MEPTEC 2015 – High Reliability Die Attach Solution for Automotive Applications

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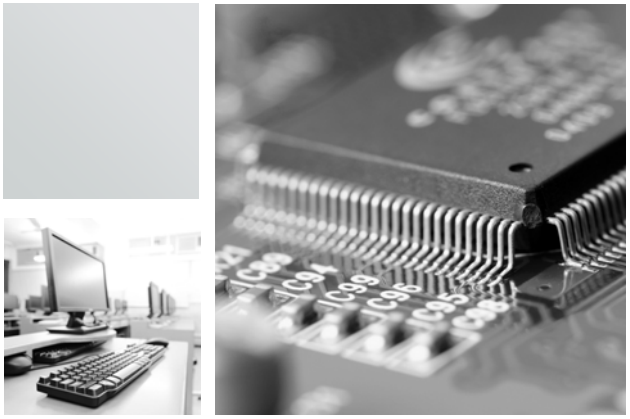
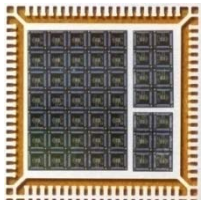
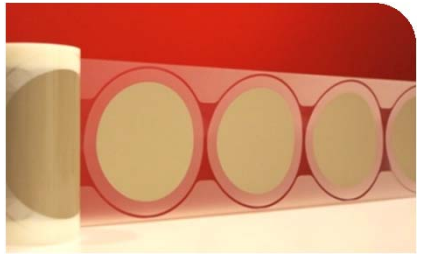
MARCH 2015







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Contents

Objectives

- Introduce cDAF value proposition.
- Introduce cDAF product portfolio.
- cDAF as die attach solution for automotive applications.

Market Trends

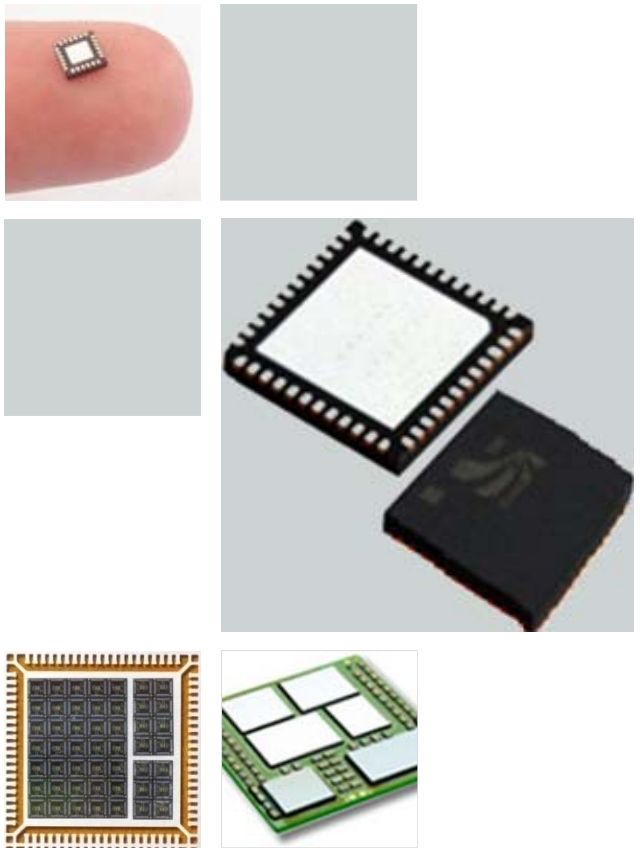
Smaller, Faster, Higher Functionalities

- Higher density design
- Higher functionalities
- Faster signal speed
- Power Management
- Lower TCoO
- Reduce package thickness

Applications space covers consumer, mobile, computing, communication healthcare, energy, industrial and automotive.

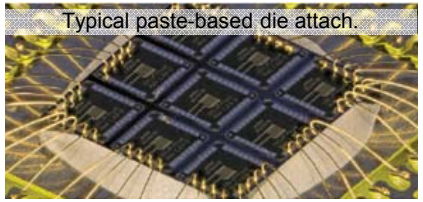
Package Trends – Wirebonded
Higher Functionality & Efficiency

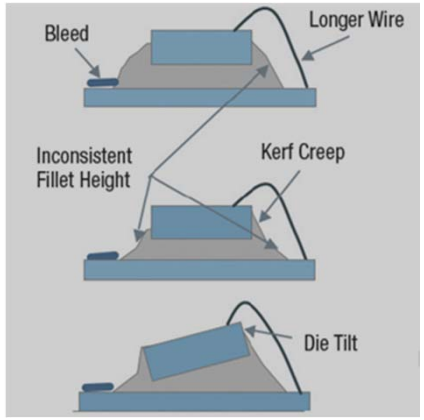
- Miniaturized packages (QFN, DFN, SOs)
  - Increased die-to-pad ratio
  - In some case D/P ratio close to 1.0
- Thinner packages (QFN, SO, QFP)
  - Packages <0.3mm
  - Thinner die <75um
  - Thinner DA bondline thickness <20um
- Higher density packages
  - Multi-dies packages
    - SiP – LGA/PBGA

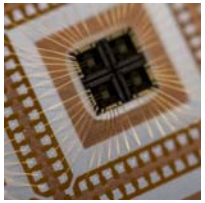


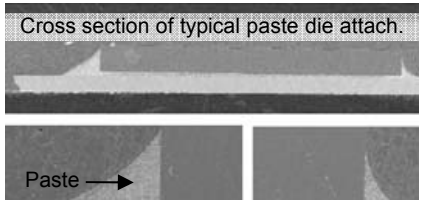
Current Material Challenges
Conducting Die Attach Paste

- Dispensing: Optimize dispense patterns for various die sizes – 0.2 x0.2 mm to >10x10mm.
- Fillet & Bleed: Forces engineers to have a minimum keep out zone around die.
- Bondline Control: Specially for smaller die BLT control is challenging and leads to die tilt.
- Kerf Creep: For thinner wafers uneven fillet height can lead to kerf creep.









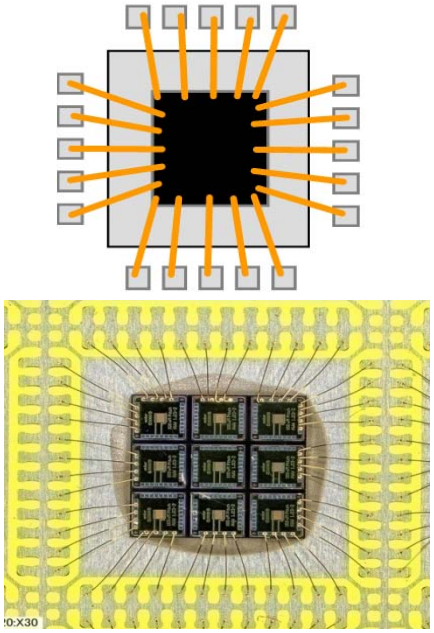
New Material Needs

What does the market really need moving forward?

