Evaluating the Recess Depths of Recess-in-Motherboards using Different Metrologies

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Abstract
The demand to produce smaller electronic devices and products to meet the needs of consumer electronic applications has resulted in thinner ball grid array (BGA) packages with finer pitches. Due to the z- height constraints of BGA packages, having a recess-in-motherboard (RiMB), where a recess is formed within the motherboard, allows for the placement of larger passive components on the land side of the BGA package. In this work, we evaluated: (i) the capabilities of three different suppliers to manufacture RiMB, (ii) three different metrologies to measure recess depths accurately, and (iii) the typical contour of a recess. There are different technologies to form recesses (i.e. laser versus mechanical routing), and this work found that there are differences in the process capabilities among suppliers, which can cause variation in the recess depths between RiMB manufactured by different suppliers. For the laser routed boards, the normalized variability plot comparing all three suppliers showed that Supplier B had the tightest range, but manufactured recesses on average were 23.4 µm below their specified target depth, resulting in shallower recess depths. Supplier C had the greatest variability and had quality issues where some of the recess depths exceeded the specified four sigma design requirement. Supplier A showed the best depth control and improved their depth accuracy from Lot 1 to Lot 2. For the mechanical routed RiMB manufactured by Supplier A, it was found that the mean recess depth was 162.0 µm ±12.6 µm. Due to the great variability and difficulty to control recess depths using mechanical routing, no further RiMB builds were pursued in this study using this manufacturing method. The metrology study found that the recess depths measured at room temperature using both an optical coordinate measuring machine (OCMM), and cross-sections were within 10 µm of those measured by the 'Golden Metrology', thus making them viable metrologies to accurately measure recess depths. Lastly, this work found that the general contour of the recess had the deepest depths at the inner edges of the recess, while the shallowest depths tended to be in the center of the recess.

1 Introduction

The movement to miniaturization has resulted in the demand for smaller, more compact designs with increasing routing density. As the BGA field reduces in pitch, the post-SMT BGA stand-off height also must reduce to optimize the assembly yield. At some point, the stand-off height becomes too small to support land side components (LSC). One potential solution to this problem is the use of a recess-in-motherboard (RiMB). Figure 1 shows: (a) the top view of a RiMB recess site, (b) side view of RiMB with LSCs, and (c) a cross-section showing an example where a the BGA stand-off height is inadequate to support LSCs, even with a recess.

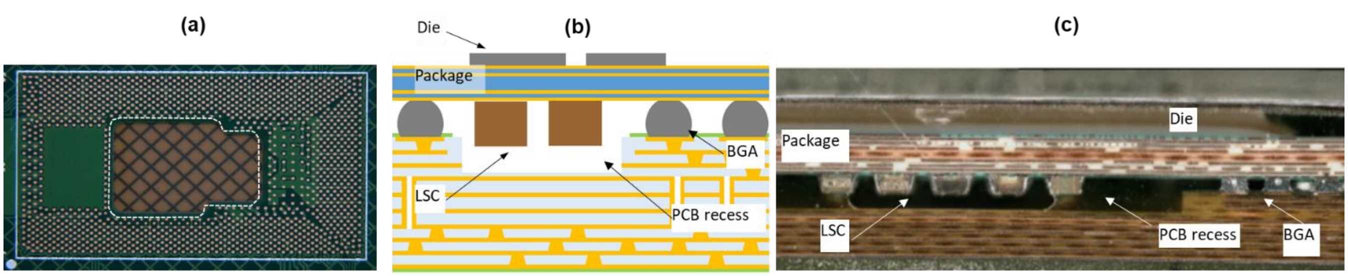

Figure 1: (a) Recess site, (b) side view of a recess with LSCs, and (c) a cross-section of a BGA

A RiMB is created by either laser or mechanical routing methods where 3 or 4 layers of the printed circuit board are removed. Work by Swettlen et al [1] provides more detailed information about RiMB and how they are manufactured. An extensive literature review has found that current work to date on RiMB has been more focused on the surface mount technology (SMT) manufacturing of components and the processing of RiMB [2-5]. To the best of the authors' knowledge, no study has focused on the use of different metrologies to evaluate recess depths. A balance in the recess depth must be struck to provide adequate depth for solder ball collapse during reflow, while retaining motherboard layers for system routing. To understand and better control the depth, we developed a process to evaluate metrology systems typical to the assembly industry.

