Development of all new structure of Dicing Die Attach Film (DDAF) for Stealth Dicing and Cool Expansion processes

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Abstract

Mobile devices, including smart phones and tablets, are increasing in complexity and require ever greater amounts of memory storage. In the past the challenge of higher memory densities and increase functionality has been met through miniaturization of device features, but as we reach the physical limits of feature size, packaging is being relied on more and more to achieve the necessary higher densities in memory and additional device functionality. Thin dies reduce overall package height, however, to achieve high memory densities in low profile packages the die attach material must have an even, thin bond line thickness. DAF (Die Attach Film) is an excellent solution. LINTEC developed an all new DDAF (Dicing Die Attach Film) with thinner DAF for CE (Cool Expansion) process. Conventional tape has a large area of exposed DAF surface which creates the risk of wafer and / or equipment contamination if DAF flies off during the CE process. We developed an all-new tape structure which is compatible with the SD (Stealth Dicing) and CE processes. The structure consists of DAF, IB (Intermediate Basefilm), and dicing tape. The diameter of the DAF and IB is close to the wafer diameter size to significantly reduce the risk of DAF separation and ejection during CE. We considered IB to improve DAF separation and it was found that a thinner IB layer is a good approach to separate DAF effectively. We can adjust adhesion between the DAF and the IB by changing the material properties of the IB, as an effective means to control die-fly and pick-up.

Key words

Dicing Die Attach Film, Stealth Dicing, Cool Expansion, Intermediate Basefilm

I. Introduction

Mobile devices, including smart phones and tablets, are increasing in complexity and require ever greater amounts of memory storage. In the past the challenge of higher memory densities and increase functionality has been met through miniaturization of device features, but as we reach the physical limits of feature size, packaging is being relied on more and more to achieve the necessary higher densities in memory and additional device functionality. One possible packaging solution is thinner DAF (Die Attach Film) on thinner wafers to increase the number of dies in package without increasing overall package height [1]. Wafers were traditionally singulated using a diamond dicing blade, however such singulation techniques on thin wafers can cause chipping, which leads to increased risk of device failure. SD (Stealth Dicing) is a singulation approach that can singulate thin wafers without significant risk of die chipping thereby increasing die breakage strength. SD does not use a mechanical dicing blade. Instead, a laser is focused inside the silicon wafer where it forms a modified layer. With SD a thin die is produced with superior durability and strength [2], [3], [4].

SDBG (Stealth Dicing Before Grinding) + CE (Cool Expansion) process is shown in Fig. 1.

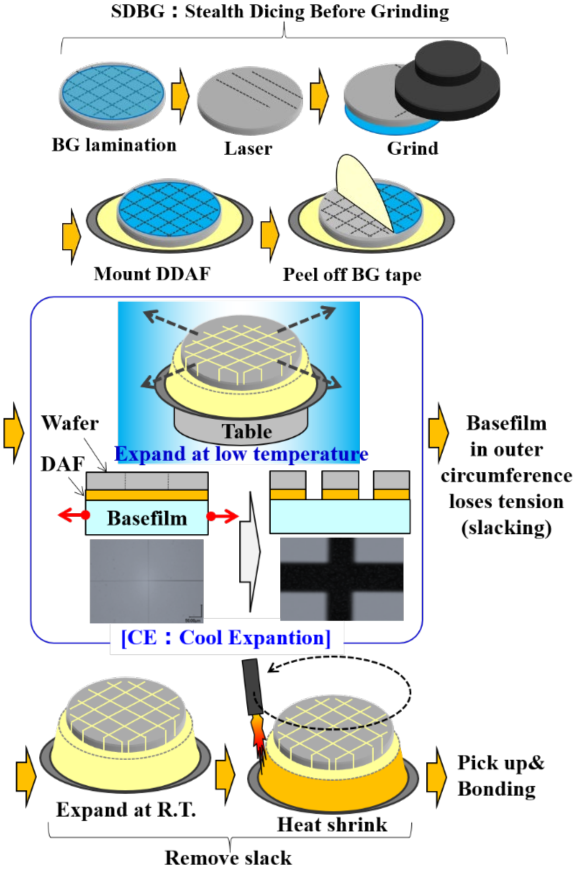


Fig. 1 SDBG + CE process flow

Thin die is diced using SDBG and the thin DAF layer is singulated by CE [5], [6].