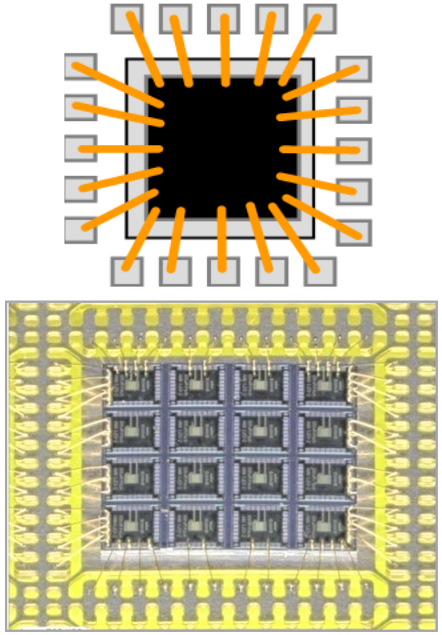
- Lower Cost
- Higher Reliability
  - Zero Delamination
- Zero Bleed
- Minimal fillet
- Consistent BLT control
- Thin Wafer handling capability
- Low to no outgassing
- Drop in solution

Control Flow
Enables Miniaturization

With Fillet



Controlled Fillet



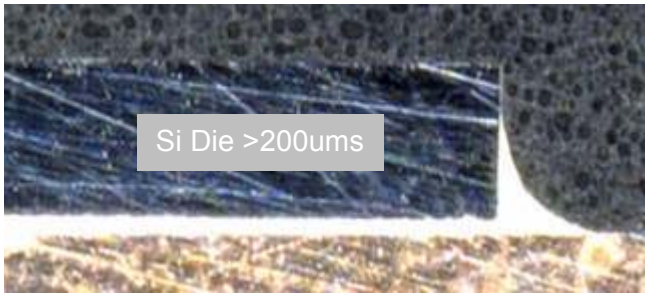
Reduced footprint → **Shorter interconnection** → **Faster signal speed**

Less Au wire, leadframe, EMC used → **Lower TCoO**

Control Flow
Enables Thin Wafer Handling

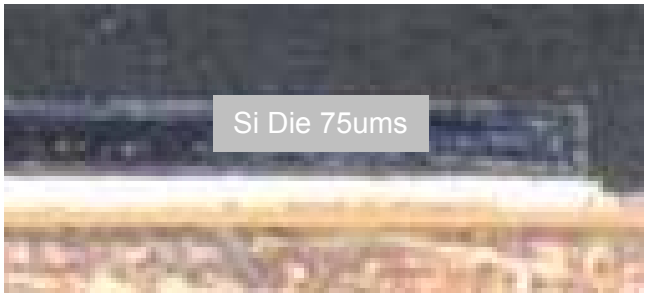
- Thinner wafer handling enabled
- Consistent Thinner bondlines achieved
- Eliminated Fillet
- Eliminated bleed

Package with Fillet



Die Attach Paste

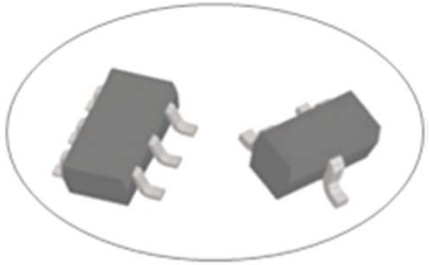
Controlled Fillet Height

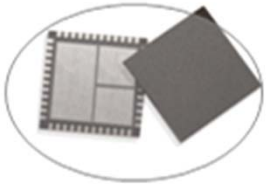


Die Attach Film

Control Flow

Technology Enabler & Lowers TCoO





Footprint reduction (>50%): Multiple packages to one using multiple die.

Single Large die containing multiple functions

Logic | Memory

Logic | RF

Expensive masks needed for designing a SoC

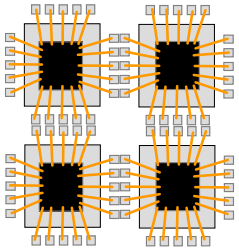
Multiple smaller die, each with its own function

Logic | Memory

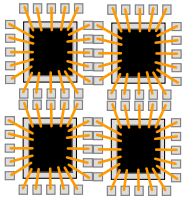
Logic | RF

Cheaper individual chips can be used for analog, digital and RF functions. The die need to be closer to each other for faster functioning

Paste



Film



Conductive film enable designing tighter Die/Pad ratio:

Reduce footprint and reduce cost of LF, effective Au wire cost/IO, mold compound per unit package.

High UPH due to high substrate density

cDAF can enable further footprint reduction of these SiP

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Control Flow
Advantages at Package Level

Enables emerging packages:

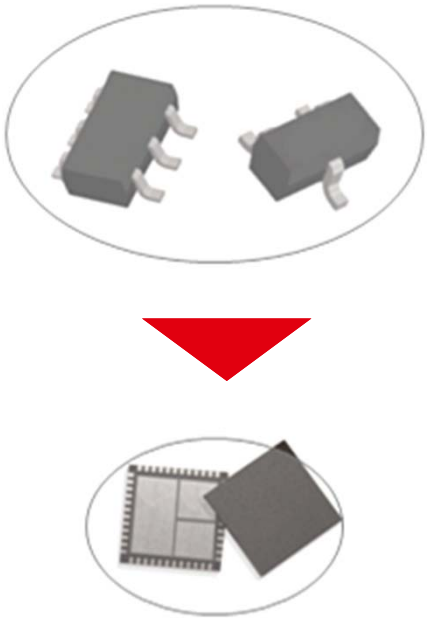
- Miniaturized
- High density
- Ultra thin

Indirectly improves package performance:

- Faster signal speed (shorter interconnection)
- Better power management (low RdSon)
- Better heat dissipation

Indirectly reduces TCoO:

- Cheaper design choice (SiP vs. SoC)
- Less material used (high packaging density)
- Improve yield



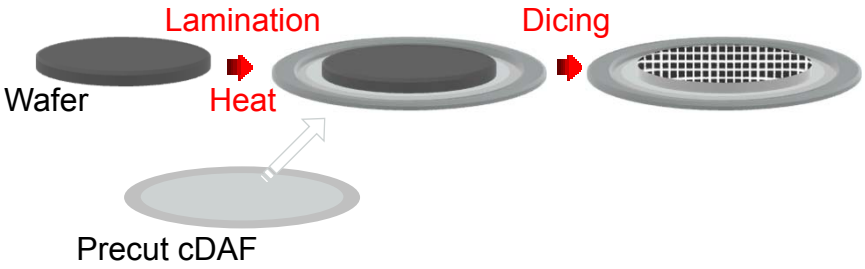
Footprint reduction (>50%):
Multiple packages to one
using multiple die.

