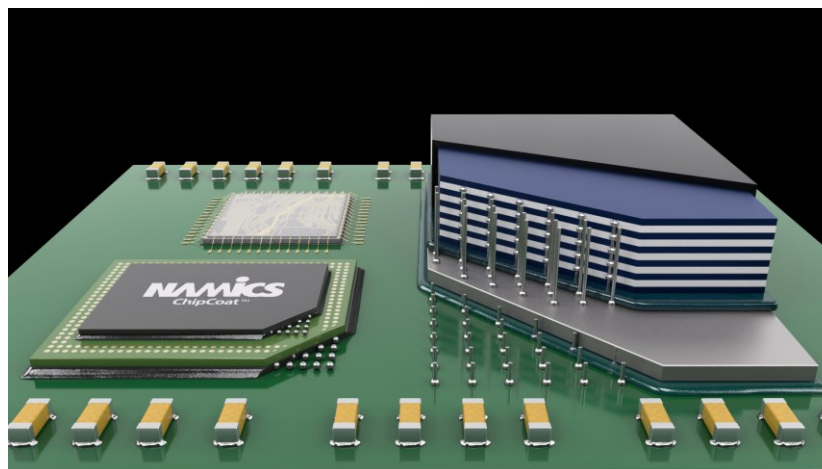




17TH INTERNATIONAL CONFERENCE ON • APRIL 12-15, 2021
DEVICE PACKAGING
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Advanced Materials for Automotive SiP Applications



Advanced Materials for Automotive SiP Applications

Contents

1. Company Profile
2. ADAS Market Trends
3. Solutions for SiP Packaging
 - a) High Thermal Conductive Die Attach
 - b) Capillary Underfill
 - c) Liquid Compression Molding
 - d) Board Level Underfills
4. Summary



Company Overview

Device Packaging Conference 2021 - April 12-15, 2021

Global leader in advanced materials for semiconductor devices and electronics packages

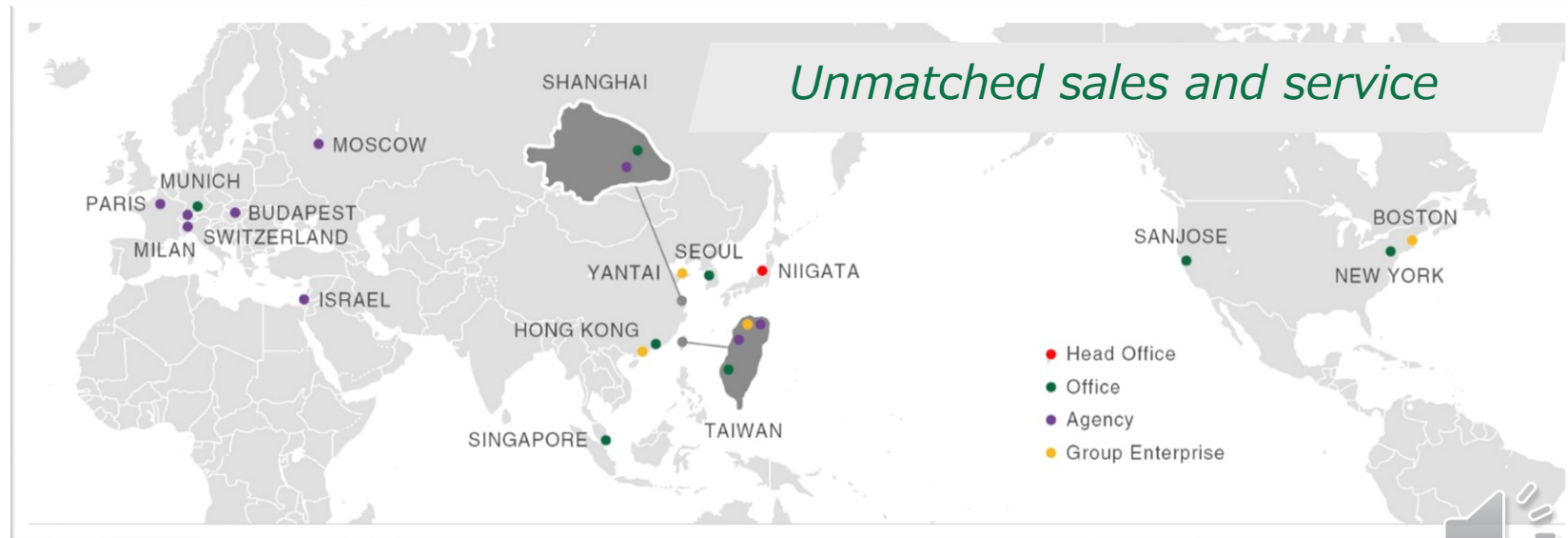


Established	February 1947
Employees	Approx. 600 worldwide
Head Office	Niigata, Japan
U.S. Subsidiary	NAMICS Technologies, Inc.
<i>Been in business for over 70 years!</i>	

Global Network

Subsidiaries in:

- USA
- Europe
- Taiwan
- Singapore
- Korea
- Hong Kong
- China



Market Trends

Device Packaging Conference 2021 - April 12-15, 2021

Meeting industries future needs for 2020 and beyond...



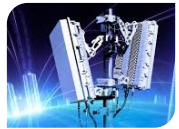
Automotive ADAS



Camera Modules for Mobile & AR / VR



5G with Cloud Computing



RF Power and Power Market



In-Mold / Flexible Electronics



Medical



Wearable

Market Needs

- Increase electrification
- High reliability

- Increased pixels
- Smaller form factor

- Increase data center demand
- Higher frequencies

- Increasing demand
- Faster data

- Functional parts
- Automotive to white goods

- Growth of medical devices
- Skin patches

- Thin, flexible electronics

NAMICS Innovative Technology

- Board Level Underfills (BLUF) & Cornerbond
- Thermal Conductive Die Attach

- Snap cure / low temperature cure adhesives
- UV Adhesives

- Underfills for 2.5D / 3D wafer level packaging
- SiP Packaging solutions

- Pressure-Less Sintering Technology
- Low Dielectric Underfills
- High thermal non-conductive films

- In-mold decorating (IME) with **functional Inks**

- Board Level Materials
- Low Temperature Curing Adhesives
- Low CTE Encapsulants

- Stretchable inks

001042



Market is accelerating → *close to 21% CAGR*



Main factors...

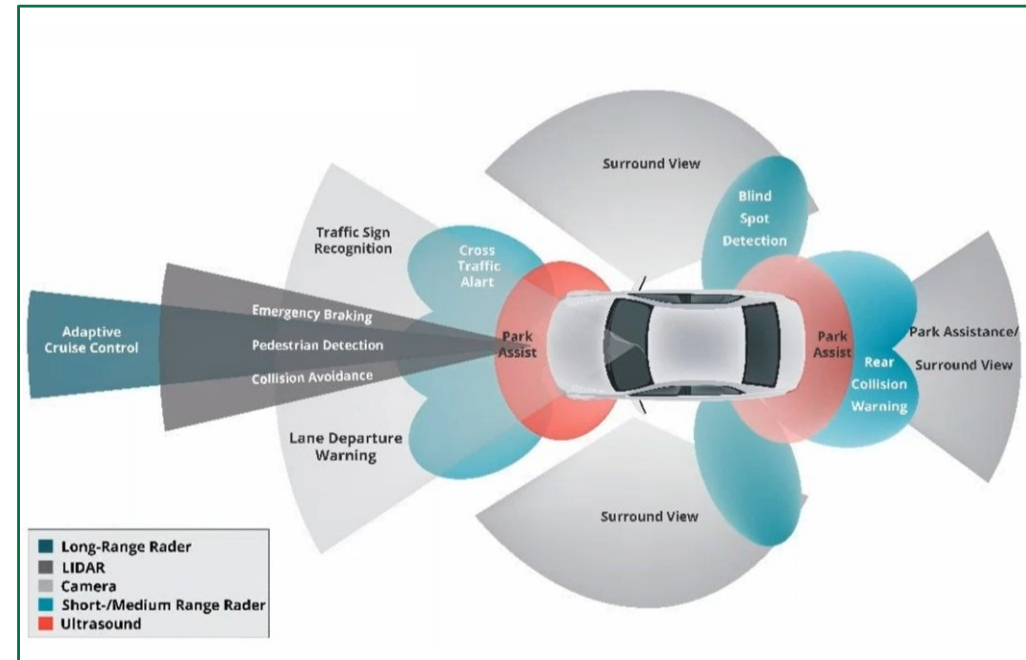
- Rise in traffic congestion & long-distance traveling
- Demand for more safety functions in passenger cars



- Market value for ADAS will exceed >USD60 billion by 2027
- Biggest potential area for growth is APAC (Asia-Pacific)



- ADAS stands for **A**dvanced **D**river **A**ssistance **S**ystems
- Enhanced and automated driving:
 - ✓ Identify objects, signs, lane, pedestrians and other vehicles
 - ✓ Sense vehicle distances in real time
 - ✓ Alert driver to potential hazards
 - ✓ Automate braking and steering



Advanced packaging will be needed to meet next generation ADAS requirements

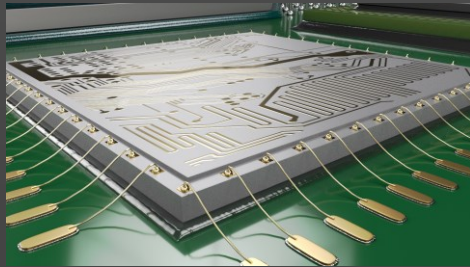


Solutions for SiP Packaging

Device Packaging Conference 2021 - April 12-15, 2021

Pressure-less sintering

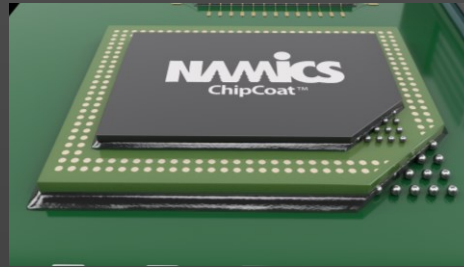
High thermal
die attach



- Unmatched thermal performance
- High reliability due to resin reinforcement and low modulus technology
- Proven ready for HVM (high volume manufacturing)

Capillary Underfill

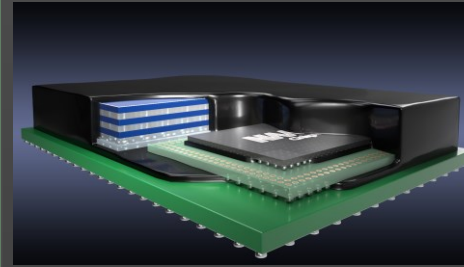
Narrow gap,
fine pitch



- Void free for narrow gap, fine pitch
- Low resin bleed for narrow KOZ (keep out zone)
- High reliability

Liquid Compression Molding

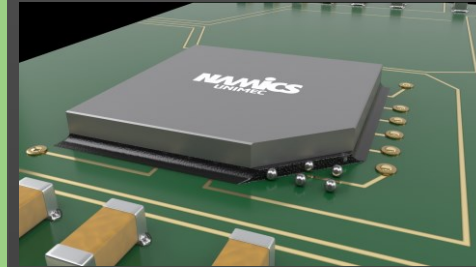
Simplified process,
low warpage



- Simplified process
- High throughput
- Reduce heat cycle improves warpage control

Board level Underfill

High reliability,
fast processing

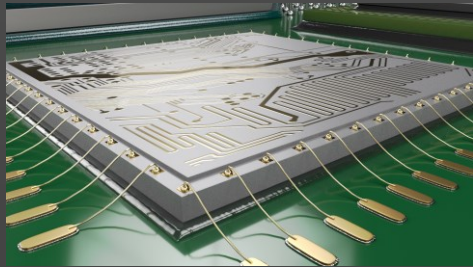


- High reliability
- Ideal for high volume production
- Meet stringent environmental requirements



