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A Study of Low Temperature Solder on Microstructure and Reliability

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Presenter: Nokibul Islam
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CONTENTS

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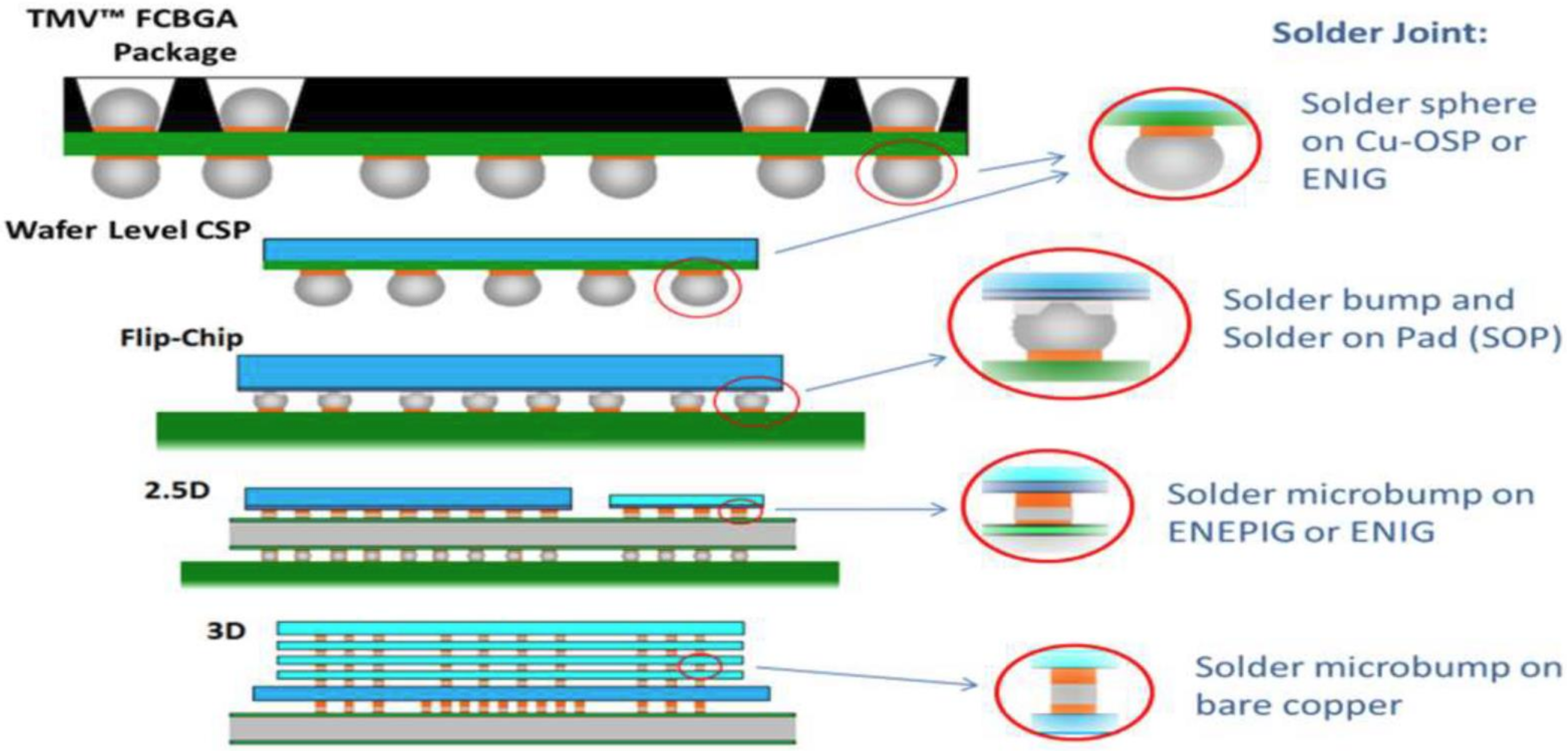
CONTENTS

Background

- Solder Joints in Heterogeneous Integration Assembly.

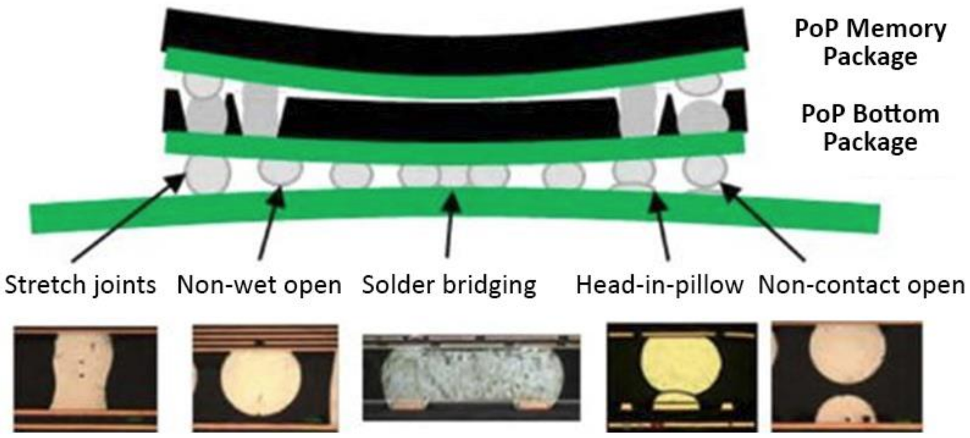


Ref., Indium

Background

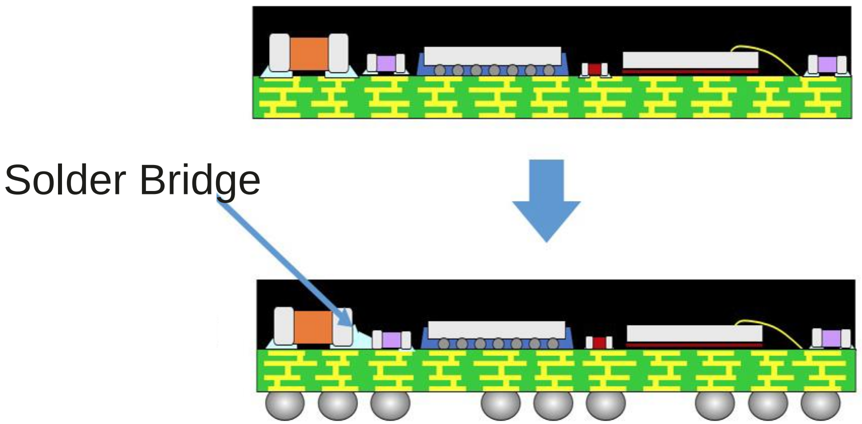
- The low thermal load on the packages minimizes warpage issues during the high-temperature solder reflow.

Typical defects on PoP package



Ref., SMT Magazine, pp. 68-76, 2016.

Solder remelting during Multi-reflow in SiP Package



Ref., Morgana Ribas, et al., Alpha Assembly Solutions, 2018

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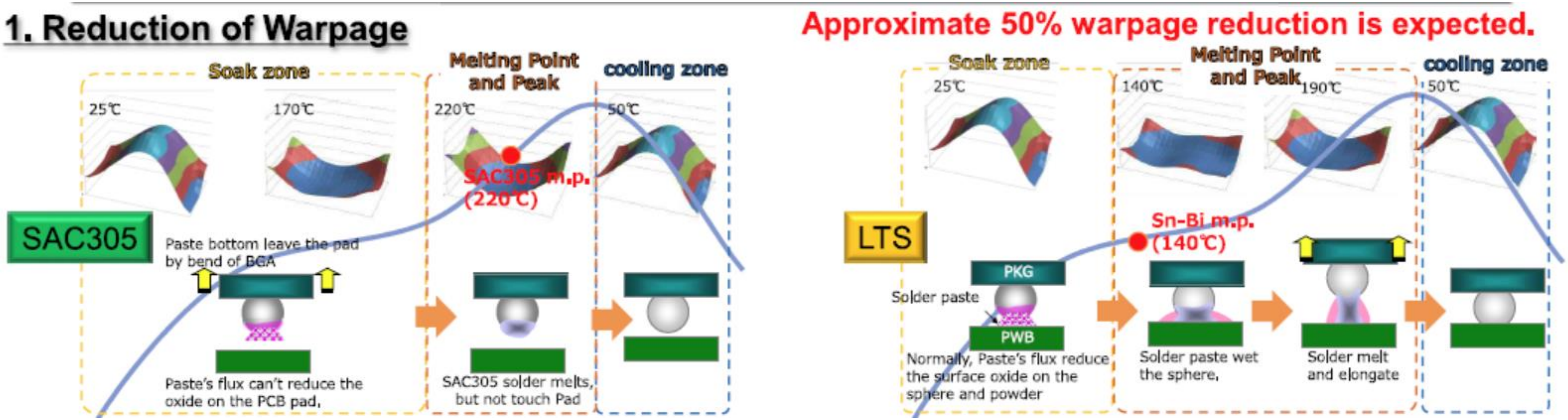
- The low thermal load on the packages minimizes warpage issues during the high-temperature solder reflow.

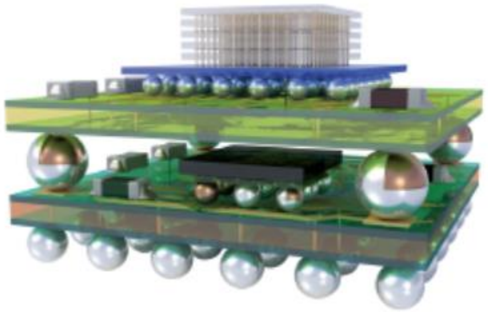


Ref., Senju

Background

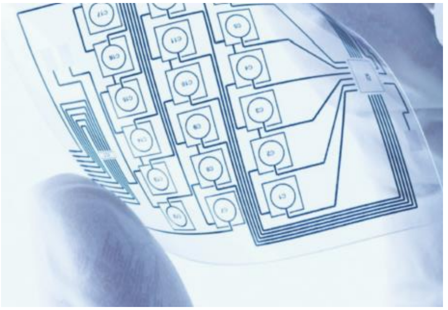
- Application

Consumer/LoT (High Density SiP)



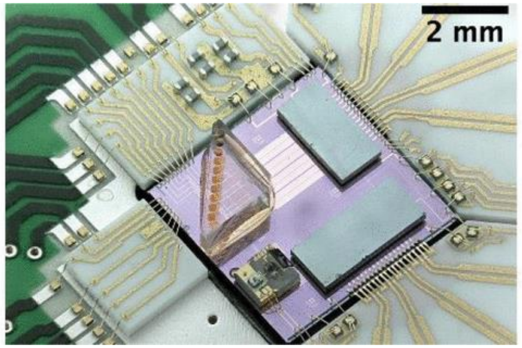
Ref., Senju & Alpha

Wearable Devices (Flexible Circuits)



Ref., Alpha

Energy (Photonic modules)



Ref., L. Ranno et al., ACS Photon., pp. 3467–3485,2022.

Background

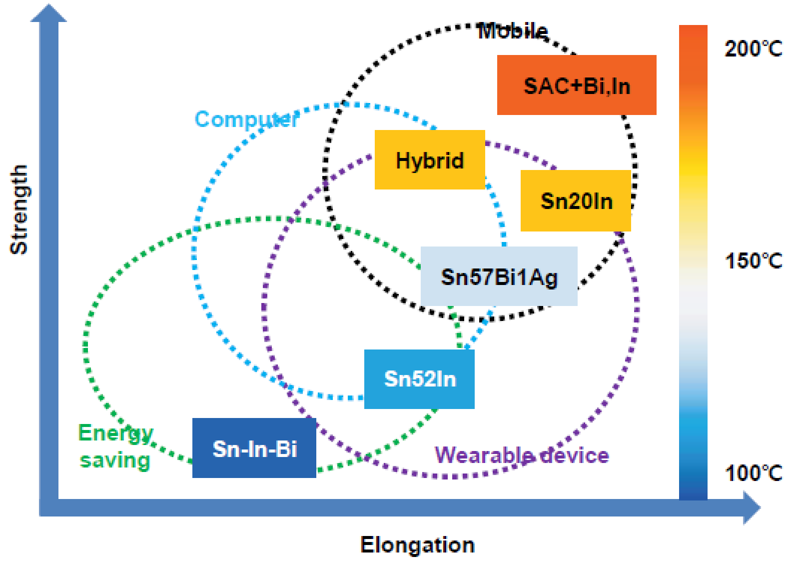
- Typically, the solder is reflowed at about 20℃ higher than the melting temperature to ensure complete melting, followed by a controlled cooling rate that determines the microstructure of the solder.
- Bi-Based and In-Based systems are the two most widely researched low temperature solder (LTS) types, due to their melting temperatures and compatibility with existing manufacturing processes.

Classification of assembly process based on peak reflow temperature

ASSEMBLY PROCESS	PEAK TEMPERATURE
High Temperature	>250°C
SAC	235 – 250°C
Medium Temperature	195 – 210°C
Low Temperature	130 – 200°C
Ultra Low Temperature	<110°C

Ref., Morgana Ribas, et al., Alpha Assembly Solutions, 2018

Bi-Based and In-Based LTS



Ref., Duksan

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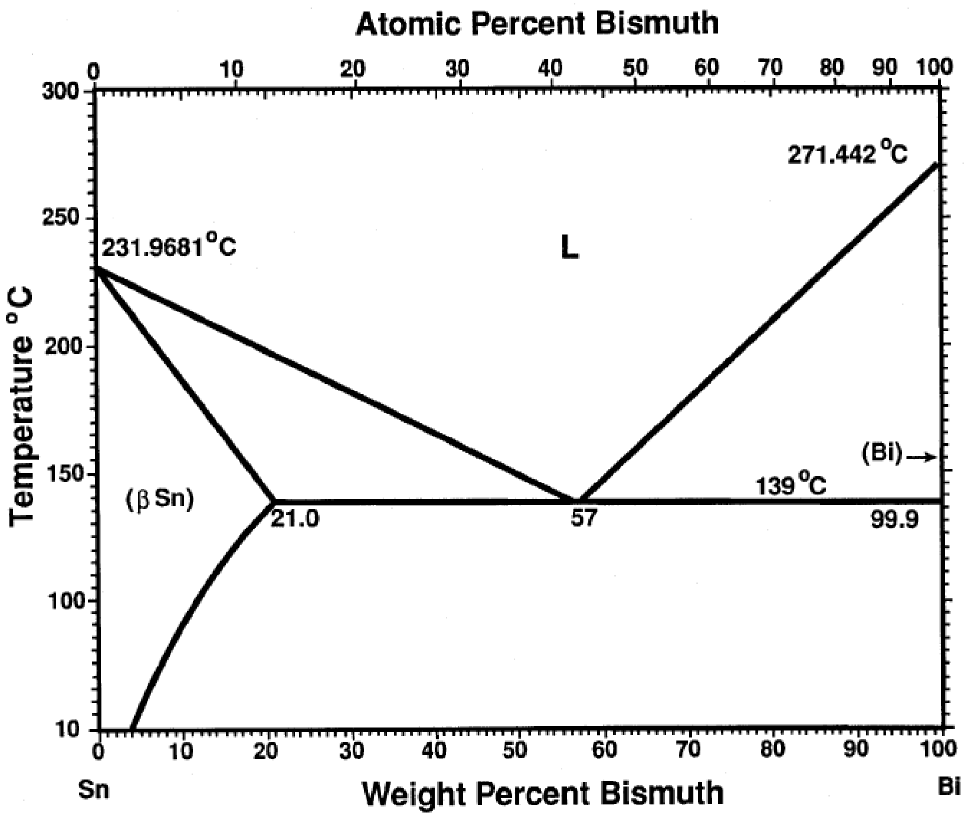
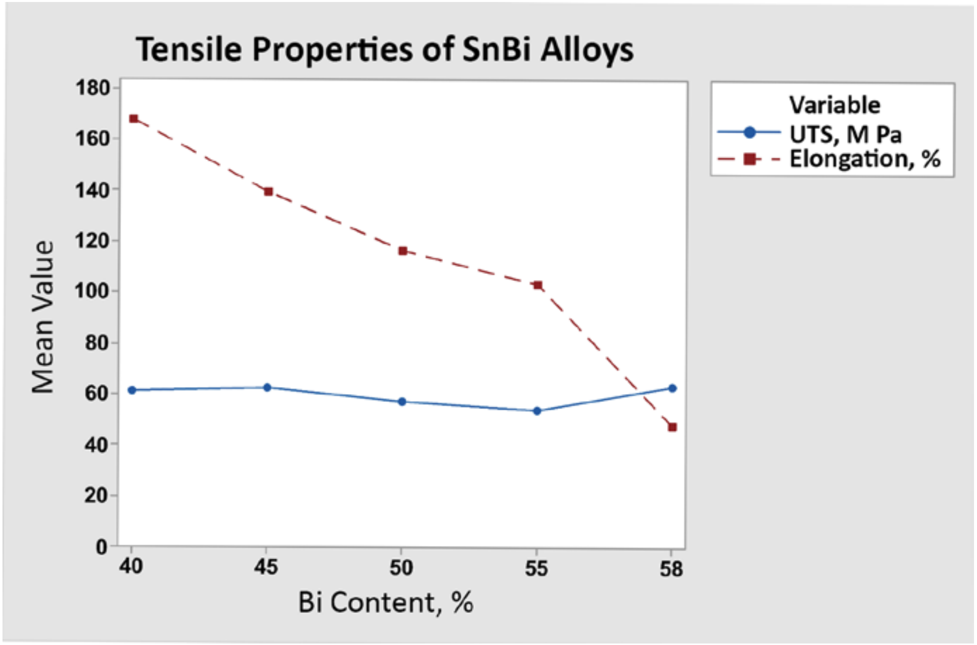
- Sn-Bi alloys have been the most widely used LTS, because the melting point lower than SAC, but higher melting point than Sn-In alloys to provided a better thermal reliability.