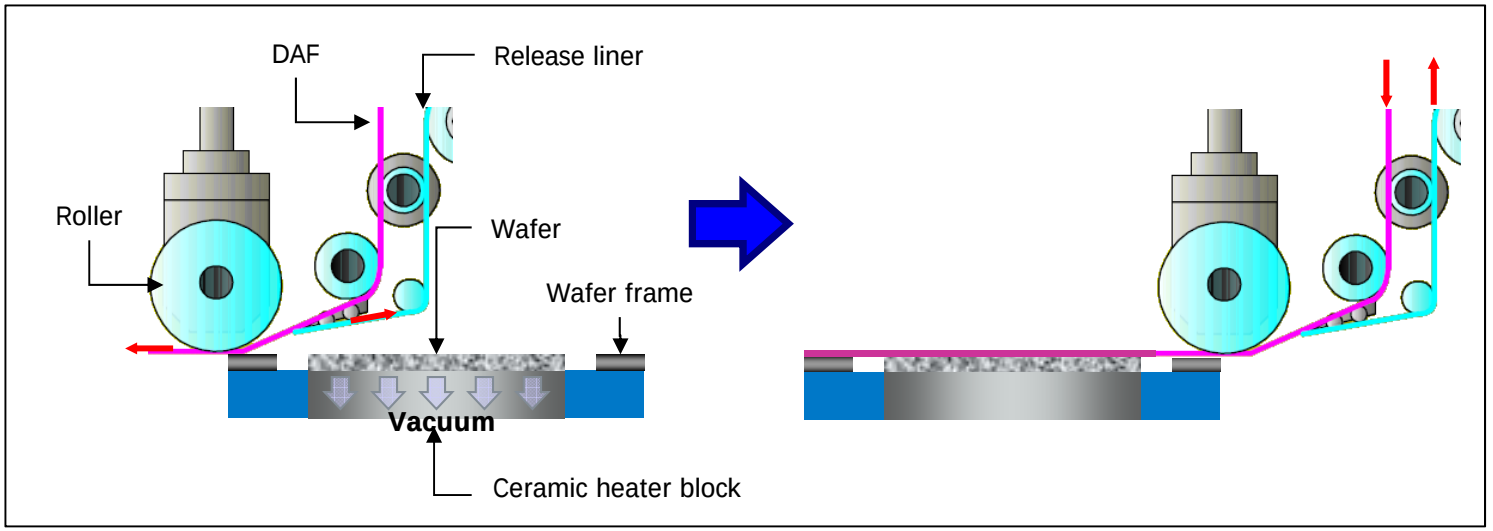
CDAF technology is well-aligned with emerging package trends

General Process

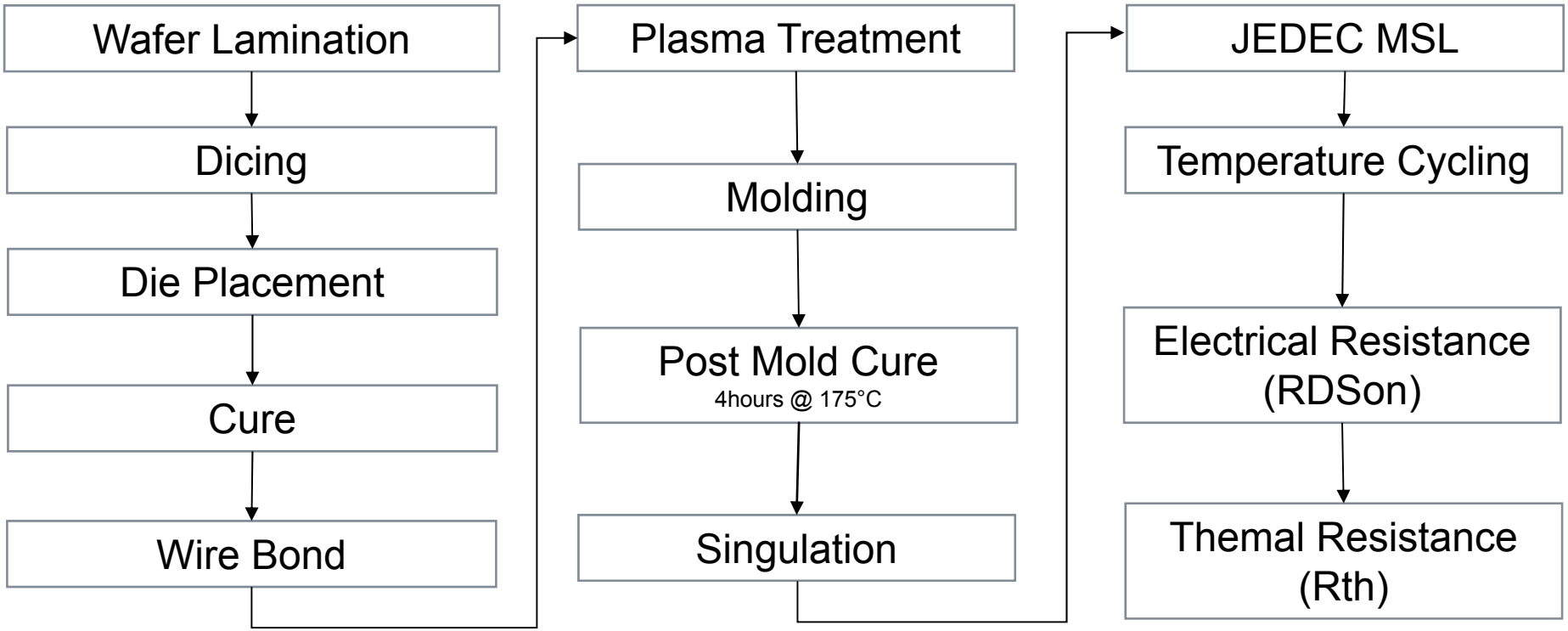
Lamination Process

Lamination Process:



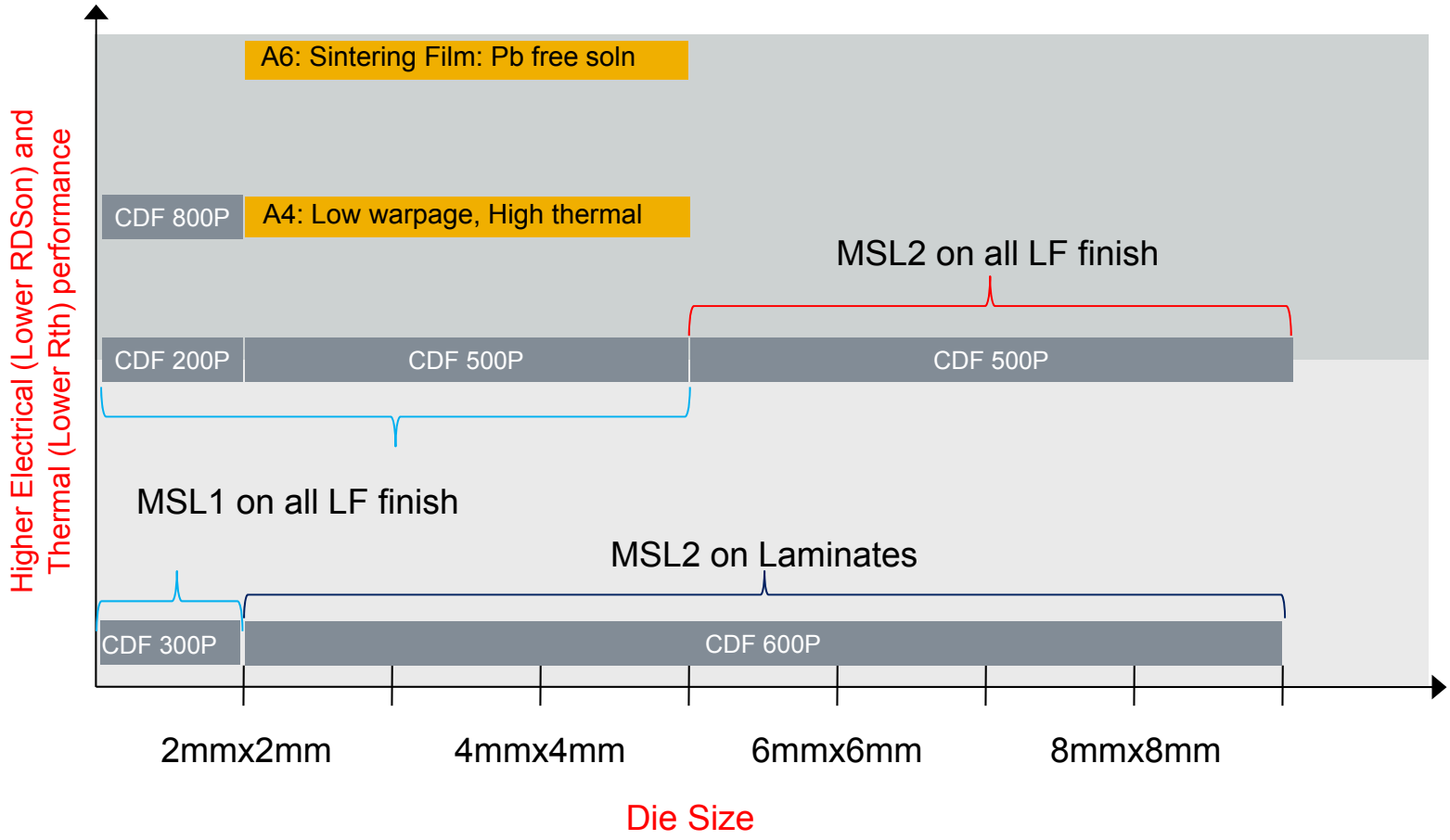


General Process
Overview



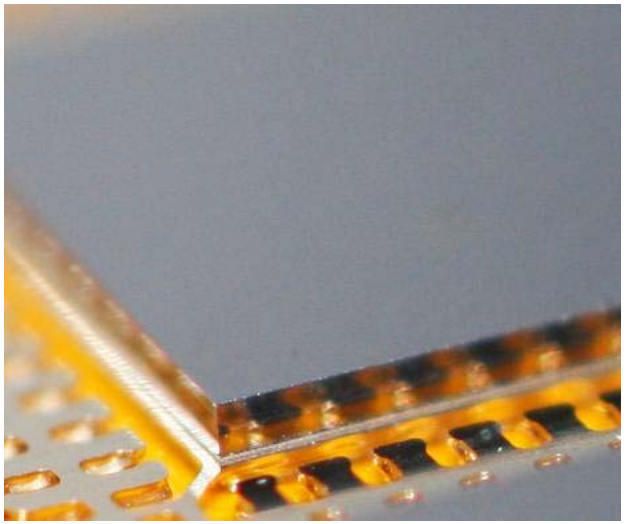
Product Portfolio

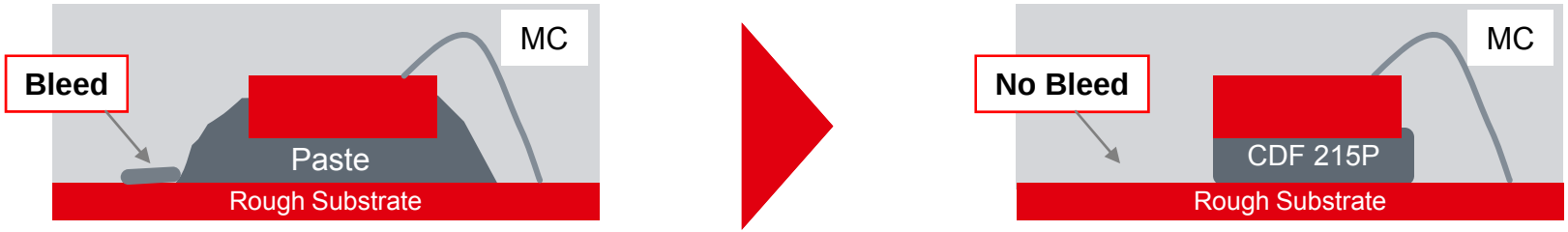
Product Space



High Reliability Die Attach Solution
Potential for Zero Delam Applications

- Conductive films do not bleed and do not have a fillet, so the adhesion of MC to LF is stronger – regardless of LF finish: smooth or rough.
- CDAF also has minimal out-gassing, which ensures clean WB bond pads & die top –
  - wirebonding or MC-die top delamination not observed



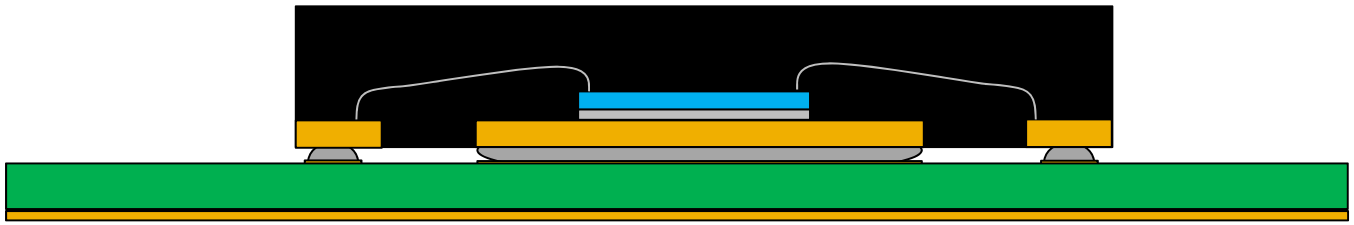


High Reliability Die Attach Solution
Test Vehicle Information

- QFN12x12 PPF packages
- 8x8x0.3mm dies, Au backed
- DA: 130'C, 2kg, 1.5s
- Cure: 30 min. Ramp + 60 min. at 200'C
- Single layer 1.6 mm thick FR4 Board with 2 layers of Copper (for added rigidity)
  - No electrical connections on board

- Henkel INNOLOTLF721AGS88.5V WGU 400gUS
  - Sn/Ag3.7/Cu0.7/Sb1.5/Bi3.0/Ni0.15, no clean solder paste