Pressure-less sintering

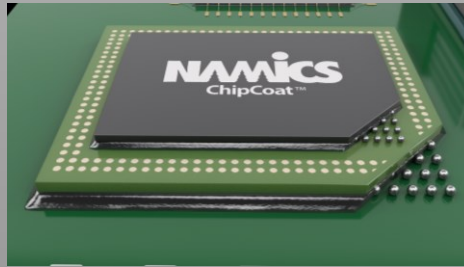
High thermal die attach



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Capillary Underfill

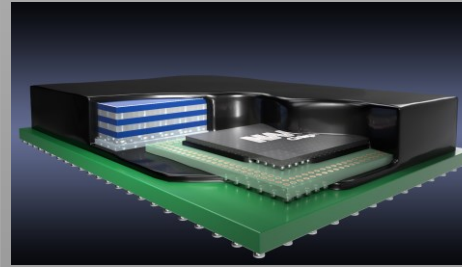
Narrow gap, fine pitch



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Liquid Compression Molding

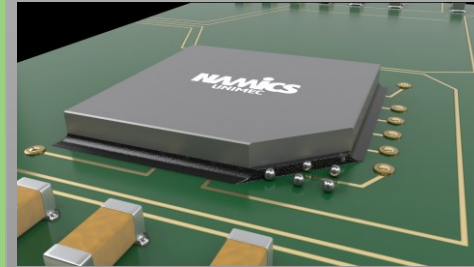
Simplified process, low warpage



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Board level Underfill

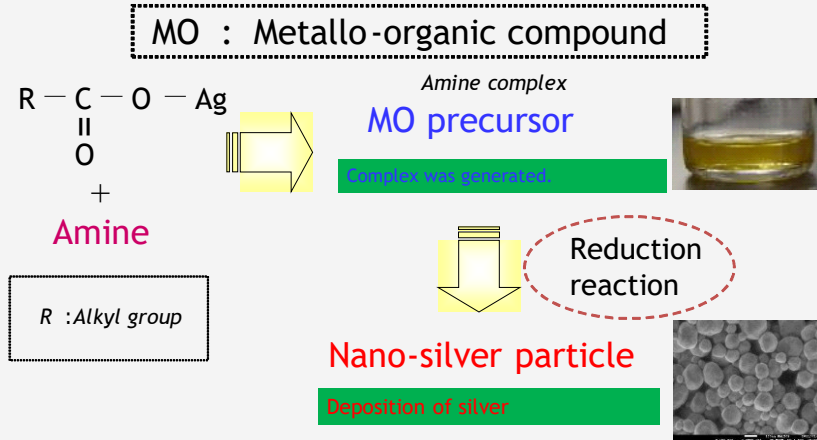
High reliability, fast processing



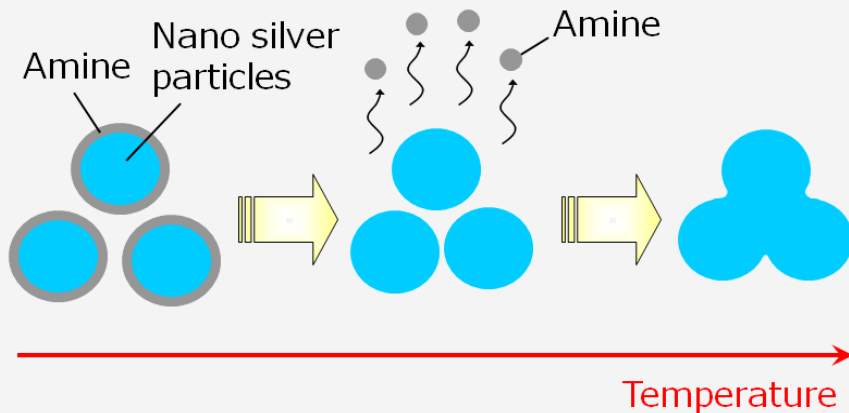
- High reliability
- Ideal for high volume production
- Meet stringent environmental requirements

■ MO technology

Schematic view for synthesizing nano silver particles using MO Technology.

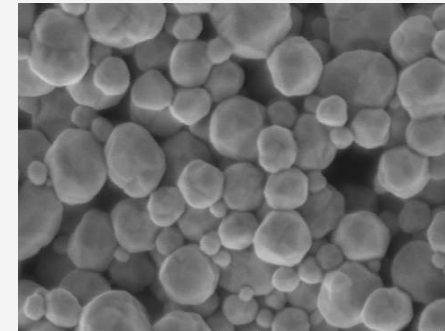


■ Sintering behavior

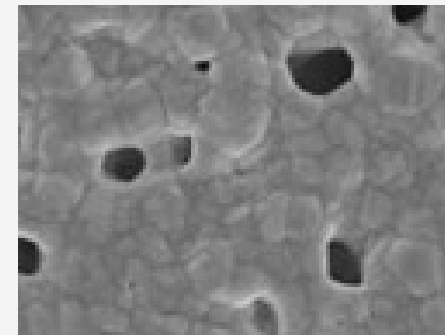


■ Observation before and after sintering

Before sintering

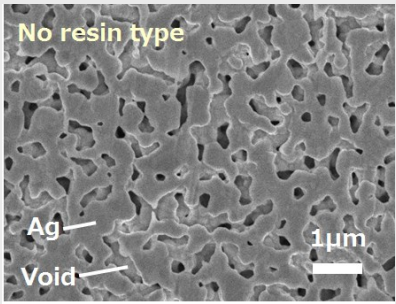


After sintering at 200°C
without pressure

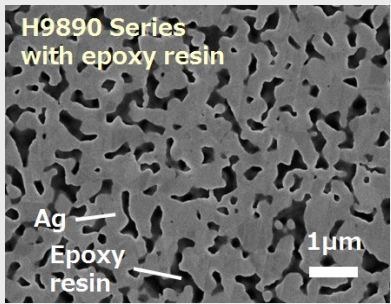
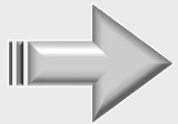


■ Reliability can be improved by adding resin

Cross-section(with and without epoxy resin)

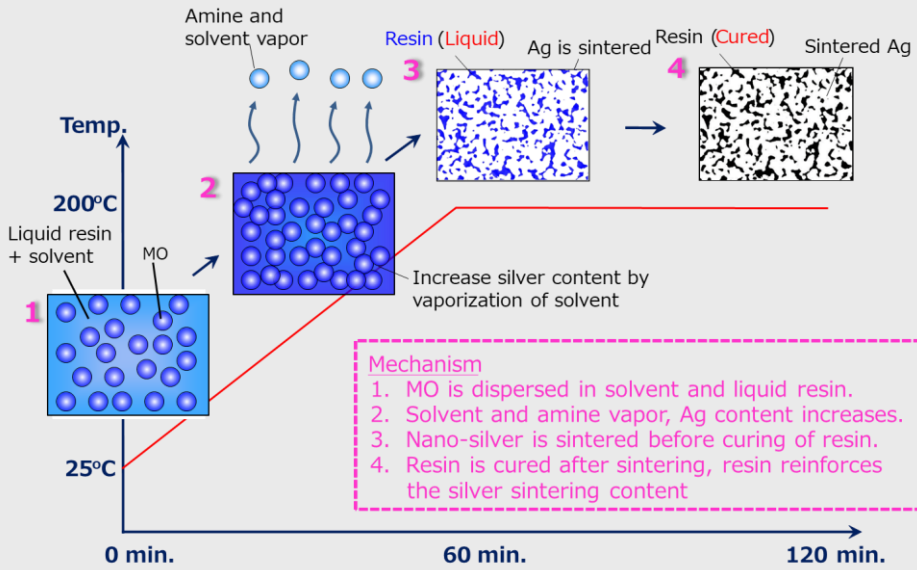


The sintered structure is filled with epoxy resin.

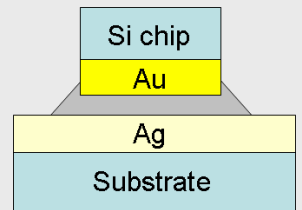


The resin prevent the cracks during thermal cycle test.

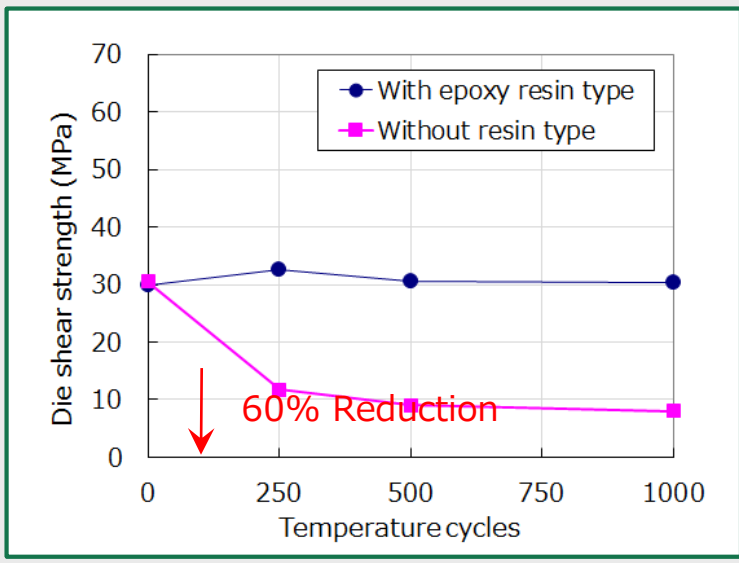
Behavior of cure and sintering



Thermal cycle test result



- Si chip: 2 x 2mm² size Si chip (backside: Au)
- Substrate: Ag plated Al₂O₃
- Test condition: -55°C(30min)/150°C(30min)

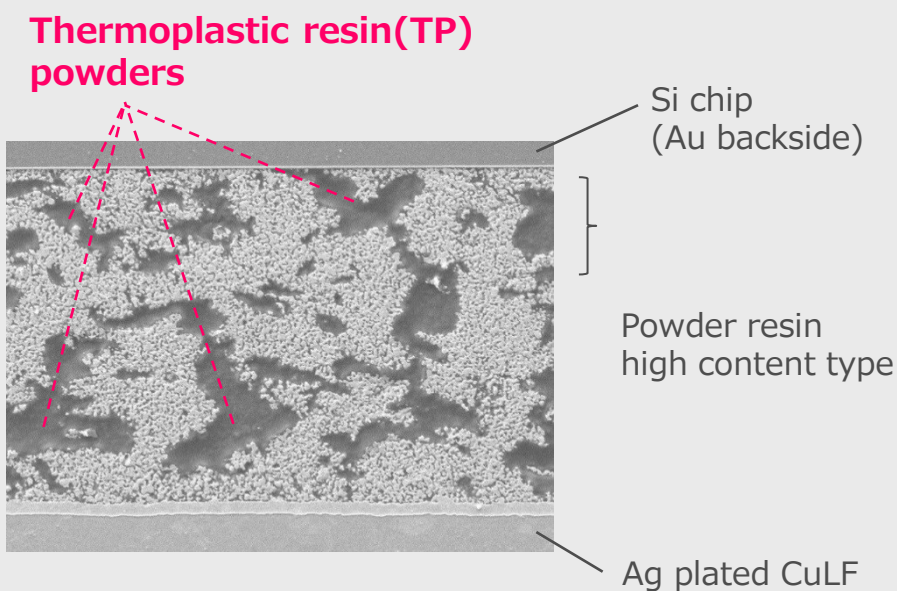


Sintered Ag with Resin showed stable die shear strength after 1,000 cycles.