Binary alloy phase diagram of the Bi-Sn system



(Ref., ASM International)

The ultimate tensile strength (UTS) and elongation of SnBi alloys



(Ref., IEEE 15th EPTC, pp. 53-57)

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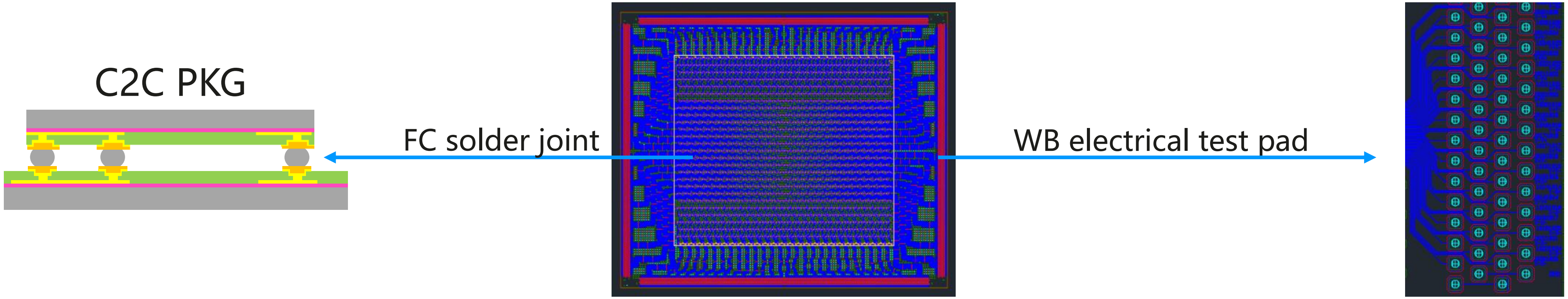
**A Study of
Low Temperature Solder
on
Microstructure and Reliability**

CONTENTS

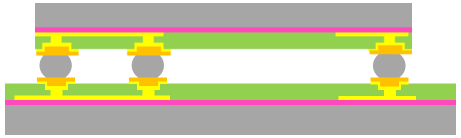
Test Vehicle Information



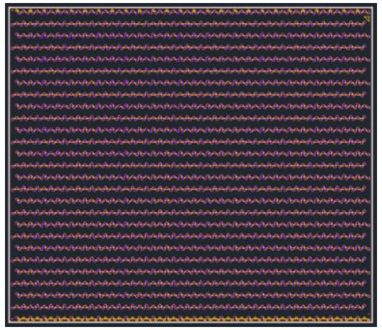
Category	Items		Information	Remark
Package	Application		**LTS Study**	C2C PKG selected to minimize warpage effect of C2S PKG, and focused on LTS study only. After LTS behavior clarified, application can be promoted to other types of PKG, such as fcBGA, SiP, etc.
	Package Type		**C2C**	
Top Die Interface	Study of Interface	UBM-Top	**CuNiAu**	Interface Au(0.3um)
			CuSnAg	Interface Cu, and SnAg(1um) for anti-oxidation
Ball	Study of LTS	POR Ball	**SAC305**	As control group
		LTS Ball	**SnBi(57)Ag**	LTS, melting temp. 139℃
			SnBi(35)AgNi	LTS, melting temp. 139-184℃
Bottom Die Interface	Study of Interface	UBM-Bot	**Cu**	Interface Cu, following with ball drop process
			CuNiAu	Interface Au(0.3um)

Test Vehicle Information

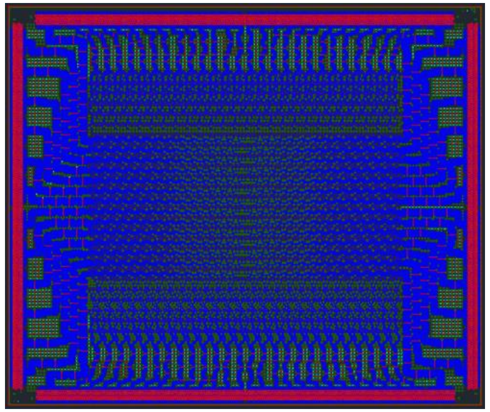
C2C PKG



Top Die
(1P2M)



Bottom Die
(1P2M+Ball Drop)



Category	Items	Information
Package	Application	LTS Study
	Package Type	C2C
	Package Size/Thickness	43x38mm
Top Die	Die Type	1P2M
	Die Size(with scribe line)	30x25mm
	Die Thickness	750um
	Ball Pitch / UBM Size	300um/145um
	UBM Material	CuSnAg/CuNiAu
Bottom Die	Die Type	1P2M+Ball Drop
	Die Size(with scribe line)	43x38mm
	Die Thickness	750um
	UBM Material	Cu/CuNiAu
	Ball material	SAC305 SnBi(57)Ag/SnBi(35)AgNi
	Ball Pitch	300um
	Ball Pad	145um
	Ball Size	150um

BOM

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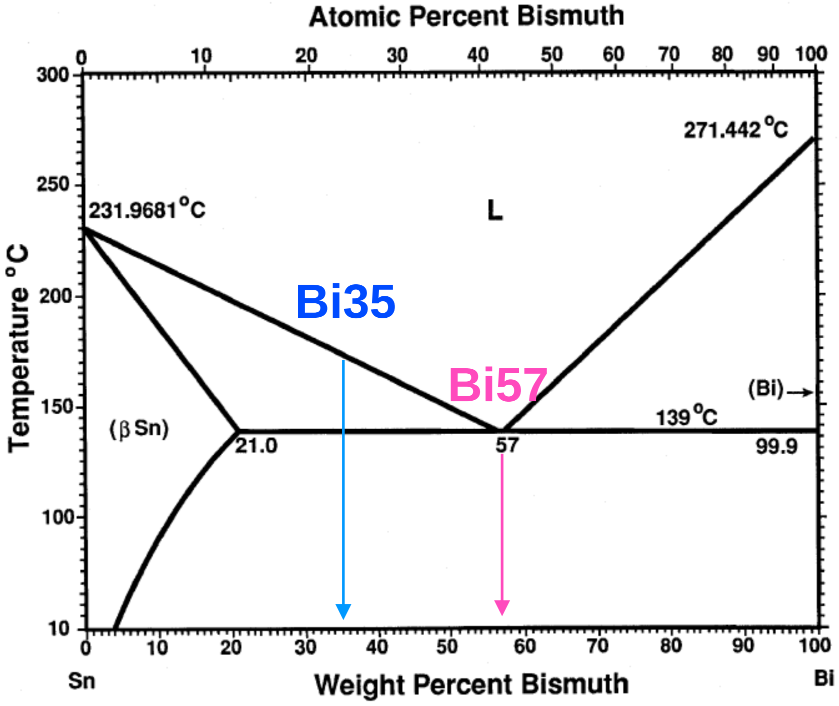

Low temp solder ball

LTS	SnBiAg	SnBiAgNi
Alloy Type	Eutectic	Non-Eutectic
Bi Content (wt%)	57	35
Melting Point (°C)	139	139-184
Tensile Strength (MPa)	74.3	81.3
Elongation (%)	41	54
Dopant-Ag	Creep deformation suppressed, improved TC reliability	
Dopant-Ni	NA	IMC growth suppression

Flux

Item	Flux(SAC)	Flux(LTS)
Flux Type	Water Soluble	Water Soluble
Viscosity (Pa*s)	32	40
Thixotropic index	0.6	NA
PH	2.7	5.7
Halogen content (ppm)	<20	Halogen Free
Tackiness (gf)	>150	100-200
Process	Printing Pin Transfer Dipping	Printing Pin Transfer Dipping

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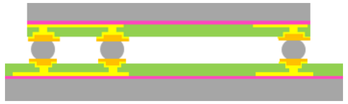
A Study of
Low Temperature Solder
on
Microstructure and Reliability

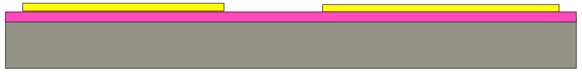
CONTENTS

Bottom Die Process Flow (1P2M+Ball drop)

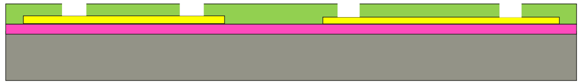


A1: Incoming wafer(0.5um SiO2)

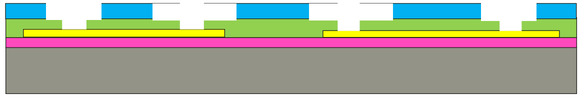
A2: Photo(M1)



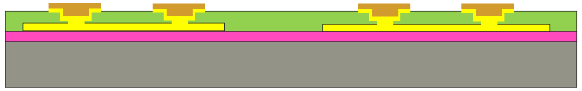
A3: Plating(M1)/AOI



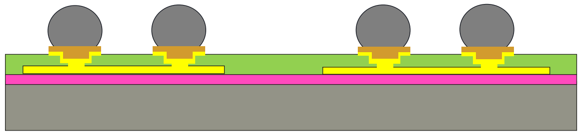
A4: Photo (PI1)



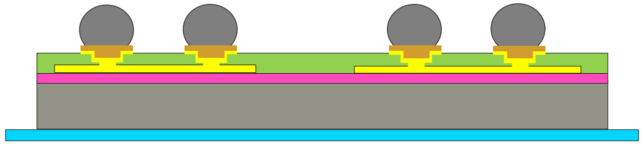
A5: Photo (M2)



