

# Effect of Inner Chamfer Angle Capillary Profile for Wire Bonding Process to Circuit Under Pad for Integrated Circuit (IC) Package

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## Abstract

In this work, an inner chamfer angle of capillary was studied for wire bonding process to circuit under pad of Integrated circuit (IC) package. Wire bonding process is so important for electrical connection of IC packaging. The capillary is an important equipment that used for connection a die with a package and profile of capillary also effect to reliability of a package. In experiment, 9x9 mm<sup>2</sup> of TQFN packages were studied for Au wire bonding. The inner chamfer angle of capillary were varied for 60, 90 and 120 degree to find appropriate angle for IC packaging reliability. For analysis, the packages were analyzed by wire pull, ball shear and intermetallic coverage (IMC) for circuit under pad packages. Moreover, the packages also observed with scanning electron microscope (SEM). The results revealed that the inner chamfer angle of capillary not effect to reliability of circuit under pad for 9x9 mm<sup>2</sup> TQFN packages.

**Keywords** : Integrated circuit (IC) packaging: Wire bonding process: Capillary: Inner chamfer angle (ICA): Circuit under pad (CUP)

## Introduction

An integrated circuit (IC) is a set of electronic circuits on one small substrate of semiconductor device, normally silicon. This can be made much smaller than a discrete circuit made from independent electronic components. At present, a semiconductor industry has come up a lot to support many application of IC product such as automobile, computer, and communication. IC can be made very compact with transistor and other electronic components up to several units.

Wire bonding is the process of making interconnections between die or other semiconductor

device and its packaging during IC packaging manufacturing.

The capillary is an important equipment that used for connection a die with a pad of a package. Especially, inner chamfer angle (ICA) capillary as an important profile of a capillary that can determine characteristic and quality of bonded ball for wire bonding.

For circuit under pad (CUP), this pad is complex and very sensitive with capillary because of characteristic of pad consist of aluminum and copper layers connect with quartz. Therefore, wire bonding process with different profile of capillary affect to reliability of IC package with circuit under pad.

Therefore, this research interested in studying effect of inner chamfer angle profile for wire bonding to circuit under pad of IC package. The inner chamfer angle of capillary were varied for 60, 90 and 120 degree to find appropriate angle for IC packaging reliability. The next section describes about materials and methods. Section 3 presents results and discussion. Finally, we conclude this paper.

### Materials and Methods

In sections, methodology was proposed for studying about effect of inner chamfer angle (ICA) to circuit under pad and find appropriate angle of capillary at wire bonding process. The profile capillary equipment for wire bonding process and inner chamfer capillary profile are shown Figure 1. The capillary is an important equipment that used for connection a die with a pad of a package. Structure of circuit under pad is shown in Figure 2.

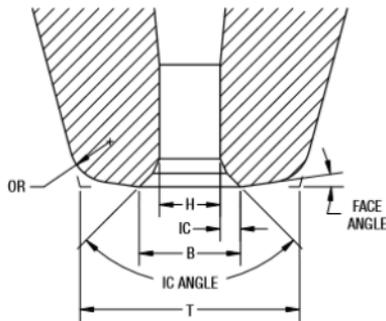


Figure 1 Inner chamfer angle (ICA) capillary profile [6]

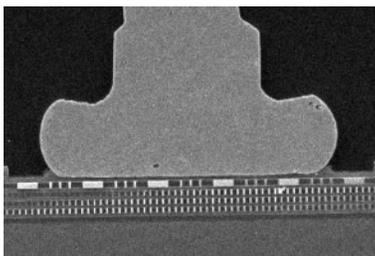


Figure 2 Structure of circuit under pad

This experiment compared suitable parameter for wire bonding process. The inner chamfer angle of capillary were varied with 60, 90 and 120 degree for sharps angle, right angle and obtuse angle, respectively. The other parameters were fixed with 240 gram power force, 32 DAC ultrasonic power and 1.0 mil Au wire. The experiment was shown in Table 1 and Figure 3 shown about diagram of operation.

Table 1 Experiment to compare suitable ICA for wire bonding process.

Sample test	ICA	Wire (1.0 mil)	Parameter	Analysis
A	60	Au	fixed	All
B	90	Au	fixed	All
C	120	Au	fixed	All

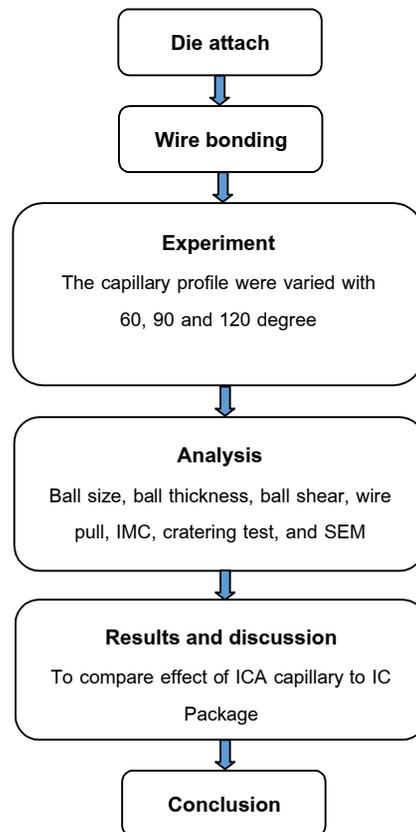


Figure 3 Diagram of operation

For analysis, the sample were analyzed to observed ball size and ball thickness. The sample also tested for ball shear, wire pull, intermetallic coverage (IMC), cratering test and scanning electron microscope (SEM) to find appropriate parameter of ICA to IC package.