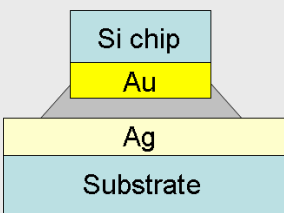
■ Reliability can be more improved by adding resin powders

Cross-section(with powder resins)

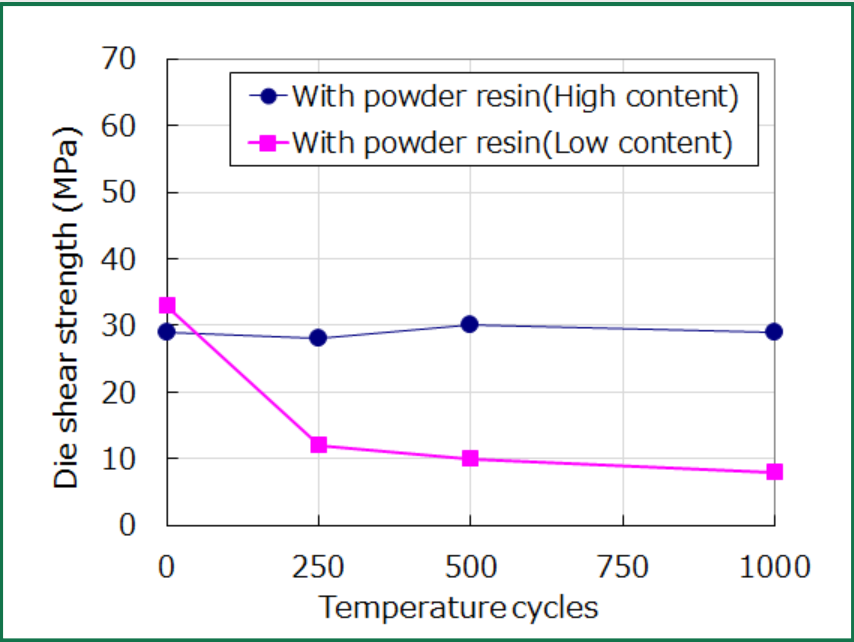


The TP powders reduce the stress during thermal cycle test.

Thermal cycle test result



- Si chip: 2 x 2mm² size Si chip (backside: Au)
- Substrate: Ag plated CuLF
- Test condition: -55°C(30min)/150°C(30min)



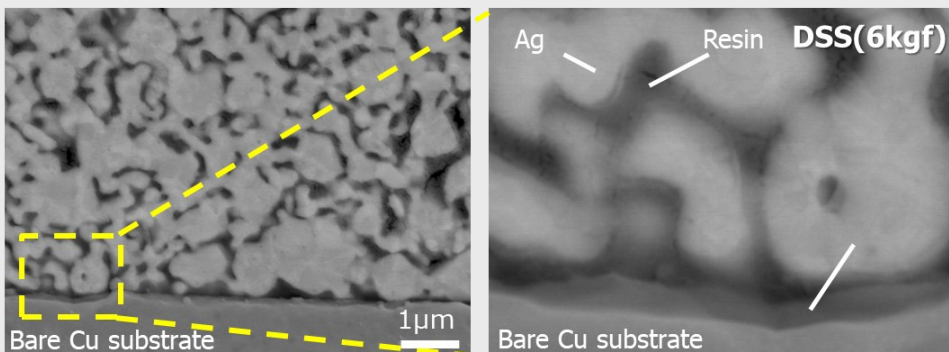
Higher powder resin content type showed better reliability during thermal cycle test.

Sintering to Bare Copper Surface

Capable of sintering to bare copper substrates

Addition of Special Additive

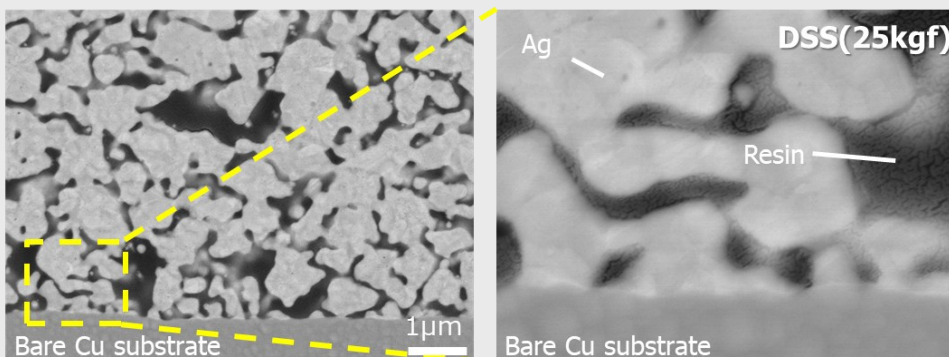
Standard Sintered Ag



❖ Very thin oxide layer exist, and it prevents the sintering.

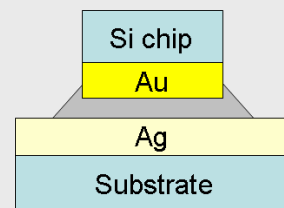
Addition of special additive

Improved Sintered Ag with Additive



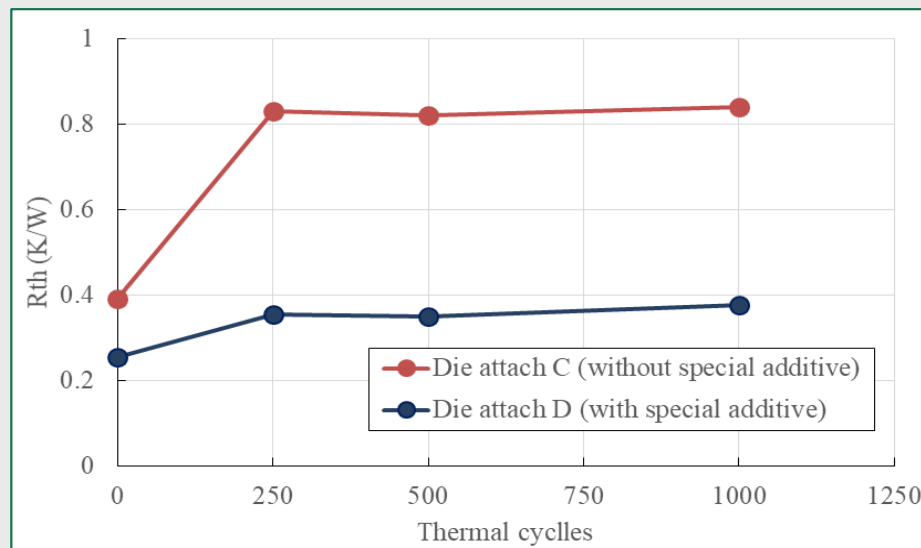
❖ Special additive removes oxide layer, excellent sintering to bare copper.

Thermal cycle test result



- Si chip: 2 x 2mm² size Si chip (backside: Au)
- Substrate: bare CuLF
- Test condition: -55°C(30min)/150°C(30min)

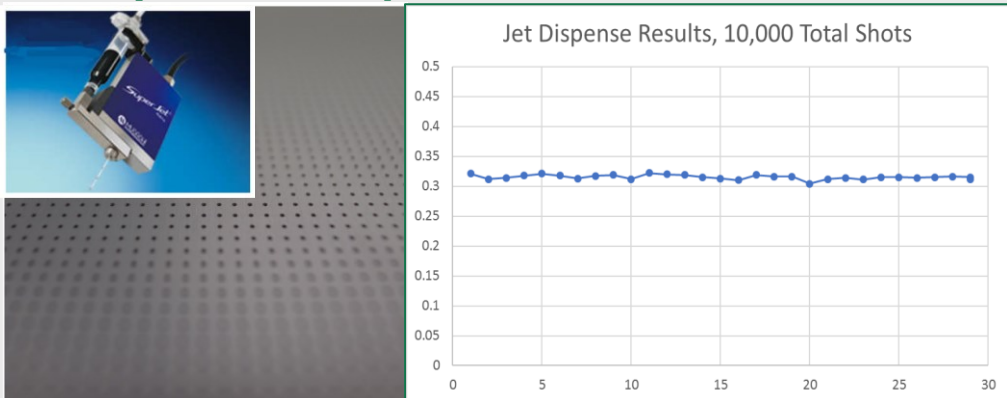
Thermal resistance results



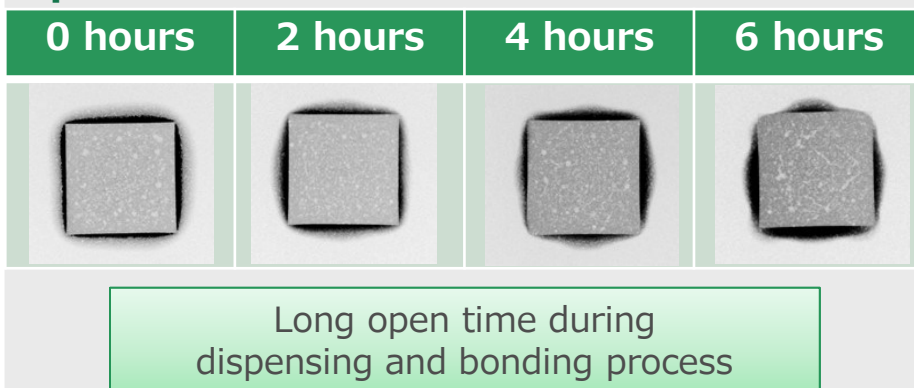
Special additive is important for the bare Cu application.

■ Designed to meet high volume manufacturing needs

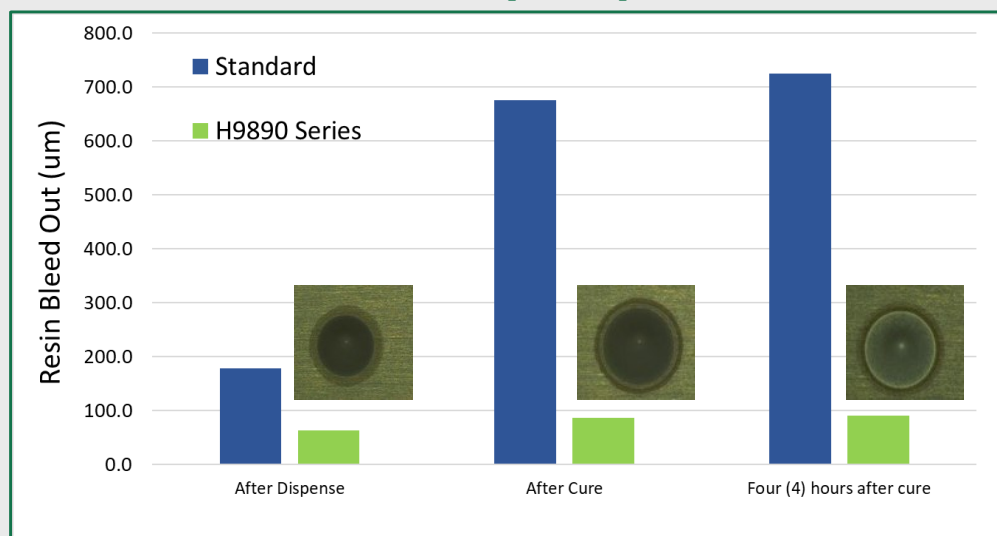
Ability to Jet Dispense



Open Time



Low Resin Bleed-Out (RBO)

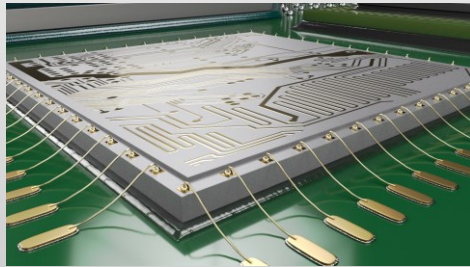


Staging Time



Pressure-less sintering

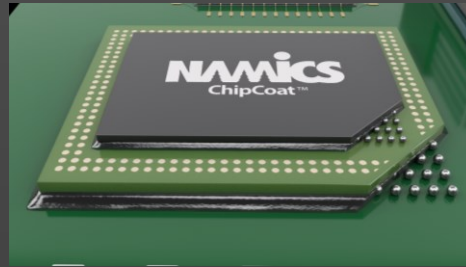
High thermal
die attach



- Unmatched thermal performance
- High reliability due to resin reinforcement and low modulus technology
- Proven ready for HVM (high volume manufacturing)