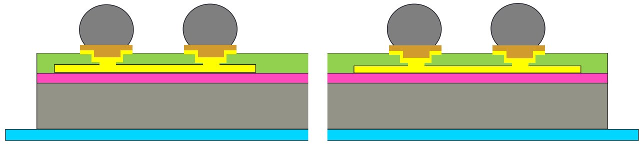
A6: Plating(M2)/AOI



A7: Ball drop and reflow/AOI



A8: Taping

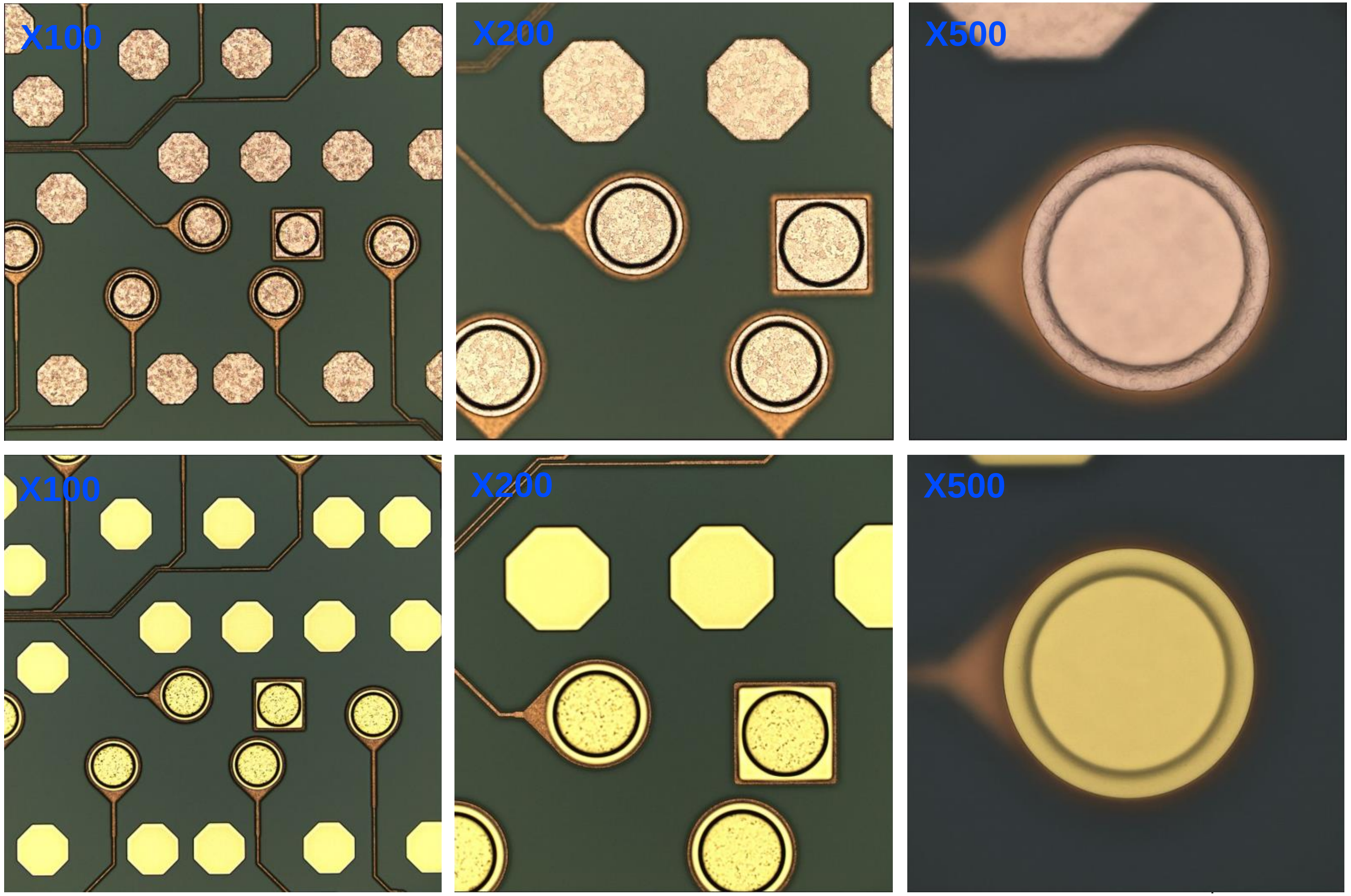


A9: Dicing

BOT Die Surface Finish

UBM: Cu

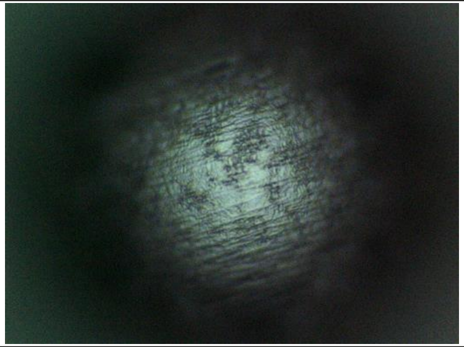
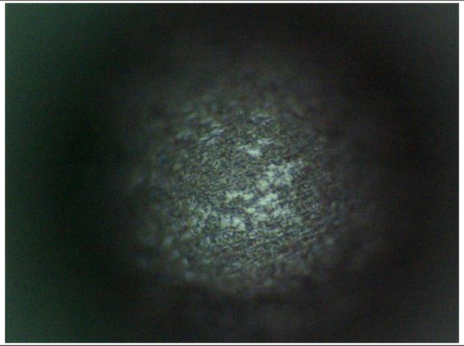
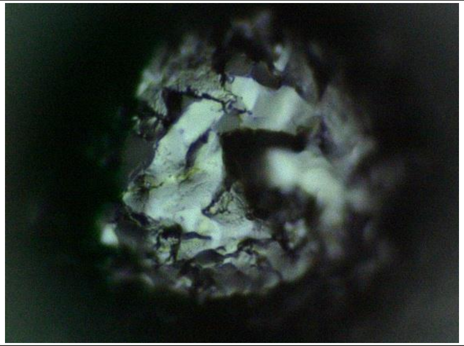
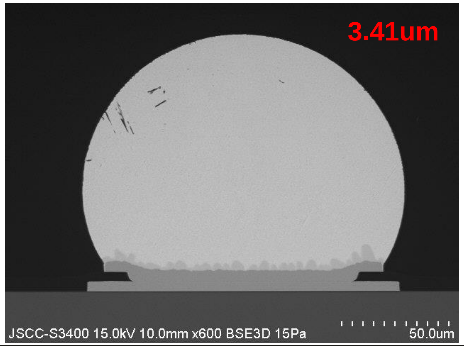
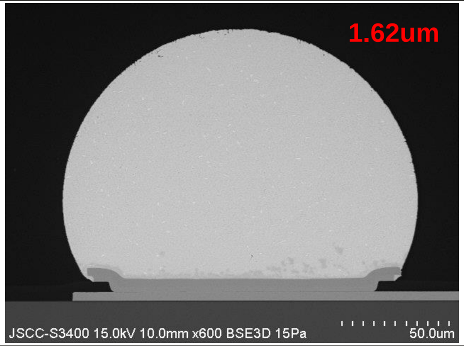
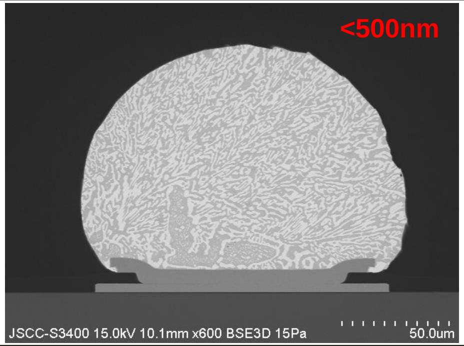
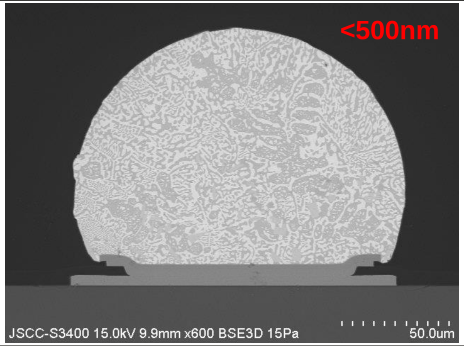
UBM: CuNiAu



Flux DOE

Flux(LTS) was suitable to obtain good ball shape when using LTS.

LEG	DOE	Alloy type		UBM type	Flux Type	Peak Temp.	Cooling Rate
1	POR	SAC305	POR	Cu	LTS(SAC)	235-245℃	< 0.5℃/s
2	Interface	SAC305	POR	CuNiAu	LTS(SAC)	235-245℃	< 0.5℃/s
3	Flux	SnBiAg	Bi(57)	CuNiAu	LTS(SAC)	160-170℃	< 0.5℃/s
4	Flux	SnBiAg	Bi(57)	CuNiAu	LTS(Flux)	160-170℃	< 0.5℃/s

	SAC-Cu	SAC-CuNiAu	LTS- Flux(SAC)	LTS-Flux(LTS)
EVI				
IMC				

Ball Drop DOE

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Effect of interface (UBM: Cu or CuNiAu) and cooling rate (<0.5 or ~5℃/s) on LTS.

LEG	DOE	Alloy type		UBM type	Flux Type	Peak Temp.	Dwell Time	Cooling Rate
1	POR	SAC305	POR	Cu	LTS(SAC)	235-245℃	-	< 0.5℃/s
2	Interface			CuNiAu	LTS(SAC)		-	< 0.5℃/s
3	Interface	SnBiAg	Bi(57)	CuNiAu	LTS(SAC)	160-170℃	-	< 0.5℃/s
4	Interface/Flux			CuNiAu	LTS(Flux)		-	< 0.5℃/s
5	Slow cooling			Cu	LTS(Flux)		-	< 0.5℃/s
6	Long reflow time			Cu	LTS(Flux)		Double time	< 0.5℃/s
7	Fast cooling			Cu	LTS(Flux)		-	~ 5℃/s
8	Interface/Slow cooling	SnBiAgNi	Bi(35)	CuNiAu	LTS(Flux)	200-210℃	-	< 0.5℃/s
9	Interface/Fast cooling			CuNiAu	LTS(Flux)		-	~ 5℃/s
10	Slow cooling			Cu	LTS(Flux)		-	< 0.5℃/s
11	Long reflow time			Cu	LTS(Flux)		Double time	< 0.5℃/s
12	Fast cooling			Cu	LTS(Flux)		-	~ 5℃/s

Cooling rate usually less than 0.5℃/s in FC process to avoid issues caused by CTE differences.

Ball Drop DOE

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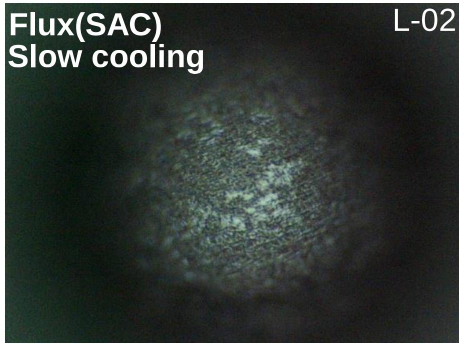
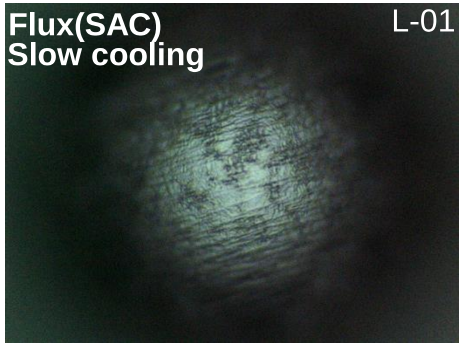
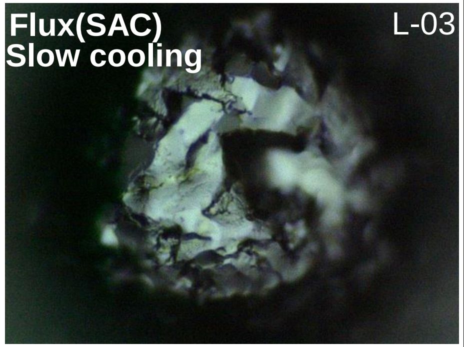
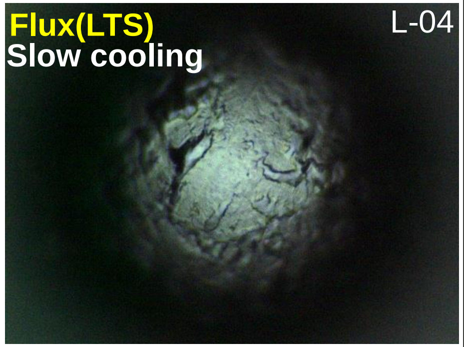
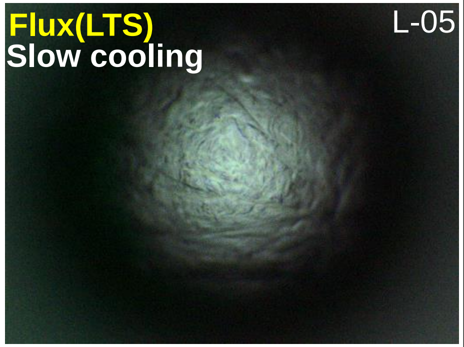
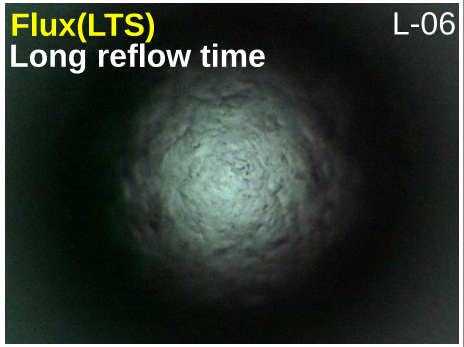
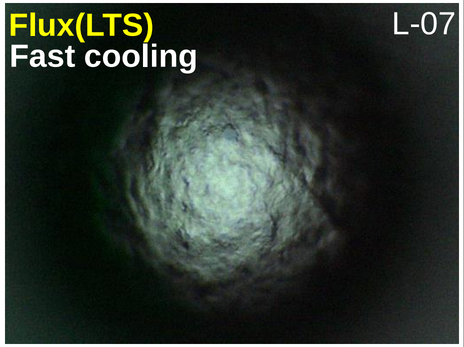
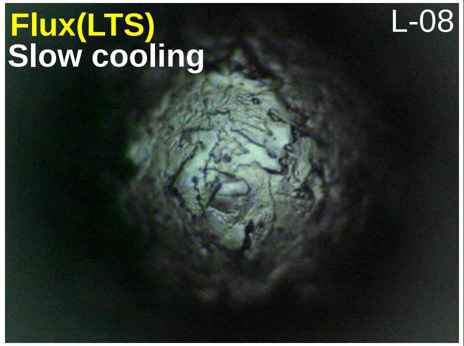
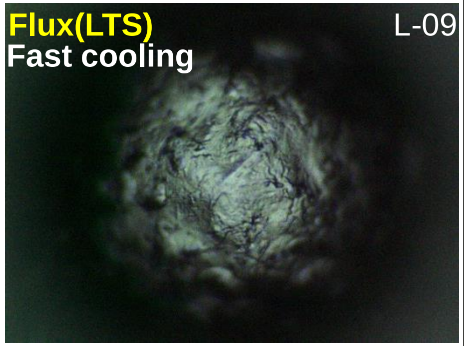
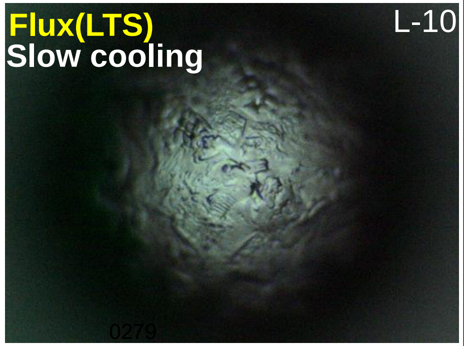
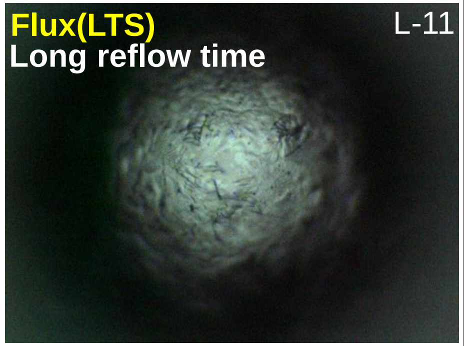
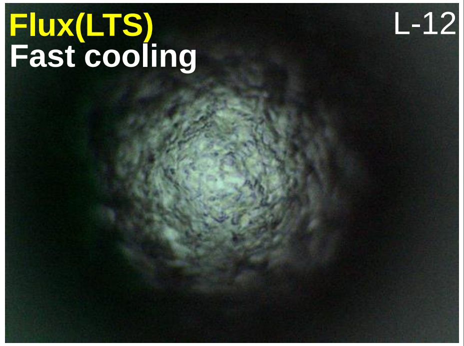
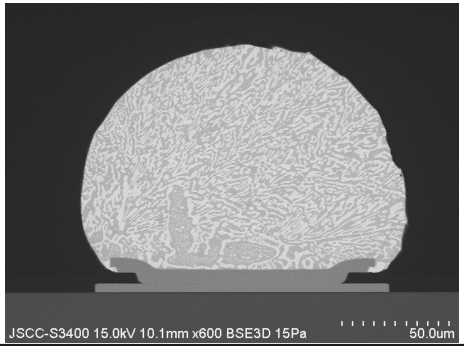
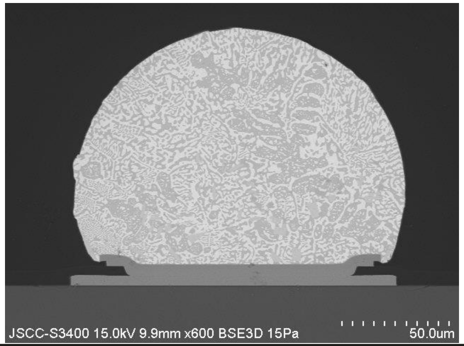
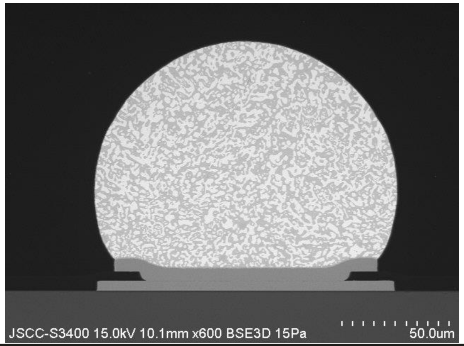
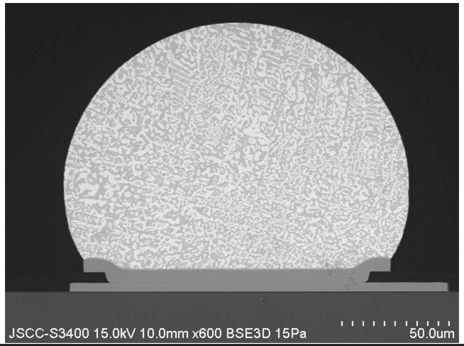
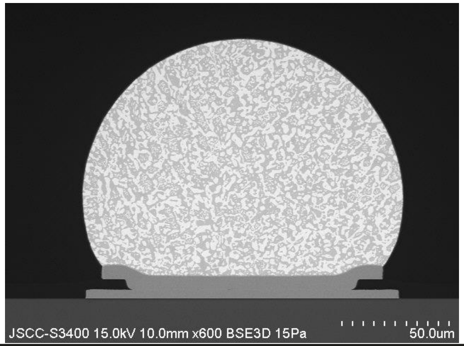
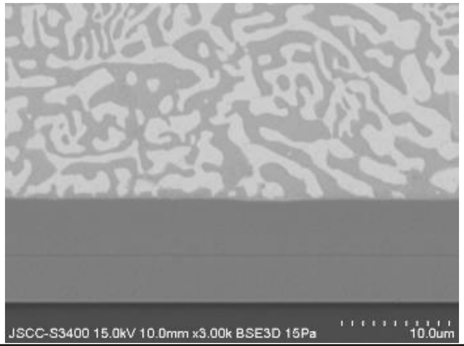
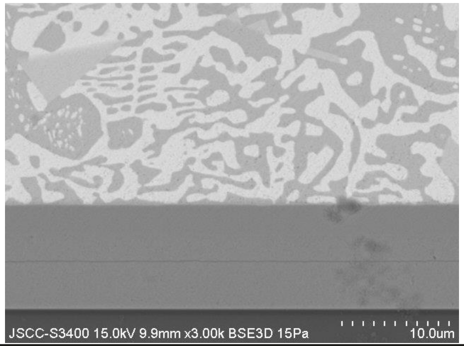
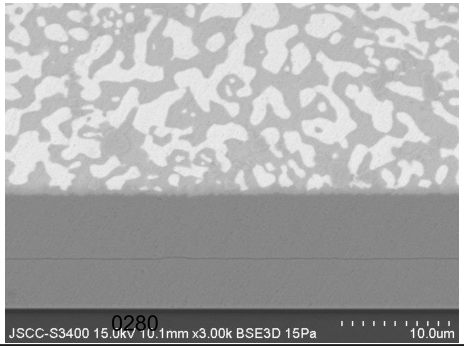
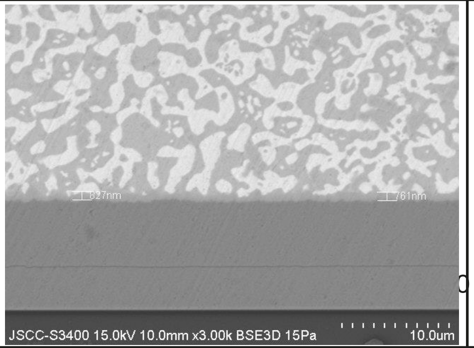
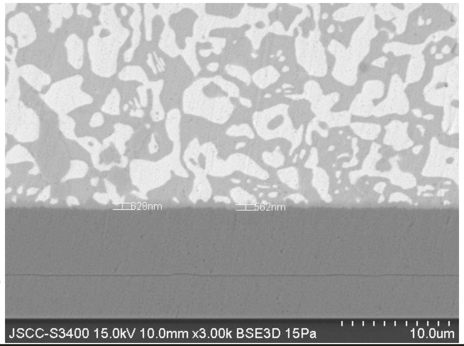
Effect of interface and cooling rate on LTS.

