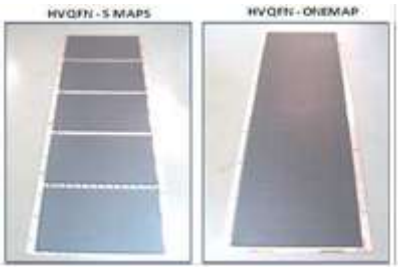

Fig. 1. Actual molded strip comparison of 5map and onemap for HVQFN

Table 1. Matrix comparison for mold compound description, panel volume and strip unit density between 5maps and onemap

LF TYPE		5 panel	1 panel
Mold Compound Description		16mm x 11.0 g	16mm x 12.0 g
Panel Volume		9027.2	9853.35
Strip Density	HVQFN40-01	270	342
	HVQFN48-01	175	256
	HVQFN52-01	270	342
	HVQFN88-02	75	115

1.1 HVQFN (Onemap) Mold Yield Performance

As per mold yield performance of the pilot package HVQFN40-01, no significant impact on yield performance during the conversion. However for the rest of the package converted there is a significant deterioration on yield specially on HVQFN52-01and HVQFN88-02 during fanout

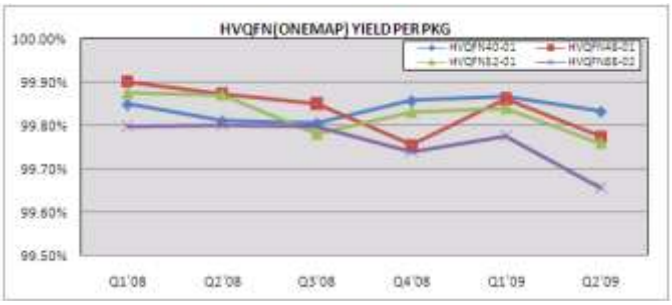

Fig. 2. HVQFN onemap packages yield trend

1.1.1 HVQFN52-01 top defect trend

The graph below highlighted in red shows that package voids, incomplete fill, crumpled leadframe and package crack has been reoccurring since the conversion of HVQFN52-01 to onemap leadframe design.

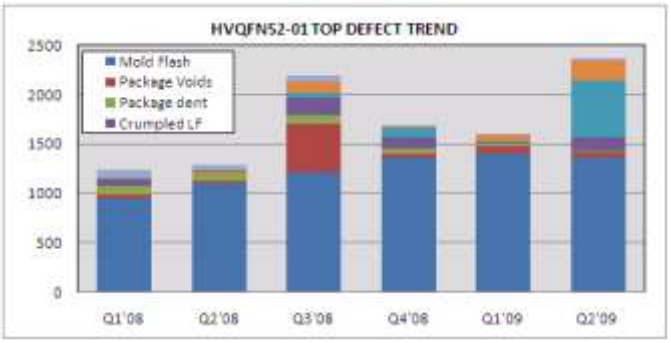

Fig. 3. HVQFN52-01 Mold top defect trend

1.2 Defect Phenomenon

Based from process mapping 90% of the crumpled leadframe and package crack occur during degating process at mold wherein cull remnants are prematurely detached and is left at degate die. This condition will cause molded leadframe for degate coming in contact with the remnants on the degate die resulting to crumpled leadframe or package crack.

For incomplete fill and package voids, it was observed that intermittent thin to zero culls were encounter for onemap as compared to flat or positive culls for 5 maps. This condition is indicative of a potential risk to product as compound volume

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requirement increases as volume occupied by die area is reduced specially for onemap leadframe design.