Capillary Underfill

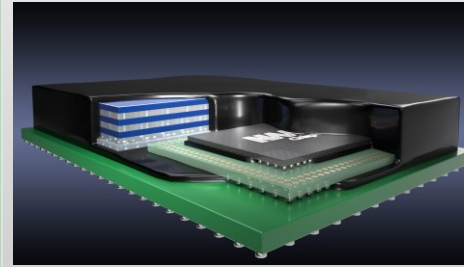
Narrow gap,
fine pitch



- Void free for narrow gap, fine pitch
- Low resin bleed for narrow KOZ (keep out zone)
- High reliability

Liquid Compression Molding

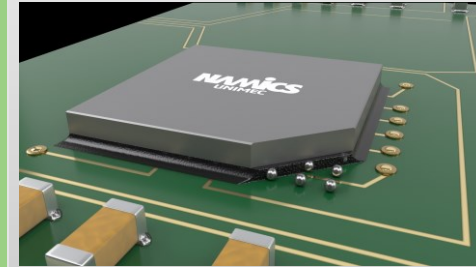
Simplified process,
low warpage



- Simplified process
- High throughput
- Reduce heat cycle improves warpage control

Board level Underfill

High reliability,
fast processing



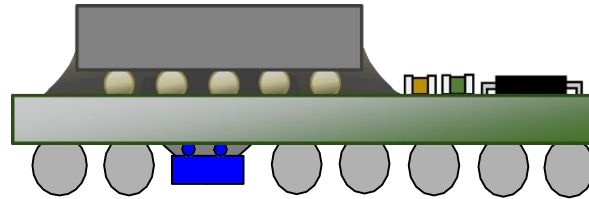
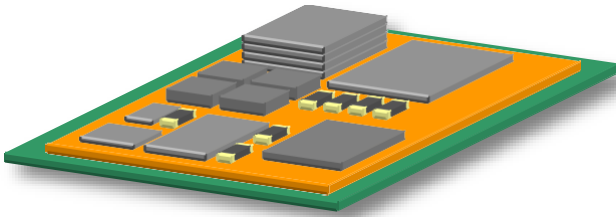
- High reliability
- Ideal for high volume production
- Meet stringent environmental requirements

Capillary Underfills Features and Challenges

Device Packaging Conference 2021 - April 12-15, 2021

■ SiP Feature

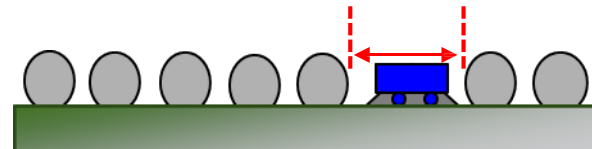
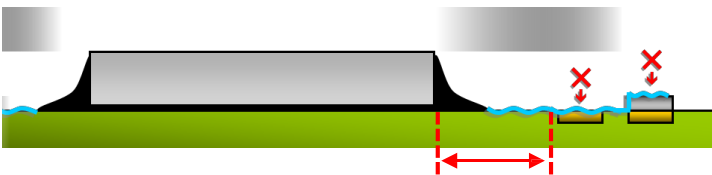
- High density packaging with several components mounted on the substrate
- Distance between each component and solder ball size is decreased with finer pitch



■ Challenge

- Narrow KOZ (keep out zone) control

Keep Out Zone (KOZ)



- ✓ Less underfill bleed
- ✓ No voids for narrow gap
- ✓ High Reliability



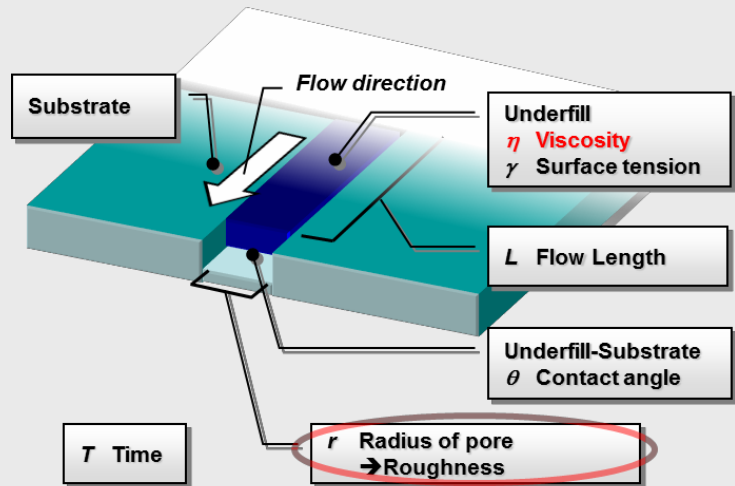
Narrow KOZ (Keep Out Zone) - RBO

■ Cause of Resin Bleed Out (RBO)

Bleed is caused by capillary action to substrate surface.

Lucas – Washburn equation
for capillary action

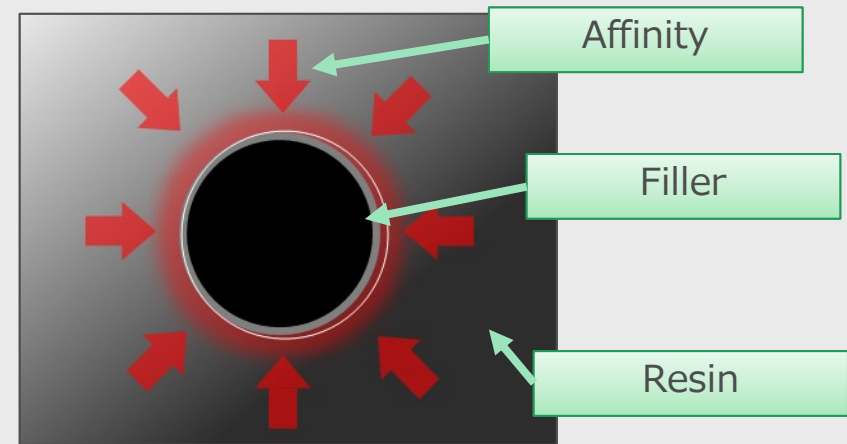
$$L = \sqrt{\frac{r\gamma \cos\theta}{2\eta} T}$$



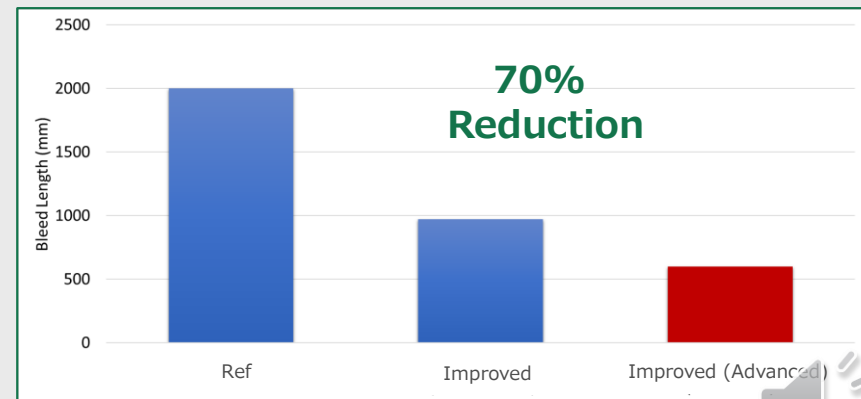
- Rough surface accelerates the bleed.
- Degree of capillary increases due to improved wettability.

■ RBO Reduction

Increase resin affinity to filler

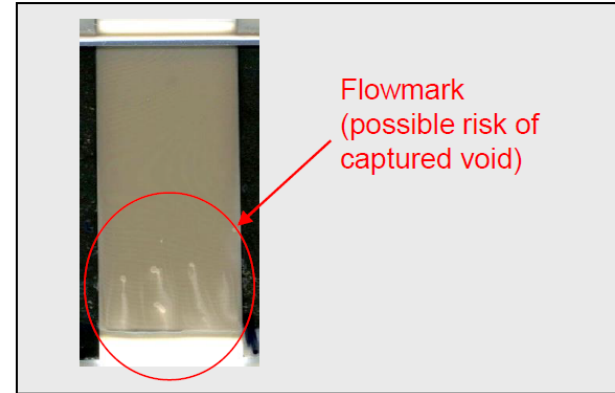
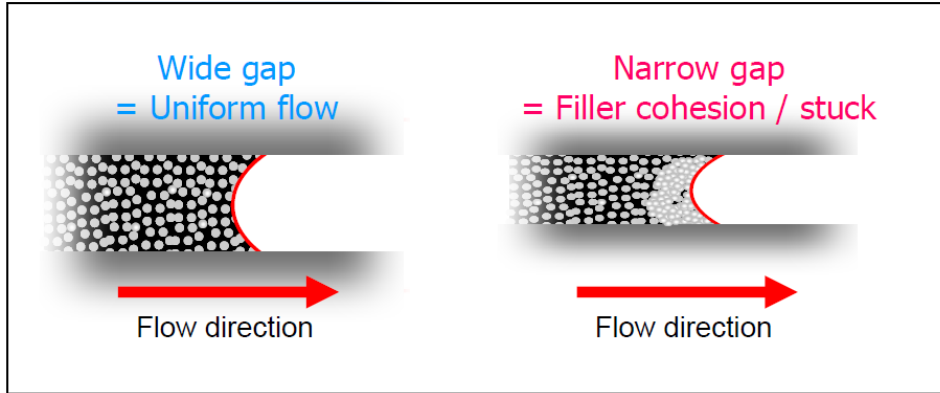


Results



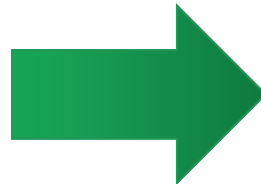
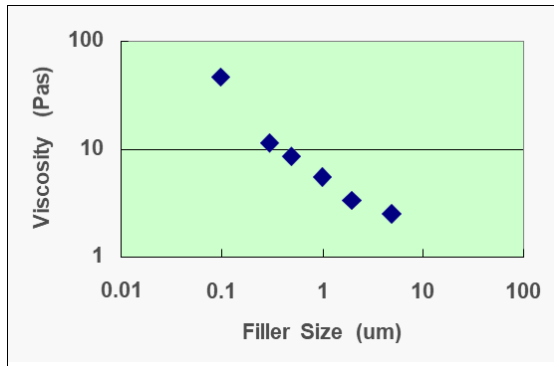
■ Filler Entrapment

- Small, narrow gaps risk for voids increases due to filler entrapment
- Flowmarks are an indicator of filler entrapment.

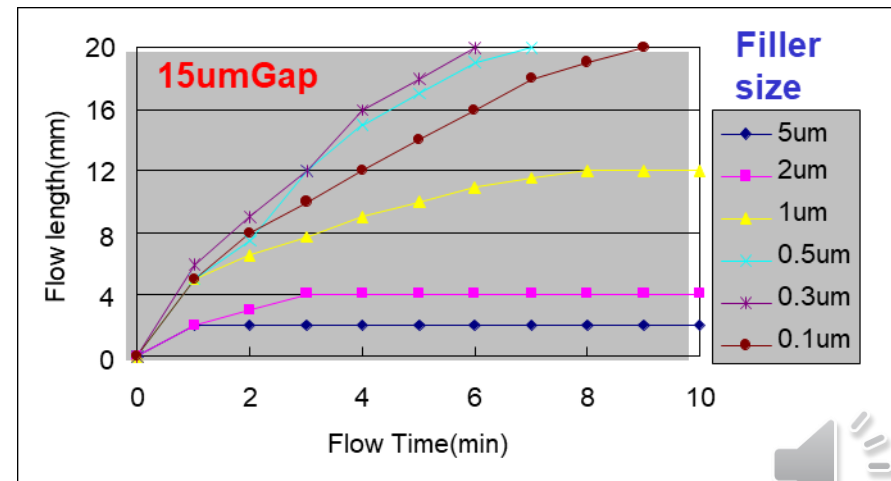


■ Filler Entrapment

Filler size needs to be finer to improve flowability.

