Chapter 5

Conclusion and Suggestions for further work.

5.1 Conclusion

Analysis on the 'FM rejects' shows that all of the FM rejects do not contain metallic elements that could provide conductivity to a certain material. In fact, the analysis shows that the 'FM rejects' are made up of mainly Carbon and Oxygen, which are organic elements that are non-conductive and non-corrosive in nature.

Depth analysis on the 'FM rejects' proved that the FM does not penetrate the leads or the surface of the dies, thus do not cause adverse effects on the physical integrity of the device.

Electrical analysis on the 'FM rejects' on two different types of packages, one of ceramic and another of plastic, shows that the presence of FM does not significantly alter the electrical properties of a device.

Functional testing on the 'FM rejects' shows that some FM rejects are actually operable devices. Those units that failed were scrutinized and the root cause of the failures were found to be unrelated to the presence of FM on these devices.

Functional testing on 'FM rejects' that were subjected to rigorous temperature cycling also shows that they were still operable. This shows that these 'FM rejects' were as reliable as 'good' units.

From all of the above statements, we can conclude that the FM rejects based on the current acceptance criteria are actually as functional and reliable as any other units that are considered acceptable under the same criteria. Therefore the current acceptance criteria for devices visually inspected at the die attach process should be revised and relaxed.

5.2 FM Reject Criteria Relaxation

As mentioned in Section 1.5.2 of Chapter 1, the current reject criteria for FM is:

TABLE II CODE 06: FM

PARA A: REJECT FOR ANY EMBEDED FM OR ANY ALUMINIUM FLAKE OR ANY GOLD FLAKE ON THE DIE SURFACE WHICH IS GREATER THAN TWO MILS IN ANY DIRECTION THAT CAN NOT BE REMOVED BY 20 PSI BLOW-OFF. REJECT FOR ATTACHED FM ON THE DIE SURFACE WHICH IS GREATER THAN 6 MILS IN ANY DIRECTION THAT CAN NOT BE REMOVED BY 20 PSI BLOW-OFF. PARA B: REJECT FOR ANY ALUMINIUM OR GOLD FLAKE WITHIN 15 MILS FROM THE TIP OF THE LEAD/POST THAT IS GREATER THAN TWO MILS IN ANY DIRECTION. REJECT FOR ATTACHED FM ON THE POST WHICH IS GREATER THAN 6 MILS IN ANY DIRECTION THAT CANNOT BE REMOVED BY 20 PSI BLOW-OFF OR TOUCHES THE BOND.

This criteria result in 10,600 units being thrown away per 1 million units produced.

The revised and relaxed criteria should be clear on what type of material is considered as defects, and offer an option for preventive or corrective action. In revising the reject criteria for FM, we took into consideration the following items:

1) For functional integrity of the device, the FM should not be of conductive material. Since this specification is used by Motorola Semiconductor Product Sector assembly sites worldwide, the definition of 'conductive material' should be left for the respective areas to define. Definition of 'conductive material' could be done through characterization study as were conducted in this study.

2) Even though this study proved that FM does not affect the performance of the device regardless of the size, it is good to have clear guidelines in regards to size limits.

The presence of relatively huge FM should be an indication of a lax in the environmental control in the manufacturing area and should be considered as a defect. Based on a study conducted prior to this one, the FM size distribution is as shown in the Figure 5.2a.

Assuming the 6-Sigma rule where any readings within the 3*Sigma (standard deviation) range from the mean is considered acceptable, we came to a maximum FM size limit as:

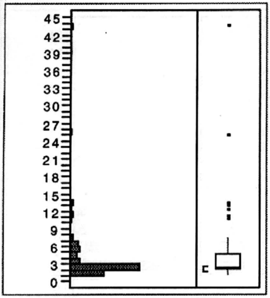
$$\begin{aligned} \text{Max} &= \text{Mean} + 3^* \text{ Standard Deviation} \\ &= 4.31682 \text{ mils} + 3^*(5.55\text{mils}) \\ &\approx 20 \text{ mils.} \end{aligned}$$

According to data from Figure 5.2a, this limit makes about 95% of the current rejects acceptable.

3) With regards to loose FM, we would offer an option for corrective or preventive action. The most common action for removing loose FM is to blow the affected units. According to an established criteria, the maximum pressure at which a wire bonded unit could be blown is at 20 psi. If blowing the unit at this pressure does not remove the loose FM, then the unit should be considered as a defect. This is to avoid any reliability concerns in the future when the FM could move about in the package cavity.

4) In Chapter 3 it was proven that FM do affect the electrical properties of the lead frame to an extent, therefore, a guideline on how close to the bonding area could an FM be located should also be included in the specification.

Column 1



Quantiles

maximum	100.0%	43.825
	99.5%	43.825
	97.5%	22.285
	90.0%	7.299
quartile	75.0%	4.624
median	50.0%	2.425
quartile	25.0%	2.088
	10.0%	1.550
	2.5%	1.206
	0.5%	1.150
minimum	0.0%	1.150

Moments

Mean	4.31682
Std Dev	5.55164
Std Err Mean	0.58847
upper 95% Mean	5.48629
lower 95% Mean	3.14735
N	89.00000
Sum Wgts	89.00000

Figure 5.2a : FM size distribution [14]

Therefore, the revised FM defects criteria was rewritten as follows:

TABLE II CODE 06: FM

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      PARA A: REJECT FOR ANY EMBEDED FM OR ANY ALUMINIUM FLAKE OR ANY
GOLD FLAKE ON THE DIE SURFACE WHICH IS GREATER THAN TWO (2) MILS IN ANY
DIRECTION THAT CAN NOT BE REMOVED BY 20 PSI BLOW-OFF. REJECT FOR
ATTACHED OR LOOSE FM ON THE DIE SURFACE WHICH IS GREATER THAN TWENTY
(20) MILS IN ANY DIRECTION THAT CAN NOT BE REMOVED BY 20 PSI BLOW-OFF.

      PARA B: REJECT FOR ANY CONDUCTIVE MATERIAL WITHIN 15 MILS FROM
THE TIP OF THE LEAD/POST THAT IS GREATER THAN TWO (2) MILS IN ANY
DIRECTION THAT CANNOT BE REMOVED BY 20 PSI BLOW-OFF. REJECT FOR
ATTACHED OR LOOSE FM ON THE POST WHICH IS GREATER THAN TWENTY (20) MILS
IN ANY DIRECTION THAT CANNOT BE REMOVED BY 20 PSI BLOW-OFF.
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5.3 Suggestions for Further Work

This study did not cover the possibility of attached FM detaching itself during the device's operating life. The presence of loose FM in the package cavity could be detected through Particle Impact Noise Detector (PIND) tests. Preferably, the PIND test should be done after the units have been subjected through temperature cycling, to simulate the state of the devices after a relatively long operating life.

More detailed study could be done on whether the presence of FM on the lead frame could produce detrimental heat sinks or hot spots within the device.

Further study could also be done on sourcing for a better inspection method. Since different materials absorb and emit energy differently, it would be possible to invent a visual detector that could differentiate conductive and non-conductive material in addition to measuring the FM size. This visual detector could then be integrated into the die attach or wire bond machines' material handlers and could inspect the units before and/or after the process and remove rejects automatically. This method would further reduce possibilities of loose FM accumulation because units would not have to be staged for manual visual inspection by operators.