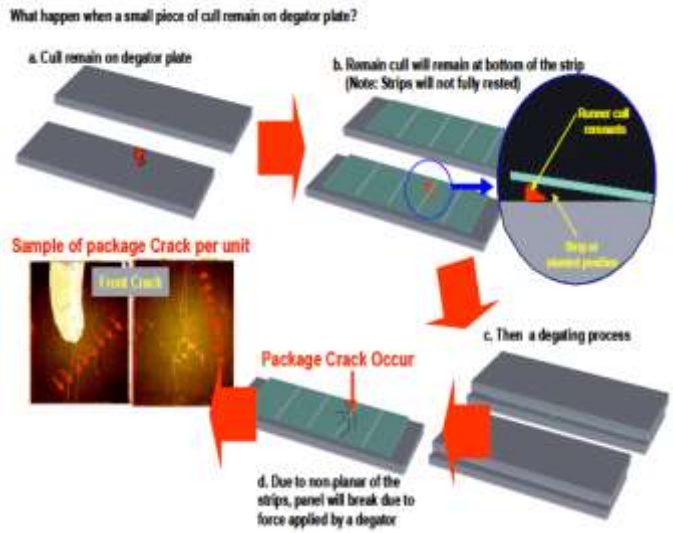

Fig. 4. Illustration of crumpled leadframe and package crack defect phenomenon

In the illustration below for positive or normal cull, full packing pressure is applied to the cull by the plunger to compress the mold compound in the panel resulting to good mold quality response. However for negative to zero cull, packing pressure is reduced to compress the mold compound in the panel as plunger has minimal compound to compress in the cull and pressure is distributed to the top cull block and the compound.

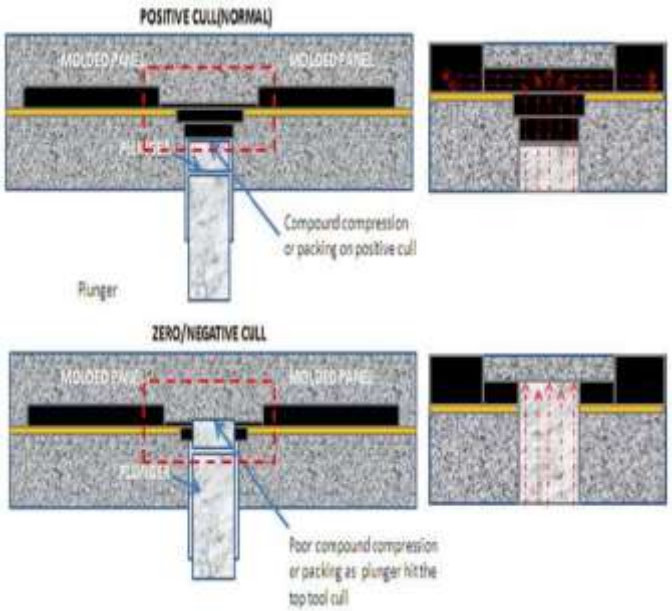

Fig. 5. Illustration of positive against zero/negative cull plunger compression of mold compound

1.2.1 Cull condition

Mold cull is the part of the molded strip where the excess compound is compressed. Below is the cull comparison between 5maps leadframe and onemap leadframe. Observe that thin culls to zero culls is encountered for onemap packages as compared to flat culls for 5 maps

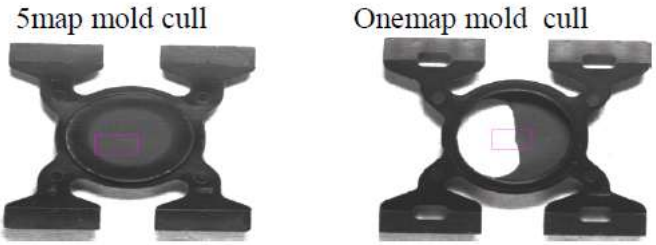

Fig. 6. Cull comparison 5 map against onemap

Due to this condition of cull for onemap, cull is weak and is susceptible to breakage during transfer leading to crumpled and package crack as previously discussed.

Fig. 7. Actual cull sample for onemap that was broken at degate area

1.2.2 Pellet weight

The mold compound volume is distributed between the panel and cull volume where the excess compound is compressed during molding. When panel volume for mold compound increases and the compound used is the same volume the cull volume will decrease resulting to negative to zero culls.