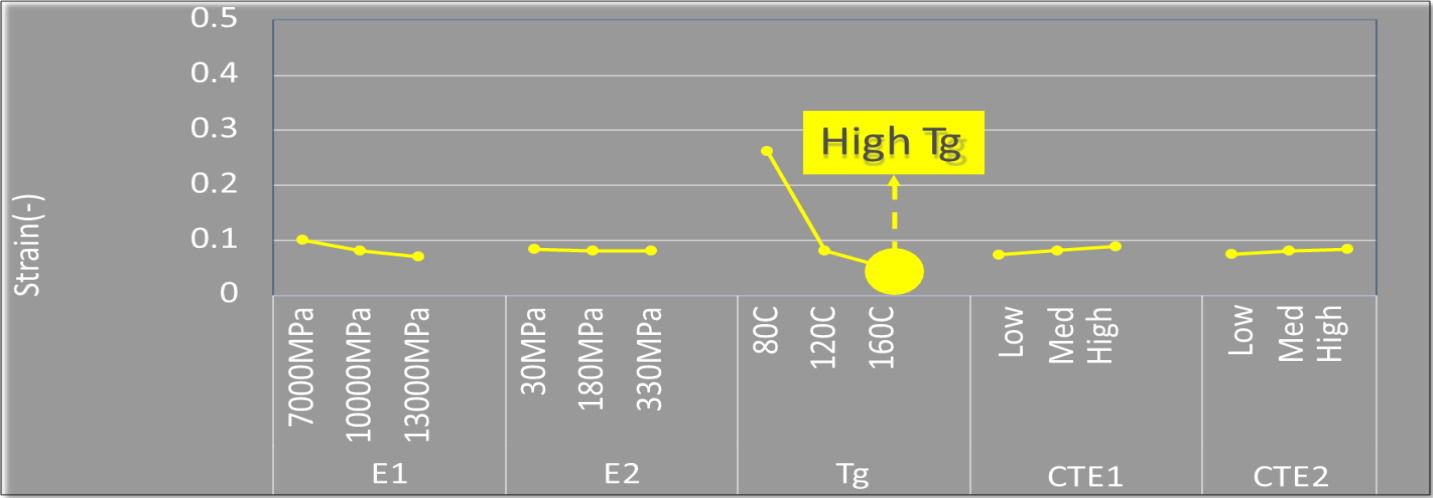
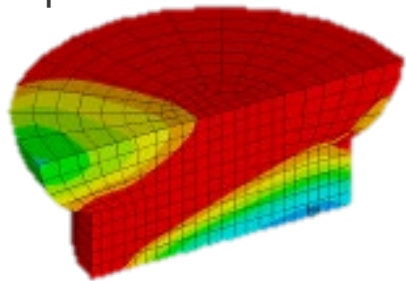


**Need to balance
filler size with viscosity
for flow**



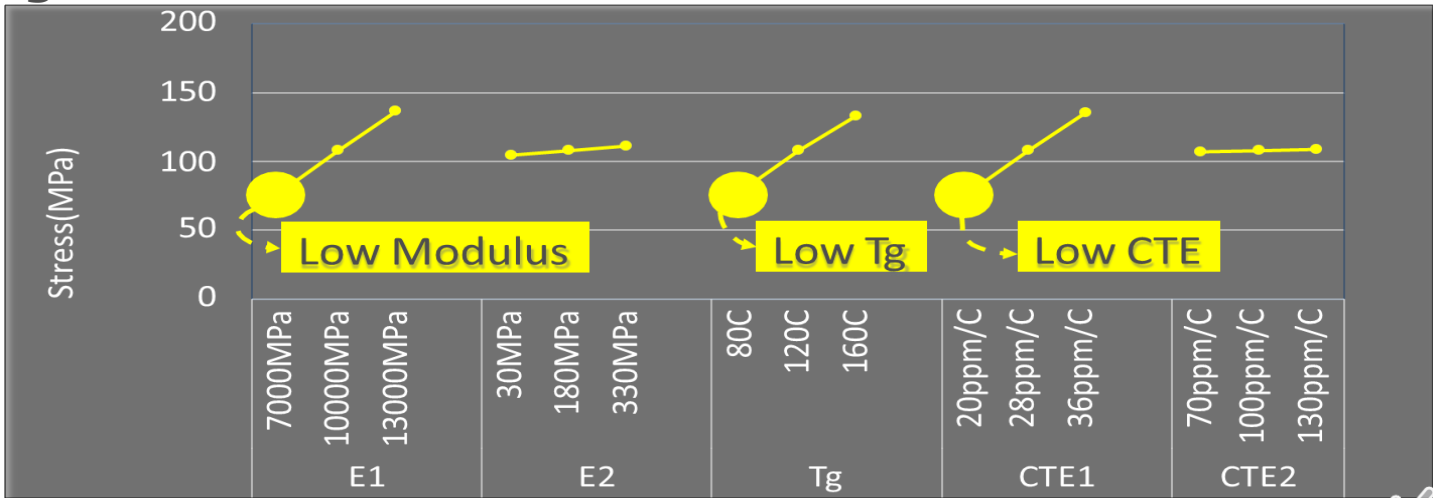
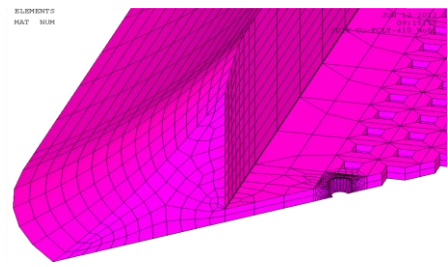
■ Reduce solder bump strain

High Tg reduces stress on solder bump



■ Reduce Fillet Cracking

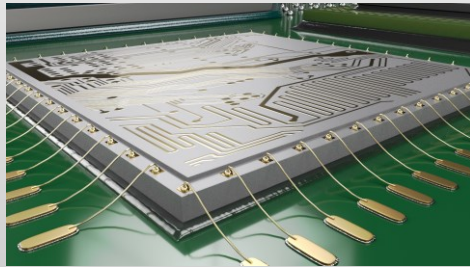
Low modulus, Low Tg and Low CTE reduces fillet cracks



Need to Optimize Properties!

Pressure-less sintering

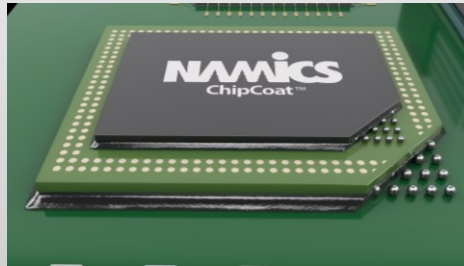
High thermal
die attach



- Unmatched thermal performance
- High reliability due to resin reinforcement and low modulus technology
- Proven ready for HVM (high volume manufacturing)

Capillary Underfill

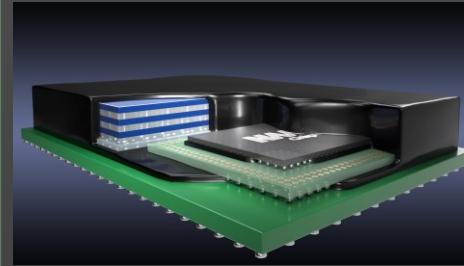
Narrow gap,
fine pitch



- Void free for narrow gap, fine pitch
- Low resin bleed for narrow KOZ (keep out zone)
- High reliability

Liquid Compression Molding

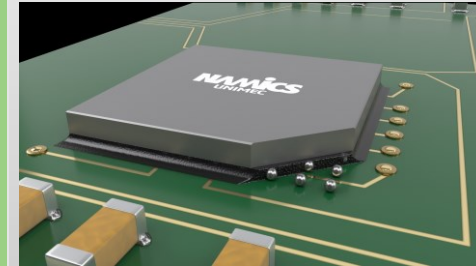
Simplified process,
low warpage



- Simplified process
- High throughput
- Reduce heat cycle improves warpage control

Board level Underfill

High reliability,
fast processing



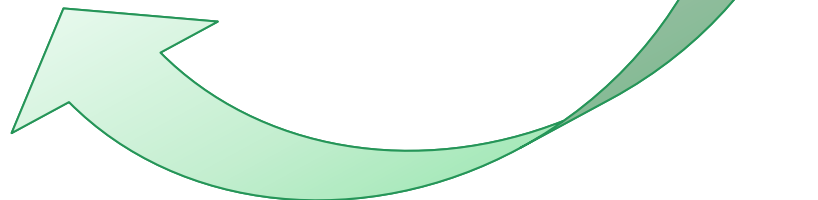
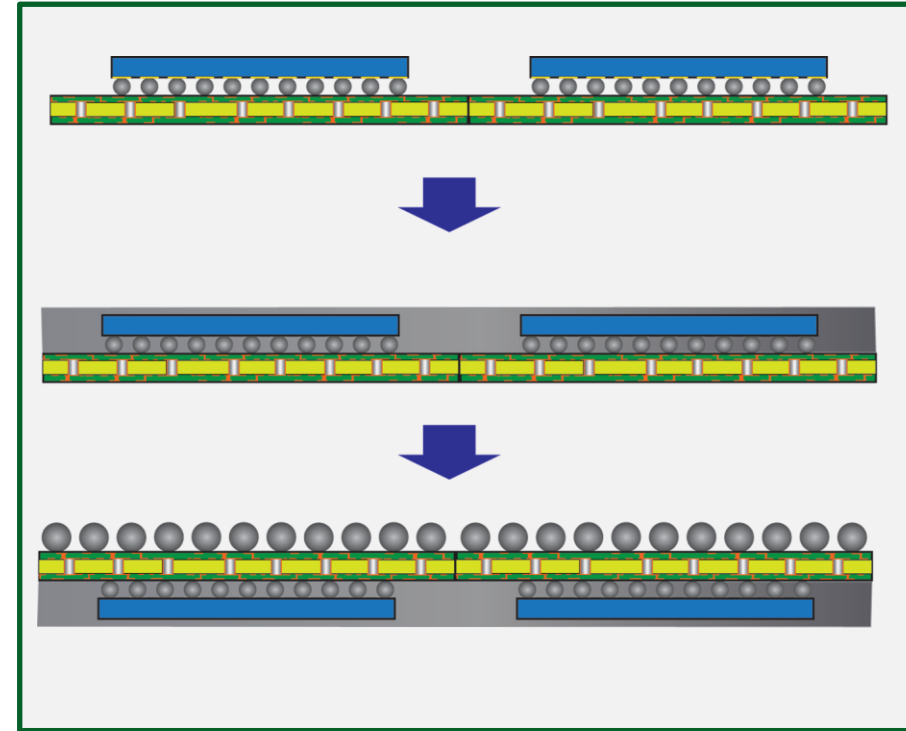
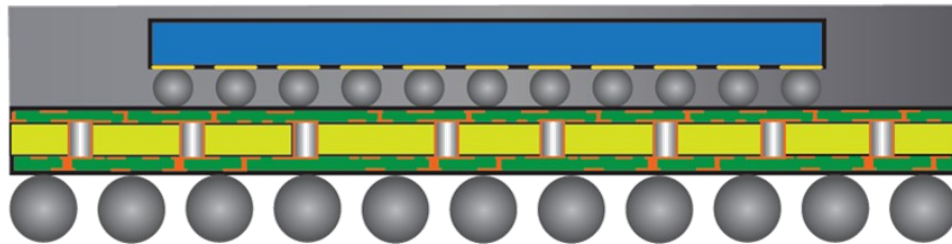
- High Tg and Low CTE to meet for reliability requirements
- Ideal for high volume production with fast flow and snap cure system
- Designed to meet stringent European Environmental requirements

Wafer Level Process for Liquid Mold Underfill

Process Advantage

- ☐ Simplified process
- ☐ High throughput
- ☐ Reduce heat cycle improves warpage control