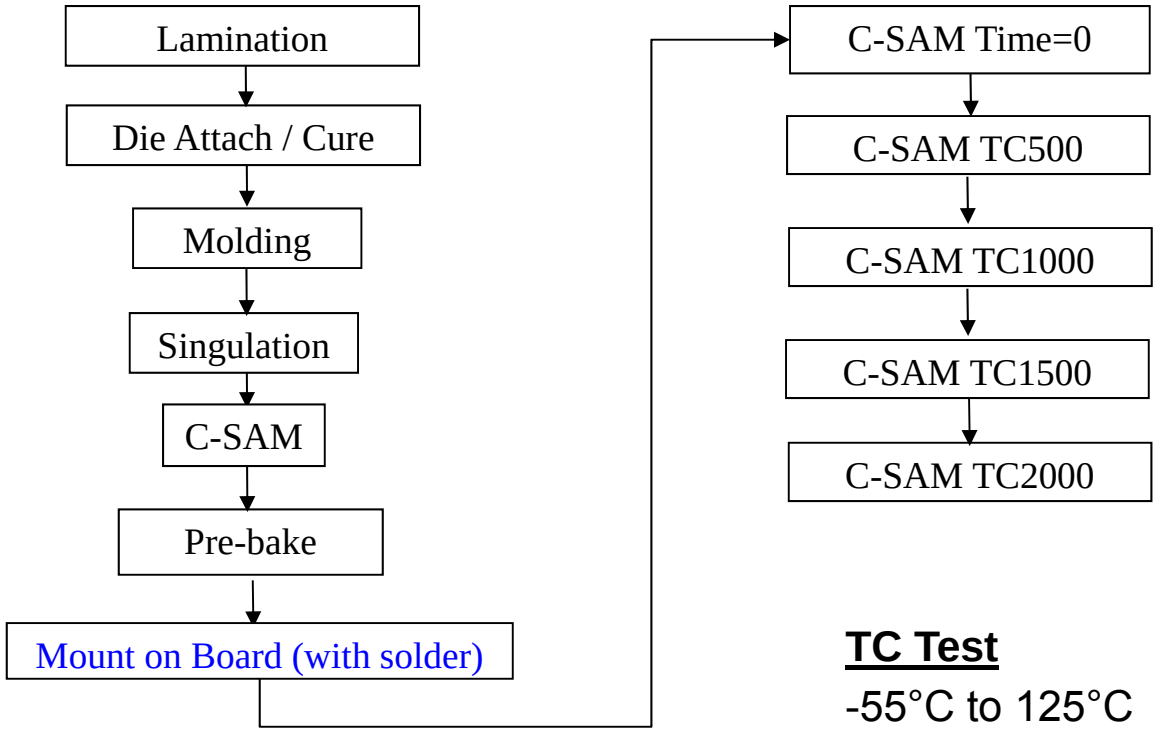
QFNs



Asymmetrical package and rigid body cause additional die stress

High Reliability Die Attach Solution

Process Flow Chart



TC Test

-55°C to 125°C

30 minutes per cycle

High Reliability Solution

Result Overview

Material	C115	CDF 515P
Thickness	15 um	15 um
Time 0, Before Mounting on Board		
Time 0, After Mounting on Board		
TC500		
TC1000		
TC1500		MC delam, no DA delam
TC2000		MC delam, no DA delam

No Delam.	
Some Die Attach Delam.	
Severe Die Attach Delam.	

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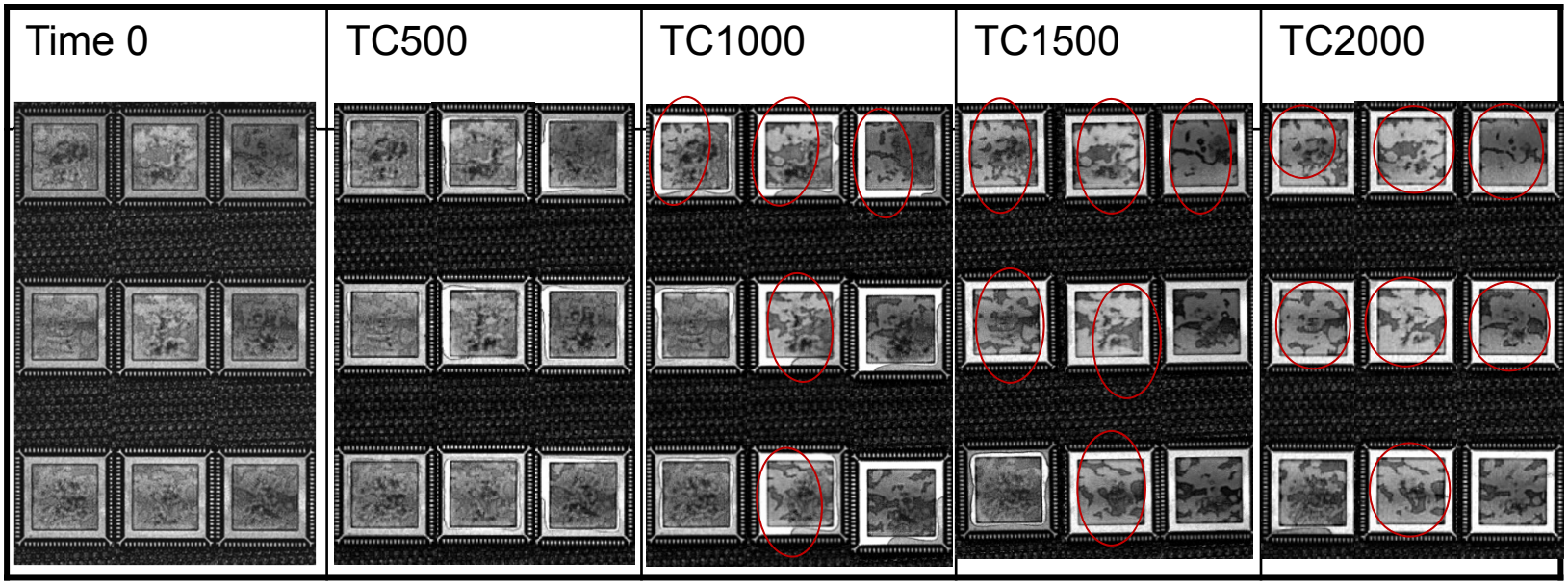
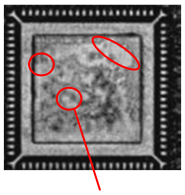
High Reliability Solution