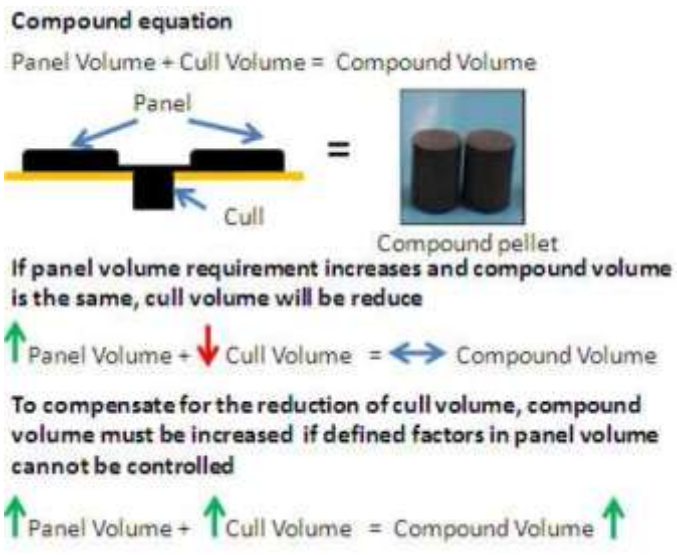

Fig. 8. Compound equation for volume

Several factors contribute to the increase of panel volume like die size, leadframe design and tool variation. If the compound volume capability also is at its low side it aggravates this effect. The experiments below will itemize all this factors considered and check which factors is controllable

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or not. Another option is to increase mold compound volume by weight.

II. Experimental Section

2.1 Project definition tree diagram

Based from our project definition tree the top ppm contributor is HVQFN using onemap leadframe. HVQFN52-01 and HVQFN88-02 are the top package for onemap with incomplete, crumpled and package among the top defect contributor. Note moldflash is excluded as it is a chronic defect for HVQFN both onemap and 5maps

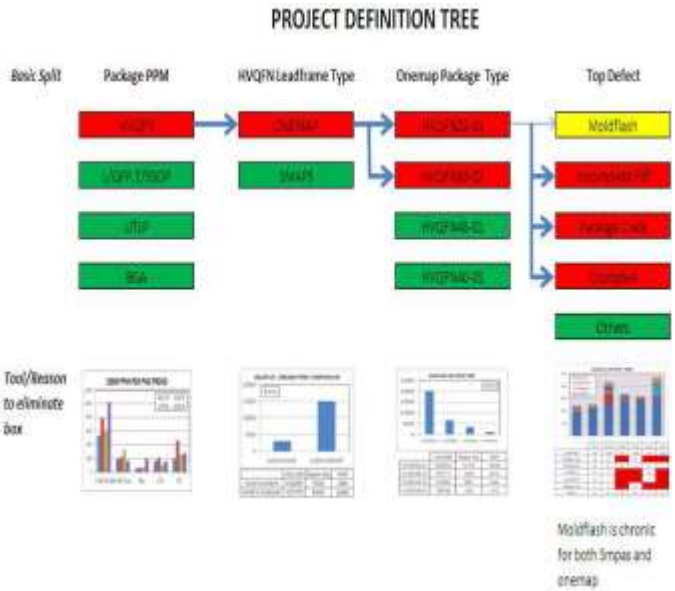


Fig. 9. Project definition tree diagram

2.2 Mold compound weight capability

Based from the incoming quality data, compound used for onemap has an average weight of 11.9757g that is below the nominal compound weight of 12.0g

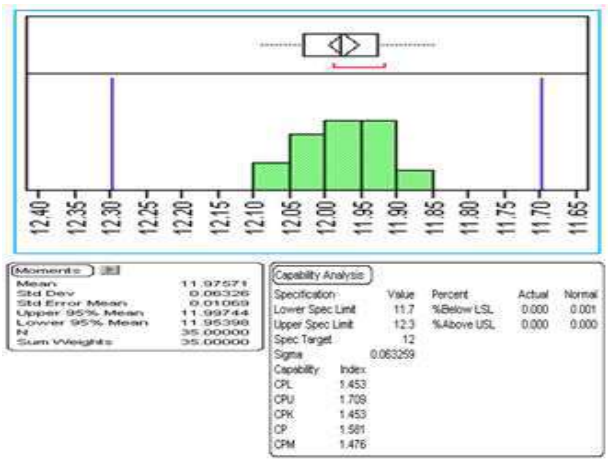
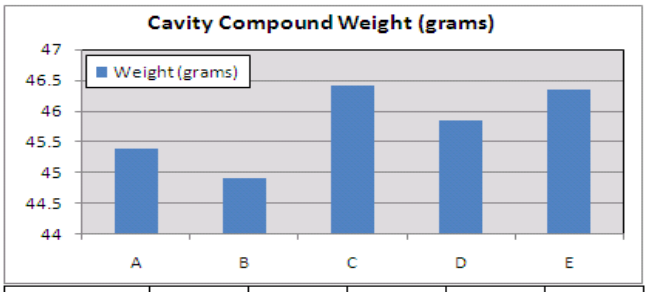


Fig. 10. Onemap mold pellet weight incoming quality data

2.2 Mold Machine Tooling Variations

Conducted compound weight comparison of mold tools used for onemap revealed wide variations between tools. Tools C, D and E having more mold compound weight requirement as compared to tool A and B.