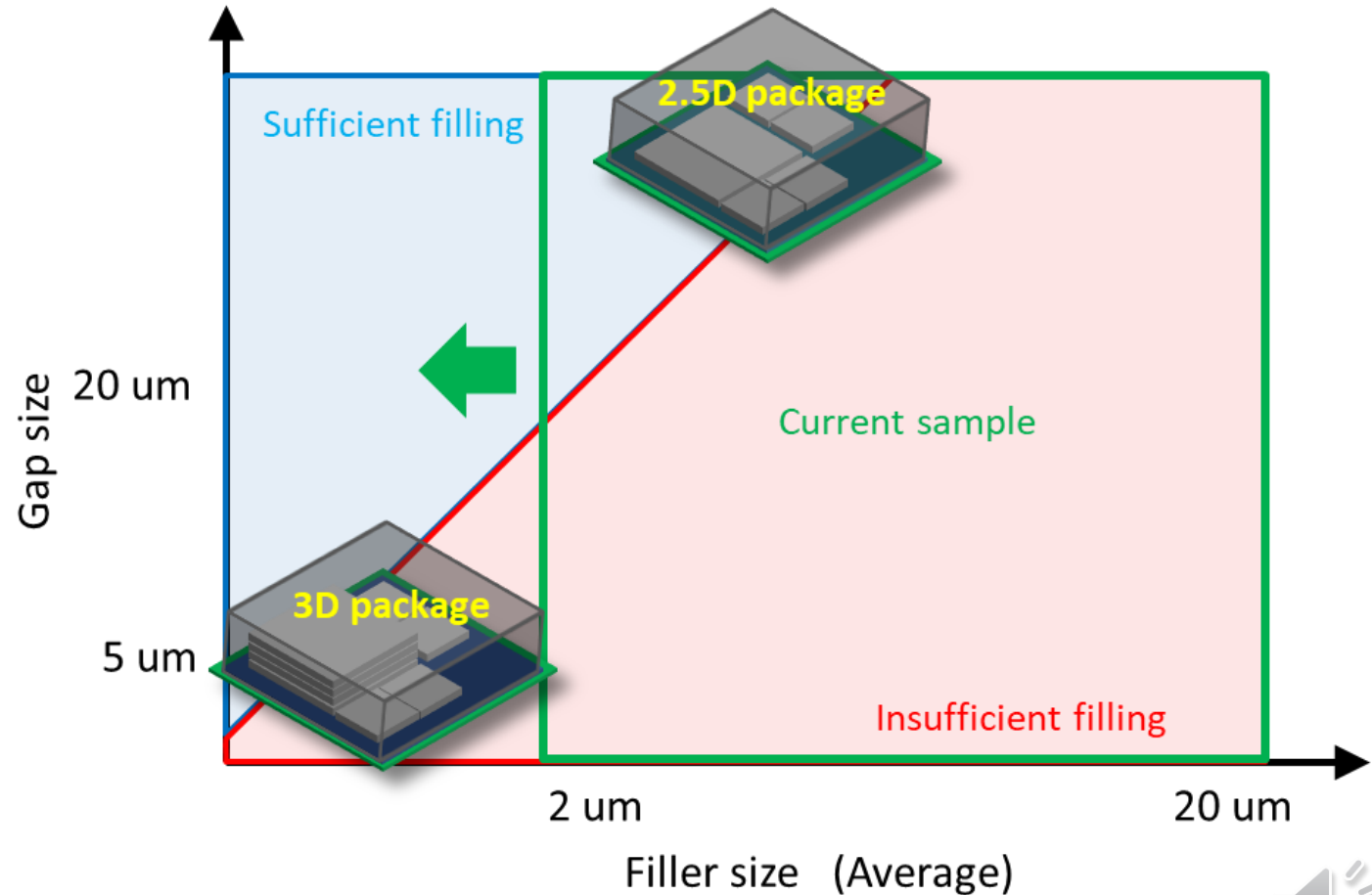
Complete Encapsulant Solution



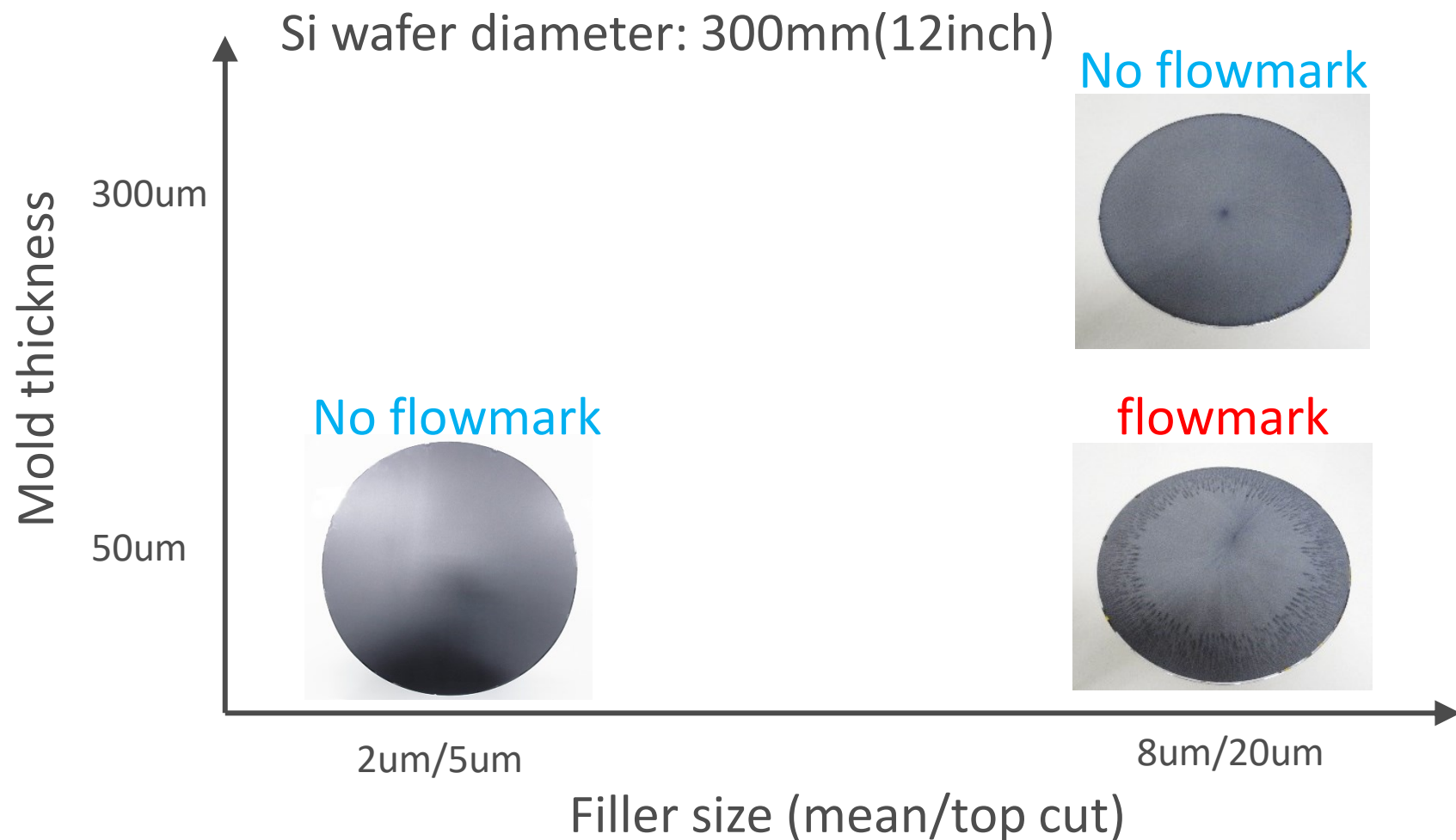
- ❑ Trend in advance package is higher density and smaller gaps
- ❑ Requires innovative solution to provide high reliability and ease of manufacturing.

Requirements

- ✓ Fine filler
- ✓ Enabling to fill over 20 μm gap
- ✓ Low warpage



Influence of filler size



❑ Evaluation

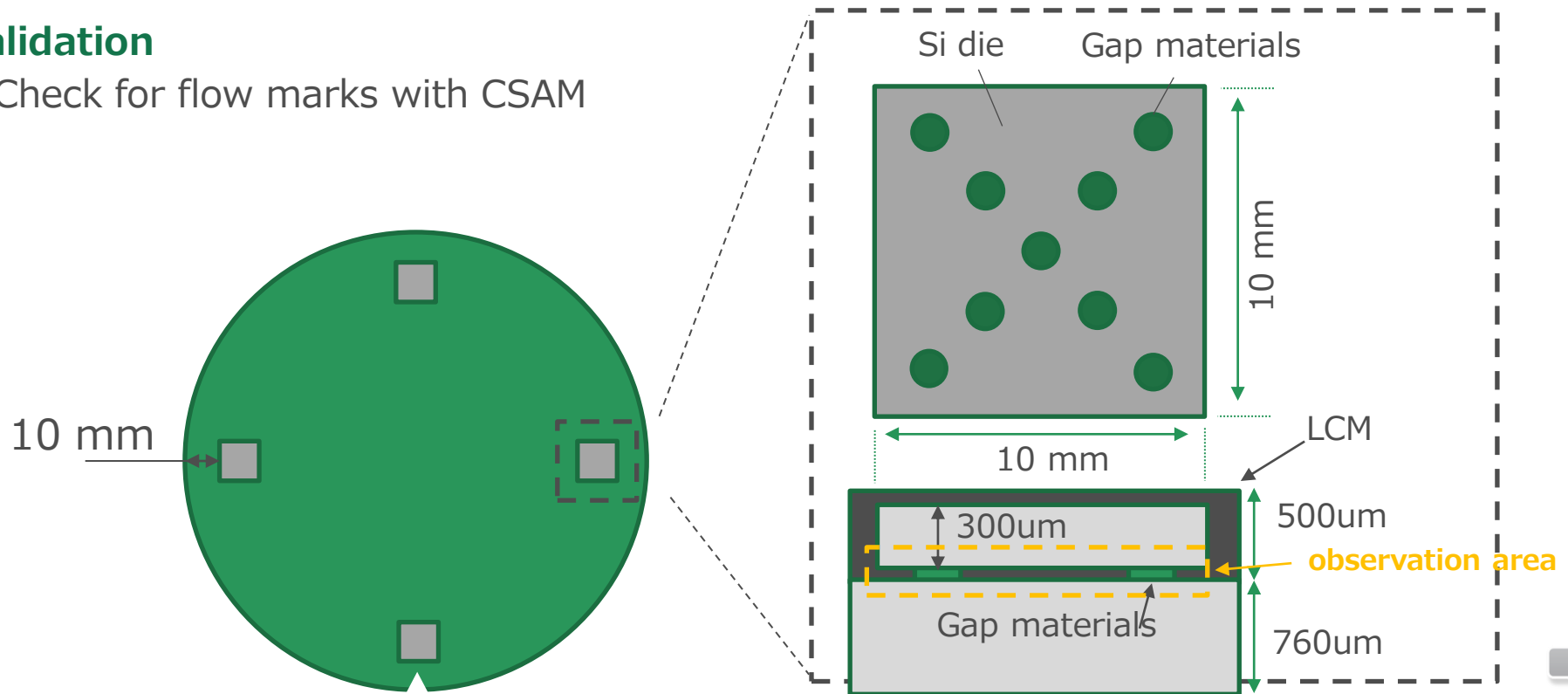
- Determine minimum gap exhibiting no flow marks