1) Back Grind (BG) tape lamination, 2) Stealth dicing, 3) BG, 4) DDAF mounting, 5) Peel off BG tape, 6) Expansion at low temperature to singulate DAF (Basefilm in outer circumference loses tension), 7) Heat Shrink after expansion is at R.T. (Basefilm of outer circumference is fixed) 8) Pick and place.

LINTEC has been providing LE tape® as a DDAF (Dicing Die Attach Film) for decades but it was originally developed for use with dicing blades not SD/CE. We developed an all new LE tape structure for CE processes. The difference in the diameter of DAF between current DAF and development DAF is shown in Fig. 2. Conventional LE tape has a large area of exposed DAF surface which creates the risk of wafer and/or equipment contamination if DAF flies off during the CE process. The structure for CE consists of DAF, Intermediate Basefilm (Hereafter called IB), and dicing tape. The diameter of the DAF and IB is close to the wafer diameter size to significantly reduce the risk of DAF separation and ejection during CE.

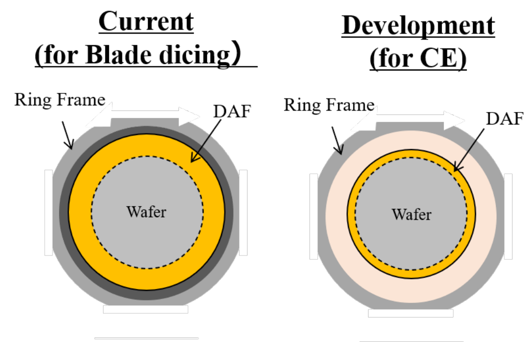


Fig. 2 Image diagram after laminating LE tapes.

II. Experiment for Initial Evaluation

We checked SDBG + CE process compatibility on a 3mm^2 die on a 12-inch Si wafer, using current and development LE tapes in our initial evaluation.

Si wafer

300 mm (12 inch) diameter sized mirror wafer was used.

BG tape lamination

BG tape Adwill E-3100UN (LINTEC Co.) was used for this evaluation. A commercially available BG tape laminator (LINTEC Co.; Model RAD-3510 F/12) was utilized for BG tape lamination.

Stealth Dicing

Wafer was diced to a die size of 3mm^2 using SD. A commercially available stealth dicer (DISCO Co.; Model DFL7361) was utilized for testing.

BG (Back side Grinding)

We obtained a final thickness of 40µm on the SDBG wafer. A commercially available grinder (DISCO Co.; Model DFG8760) was utilized for backside grinding.

LE tape mount / Peel off BG tape

2 types of LE tapes [Current / Development (The same thin DAF layer is used)] were mounted to a SDBG wafer at 60°C. BG tape was then peeled off from the circuit side of the wafers. A commercially available tape mounter (LINTEC Co.; Model RAD-2510 F/12) was utilized for dicing tape lamination and BG tape removal.

Cool Expansion

A commercially available tape expander (DISCO Co.; Model DDS2300) was utilized for this test. Cool expansion conditions are listed below.

-Expansion temperature: -15°C
-Ascending height of table: 12 mm
-Ascending speed of table: 100 mm/s

Table 1. Appearance after CE (Heat-Shrink).

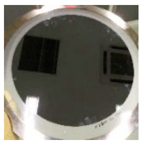
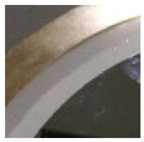
	Appearance: Overall view	Appearance: Zoom	Heat-Shrink Ability
Current LE Tape Blade dicing			Poor
Development LE Tape CE			Good

Table 1 shows appearance after CE. Generally, basefilm in outer circumference has reduced tension after expansion at low/room temperatures and this issue was resolved during heat-shrink. However, the basefilm of current LE tape never regained tension after heat-shrink. Development CE's lack of tension issue was resolved during the heat-shrink process.

Table 2. Kerf-Width and DAF Separation after CE.