C115 Board Level TCT

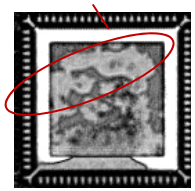


Time 0 Wetting



Variation in wetting

Die Attach Delam after TC1000

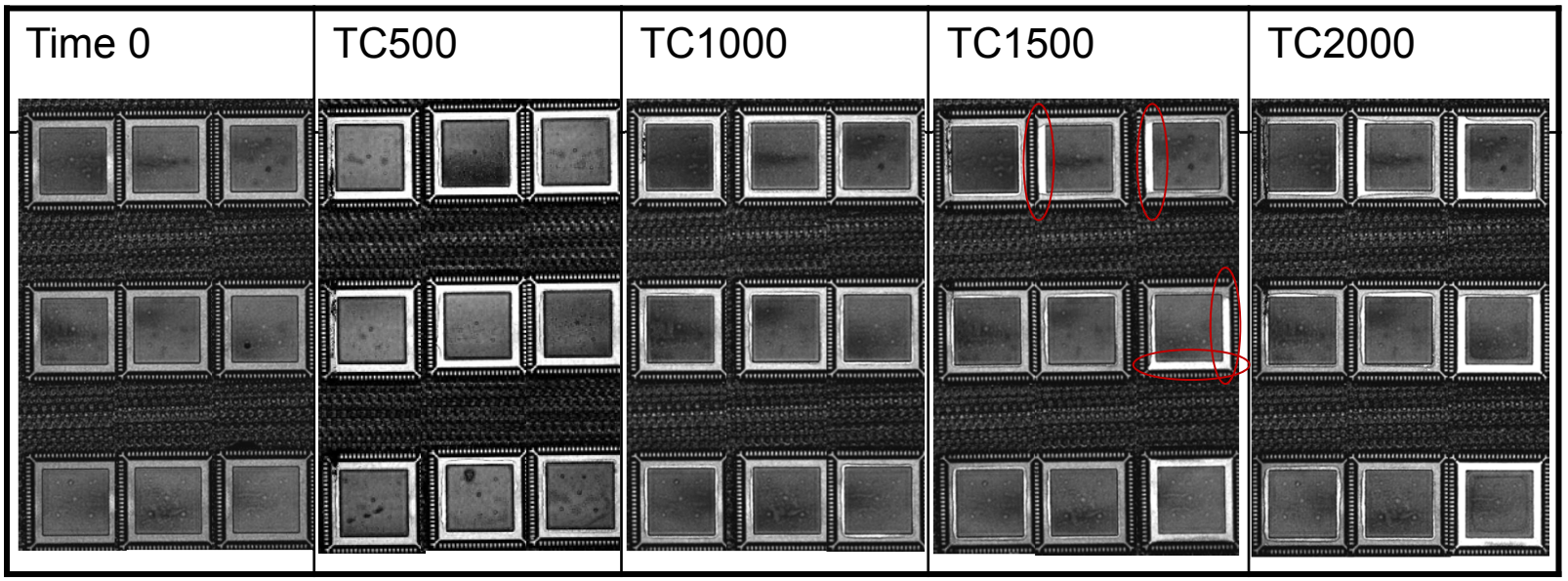


Center delam

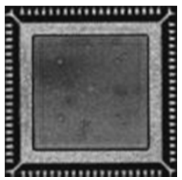
- Parts begin to show severe delamination at TC1000.

High Reliability Solution

CDF 515P Board Level TCT

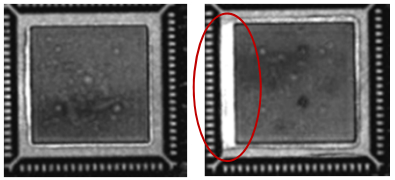


Time 0 Wetting



No delam

Package Delam after TC1500



No delam Package delam

- Parts begin to show package delamination at TC1500, but no die attach delamination up to TC2000

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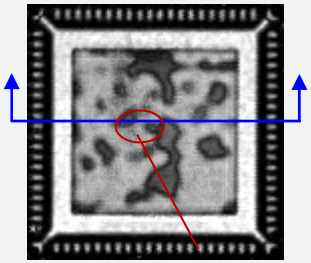
High Reliability Die Attach Solution
Failure Analysis

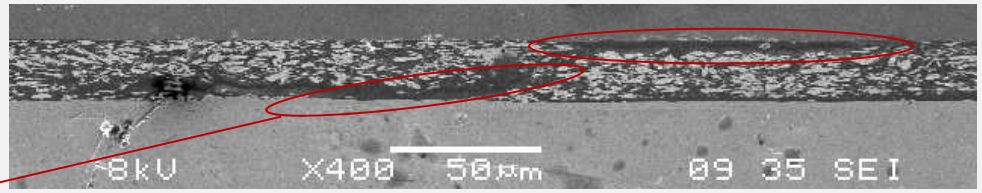
T-SAM after TC2000

Cross-section after TC2000 & demounting from board

C115:



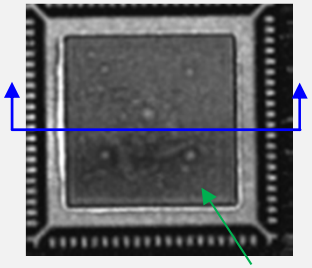
Middle



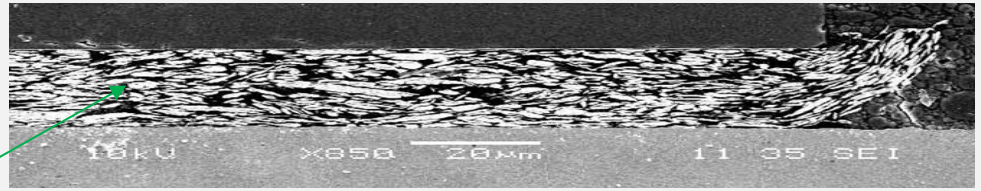
Crack filled in with potting compound

➢ Confirmed cracking / delam.

CDF 515P:



Middle



➢ No die attach delam found.

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High Reliability Solution
Material Properties

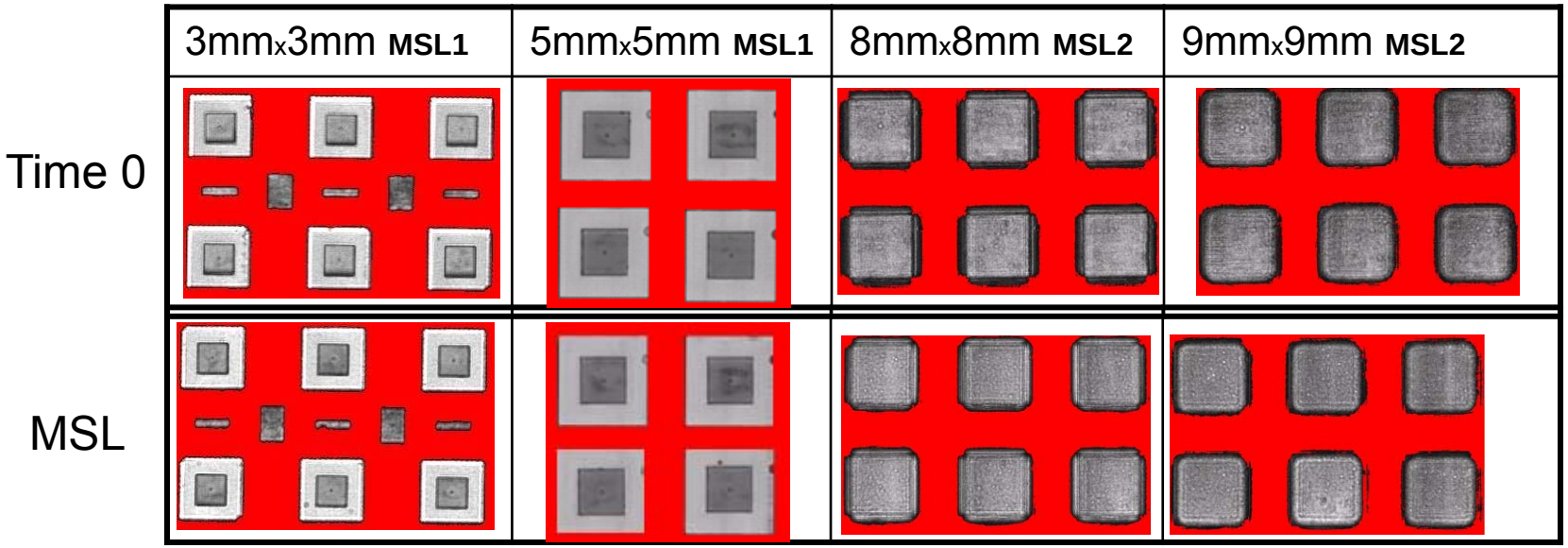
		C115	515P	Note
Modulus (Mpa)	@ -65°C	14300	13670	Lower modulus helps to reduce stress during testing, as reflected in unmolded warpage
	@ 25°C	10710	7590	
	@ 150°C	3960	530	
	@ 200°C	2820	410	
	@ 250°C	2030	360	
Warpage (um)	200°C Cure	75	54	
CTE by TMA (ppm/°C)	CTE (alpha1) below Tg, post cure	45	60	Materials do not significantly differ
	CTE (alpha2) above Tg, post cure	120	245	
	Tg by TMA (°C)	40	10	
HDSS (kg/mm2)	260°C on 2x2mm PPF	1.3	1.1	Adhesion does not significantly differ
MSL Level	Capability	2	1	MSL capability may be a parameter to practically demonstrate the DA film adhesion
TC2000 Result	Change recorded	Severe DA failure	Only Package failure	