Both LTSs obtained better ball shape on Cu Pad than CuNiAu Pad. Cooling rate or reflow time showed little influence on ball shape.

EVI	UBM: CuNiAu		UBM: Cu		
SAC305					
SnBiAg Bi(57)					
SnBiAgNi Bi(35)					

Microstructure after Ball Drop

SnBi(57)Ag:
1. IMC grew slower on CuNiAu interface than Cu interface, due to Ni suppression.
2. Bi phase distributed slightly more homogeneously on Cu interface.
3. Cooling rate or reflow time showed little influence on both IMC growth or Bi distribution.

SnBiAg	Leg3	Leg4	Leg5	Leg6	Leg7
Ball	SnBiAg	SnBiAg	SnBiAg	SnBiAg	SnBiAg
BOT UBM	CuNiAu	CuNiAu	Cu	Cu	Cu
DOE	Flux 6317P (Slow Cooling)	Flux-LTS (Slow Cooling)	Slow cooling	Long reflow time	Fast cooling
IMC THK.	< 500nm	< 500nm	0.64um	0.71um	0.68um
Bi Distribution					
IMC Growth					

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Microstructure after Ball Drop

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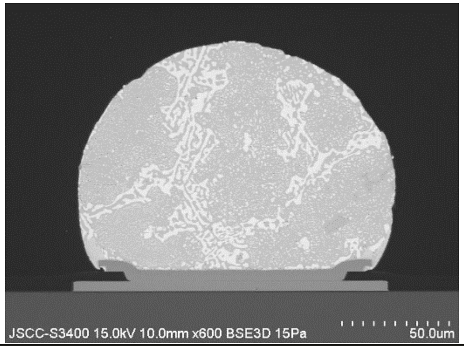
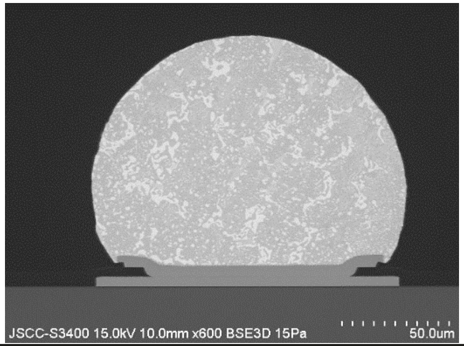
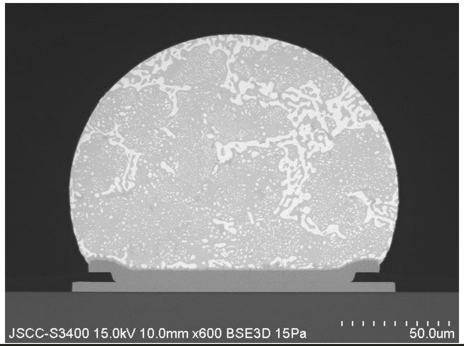
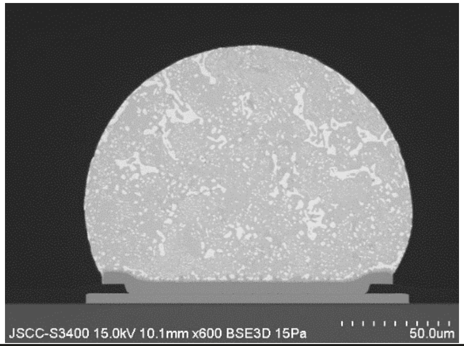
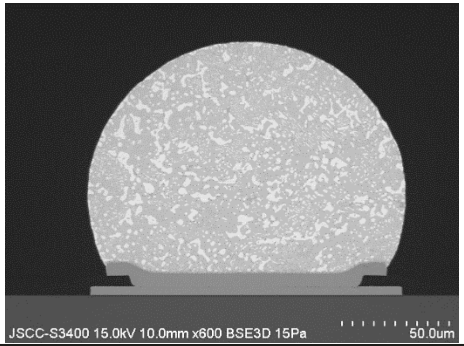
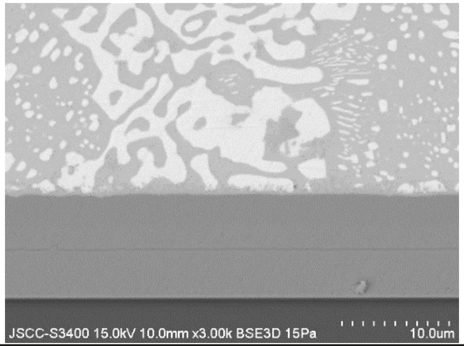
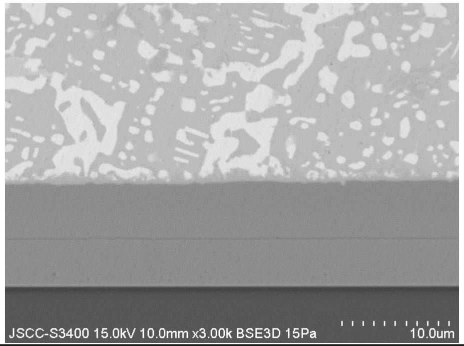
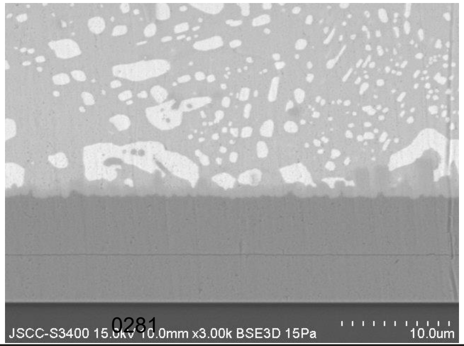
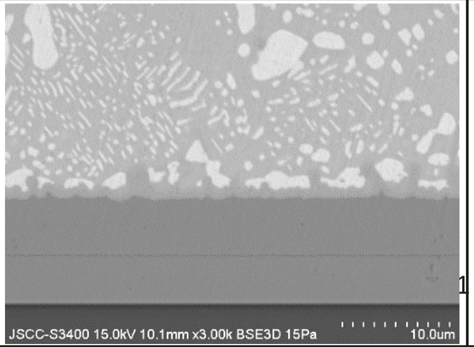
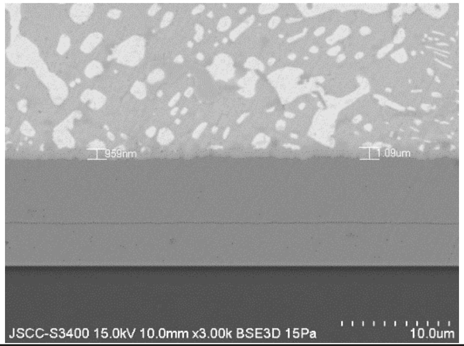
SnBi(35)AgNi:
1. IMC grew slower on CuNiAu interface than Cu interface, due to Ni suppression.
2. Bi phase distributed slightly more homogeneously on Cu interface.
3. Cooling rate or reflow time showed little influence on IMC growth, but it provided more homogeneous Bi phase distribution when prolonged reflow time or increased cooling rate.

SnBiAgNi	Leg8	Leg9	Leg10	Leg11	Leg12
Ball	SnBiAgNi	SnBiAgNi	SnBiAgNi	SnBiAgNi	SnBiAgNi
BOT UBM	CuNiAu	CuNiAu	Cu	Cu	Cu
DOE	Slow cooling	Fast cooling	Slow cooling	Long reflow time	Fast cooling
IMC THK.	< 500nm	< 500nm	0.97um	1.02um	0.93um
Bi Distribution					
IMC Growth					

Microstructure after Ball Drop

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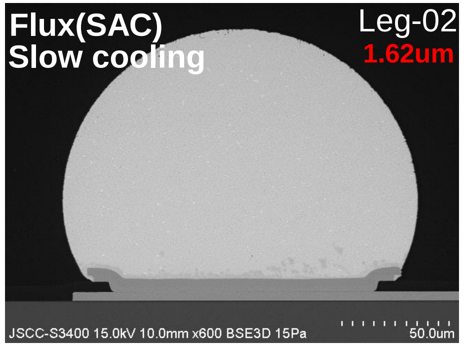
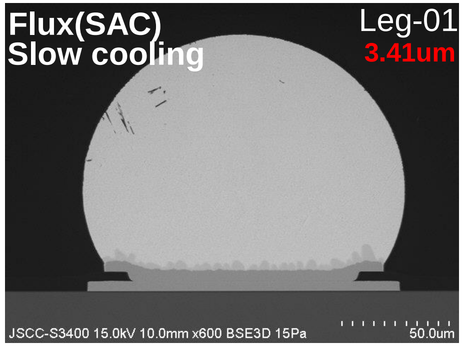
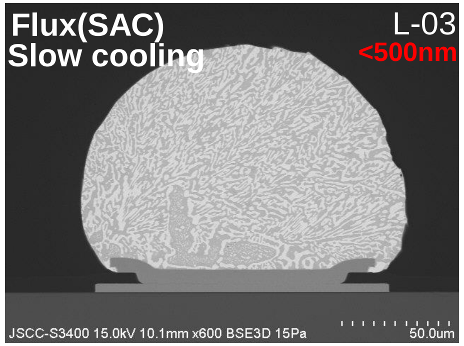
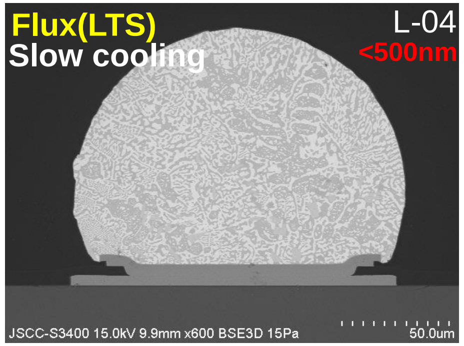
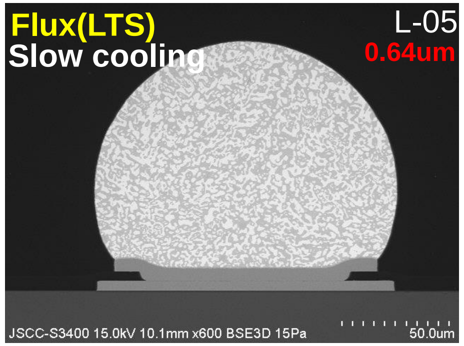
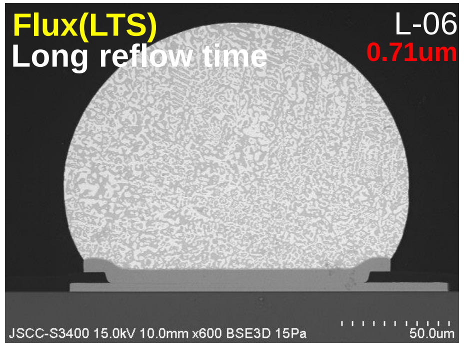
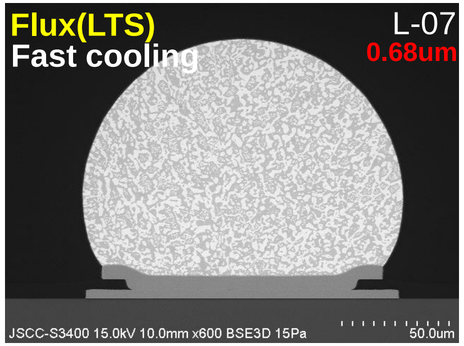
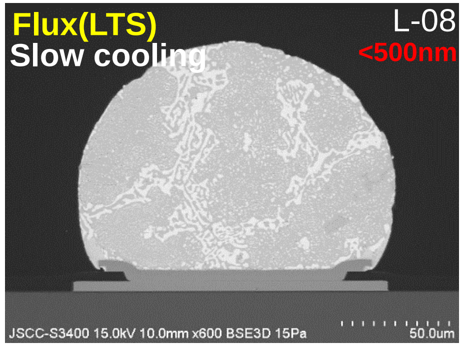
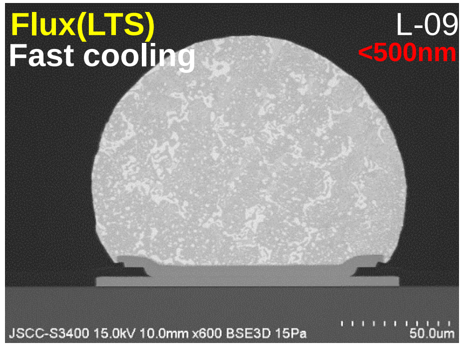
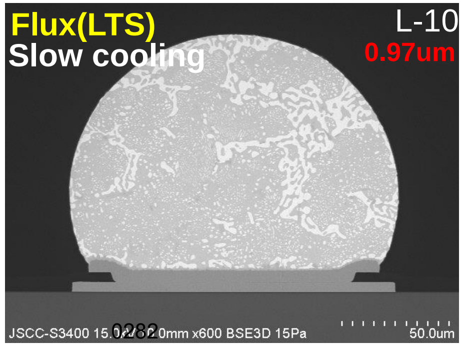
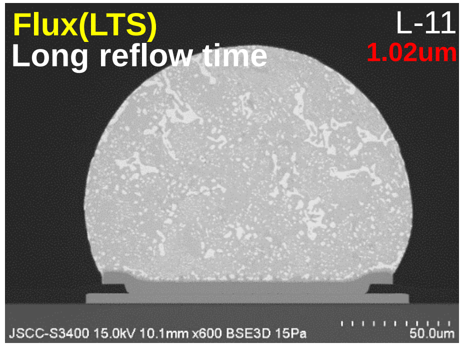
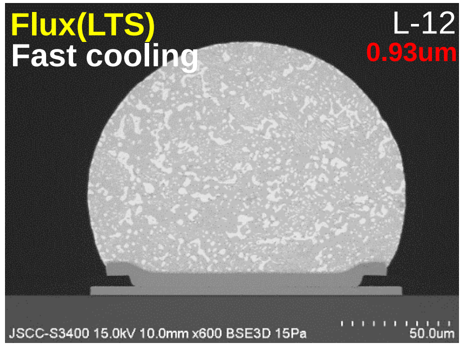
Compared to SnBi(35)AgNi, SnBi(57)Ag showed more homogenous Bi distribution and thinner IMC thickness. Both LTSs generated thinner IMC than SAC, for both Cu and CuNiAu UBM.