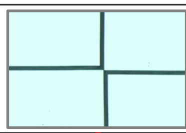
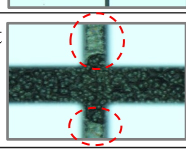
	Microscope Image	Kerf-width (μm)	DAF Separation
Current LE Tape Blade dicing		2	Poor
Development LE Tape CE		20	Not enough Red Circled Area

Table 2 shows kerf-width and DAF separation after CE. Current tape basefilm lost tension (slack), so kerf-width was only 2 μm and DAF separation was poor. Conversely, a 20 μm kerf-width was obtained with development CE tape because there was better tension after heat-shrink.

However, in the development tape it was found that the DAF failed to completely separate (Red Circled Area). It is necessary to widen the kerf-width to more than 20 μm to separate the DAF completely.

III. Simulation analysis

In order to know how to obtain a wider kerf-width, we conducted simulation analysis using Finite Element Analysis by ABAQUAS.

CE Development Tapes consists of layers of DAF, IB, adhesive and basefilm. As a result of various studies, we reached a conclusion that the properties of the IB layer affect kerf-width expandability. We tried changing the thickness of the IB layer to increase the kerf-width.

Fig. 3 shows the simulation analysis results (a) before and (b) after thinning IB. It was found that a thinner IB layer is one good approach to a wider kerf-width. It is assumed that IB became easier to stretch with a small amount of force because the tensile stress was reduced in thinner IB layer.

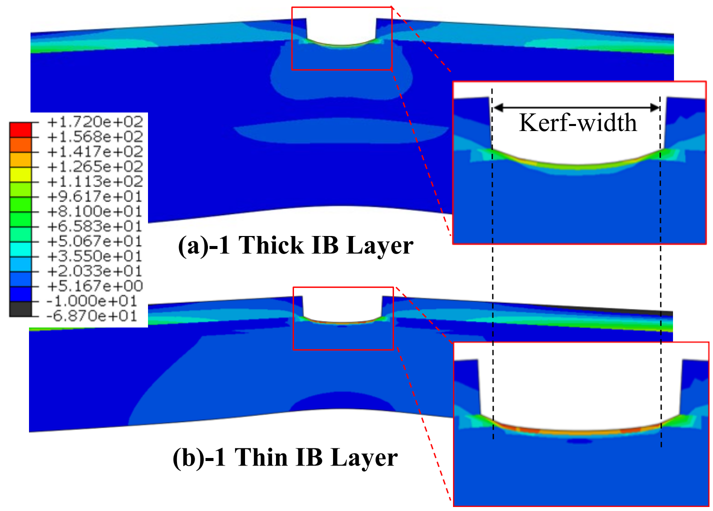


Fig. 3 Result of Simulation Analysis.

IV. Experiment and Results

Utilizing the simulation results above, we tried making a new tape with a thinner IB layer. Fig. 4 shows the different structures of development tapes with different thicknesses of IB layers. The new tape has ¼ the IB layer thickness of the initial development CE tape.

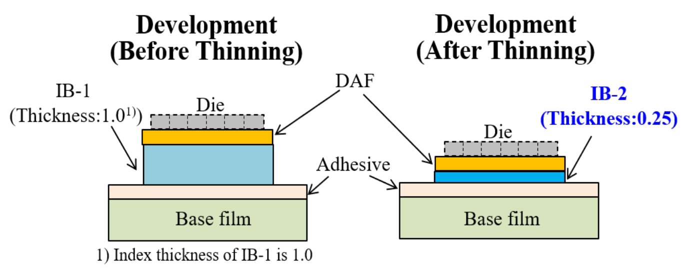
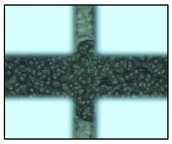
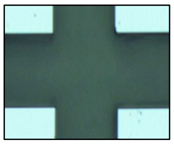


Fig. 4. Structure with Thinner IB Layer

SDBG + CE tests were conducted, and we used the tape with the thinner IB layer. Experimental methods were the same. See "II. Experiment for Initial Evaluation".

Table 3 shows the results of CE using both thick and thin IB layer tapes. In the case of thicker IB layer tape (IB-1), DAF separation was not enough because kerf-width was only 20 μm. Thinner IB layer tape (IB-2), kerf-width was increased to 35 μm and the DAF completely separated. This result was in line with the simulation results.