HDSS Strength is comparatively similar between formulations

- **Lowering modulus is key factor to improve TC performance**

High Reliability Solution

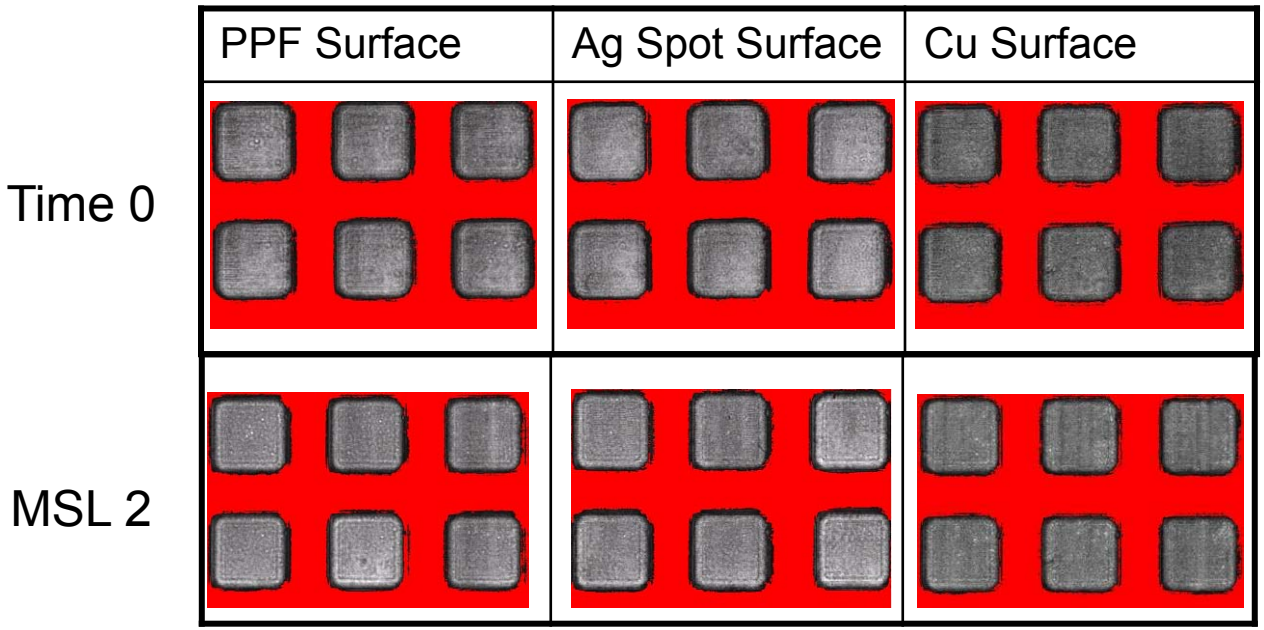
CDF 515P Die Size Range



CDF 515P die size range is up to 5x5mm² for MSL1 and up to 9x9mm² for MSL2.

High Reliability Solution

CDF 515P Compatibility with Various Leadframe Surfaces

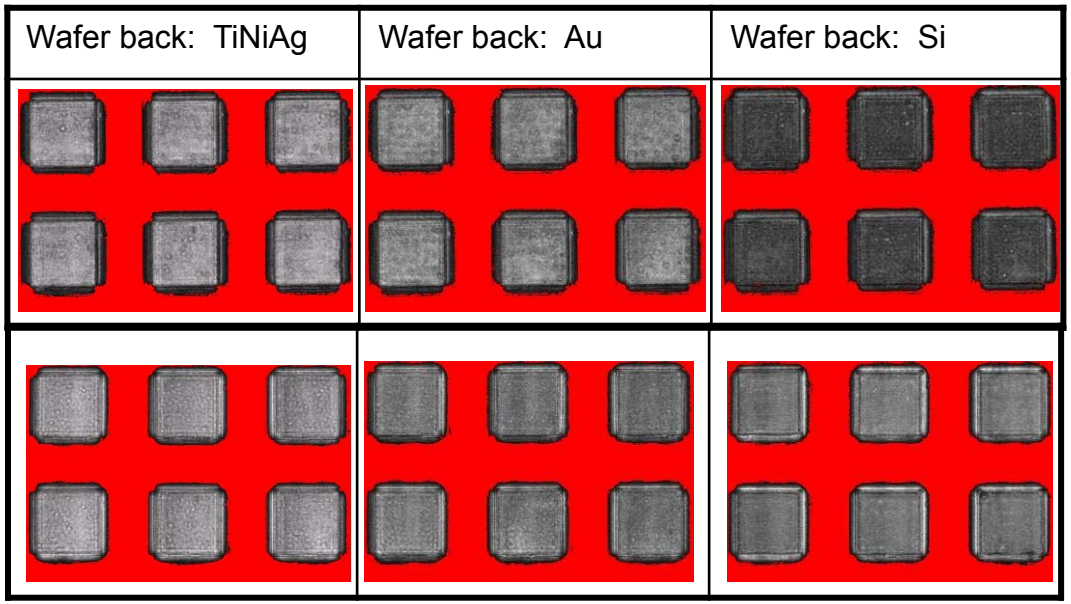


Note: Die size 8x8mm

CDF 515 is compatible with various leadframe surfaces and passed MSL2.

High Reliability Solution

CDF 515P Compatibility with Various Wafer Back Surfaces



Note: Die size 8x8mm

CDF 515P is compatible with various wafer back surfaces and passed MSL 2.

Summary

Thin wafer handling with precut format

- Excellent electrical conductivity, very low RDSon shift (<10%)
- Thinner package and smaller footprint (higher density packaging)
- Potentially eliminate wafer backside metallization
- In multi-die packages allow shorter die-to-die wirebonds for faster speeds.

Consistent bondline thickness and controlled flow

- No die tilt,
- Design flexibility from tight clearance between die and die pad

Clean dry process

- No dispensing, printing/B-staging necessary
- No bleed (even on rough LFs), no fillet, uniform bondline, no kerf creep

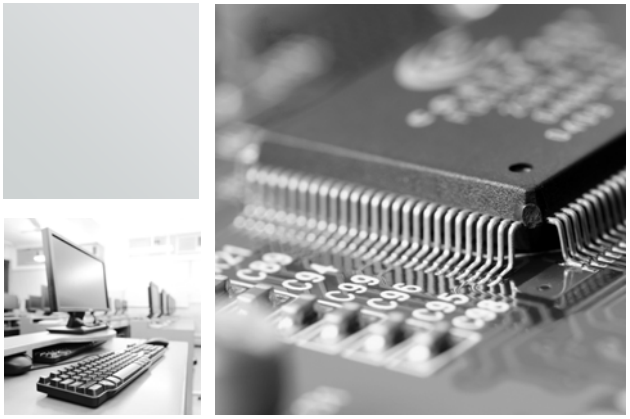
Reliability performance

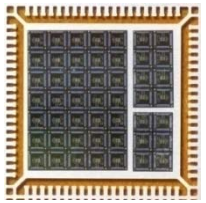
- Higher reliability performance (MSL1) on mulitiple substrates (PPF, Ag Spot, Cu) and various wafer back metallization (Si, Au, Ag)
- Achieve better efficiency, reduce yield loss: Efficient and robust process
- Robust board-level temperature cycling performance for automotive application

Cost Savings

- Higher density leadframes, shorter Au wires and less mold compound usage

Thank you!





