TAIWAN SEMICONDUCTOR

AN-1009

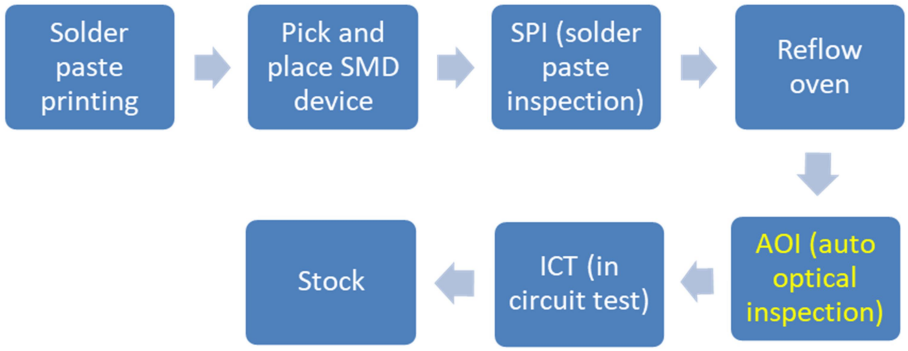
Wettable flank packages of PDFN56U, SMPC4.6U enable AOI choice - application note

Content

1. AOI solder joint inspection used in SMT

1.1 AOI apply in SMT background

SMT (Surface mount technology) of assembly device on PCB had become popular now. Among SMT process procedure (Figure 1), AOI (Auto Optical Inspection) is important that make sure device pin solder joint soldering well that guarantee soldering reliability .



(Figure 1 – SMT process procedure)

Before 2005 year, most factories rely on human visual inspection to check device solder joint status. However human visual inspection exists subjectivism, there is no objective criteria caused by different human examination occur different result. On the contrary AOI (Auto Optical Inspection) adopt digital photographic process to compare the difference and judge the result, the judgement tolerance could be control to smaller level. AOI could contribute repetitive and faster SMT solder joint examination than human visual inspection, so most factories adopt AOI to examine device solder joint status in the present day.

1.2 AOI basic theory

AOI adopt tower illumination system to illuminate device via 360 degree phase (Figure 2), the high resolution speedy CCD camera acquire the pictures then transferring to computer. The computer specific software analyze and compare the data according compiled programs, the computer judge if the device solder joint comply with predictable standard. Photography acquisition that use CCD camera to acquire device reflected light signal and transfer electrical signal to graphic system, then the graphic system send electrical signal to computer to do analysis. Simply speaking AOI examine device process likely to simulate human visual inspection examine device process, it turns human visual inspection to be automatic, intelligent and programmable.

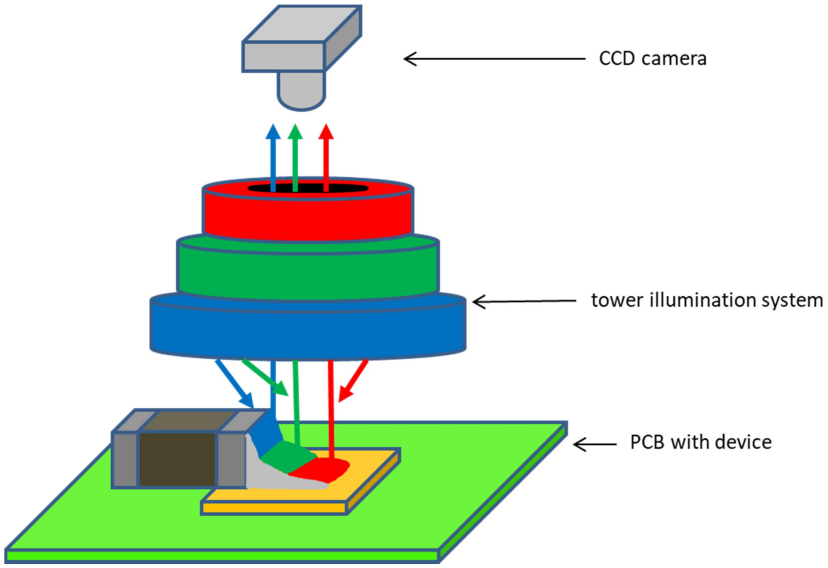
The AOI process procedure

1. Optical photography:

   Tower illumination system emits three color light source of Red, Green and Blue with 360 degree phase to device. The three color lights would be reflected by the device surface, and it could provide device solder joint different reflective color signal light via light reflectivity. Red light will be reflected to CCD camera mostly while device surface is smooth flat; Blue light will be reflect to CCD camera mostly while there is an inclined plane.

2. Graphic picture comparison:

   CCD camera grab light signals, then graphic system transfer the light signals to digital signals to computer. Computer statistically calculate signal tolerance and compare to standard model signals for pass or fail judgement.