Table 3. CE Results (Different IB Layer Thicknesses)

IB	Microscope Image	Kerf-width (μm)	DAF Separation
IB-1 (Thick IB Layer)		20	Insufficient
IB-2 (Thin IB Layer)		35	Good

Initial test was conducted on 3mm^2 dies, we conducted additional tests using various die sizes (SDBG wafer) [5mm^2, 8mm^2]. DAF separation was good, same as 3mm^2, however Edge Float as shown in Fig. 5 was observed on 8mm^2 dies. This phenomenon occurs when the adhesion between DAF / IB is low, and it may lead to DAF delamination, difficulty picking die, and other issues.

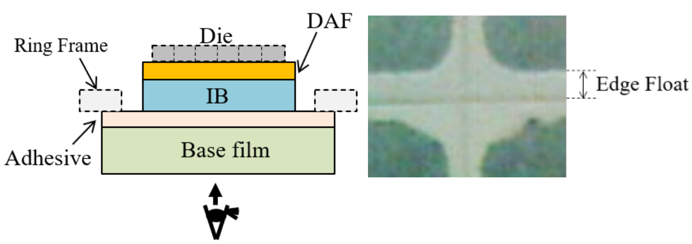


Fig. 5 Edge Float Measurement Method

We tried to increase the adhesion between the two layers to prevent Edge Float by changing to a different IB material. Table 4 shows adhesion vs. DAF in each IB test tape [IB-1 ~ IB-4]. We prepared, in total, four different types of tape with different thickness of IB layers and different IB material.

Table 4. Adhesion Between IB and DAF Layers

IB			Adhesion vs. DAF[2)]
Name	Thickness[1)]	Material	
IB-1	1.0	A	1.0
IB-2	0.25	B	1.1
IB-3	0.25	C	1.5
IB-4	0.25	D	2.0

1) Index thickness of IB-1 is 1.0
2) Index adhesion vs. DAF of IB-1 is 1.0

We evaluated Edge Float and pick up process using various development IB tapes. Table 5 shows Edge Float and Pick Time results for each IB development tape. Edge Float was not observed in the IB-4 material. There was a concern that it would be difficult to pick up the die with test subject IB-4 due to its high adhesion, however it could be picked up under 100ms by increasing the pick height. Adhesion of IB-4 is within an acceptable die pick range.

Table 5. Results of various IB.

	Edge Float (mm)			Pick Time (ms)		
Target	0 in the aim die			≤ 100		
Die Size (mm^2)	3	5	8	5		
Pick Height (μm)	-	-	-	150	200	250
IB-1	0	0	> 1	100	100	100
IB-2	0	0	> 1	100	100	100
IB-3	0	0	> 1	200	100	100
IB-4	0	0	0	300	100	100

V. Conclusion

We propose a novel DDAF tape for SDBG + CE processing which has following below features.
- Suitable for Cool Expansion and Heat Shrink
- Reduction in the risk of DAF-fly during CE
- Easy to control adhesion between DAF / IB

3mm^2 SDBG wafer with DAF can be separated by reducing thickness of IB. The novel DDAF can prevent Edge Float, die-fly and poor pick-up issues because we can control adhesion between DAF/IB by changing material properties of the IB layer.

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References

[1] T. Tanaka et al, "The Current and Future Prospect in Thin Packages" Proc. The Japan Institute of Electronics Packaging, Vol. 13 No. 1 (2010), pp. 37-38W.-K. Chen, *Linear Networks and Systems* (Book style). Belmont, CA: Wadsworth, 1993, pp. 123–135.

[2] "Stealth Dicing Technology and Applications," Hamamatsu Photonics Technical Information, March 2005.

[3] "Stealth Dicing Technical Information for MEMS," Hamamatsu Photonics Technical Information, March 2014.

[4] K. Furuno, et al, "A Novel Dicing tape for WLCSP Using Stealth Dicing Through Dicing tape and Back Side Protection-Film" Proc. 52nd International Microelectronics Assembly and Packaging Society, Boston, MA, Oct. 2019

[5] Gerald Klug, "DISCO solutions for thinning, dicing and packaging of thin devices made of Silicon, Sapphire and Compound materials like SiC and GaN", Aug. 2015, pp. 31

[6] W. H. Teh, et al, Multi-strata subsurface laser die singulation to enable defect-free ultra-thin stacked memory dies, May 2015.