The three metrologies evaluated in this work were the optical coordinate measuring machine (OCMM), cross-sections, and a white light confocal microscope. The OCMM is one potential non-destructive, non-contact metrology that can be used to measure recess depths, but a better understanding is required on its ability to accurately measure recess depths. In addition to the OCMM, cross-sectioning is an alternative way to measure recess depths, but this method is destructive, time consuming, and limited on the number of recess depth measurement points. To gain a better understanding on the ability of the OCMM and cross-sections to accurately measure recess depths, the white light confocal microscope was used as the 'Golden Metrology' in this work because of its accuracy and depth resolution. All three metrologies are summarized in Table 1. The authors acknowledge that the white light confocal microscope is a very specialized technique. Not all suppliers, original design manufacturers (ODMs), and original equipment manufacturers (OEMs) may have this tool, but it was important to include it in this study to ensure that more practical metrologies like the OCMM and cross-sections are validated as viable metrologies to measure recess depths.

This paper will evaluate: (i) the capabilities of multiple suppliers to manufacture RiMB using laser routing, ii) the variability in depth control between mechanical and laser routed boards, and (iii) the accuracy of the OCMM and cross-sections to measure recess depths versus a 'Golden Metrology' which was chosen to be the white light confocal microscope.

Table 1 – Comparison of Metrologies

	White Light Confocal Microscope	OCMM	Cross-sections
Method	-Non-contact -Uses a confocal microscope with white light	-Non-contact -Image capture camera	-Two reference pads are used as a reference to cut a section of the recess. -This section is then potted in an epoxy material and polished.
Destructive	No		Yes
Resolution	-Depth resolution: 0.2 µm -Spatial resolution: 1 µm	Depth & spatial resolution: 5X magnification: 2 µm/pixel	-This will be dependent on the optical microscope used, but the magnification ranges from 100X – 1000X.
Accuracy	-Depth: ±0.2 µm -X & Y: ±10 µm over a 200 mm travel distance	-Depth: ±1.5 µm -X & Y: ±1.5 µm	-This will be dependent on the operator and microscope. -Typically → ±10 µm
How the depth is determined in this work?	-Z-reference plane -100 µm beam spot size with 5 µm scan steps -An average value is calculated within the 100 µm spot size to determine the recess depth for each point in the recess.	-Z-reference plane -Camera focuses on the cavity point and determines the value.	-An optical microscope that is typically set to a magnification of 200X or 300X is used with compatible software to stitch an image of the recess area of interest. -Depending on the length of the recess area, a specified number of measurements are taken using software that is compatible with the optical microscope
Vacuum	Yes	No	

2 Experimental Methods and Validation

This section is divided in two parts. The first part will highlight the experimental method used to measure recess depths for RiMB manufactured by 3 different suppliers using the optical coordinate measuring machine (OCMM). The second part highlights the validation of OCMM and cross-section results using the 'Golden Metrology'.

2.1 Optical Coordinate Measuring Machine (OCMM)

In this work, a production optical coordinate mechanical coordinate (OCMM) was used to measure the recess depths for three different suppliers. The RiMB were either mechanically or laser routed. A typical RiMB test vehicle (TV) has 2 recess test boards (RTBs), with 3 unique recess sites per RTB, for a total of 6 unique sites per TV. A typical TV is shown in Figure 2.