Mold Tool	A	B	C	D	E
Weight (grams)	45.38	44.9	46.4	45.83	46.34

Fig. 11. Mold tool cavity weight comparison for onemap

2.3 Die Size Variations

Conducted volumetric weight equivalent of the die variations of the packages using onemap leadframe. As computed from the die volume density, die total weight is higher for HVQFN40-01 and HVQFN48-01 as compared to HVQFN52-01 and HV88-02. This means that per weight, HVQFN52-01 and HVQFN88-02 has higher compound volume requirement due to lower die volume density.

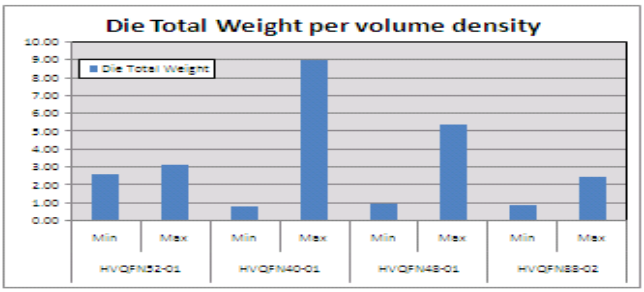


Fig. 12. Die total weight comparison per package

2.4 Leadframe design variation

Performed volumetric comparison of the different leadframe used per package which shows that HVQFN52-01 has the most mold compound volumetric requirement amongst all onemap packages due to its less metal volume design per leadframe followed by HVQFN88-02.

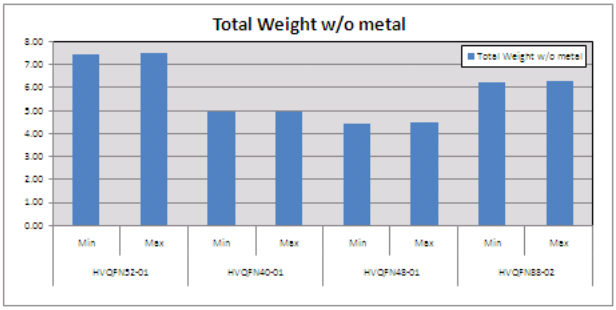


Fig. 13. Mold volume/weight requirement per package leadframe design

2.5 Summary of Variations

The compounded effect of having average compound weight capability below the nominal and mold tool to mold tool variations makes HVQFN52-01 and HVQFN88-02 more

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susceptible to quality issue as this packages have higher compound volume requirement due to leadframe design and lower die volume density.

It was coordinated with mold compound supplier for the request to increase pellet weight to make it robust to process variations. The supplier inputs was considered to arrive a weight for evaluation.

III. Results and Discussion

3.1 Mold Supplier Pellet Laboratory Test

Request to build different pellet size was requested to compound supplier to increase significantly the cull thickness but evaluation was limited up to 12.5g only due to outgoing mold compound properties will be affected. Base from mold supplier data, pellet strength was reduced by increasing the pellet weight but there is no significant difference between the evaluated sizes 12.3g and 12.5g with both passing the minimum pellet strength of 14kg. This is critical to risk assess impact of weight change that may lead to potential broken pellet.

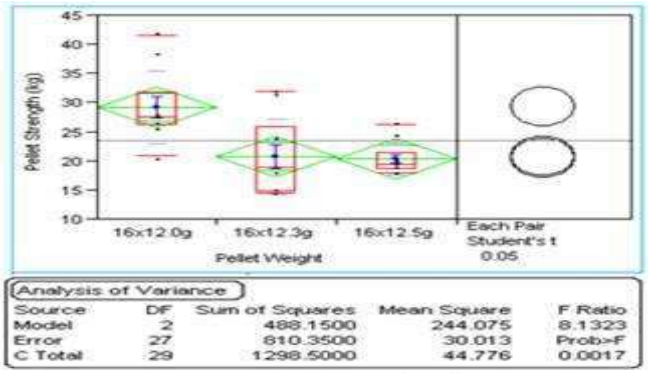

Fig. 14. Pellet strength comparison for different weights

Weight and density was also provided with passing Cpk values for both 12.3g and 12.5g as shown in table.