IMC Thk	UBM: CuNiAu		UBM: Cu		
SAC305	 Flux(SAC) Slow cooling Leg-02 1.62um JSCC-S3400 15.0kV 10.0mm x600 BSE3D 15Pa 50.0um		 Flux(SAC) Slow cooling Leg-01 3.41um JSCC-S3400 15.0kV 10.0mm x600 BSE3D 15Pa 50.0um		
SnBiAg Bi(57)	 Flux(SAC) Slow cooling L-03 <500nm JSCC-S3400 15.0kV 10.1mm x600 BSE3D 15Pa 50.0um	 Flux(LTS) Slow cooling L-04 <500nm JSCC-S3400 15.0kV 9.9mm x600 BSE3D 15Pa 50.0um	 Flux(LTS) Slow cooling L-05 0.64um JSCC-S3400 15.0kV 10.1mm x600 BSE3D 15Pa 50.0um	 Flux(LTS) Long reflow time L-06 0.71um JSCC-S3400 15.0kV 10.0mm x600 BSE3D 15Pa 50.0um	 Flux(LTS) Fast cooling L-07 0.68um JSCC-S3400 15.0kV 10.0mm x600 BSE3D 15Pa 50.0um
SnBiAgNi Bi(35)	 Flux(LTS) Slow cooling L-08 <500nm JSCC-S3400 15.0kV 10.0mm x600 BSE3D 15Pa 50.0um	 Flux(LTS) Fast cooling L-09 <500nm JSCC-S3400 15.0kV 10.0mm x600 BSE3D 15Pa 50.0um	 Flux(LTS) Slow cooling L-10 0.97um JSCC-S3400 15.0mm x600 BSE3D 15Pa 50.0um	 Flux(LTS) Long reflow time L-11 1.02um JSCC-S3400 15.0kV 10.1mm x600 BSE3D 15Pa 50.0um	 Flux(LTS) Fast cooling L-12 0.93um JSCC-S3400 15.0kV 10.0mm x600 BSE3D 15Pa 50.0um

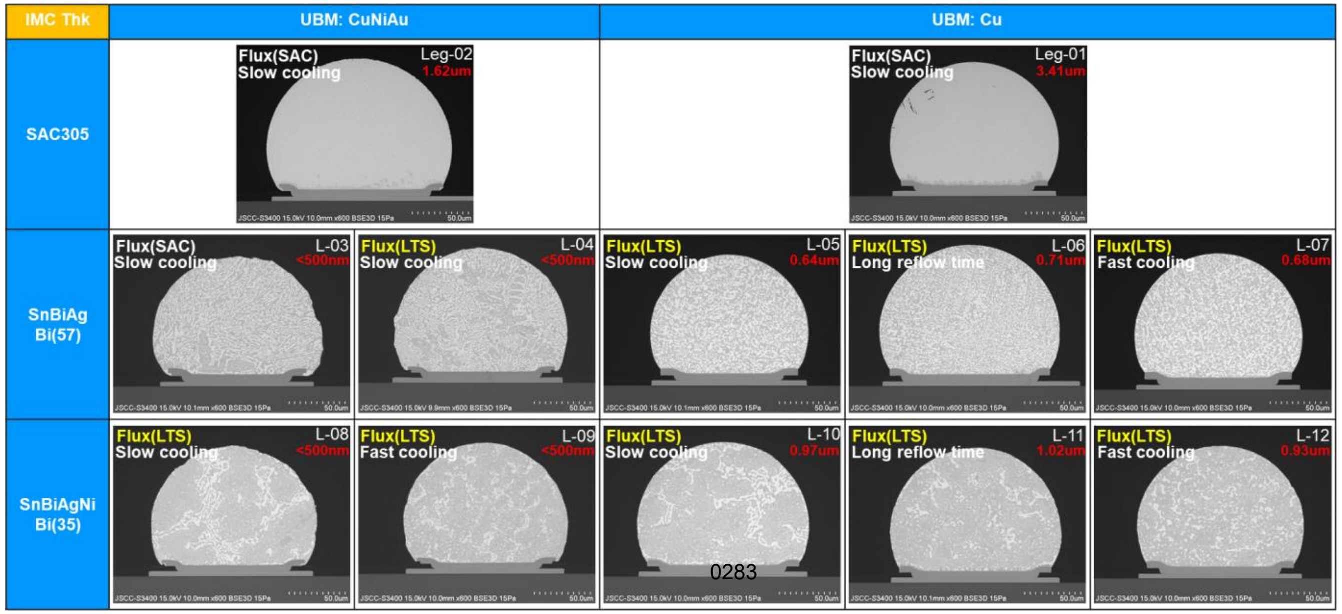
Microstructure after Ball Drop

Effect of interface and cooling rate on two type of LTSs, SnBi(57)Ag & SnBi(35)AgNi.

SnBi(57)Ag:
1. **IMC grew slower on CuNiAu interface than Cu interface, due to Ni suppression.**
2. **Bi phase distributed slightly more homogeneously on Cu interface.**
3. **Cooling rate or reflow time showed little influence on both IMC growth or Bi distribution.**

SnBi(35)AgNi:
1. **IMC grew slower on CuNiAu interface than Cu interface, due to Ni suppression.**
2. **Bi phase distributed slightly more homogeneously on Cu interface.**
3. **Cooling rate or reflow time showed little influence on IMC growth, but it provided more homogeneous Bi phase distribution when prolonged reflow time or increased cooling rate.**

Compared to SnBi(53)AgNi, SnBi(57)Ag showed more homogenous Bi distribution and thinner IMC thickness. Both LTSs generated thinner IMC than SAC, for both Cu and CuNiAu UBM.

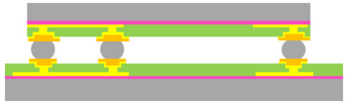


JCET

A Study of
Low Temperature Solder
on
Microstructure and Reliability

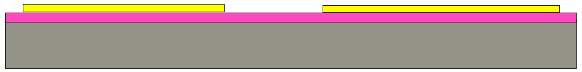
CONTENTS

Top Die Process Flow (1P2M)

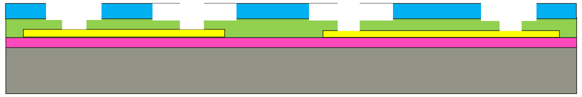


A1: Incoming wafer(0.5um SiO2)

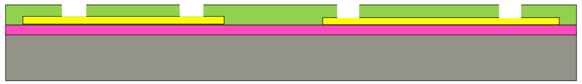
A2: Photo(M1)



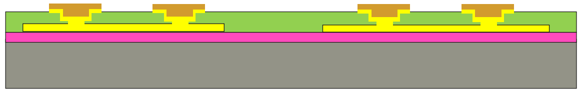
A3: Plating(M1)/AOI



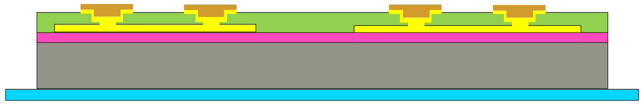
A5: Photo (M2)



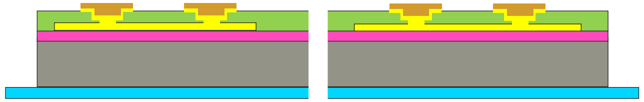
A4: Photo (PI1)



A6: Plating(M2)/AOI



A7: Taping



A8: Dicing

TOP Die Surface Finish

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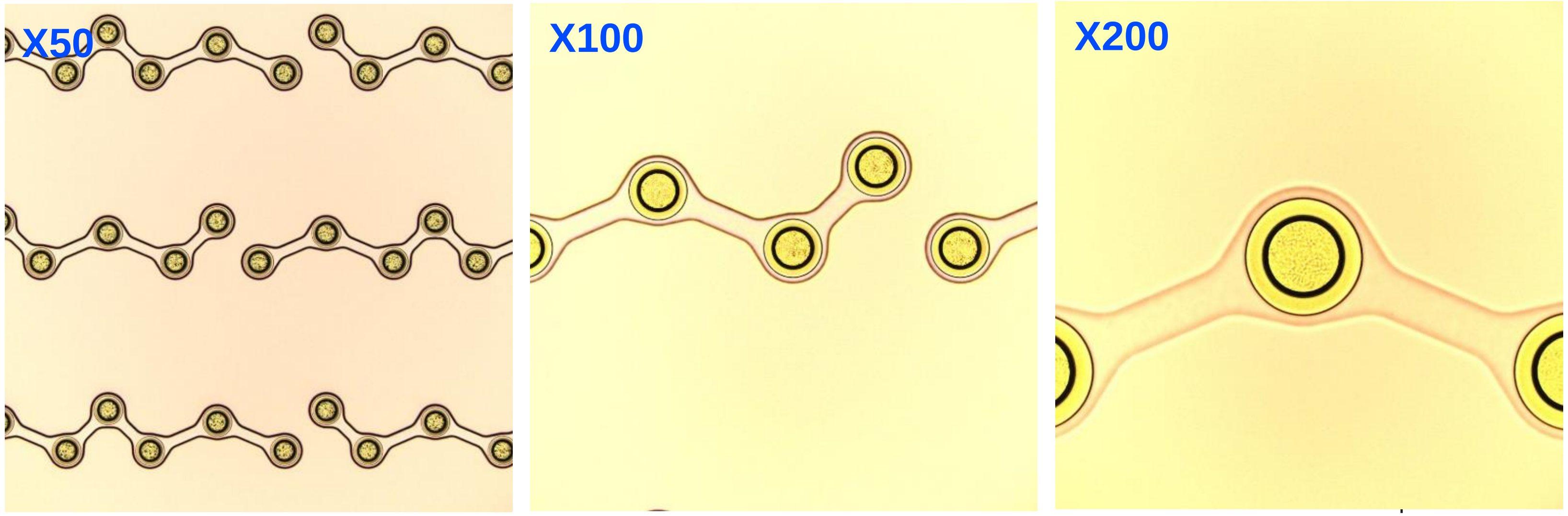
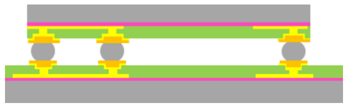
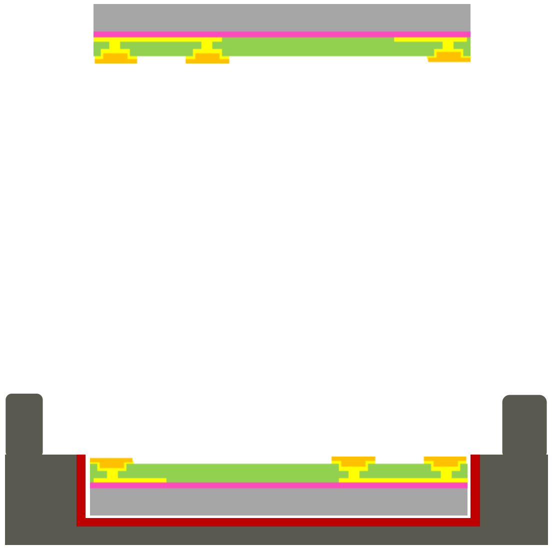
UBM: CuSnAg
(1um SnAg for anti-oxidation)

UBM: CuNiAu

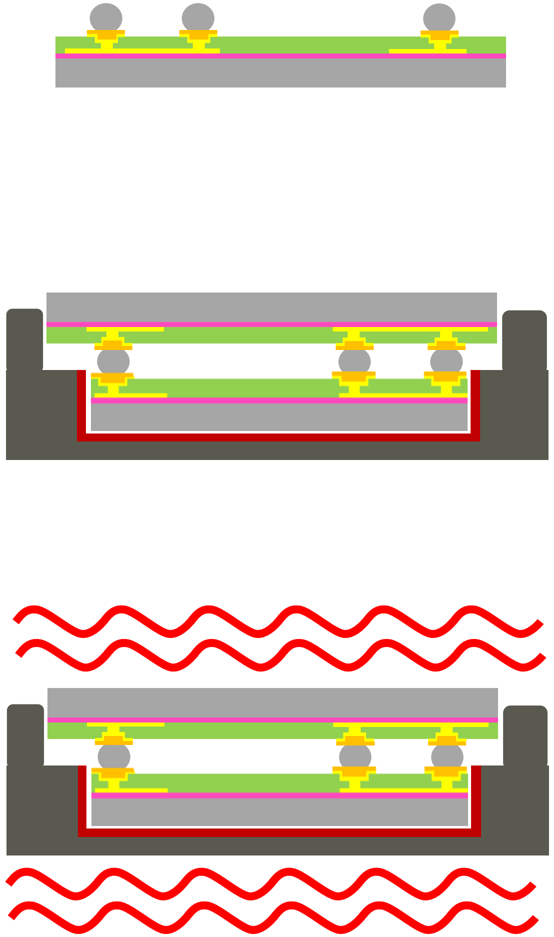


C2C Process Flow

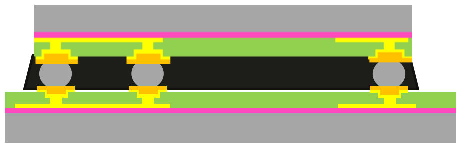




Top Die Load



Flip Chip Attach + Reflow



UF(for Cross Section)