(Figure 2 – AOI tower illumination system)

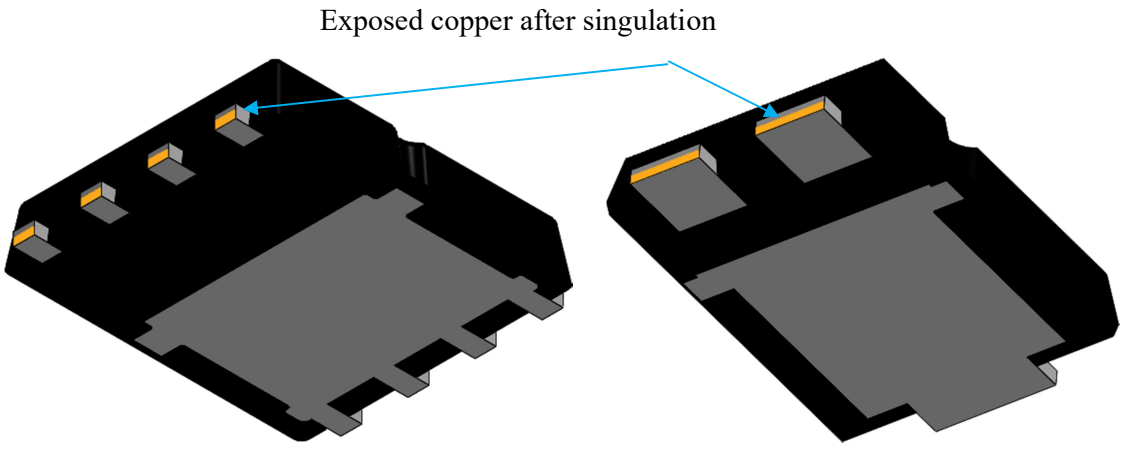
1.3 AOI pass and fail judgement

Automatic optical inspection (AOI) of solder joint is a standard post reflow soldering inspection method to check assemblies failures. It is common to systems that an optical gray or color image of a solder joint, recorded with a CCD camera system under different conditions of illumination and be viewed from different directions is subjected to an image analysis procedure which quantifies image features as color, gray images, and gradients. These feature images can then be compared against certain threshold values to arrive at a pass and fail classification for a device solder joint. The false calls represents inspection result is fail even though it is pass actually, AOI should has low number of false calls in mass production. Low false calls are benefit to save return or scrap costs, so how to make device pin solder joint soldering well and good identify Tin soldering profile is the key for AOI.

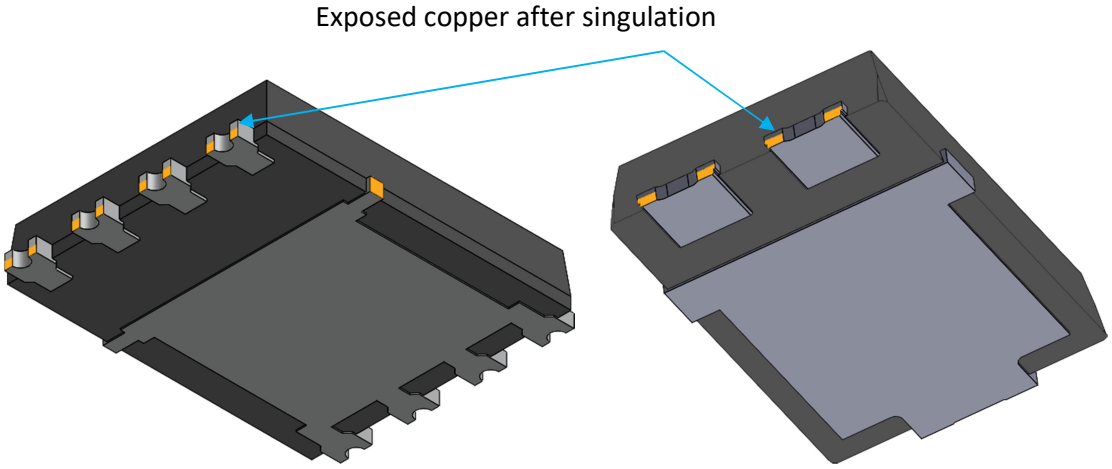
2. Wettable flank package

2.1 PDFN56U, SMPC4.6U wettable flanks package structure

Normally PDFN56 and SMPC4.6 package pins of leadframe generated by the singulation process from the strip during package assembly. The singulation process will make pin surface exposed copper and there lacks plating in the exposed surface. The exposed copper will easily suffer oxidation which hardly solder wettable, solder fillet doesn't develop generally (Figure 3). How to lower down the pin surface exposed copper area after singulation process to avoid pin oxidation as possible is the key to get well solder joint for AOI yield improvement. This kind of improving package leadframe called – wettable frank packages of PDFN56U and SMPC4.6U. The PDFN56U and SMPC4.6U package particular designed leadframe to gain more plating area after singulation process, it provides good adhesion between Tin solder and leadframe pin after reflow process (Figure 4). The solder tin amount combine with leadframe pin more, the AOI judgement pass yield rate become more and also can guarantee package device solder reliability well.