Table 2. Table for pellet characteristic data per weight

	Pellet Strength(kg)				Weight(g)			Density(g/cm3)		
	Spec	Average	Max	Min	Spec	Average	Cpk	Spec	Average	Cpk
16 x 12.0g	14Kg	29.2	42.0	20.5	12.0 +/-0.5	12.02	4.86	min 1.75	1.89	9.71
16 x 12.3g	14Kg	20.5	32.0	18.0	12.3 +/-0.5	12.32	3.96	min 1.75	1.89	9.22
16 x 12.5g	14Kg	20.9	26.5	14.5	12.5 +/-0.5	12.50	4.71	min 1.75	1.89	13.61

3.2 Mold Cull Thickness Comparison

Big increase in the cull thickness from 0.098-0.118mm to 2.522-2.588mm was realized with a change of compound weight by 0.5grams.

Table 3. Cull thickness comparison per pellet weight

Machine	Pellet size	Cull thickness(mm)		Visual	X-ray	SCAT
		w/o die	w/ die			
A	12.0g	0.098	0.951	P	P	P
	12.3g	0.558	1.831	P	P	P
	12.5g	1.054	2.588	P	P	P
B	12.0g	0.118	0.987	P	P	P
	12.3g	0.623	1.924	P	P	P
	12.5g	1.108	2.522	P	P	P

3.3 Quality Responses

Based from the qualification result, no delamination and wire related problems was induced for both 12.3g and 12.5g. Note that this passed internal review in ST Calamba and quality data requirements was assessed to be not critical as this is only a change in size and all other properties of the mold compound was retained.

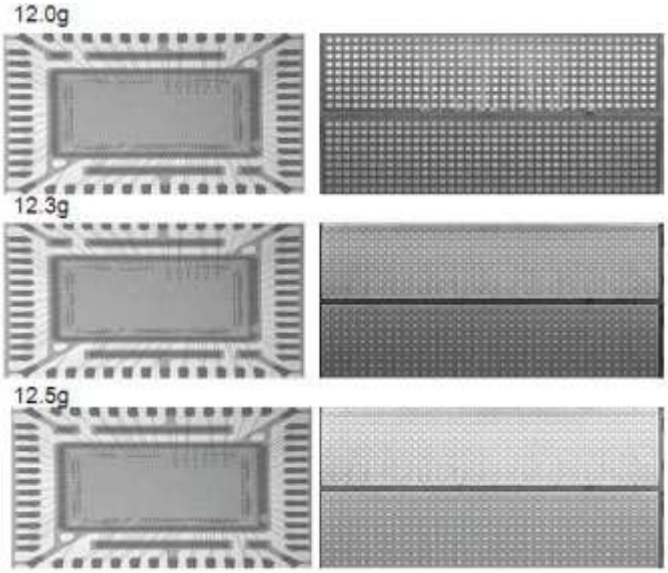

Fig. 15. X-ray and delamination sample for different pellet weight

3.4 Implementation and Impact

Currently mold compound using 12.0g is being depleted while incoming orders delivered are already using 12.5g with no broken pellet issues. Target date of full implementation will be March 2010.

Intangible benefit is that it lessen the risk of customer complaint due to package crack which is a critical defect and improve mold yield once implemented.

IV. Conclusion

We conclude therefore that given the supplier input capability as consideration to increase pellet weight without compromising compound quality, the change of mold compound weight from 12.0g to 12.5g will produce cull thickness that is sufficient to prevent quality problems due to process variations thereby making the onemap leadframe robust and realize its cost savings.

V. Recommendations

It is recommended to monitor the pellet incoming quality for broken pellet during the implementation of the conversion of pellet weight.

To assess the volumetric compound requirement for incoming HVQFN packages that will be using onemap leadframe design.

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REFERENCES

- HVQFN40-01 , HVQFN52-01, HVQFN48-01 &
- HVQFN88-02 Leadframe drawings
- Mold tool drawing for onemap
- Report No. 0911036: Hitachi Pellet comparison data for CEL-9220HF13
- DAI-ICHI GP-PRO Operation & Maintenance

Equipment Manual

ABOUT THE AUTHORS

Ernani D. Padilla is a licensed Electronics and Comm. Engineer from the Univ. of the East. Presently assigned as a Senior Staff Engr supervising the process engineering group for mold operation

Lester Belalo a Mechanical Engineering graduate from Technological University of the Philippines. Presently assigned as Senior engineer for mold advance packages