❑ Test method

- Wafer Size: 12 inch
- Mold Thickness: 500 μm
- Molding Temperature: 120 C

❑ Validation

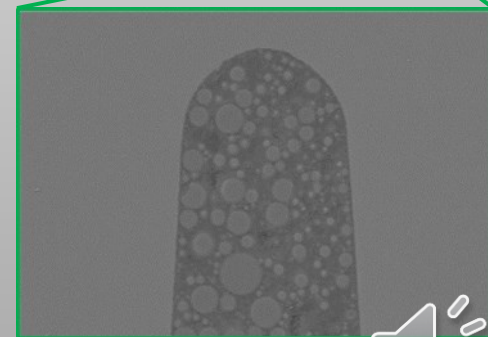
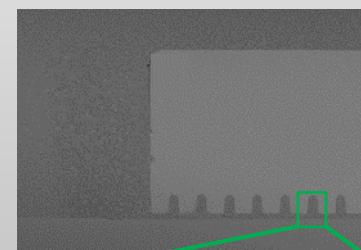
- Check for flow marks with CSAM

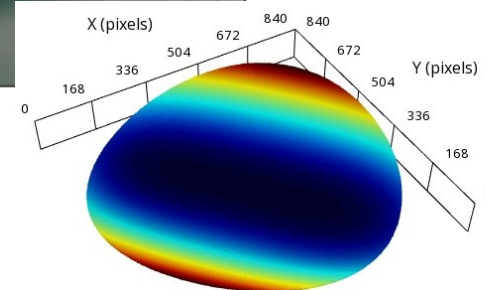
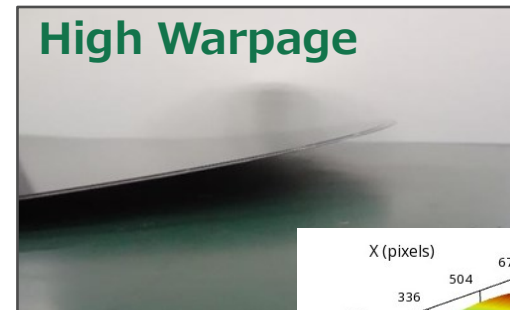
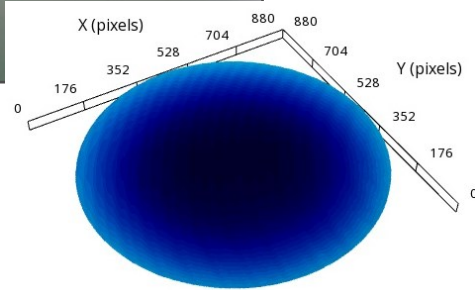


□ Result

Gap	Filling Result	
30 μm	Good	 Good
20 μm	Good	 Good
10 μm	Flowmark	 Flowmark

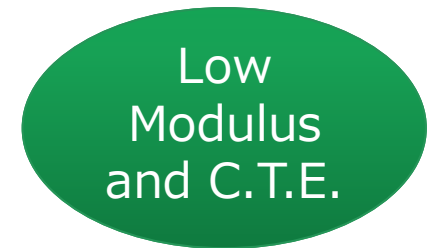
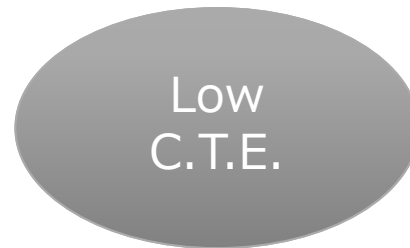
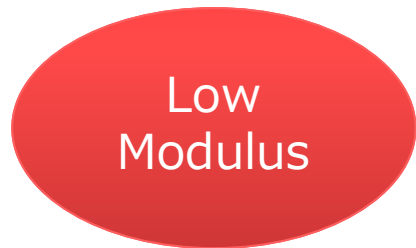
*High flowability
down to
20 μm gaps*





□ Concept for low warpage

- Lower stress will result in low warpage



Trade-off

✓ Lower filler content

✓ Lower modulus materials



✓ Higher filler content

✓ Higher filler content

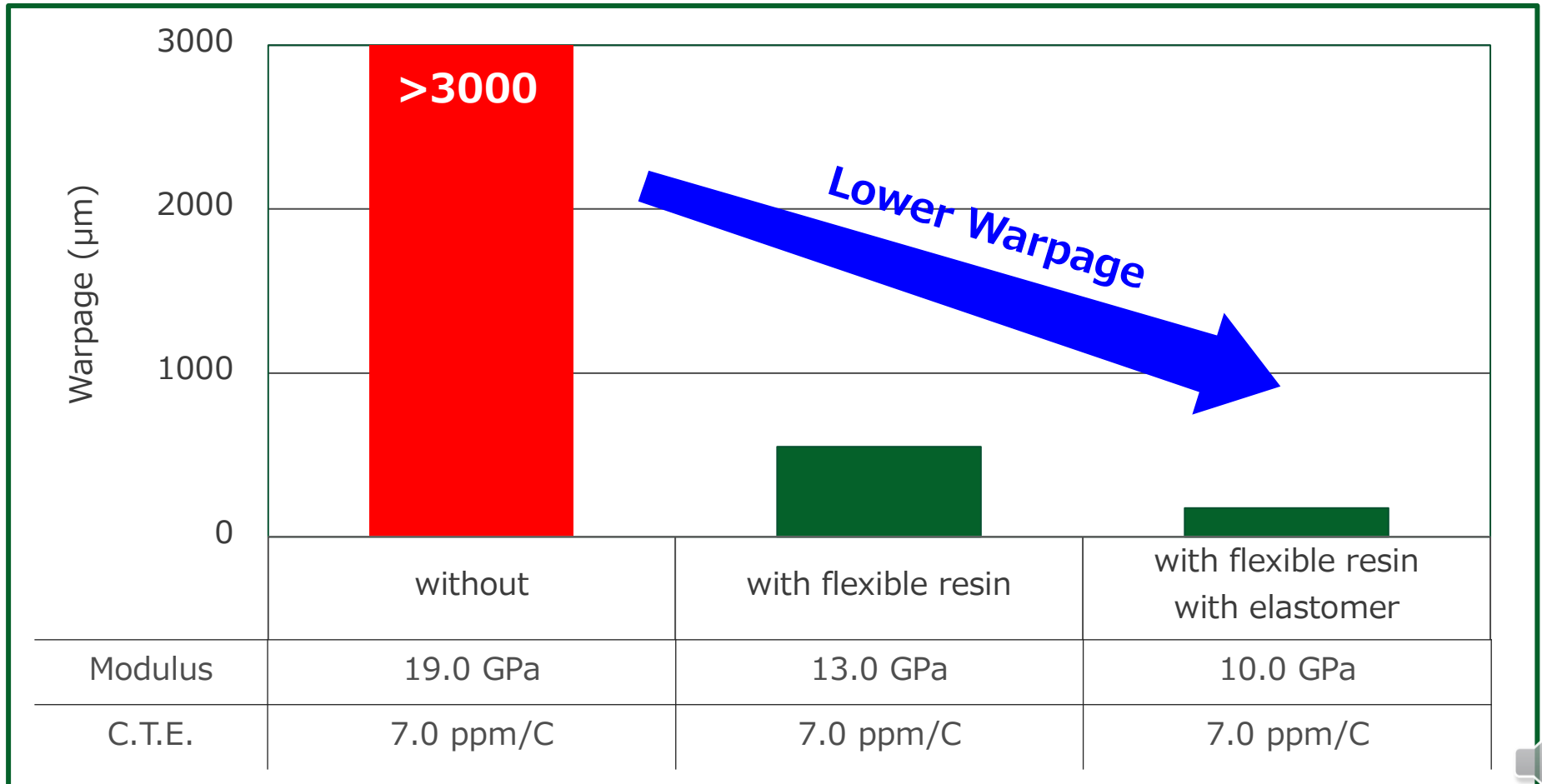
✓ Using elastomer

✓ Using flexible resin



□ Results for low warpage

- Warpage on 300 mm (12 inch) wafer after post molding conditions (PMC)
- Evaluating same filler amount (i.e. same C.T.E.)
- Comparing addition of flexible resin system and elastomer

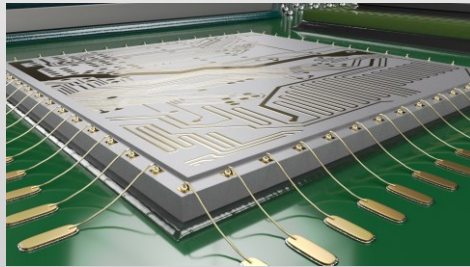


Solutions for SiP Packaging

Device Packaging Conference 2021 - April 12-15, 2021

Pressure-less sintering

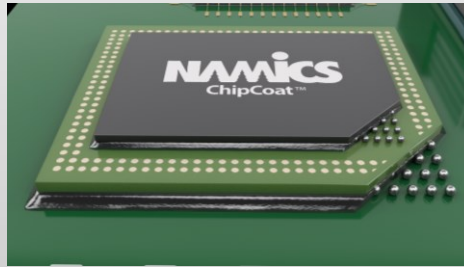
High thermal
die attach



- Unmatched thermal performance
- High reliability due to resin reinforcement and low modulus technology
- Proven ready for HVM (high volume manufacturing)

Capillary Underfill

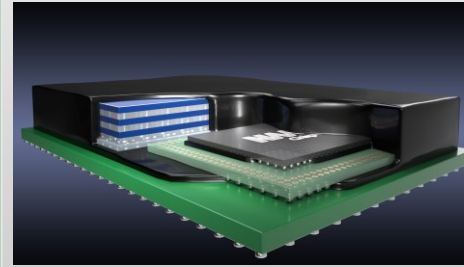
Narrow gap,
fine pitch



- Void free for narrow gap, fine pitch
- Low resin bleed for narrow KOZ (keep out zone)
- High reliability

Liquid Compression Molding

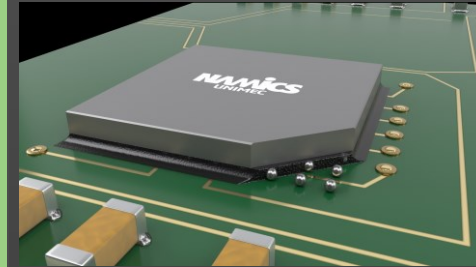
Simplified process,
low warpage



- Simplified process
- High throughput
- Reduce heat cycle improves warpage control

Board level Underfill

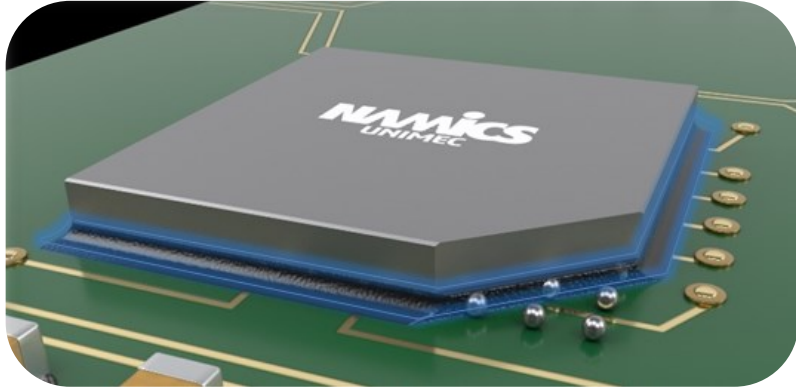
High reliability,
fast processing



- High reliability
- Ideal for high volume production
- Meet stringent environmental requirements

Board Level Underfill (BLUF) Needs

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- Increase reliability
- Enhanced mechanical shock resistance
- Improve thermal cycle performance
- Drop resistance and vibration protection
- Thermal reliability
- Moisture resistance



Automotive needs:

- ☐ **High Tg** and **Low CTE** to meet for reliability requirements
- ☐ Ideal for high volume production
 - ☐ Fast flow
 - ☐ Snap cure system
- ☐ Green – meets requirements for upcoming REACH 2022, Annex XIV

Packaging evolution:

- ☐ CSP/BGA package are increasing
- ☐ Chip size is getting larger >10mm²
- ☐ Smaller ball size <0.4mm
- ☐ Finer ball pitch <0.5mm