C2C DOE and Reliability Test

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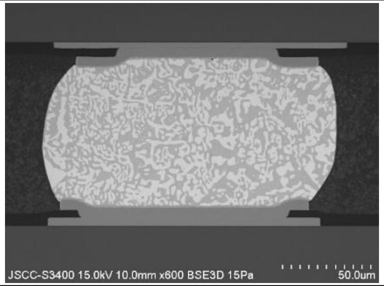
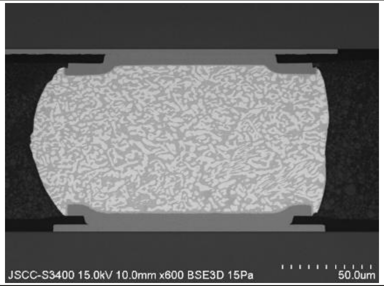
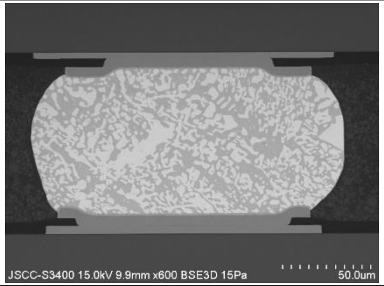
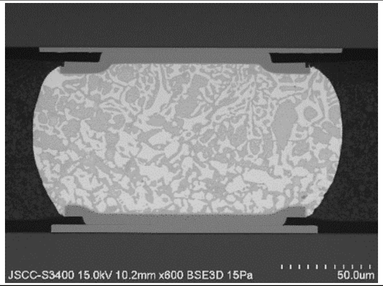
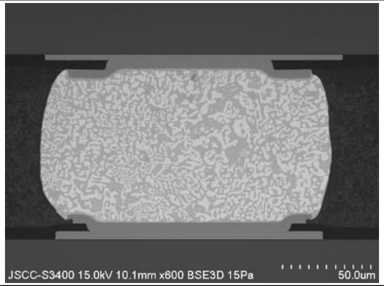
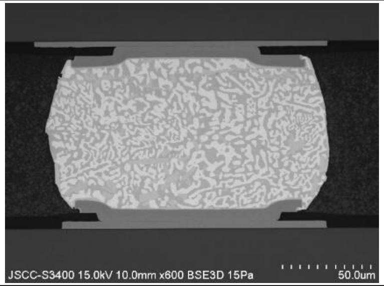
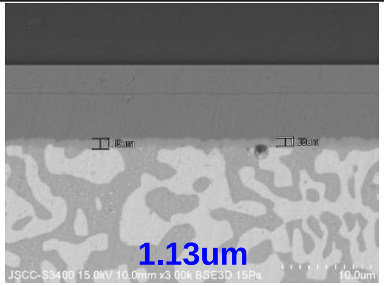
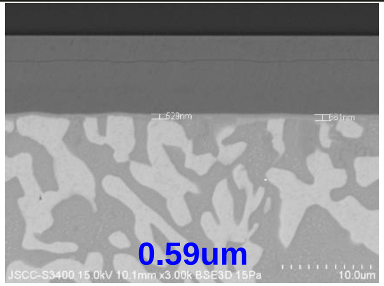
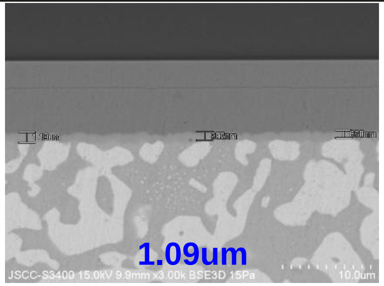
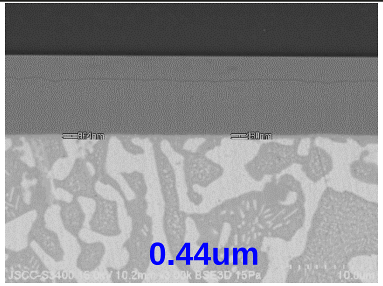
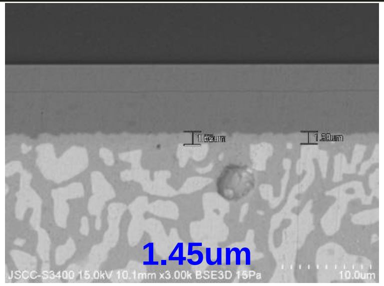
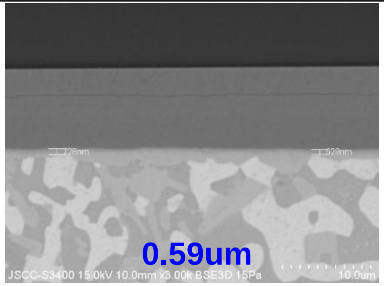
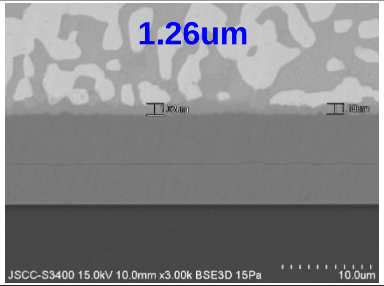
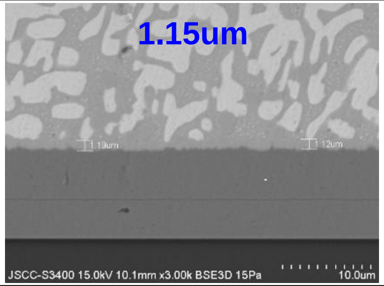
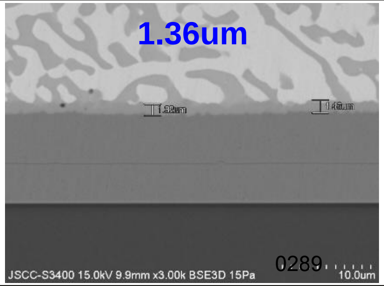
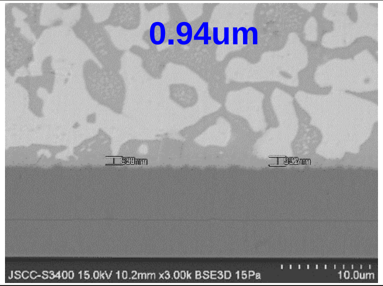
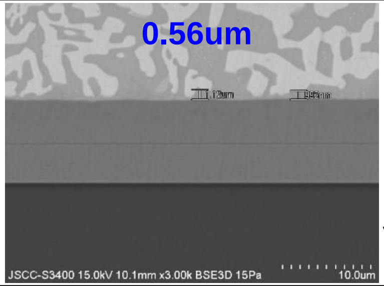
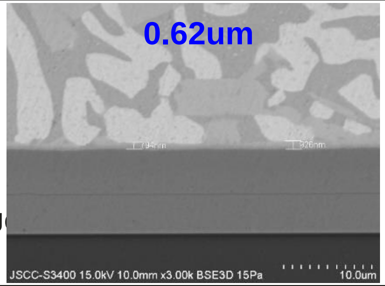
Both SnBi(57)Ag & SnBi(35)AgNi C2C test vehicle passed HTSL 500h (Condition A) & TC 500cycles (Condition B), for all 4 kinds of TOP/BOT UBM combinations (Cu-Cu, Au-Cu, Cu-Au, Au-Au).

TOP UBM		Ball Drop DOE				C2C Profile		OS Test		
LEG	TOP UBM	Ball Drop Profile	Alloy type		BOT UBM	Peak Temp.	Cooling Rate	C2C T0	HTSL	TCT
1-1	CuSnAg	Slow cooling	SAC305	POR	Cu	235-245℃	< 0.5℃/s	Pass	/	/
1-2	CuNiAu							Pass	/	/
2-1	CuSnAg	Slow cooling	SnBiAg	Bi(57)	Cu	160-170℃	< 0.5℃/s	Pass	Pass	/
2-2	CuNiAu							Pass	Pass	/
3-1	CuSnAg	Fast cooling			Cu			Pass	Pass	/
3-2	CuNiAu							Pass	Pass	/
4-1	CuSnAg	Slow cooling			CuNiAu			Pass	Pass	/
4-2	CuNiAu							Pass	Pass	/
5-1	CuSnAg	Slow cooling	SnBiAgNi	Bi(35)	Cu	200-210℃	< 0.5℃/s	Pass	Pass	Pass
5-2	CuNiAu							Pass	Pass	Pass
6-1	CuSnAg	Fast cooling			Cu			Pass	Pass	/
6-2	CuNiAu							Pass	Pass	/
7-1	CuSnAg	Slow cooling			CuNiAu			Pass	Pass	Pass
7-2	CuNiAu							Pass	Pass	Pass

Microstructure after C2C

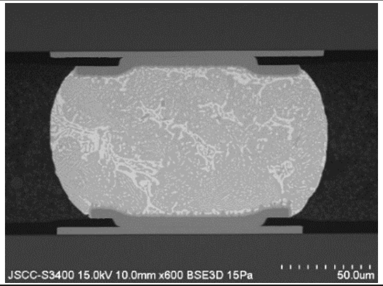
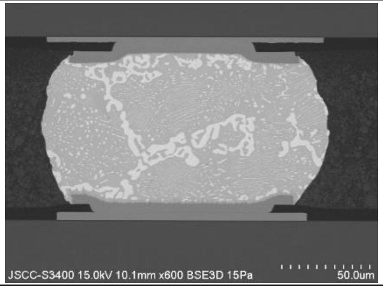
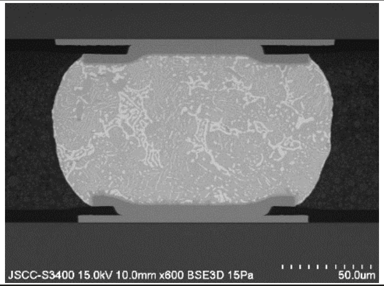
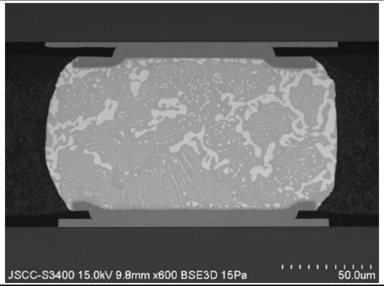
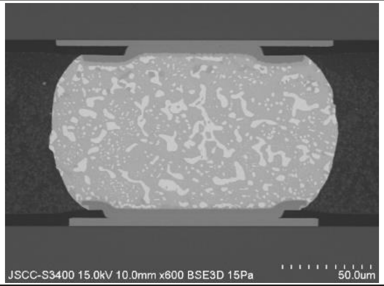
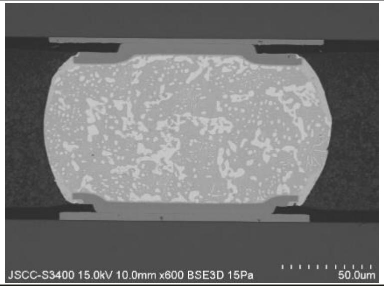
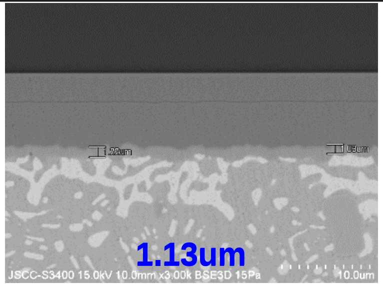
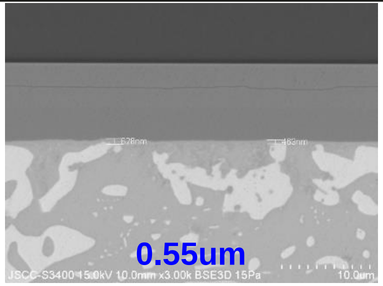
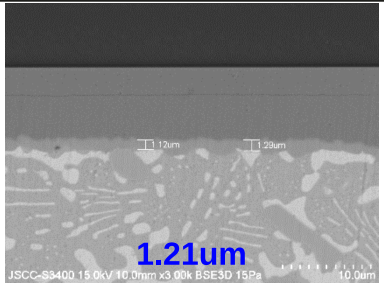
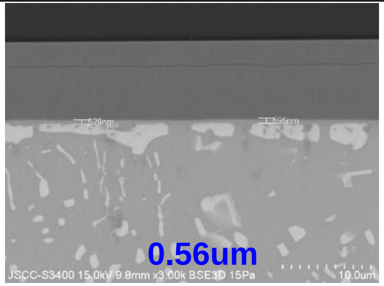
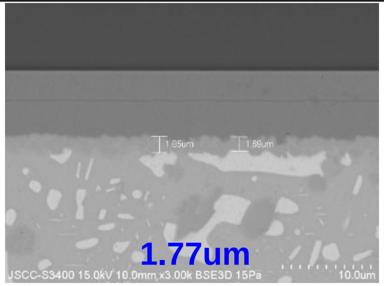
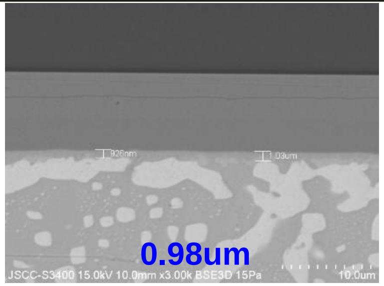
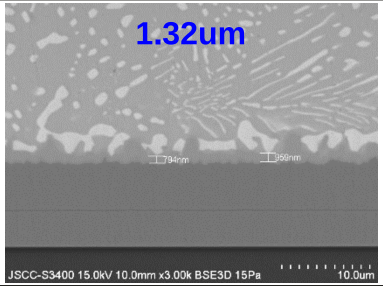
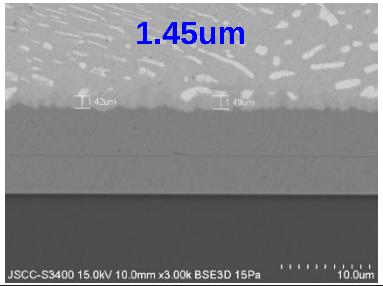
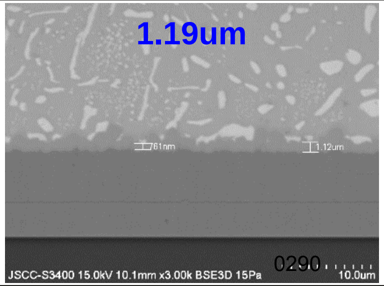
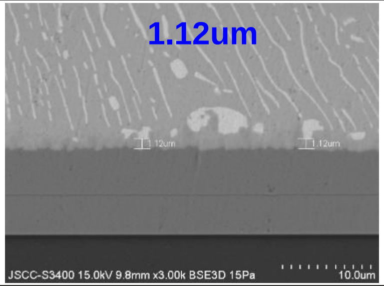
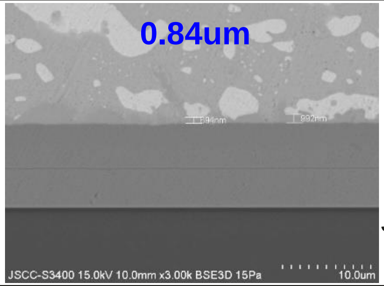
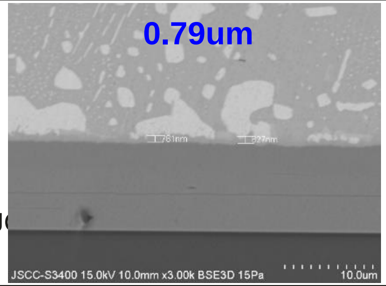
SnBi(57)Ag: 1. IMC grew slower on CuNiAu interface than Cu interface, due to Ni suppression.

2. Cooling rate showed little influence on IMC growth, but some Bi phase aggregation at fast cooling rate. However, all presented homogenous Bi phase distribution.

SnBiAg	Leg 2-1 (Top Cu)	Leg 2-2 (Top Au)	Leg 3-1 (Top Cu)	Leg 3-2 (Top Au)	Leg 4-1 (Top Cu)	Leg 4-2 (Top Au)
Top UBM	CuSnAg	CuNiAu	CuSnAg	CuNiAu	CuSnAg	CuNiAu
Ball	SnBiAg	SnBiAg	SnBiAg(Fast cooling)	SnBiAg(Fast cooling)	SnBiAg	SnBiAg
BOT UBM	Cu	Cu	Cu	Cu	CuNiAu	CuNiAu
Bi Distribution						
Top Side IMC						
BOT Side IMC						