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Appendix

Product Portfolio

Product Development

Low Cost Platform

Completed	Completed	Active	CTQ	Completed	Completed	Completed	Completed
Project A1	**Project A2**	**Project A4**	**Project Type**	**1st Gen C100**	**Project B**	**Project C**	**Project L**
Small Die	**Small Die**	**Medium-Large**	**Pkg Type**	**Medium Die**	**Large Die**	**Large Die**	**Small Die**
• QFN, SO		• QFN, PWSO, eTQFP	Pkg type	• TQFP	• TQFP, QFN	• FBGA, PBGA	• QFN – LF • PPF, Ag, Cu
• <65°C			Lamination Temp	• >90°C	• <65°C	• <65°C	• <65°C
• 2x2mm2	• 2x2mm2	• 4x5 mm2	Die Size - Target	• 5x5mm2	• 8x8 mm2	• 10x10 mm2	• 2x2 mm2
• 0.5x0.5 – 3x3mm2	• 0.5x0.5 – 3x3mm2	• 3.0x3.0 – 6x6mm2	Die Size - Range	• 0.5x0.5 – 7x7mm2	• 5x5-10x10mm2	• 5x5-12x12mm2	• 0.5x0.5 – 3x3mm2
• 3W/mK • 1.4 K/W	• 5W/mK • 0.8 K/W	• 25W/mK • 0.6 K/W	Thermal - Bulk Thermal - In Pkg	• 1W/mK • 2-2.2 K/W	• 3W/mK • 1.5 K/W	• 1W/mK • 3.5 K/W	• 1W/mK • 3.5 K/W
• VR<0.00005 Ohm cm • 78 mOhm • <5%	• VR<0.00005 Ohm cm • 38 mOhm • <5%	• VR<0.00005 Ohm cm • <5 mOhm • <5%	Electrical – VR Electrical – In Pkg RDSOn Shift	• VR<0.00005 Ohm cm • 158 mOhm • <2%	• VR<0.00005 Ohm cm • 70 mOhm • <5%	• VR<0.0005 Ohm cm • 150 mOhm • <5%	• VR<0.0005 Ohm cm • 150 mOhm • <5%
• MSL1 –must • 500 cycles			MSL TCT	• MSL3/MSL1 • 500 Cycles	• MSL1 – must • 500 cycles	• MSL3 – must • 500 cycles	• MSL1 – must • 500 cycles
Precut –15			Format	Roll 15/30um	Precut -15um	Precut – 30 um	Precut -20um
Q2 2012	Q4 2012	Q1 2015	Timeline -launch	Q4 2009	Q3 2013	Q4 2013	Q3 2014

Improve electrical & Thermal for Small Die

Improve warpage & Wetting for Large Die

CDF200P **CDF800P** **CDF500P** **CDF600P** **CDF300P**

Henkel

Portfolio of CDAF Products

Property table for film and paste

	unit	CDF 200P	QMI519	84-1LMI SR4	8290	8008HT	CDF 800P	QMI529HT	CDF 500P	FS849-TI	CDF 600P	2100A	CDF 300P
Material Property													
Volume Resistivity	ohm-cm	0.0014	0.0001	0.0002	0.008	0.00006	0.0003	0.00004	0.0002	0.00002	0.0008	0.05	0.0010
Thermal conductivity	W/mK	2	3.8	2.5	1.6	11	3.5	6.5	1 - 2	7.8	1	1.35	1
CTE alpha1	ppm/C	48	40	40	81	37	40	53	60	44	75	65	50
CTE alpha2	ppm/C	120	140	150	181	62	118	156	245	155	320	200	200
Tq	°C	15	75	120	38	264	11	3	10	211	"-5	60	10
Modulus @ 25C	Mpa	5,400	5,300	3,930	3,034	6,659	7,100	3,300	6,300	7,800	3,000	3,200	5,400
Modulus @ 250C	Mpa	1,000	284	303	117	2,450	900	-	130	1,070	40	230	400
Performance													
HDSS (260°C) on Ag	kg/mm^2	1.3	0.8	0.2	0.6	0.7	1.0	0.5	0.7	0.5	0.7	0.4	0.7
Room Temp DSS on PPF	kg/mm^2	2.14	4.9	3.0	5.0	-	> 2.0	-	-	-	-	-	-
Room Temp DSS on Aq	kg/mm^2	3.02	4.8	2.3	5.1	1.5	> 2.0	2.2	-	-	-	-	-
Room Temp DSS on Cu	kg/mm^2	3.17	1.8	1.2	2.5	1.5	> 2.0	-	-	-	-	-	-
Failure Mode		Cohesive	Cohesive	Cohesive	Cohesive	-	Cohesive	Cohesive	Cohesive	-	Cohesive	Cohesive	Cohesive
Thermal Resistance, Rth	K/W	1.4	1.3	0.8	1.8	1.5	0.8	0.8	1.5	0.7	2.6	2.3	2.1
RD Son	ohm-cm	0.065	0.044	0.033	n/a	0.067	0.033	0.042	0.053	0.038	n/a	n/a	0.052
RD Son Shift (500 TC)	%	2.2	n/a	10.0	n/a	n/a	5.7	42	n/a	28.0	n/a	n/a	n/a
RD Son Shift (1000 TC)	%	6.6	n/a	15.6	n/a	n/a	6.4	42	n/a	28.8	n/a	n/a	n/a
JEDEC MSL 260°C (on 7x7mm PPF QFN with 2.5x2.5x0.33 die)	MSL level	1	MSL1 capable for small die	3	MSL1 capable for small die	3	1	MSL1 capable for small die	1	MSL1 capable for small die	2 (PBGA)	2 (PBGA)	1
JEDEC MSL 260°C (on 7x7mm PPF QFN with 5x5x0.36 die)	MSL level	2	-	-	-	-	2	-	1	3	2 (PBGA)	2 (PBGA)	-
Processing													
Cure	profile	30 min ramp to 200C + 1 hr soak @ 200C	30 min ramp + hold 60 min @ 100°C + 15 min ramp + hold 60 min @ 200°C	30 min ramp to 175C + 1 hr soak @ 175C	30 min ramp to 175C + 15 min soak @ 175C	20 seconds @ 280°C	30 min ramp to 200C + 1 hr soak @ 200C	30 min ramp to 185C + 30 min soak @ 185C	30 min ramp to 200C + 1 hr soak @ 200C	30 min ramp to 175C + 30 min soak @ 175C	30 min ramp + 100C/30 min + 30 min ramp + 170C/1hr	30 min ramp to 175C + 15min soak @ 175C	30 min ramp to 200C + 1 hr soak @ 200C

Global Contacts
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