(Figure 3 – PDFN56, SMPC4.6 package)



(Figure 4 – PDFN56U, SMPC4.6U package)

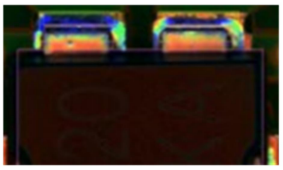
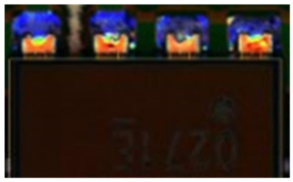
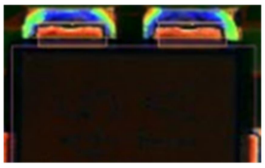
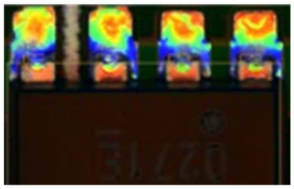
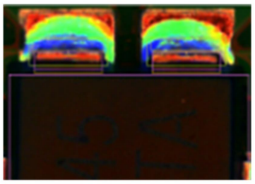
2.2 Experiment of wettable flank – comparison group

In order to compare normal PDFN56, SMC4.6 and wettable PDFN56U, SMPC4.6U solder performance, we set up test samples groups by different footprint length as below. The standard footprint length is 1.27mm, we add in another group of wettable PDFN56U, SMPC4.6U pin length extend 0.5mm to make pin length 1.77mm and 1.92mm to see if it still help for AOI inspection while Tin solder quantity keeps the same:

Group	Package	pin length	Package	pin length
1	PDFN56	1.27mm	SMPC4.6	1.42mm
2	PDFN56U	1.27mm	SMPC4.6U	1.42mm
3	PDFN56U	1.77mm	SMPC4.6U	1.92mm

2.3 Experiment of wettable flank – AOI result

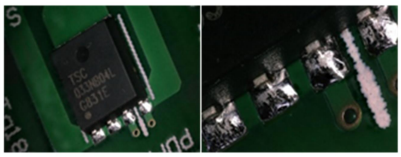
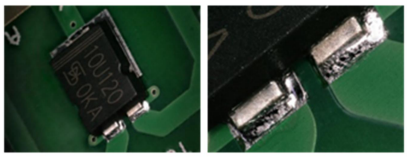
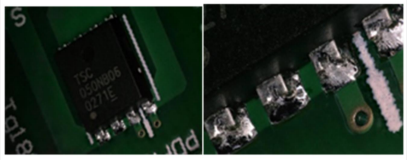
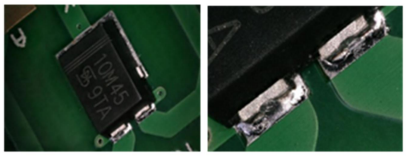
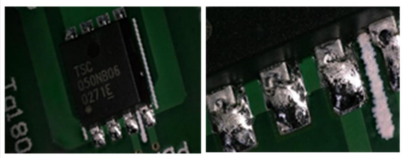
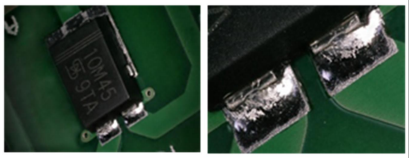
Take the experiment groups of samples to do AOI solder joint inspection after reflow process, adapt color light reflectivity signal to display tin solder slope level (Figure 5). Compare normal PDFN56, SMPC4.6 to wettable frank PDFN56U, SMPC4.6U, the result of wettable frank PDFN56U, SMPC4.6U light reflectivity gradient is more significant than normal PDFN56, SMPC4.6. It represents wettable frank PDFN56U, SMPC4.6U solder joint is more uniformity than normal PDFN56, SMPC4.6. If compare extend footprint pin length PDFN56U, SMPC4.6U to normal footprint pin length PDFN56, SMPC4.6, the result of extend footprint pin length PDFN56U, SMPC4.6U light reflectivity gradient is more significant than normal footprint pin length PDFN56, SMPC4.6. It represents extend footprint pin length PDFN56U, SMPC4.6U solder joint is more uniformity than normal footprint pin length PDFN56, SMPC4.6 also.