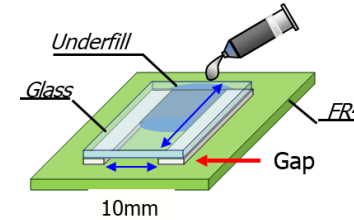
Test flow rate of each SUF to determine package size based on design criteria

Judgement criteria

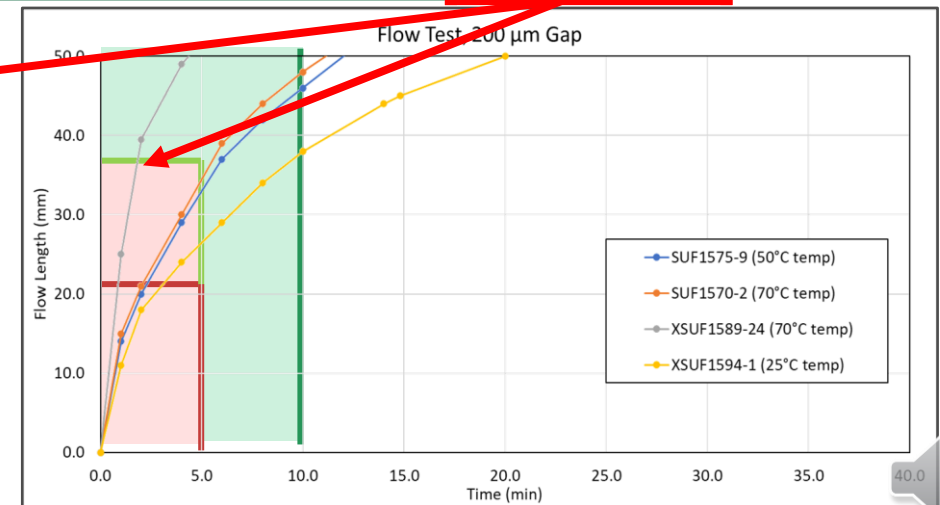
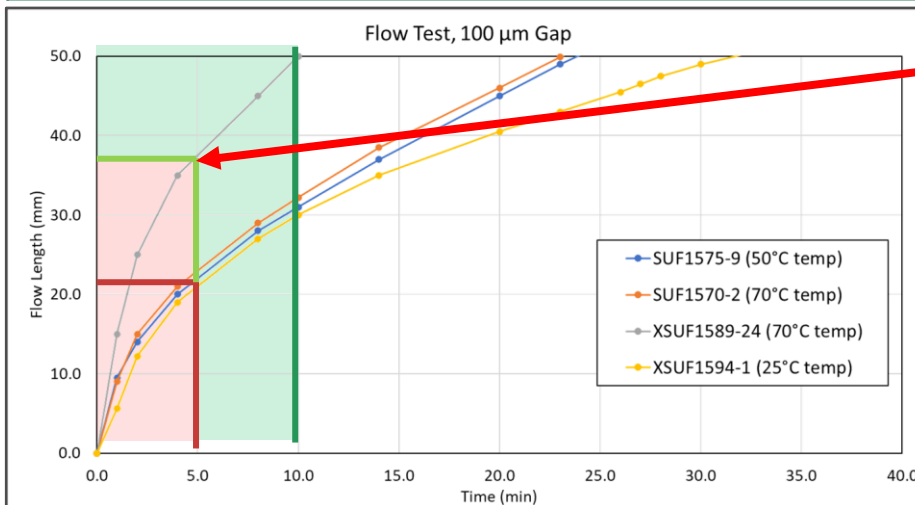
Package size of $\leq 20\text{mm}$ $\rightarrow$ Flow 20mm in 5 min

Package size of $\leq 35\text{mm}$ $\rightarrow$ Flow 35 mm in 5min

Package size of $\leq 35\text{mm}$ $\rightarrow$ Flow 50mm in 10min



Package Gap (Ball Height)	Package Size	SUF1575-9	SUF1570-2	XSUF1594-1	XSUF1589-24
100 μm	<20 mm	●	●	●	●
	<35 mm				●
	>35 mm				●
200 μm	<20 mm	●	●	●	●
	<35 mm	●	●	●	●
	>35 mm				●

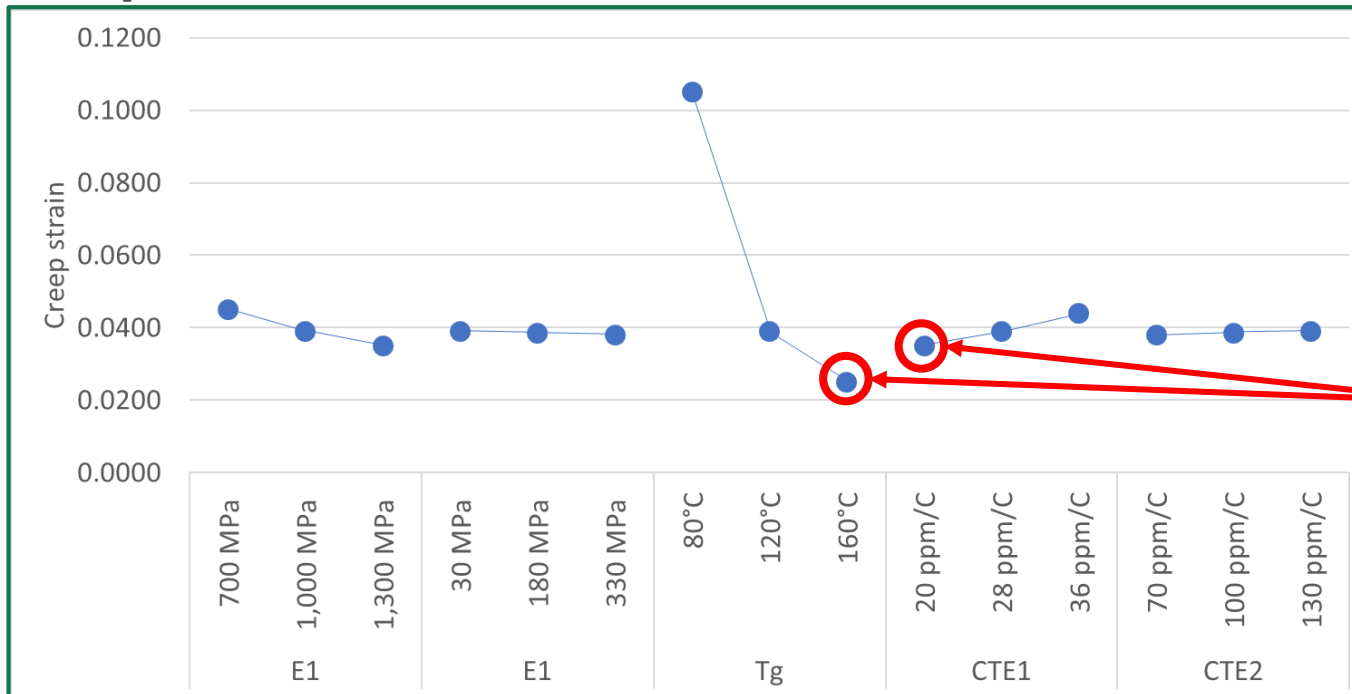


This is only for reference and the results may differ depending on the package specification.

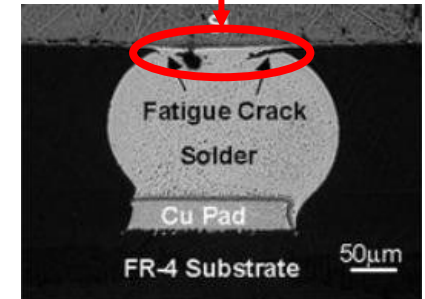
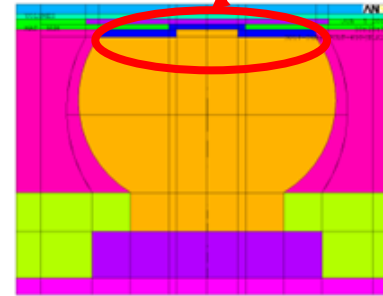
High reliability for low bump stress

High Tg and Low CTE improve to the protection of solder ball connection.

Bump Strain



High Stress Area



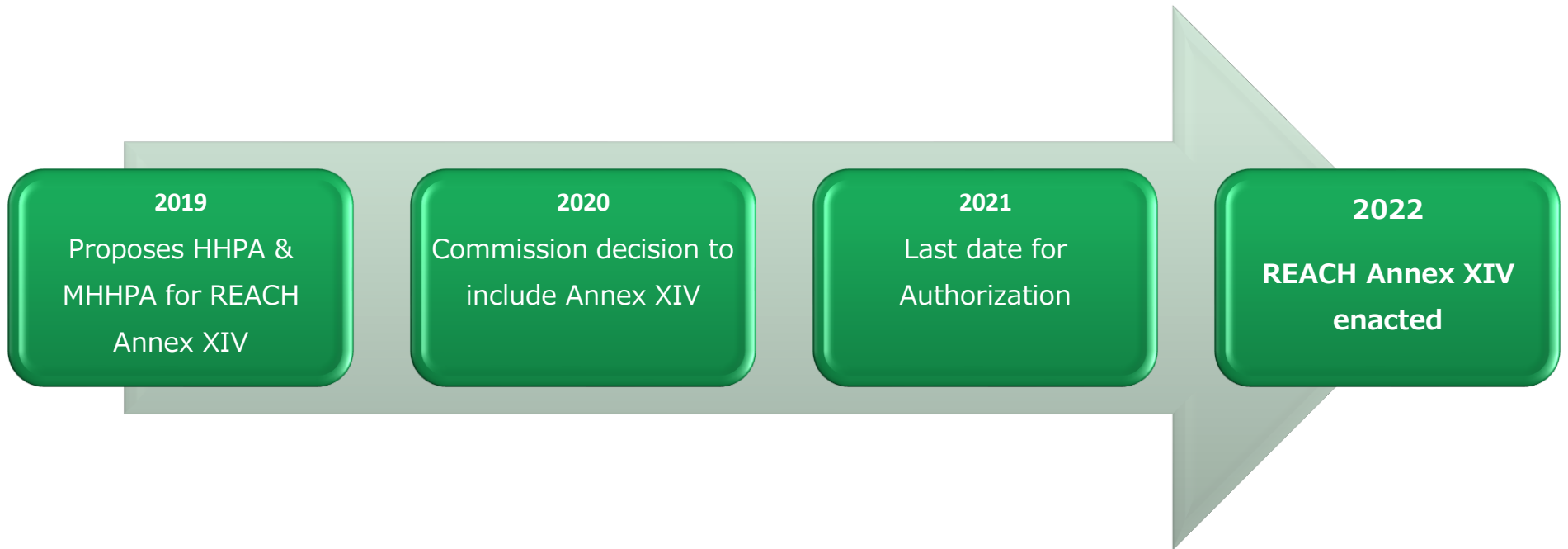
Ideal Underfill
High Tg >160°C
Low CTE <20 ppm



New REACH Requirements

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ECHA (European Chemicals Agency) has added 18 new chemicals to REACH affecting current board level underfills (BLUF) and cornerbond materials used in electronic assembly.



NAMICS Board Level Underfill (BLUF) are designed to meet Future REACH 2022 Annex XIV!



- **Growth of ADAS** will require advanced packaging to meet future requirements
- SiP packaging will need **advanced material solutions** to handle:
 - *Increase in thermal dissipation*
 - *Small form factor*
 - *High reliability to meet future automotive applications*
- Innovative solutions to handle these upcoming package challenges include:
 - **High thermal conductive adhesives**
 - High thermal performance
 - High reliability
 - Proven ready for HVM
 - **Capillary Underfill**
 - Void free for narrow gap, fine pitch
 - Designed narrow KOZ (keep out zone)
 - High Reliability
 - **Liquid compression molding**
 - Simplified process
 - High throughput
 - Reduce heat cycle improves warpage control
 - **Board Level Underfills**
 - Designed for high reliability
 - Ideal for high volume production
 - Meet stringent environmental requirements





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