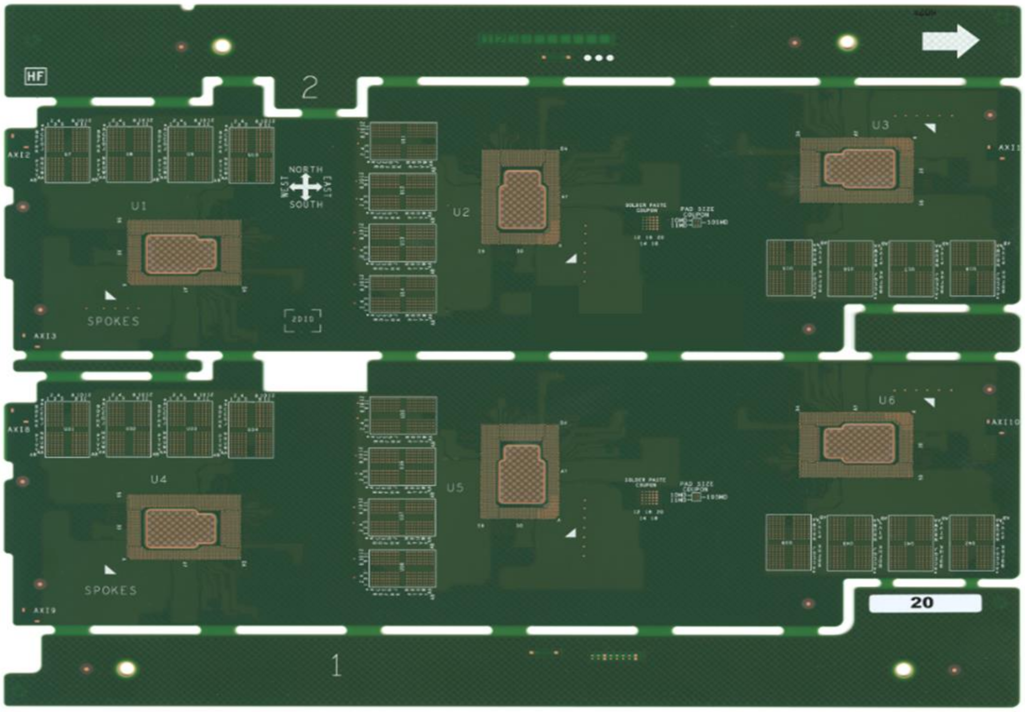

Figure 2: A typical RiMB test vehicle with six recess sites

The sample size and number of RTBs measured using the OCMM is summarized in Table 2.

Table 2 – Summary of the Number of Samples Measured

Supplier	Lot	Manufacturing Method	Number of TVs Measured	Number of RTBs	Number of recess sites
A	1	Laser Routed	20	40	120
A	2	Laser Routed	20	40	120
A	1	Mechanically Routed	20	40	120
B	1	Laser Routed	20	40	120
C	1	Laser Routed	16	32	96

The recess measurement points, and reference pads used to determine the recess depths in this work are shown in Figure 3.

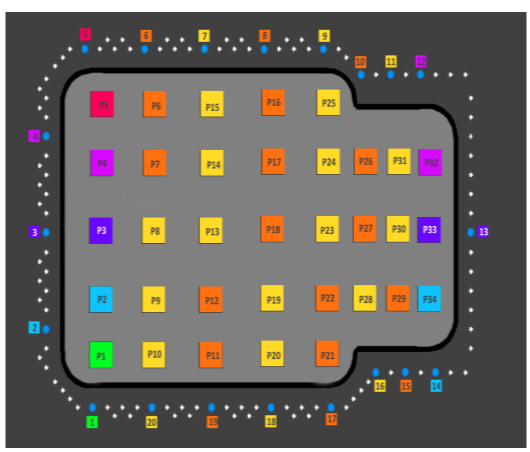

Figure 3: OCMM measurement points and reference pads

From Figure 3, it can be seen that 34 recess measurement points (i.e. P1 – P34) were measured in each recess, for a total or 204 measurement points per TV. To ensure accurate results, a total of 20 reference pads (i.e. labelled 1 – 20) nearest the recess measurement points were chosen. To ensure that the most accurate depths were determined, the surface reference pads nearest the recess measurement points were selected in order to nullify sample tilt and minimize bow and twist in the calculation of the recess depths. The matching color coding between the reference pads and recess measurement points were used to determine the recess depths (i.e. recess depth = |1-P1|, |2-P2|, etc.).