Package	Footprint pin length	AOI result	Package	Footprint pin length	AOI result
PDFN56	1.27mm		SMPC4.6	1.42mm	
PDFN56U	1.27mm		SMPC4.6U	1.42mm	
PDFN56U	1.77mm		SMPC4.6U	1.92mm	

(Figure 5 – normal and wettable frank with different footprint pin length AOI result)

2.4 Experiment of wettable flank – pin outline examination

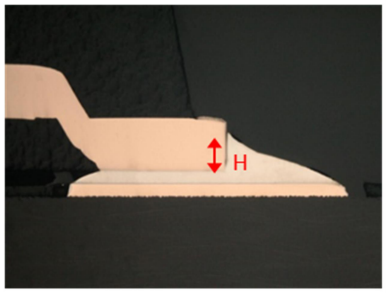
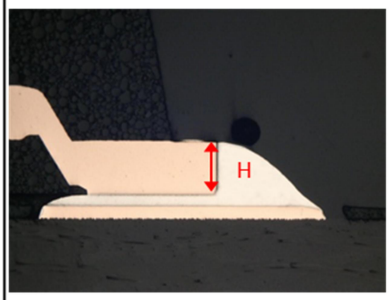
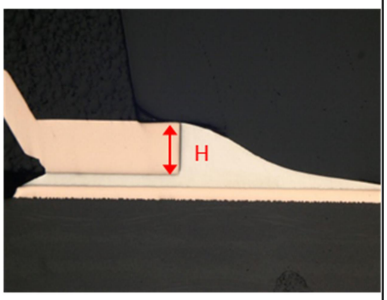
Optical microscope examined samples pin solder joint status (Figure 6). Wettable frank PDFN56U, SMPC4.6U tin soap profile is significant than normal PDFN56, SMPC4.6, and extend footprint pin length PDFN56U, SMPC4.6U tin soap profile is significant than normal footprint pin length PDFN56, SMPC4.6 also.

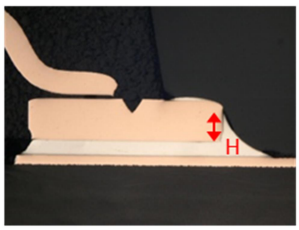
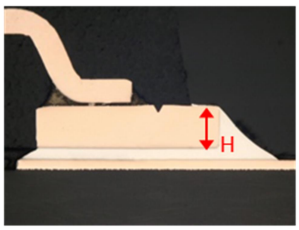
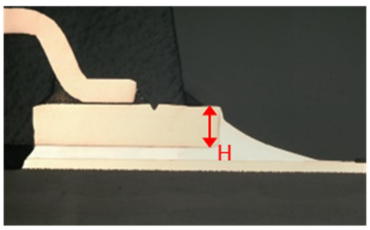
package	footprint pin length	pin outline examination	package	footprint pin length	pin outline examination
PDFN56	1.27mm		SMPC4.6	1.42mm	
PDFN56U	1.27mm		SMPC4.6U	1.42mm	
PDFN56U	1.77mm		SMPC4.6U	1.92mm	

(Figure 6 – normal and wettable frank with different footprint pin length outline examine result)

2.5 **Experiment of wettable flank – soldering paste examination**

In order to check the solder combination profile of solder tin and lead pin, we apply cross section to examine them (Figure 7). Monitor and compare the solder wetting height “H” which represents higher “H” means better solder effect. Wettable frank PDFN56U, SMPC4.6U wetting height “H” is higher than normal PDFN56, SMPC4.6, these wettable frank packages wetting height “H” even cover whole lead height. If compare extend footprint pin length PDFN56U, SMPC4.6U to normal footprint pin length PDFN56, SMPC4.6, the wettable frank package wetting height “H” is higher than normal package, these wettable frank packages wetting height “H” even cover whole lead height also.

Package	PDFN56	PDFN56U	PDFN56U
footprint pin length	1.27mm	1.27mm	1.77mm
pin solder cross section			

Package	SMPC4.6U	SMPC4.6U	SMPC4.6U
footprint pin length	1.42mm	1.42mm	1.92mm
pin solder cross section			

(Figure 7 – cross section pin soldering profile)

Summary

Automatic Optical Inspection (AOI) is used for many applications during the assembly process to ensure quality. Packages with wettable flank leads are designed to improve solder joint reliability and AOI's accuracy. The PDFN56U and SMPC4.6U wettable frank package particular designed leadframe to gain more plating area after singulation process, it provides good adhesion between Tin solder and leadframe pin after reflow process. The solder tin amount combine with leadframe pin more, the AOI judgement pass yield rate become more and also can guarantee package device solder reliability well.

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Notice

This application note information is for reference only based on this experiment and limited quantity of samples, please follow datasheet specification or inquire contact windows before you using in application.

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