## Results and Discussion

### Ball shear test

The results of ball shear test are shown in Figure 4. The results show that average values of ball shear test with 40.83, 43.43 and 44.11 grams average for 60, 90 and 120 degree, respectively. The ball shear test results are acceptable for IC packaging manufacturing process.

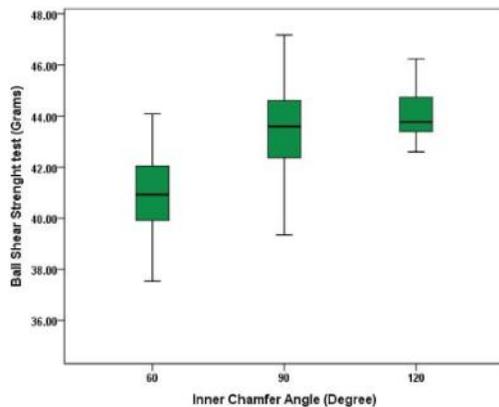


Figure 4 The results of ball shear test

### Wire pull test

The wire pull test are shown in Figure 5. The results show that average values of wire pull test with 7.77, 8.19 and 8.07 grams average for 60, 90 and 120 degree, respectively. The wire pull test results are acceptable for IC packaging manufacturing process.

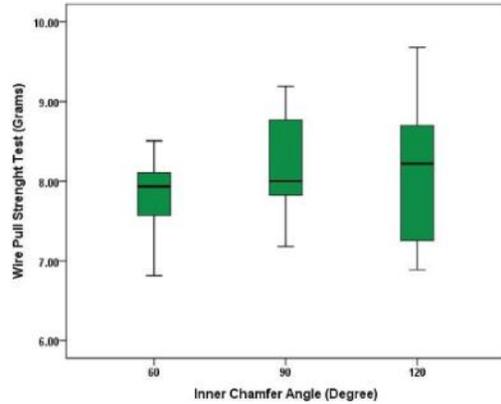
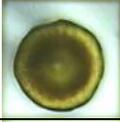
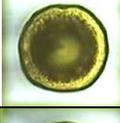
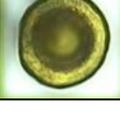


Figure 5 The results of wire pull test

### Ball size and Ball thickness

The result of ball diameter and ball thickness quantities are shown in Table 2. The results reveal that all ICA profile can used for wire bonding due to good quantity of ball diameter and ball thickness.

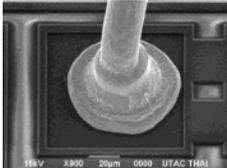
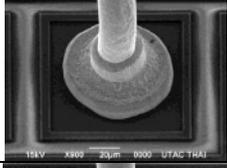
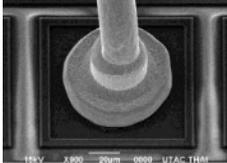
Table 2 The results of ball diameter and ball thickness.

Sample	ICA	Force power (gram)	Ultrasonic power (DAC)	Figure
A	60	240	32	
B	90	240	32	
C	120	240	32	

**Scanning electron microscope (SEM)**

The bonded ball were captured with scanning electron microscope are shown in Table 3. The results of bonded ball reveal that all ICA profile can used for wire bonding due to good quantity of bonded ball.

**Table 3** The results of bonded ball from scanning electron microscope.

Sample test	ICA	Figure
A	60	
B	90	
C	120	

**Cratering test**

The bonded ball were captured with cratering test are shown in Table 4. The results of bonded ball reveal that all ICA profile can used for wire bonding due to good quantity of bonded ball.

**Table 4** Cratering test results.

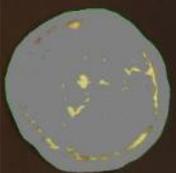
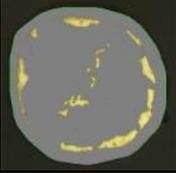
Sample test	ICA	Figure
A	60	

B	90	
C	120	

**Intermetallic coverage (IMC)**

The intermetallic coverage are shown in Table 5. The results of intermetallic coverage reveal that all ICA profile can used for wire bonding due to intermetallic are more than 85% which are in interval of acceptable standard value for analysis of IC packaging manufacturing process.

**Table 5** Intermetallic coverage results.

Sample test	ICA	Figure	Percent of IMC (%)
A	60		93.38
B	90		88.73
C	120		89.09

## Conclusion

In this work, inner chamfer angle (ICA) profile can be indicated about affecting wire bonding process. 9x9 mm<sup>2</sup> of TQFN packages were studied for Au wire bonding. The inner chamfer angle of capillary were varied for 60, 90 and 120 degree can be used for appropriate angle for wire bonding process. The results revealed that the inner chamfer angle of capillary not effect to reliability of circuit under pad for 9x9 mm<sup>2</sup> TQFN packages.

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