Microstructure after C2C

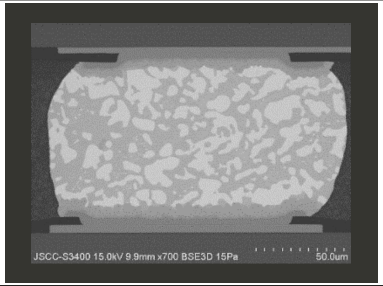
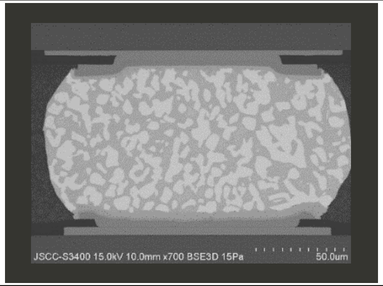
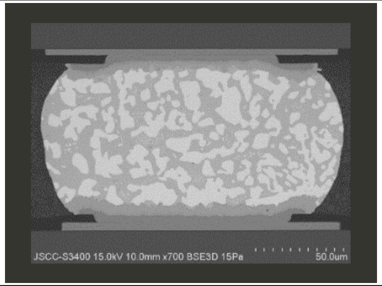
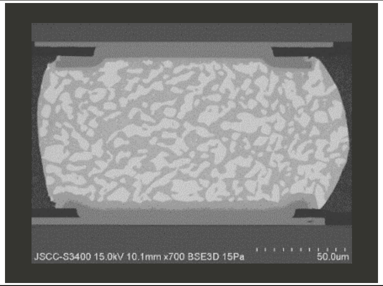
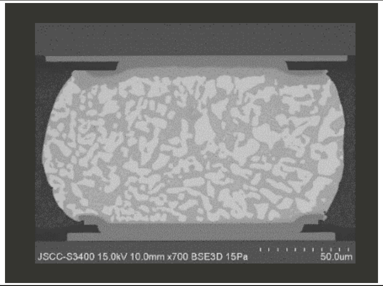
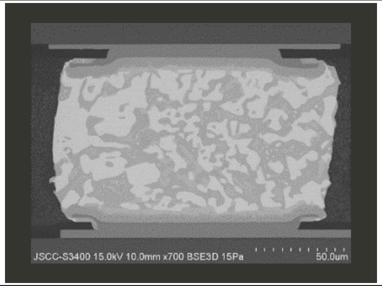
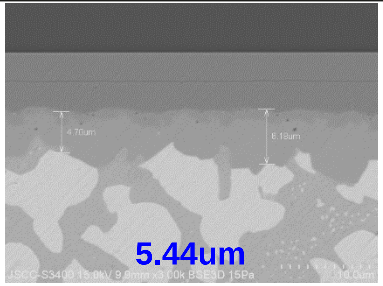
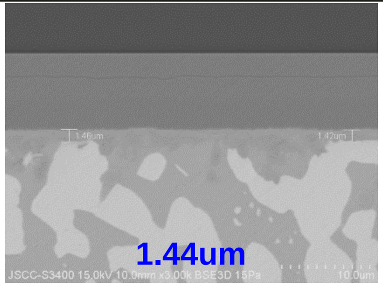
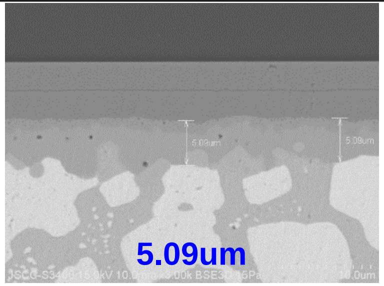
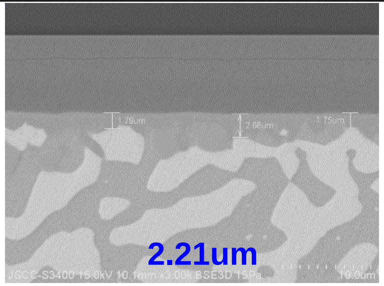
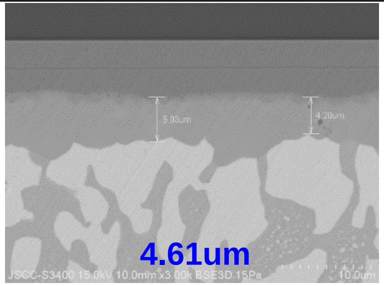
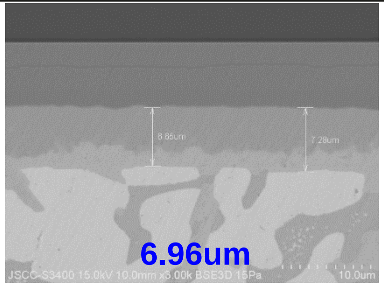
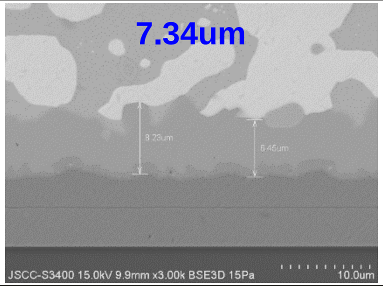
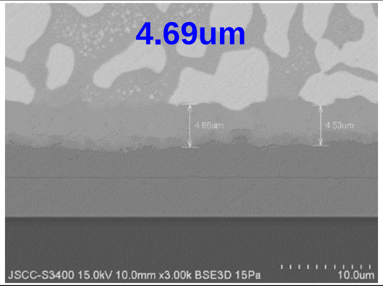
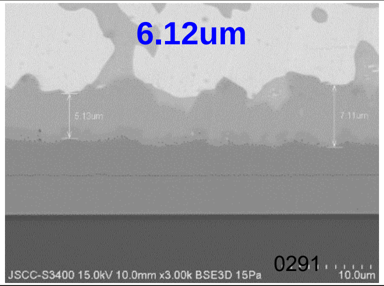
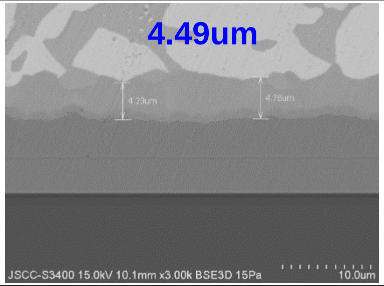
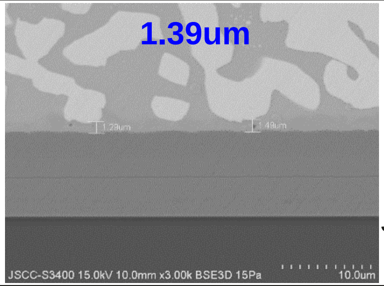
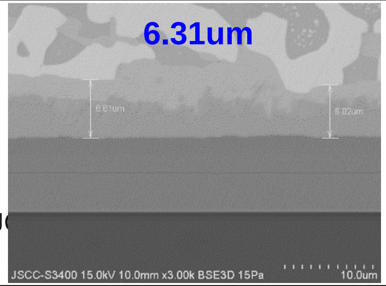
SnBi(35)AgNi: 1. IMC grew slower on CuNiAu interface than Cu interface, due to Ni suppression.
2. Cooling rate showed little influence on IMC growth or Bi phase distribution.
3. CuNiAu UBM promoted the aggregation of Bi, especially when Bot UBM reflowed 2x.

SnBiAgNi	Leg 5-1 (Top Cu)	Leg 5-2 (Top Au)	Leg 6-1 (Top Cu)	Leg 6-2 (Top Au)	Leg 7-1 (Top Cu)	Leg 7-2 (Top Au)
Top UBM	CuSnAg	CuNiAu	CuSnAg	CuNiAu	CuSnAg	CuNiAu
Ball	SnBiAgNi	SnBiAgNi	SnBiAgNi(Fast cooling)	SnBiAgNi(Fast cooling)	SnBiAgNi	SnBiAgNi
BOT UBM	Cu	Cu	Cu	Cu	CuNiAu	CuNiAu
Bi Distribution						
Top Side IMC						
BOT Side IMC						

Microstructure after HTSL500h (Condition A: 125C)

JCET

SnBi(57)Ag: 1. IMC grew slower on CuNiAu interface than Cu interface, due to Ni suppression. However, when both sides were CuNiAu interfaces, another type IMC was generated, totally produced thicker IMC.
2. Compared to T0 (C2C), all showed Bi aggregation, and still homogenous Bi distribution.

SnBiAg	Leg 2-1 (Top Cu)	Leg 2-2 (Top Au)	Leg 3-1 (Top Cu)	Leg 3-2 (Top Au)	Leg 4-1 (Top Cu)	Leg 4-2 (Top Au)
Top UBM	CuSnAg	CuNiAu	CuSnAg	CuNiAu	CuSnAg	CuNiAu
Ball	SnBiAg	SnBiAg	SnBiAg(Fast cooling)	SnBiAg(Fast cooling)	SnBiAg	SnBiAg
BOT UBM	Cu	Cu	Cu	Cu	CuNiAu	CuNiAu
Bi Distribution						
Top Side IMC						
BOT Side IMC						

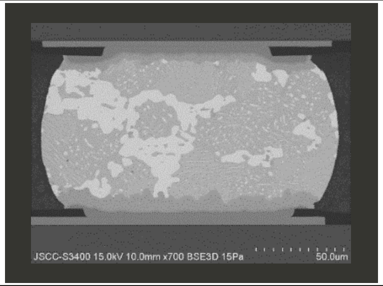
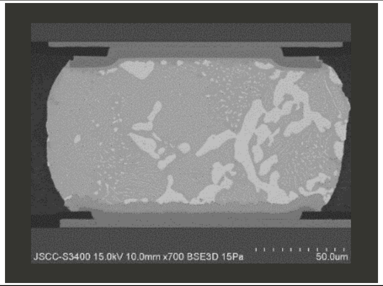
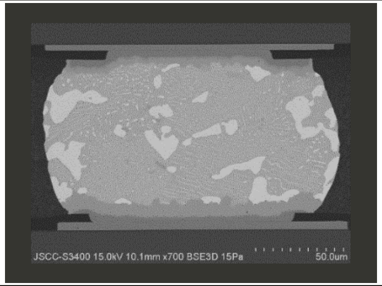
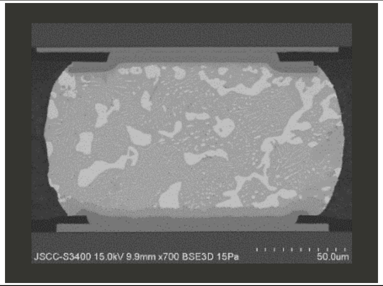
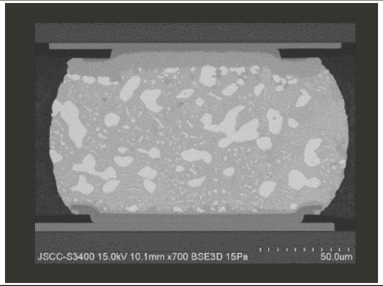
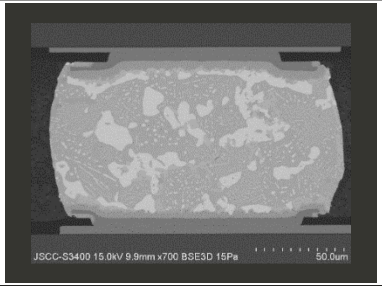
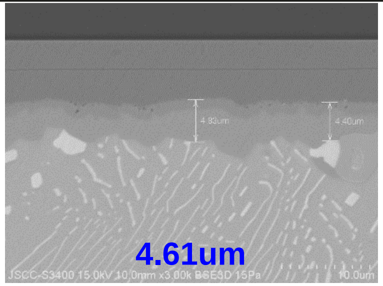
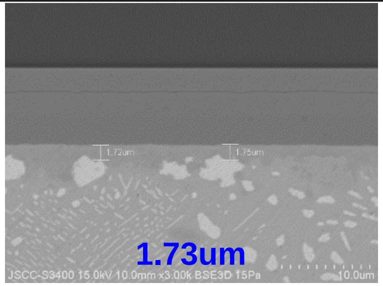
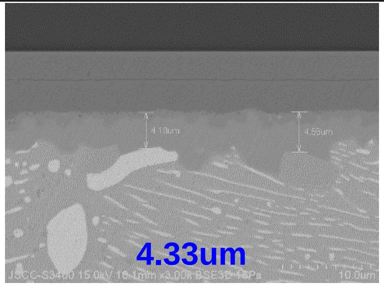
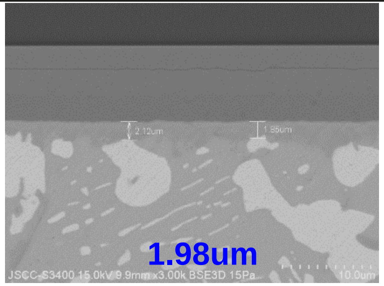
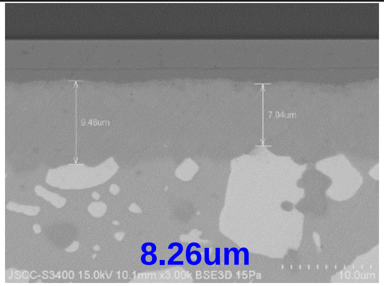
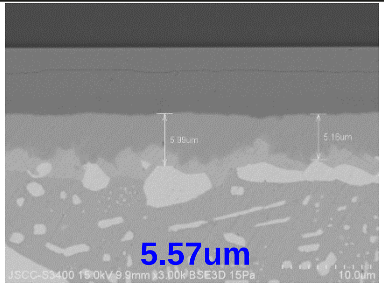
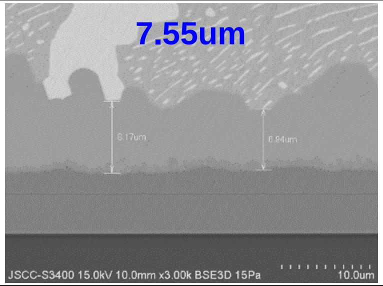
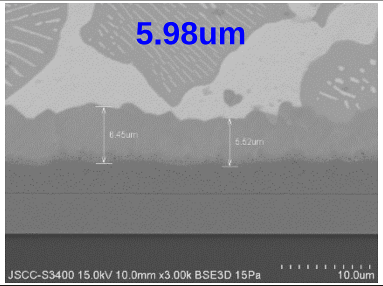
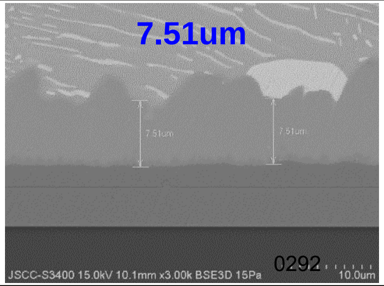
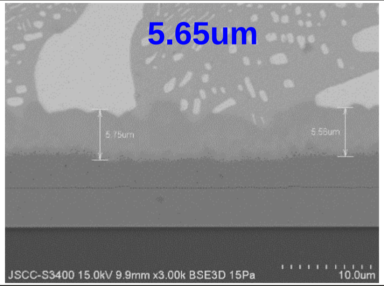
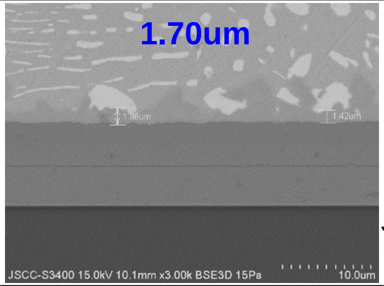
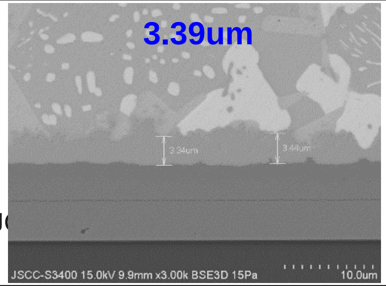
0291

Microstructure after HTSL500h (Condition A: 125C)

JCET

SnBi(35)AgNi: 1. IMC grew slower on CuNiAu interface than Cu interface, due to Ni suppression. However, when both sides were CuNiAu interfaces, another type IMC was generated, totally produced thicker IMC.

2. Compared to T0 (C2C), all showed Bi aggregation, but still heterogeneous Bi distribution.

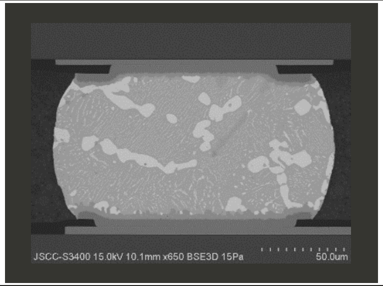
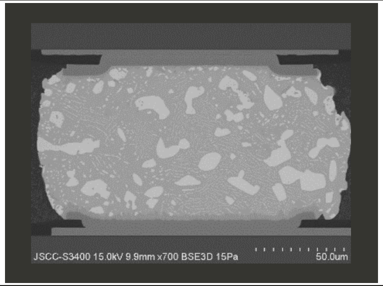
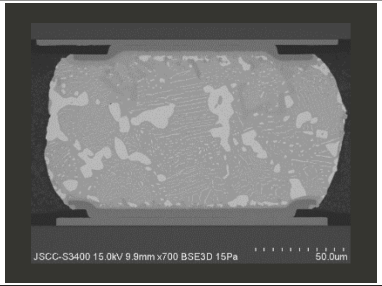
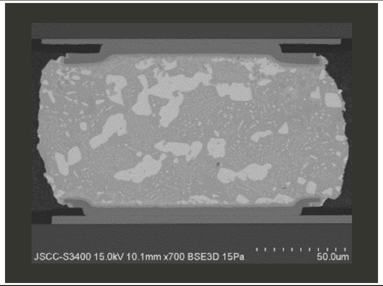
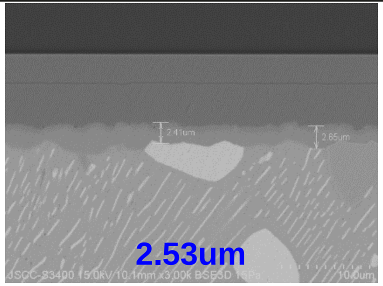
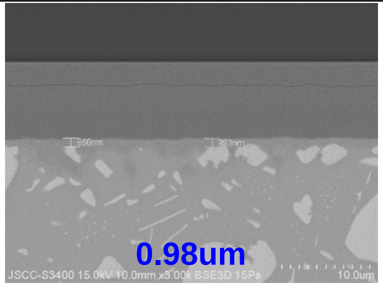
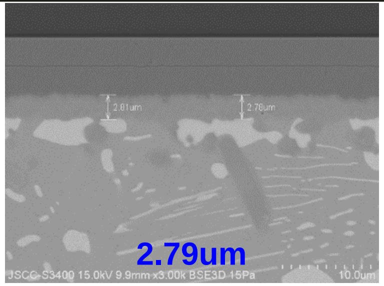
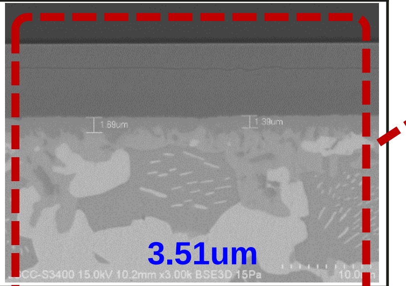
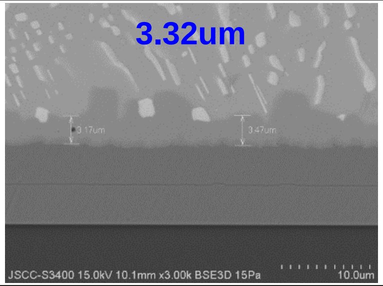
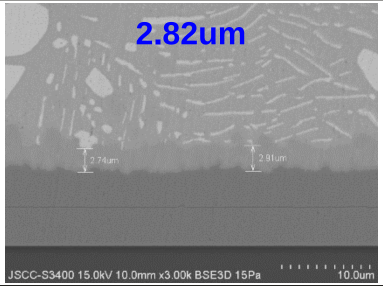
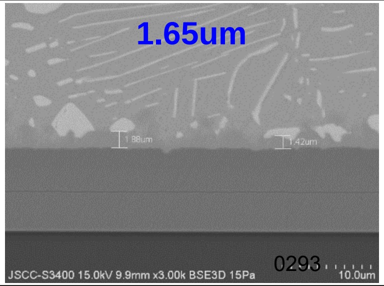
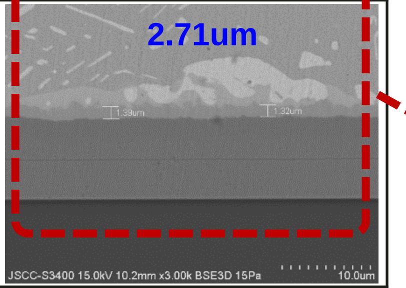
SnBiAgNi	Leg 5-1 (Top Cu)	Leg 5-2 (Top Au)	Leg 6-1 (Top Cu)	Leg 6-2 (Top Au)	Leg 7-1 (Top Cu)	Leg 7-2 (Top Au)
Top UBM	CuSnAg	CuNiAu	CuSnAg	CuNiAu	CuSnAg	CuNiAu
Ball	SnBiAgNi	SnBiAgNi	SnBiAgNi(Fast cooling)	SnBiAgNi(Fast cooling)	SnBiAgNi	SnBiAgNi
BOT UBM	Cu	Cu	Cu	Cu	CuNiAu	CuNiAu
Bi Distribution						
Top Side IMC						
BOT Side IMC						

Microstructure after TCT 500x (Condition B: -55-125℃)

JCET

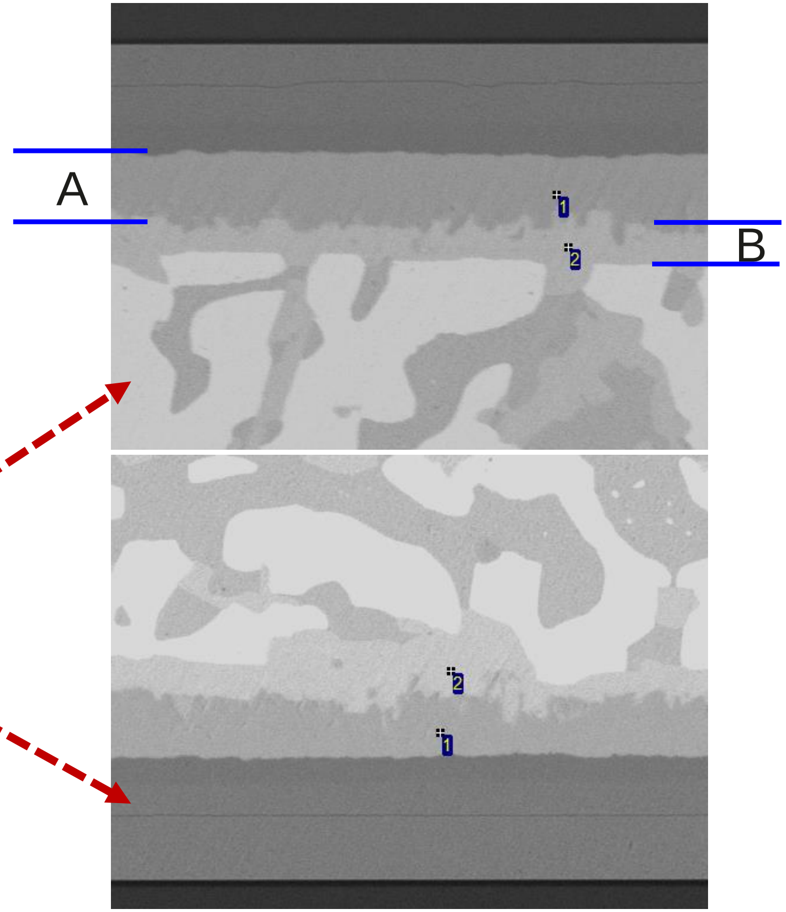
SnBi(35)AgNi: 1. IMC grew slower on CuNiAu interface than Cu interface, due to Ni suppression. However, when both sides were CuNiAu interfaces, another type IMC was generated, totally produced thicker IMC.

2. Compared to T0 (C2C), all showed Bi aggregation, but still heterogeneous Bi distribution.

SnBiAgNi	Leg 5-1 (Top Cu)	Leg 5-2 (Top Au)	Leg 7-1 (Top Cu)	Leg 7-2 (Top Au)
Top UBM	CuSnAg	CuNiAu	CuSnAg	CuNiAu
Ball	SnBiAgNi	SnBiAgNi	SnBiAgNi	SnBiAgNi
BOT UBM	Cu	Cu	CuNiAu	CuNiAu
Bi Distribution				
Top Side IMC	 2.53um	 0.98um	 2.79um	 3.51um
BOT Side IMC	 3.32um	 2.82um	 1.65um	 2.71um

A: Ni_3Sn_4

B: $(Ni_xAu_{1-x})Sn_4$



JCET

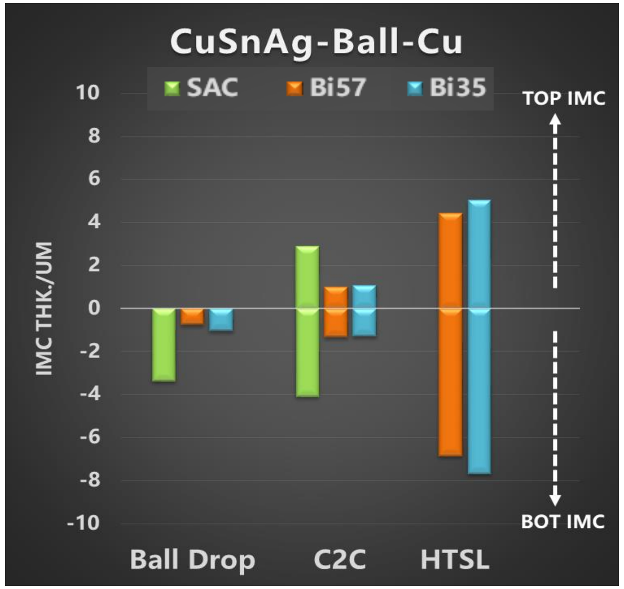
A Study of Low Temperature Solder on Microstructure and Reliability

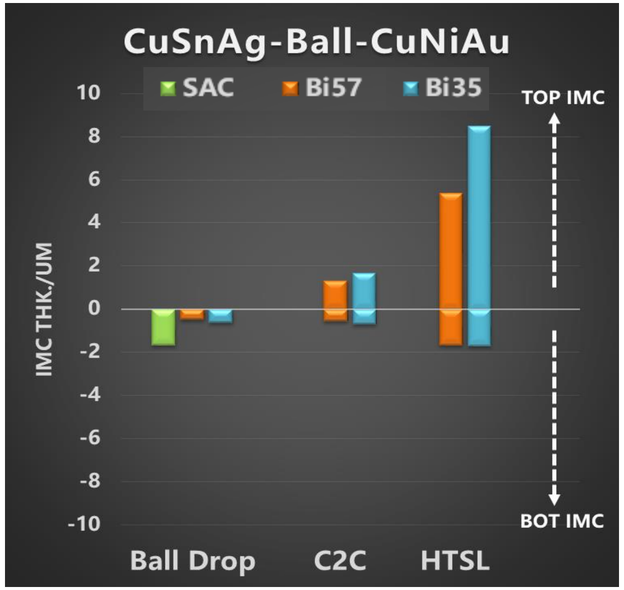
CONTENTS

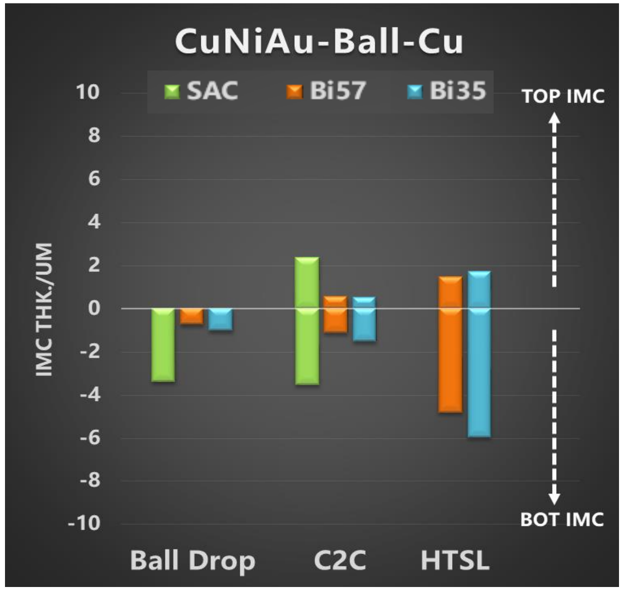
Conclusion

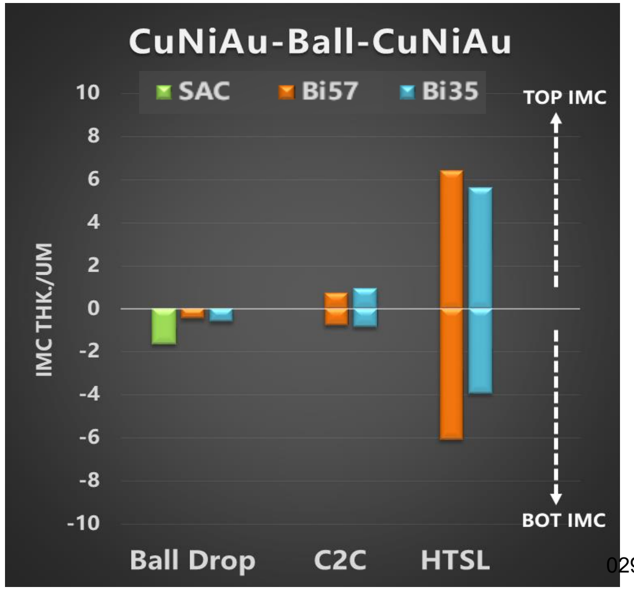
JCET

A Study of Low Temperature Solder on Microstructure and Reliability

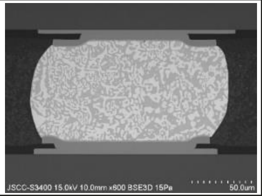
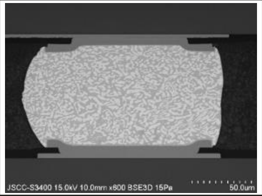
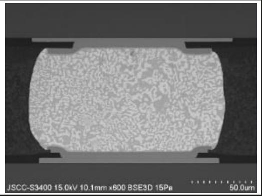
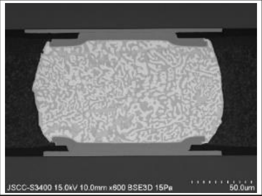
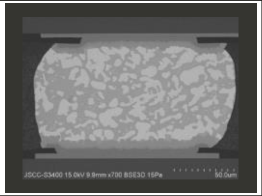
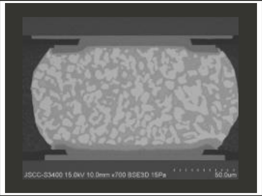
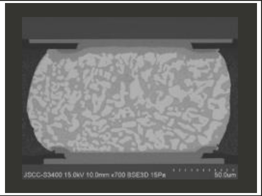
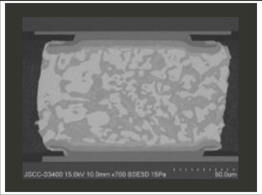




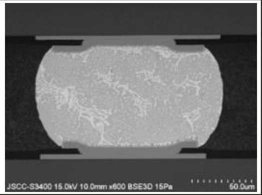
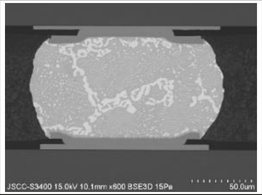
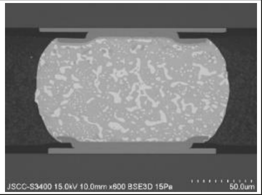
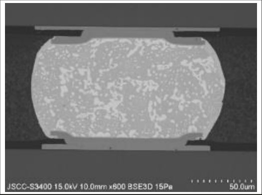
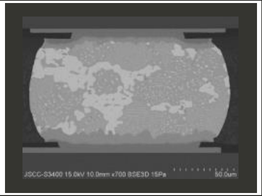
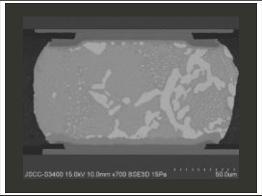
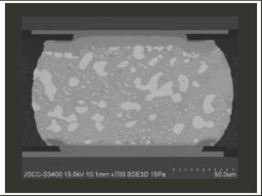
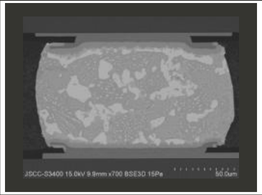




SnBi(57)Ag

Bi57	Cu-Cu	Au-Cu	Cu-Au	Au-Au
C2C				
HTSL 500h				

SnBi(35)AgNi

Bi35	Cu-Cu	Au-Cu	Cu-Au	Au-Au
C2C				
HTSL 500h				

Conclusion

JCET

A Study of Low Temperature Solder on Microstructure and Reliability

LTS Effect: SnBi(57)Ag & SnBi(35)AgNi

1)Compared to SAC, SnBi(35)AgNi formed thinner IMC and SnBi(57)Ag even thinner IMC.

2)SnBi(57)Ag showed more homogenous Bi distribution than SnBi(35)AgNi, under all process flow (ball drop, C2C, HTSL and TC reliability).

Interface Effect: UBM Cu & CuNiAu

1)There was a synergistic effect of both TOP/BOT UBM interfaces on solder joints.

2)The synergistic effect turned significant after HTSL and TC aging.

When only one side UBM was CuNiAu, Ni suppression to generate only thinner Ni_3Sn_4 IMC. However, when both side were CuNiAu (Au 0.3um), double Au content induced the generation of $(Ni_xAu_{1-x})Sn_4$ on the base of Ni_3Sn_4, totally produced much thicker IMC.

Reliability: HTSL (Condition A) & TC (Condition B)

1)Both SnBi(57)Ag & SnBi(35)AgNi C2C test vehicle passed HTSL 500h and TC 500cycles, for all 4 kinds of TOP/BOT UBM combinations (Cu-Cu, Au-Cu, Cu-Au, Au-Au).

2)All above conclusions will be further explore until HTSL and TC continued to 1000h and 1000cycles.

Thank You!

JCET Group