2.2 Validation of the Metrology to Measure Recess Depth

To evaluate and validate the OCMM recess depth results, one TV that was laser routed was chosen from supplier A. For this portion of the study, the exact same recipe highlighted in Figure 2 was followed to ensure that the exact same measurement points and reference pads could be matched to the OCMM results. Since the OCMM results needed to be validated, a 'Golden Metrology' was chosen in this work. Due to its high accuracy and resolution, a production white light confocal microscope was chosen to be the 'Golden Metrology'. The units were prepared using standard potting and polishing methods, and a total of 6 cross-sections were evaluated. The entire area of each cross-section was imaged at 300X using a production optical microscope, and compatible software was used to measure the recess depths. Two distinct recesses were cross-sectioned, and 3 cross-sections per recess were prepared. Figure 4 highlights the cross-section locations. Each red line indicates one cross-section, and from Figure 4 it can be seen that measurement points P1 – P5 (cross-section 1), P16-P20 (cross-section 2), and P32-P34 (cross-section 3) were matched to the same measurements points as the OCMM and confocal microscope. This was repeated for a second recess.

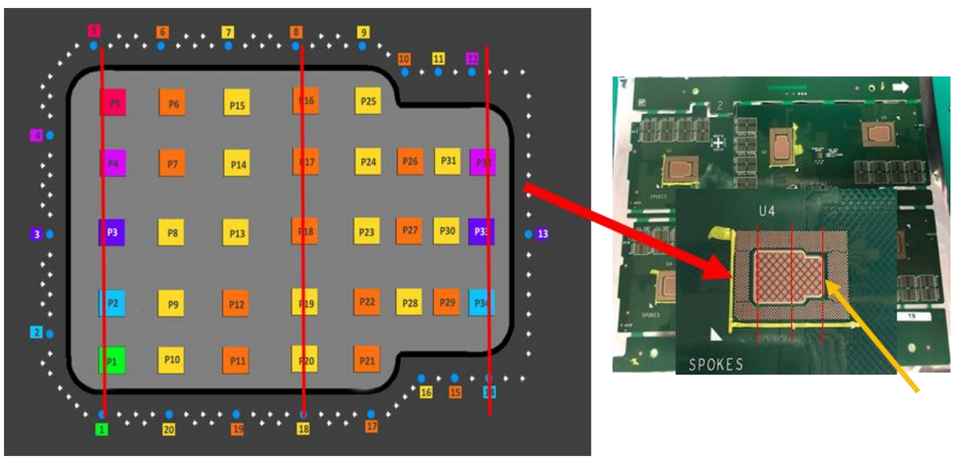

Figure 4: Cross-section locations

3 Results and Discussion

This section will discuss: (3.1) the recess depths measured using the OCMM for 3 different suppliers, (3.2) evaluate the ability of the OCMM and cross-sections to accurately measure recess depths versus the 'Golden Metrology', and (3.3) the typical recess contour.

3.1 OCMM Recess Depth Measurements

The initial OCMM recess depths were measured on Lot 1 for suppliers A, B, and C. A second lot from supplier A was added to the analysis to evaluate the process capability of supplier A, and to see how the recess depth varied between lots. The target recess depths specified by each supplier and the four sigma design tolerance is summarized in Table 3.

Table 3 – Supplier Specified Target Recess Depth and 4σ Design Tolerance

Supplier	Supplier Target Recess Depth (μm)	Tolerance[1] (μm)
A	198	±50
B	205	
C	186	

[1]Note – The tolerance represents a 4σ Value

The box plots in Figure 5 summarizes the recess depths measured by the OCMM, and the mean recess depth and standard deviation values are summarized in Table 4.

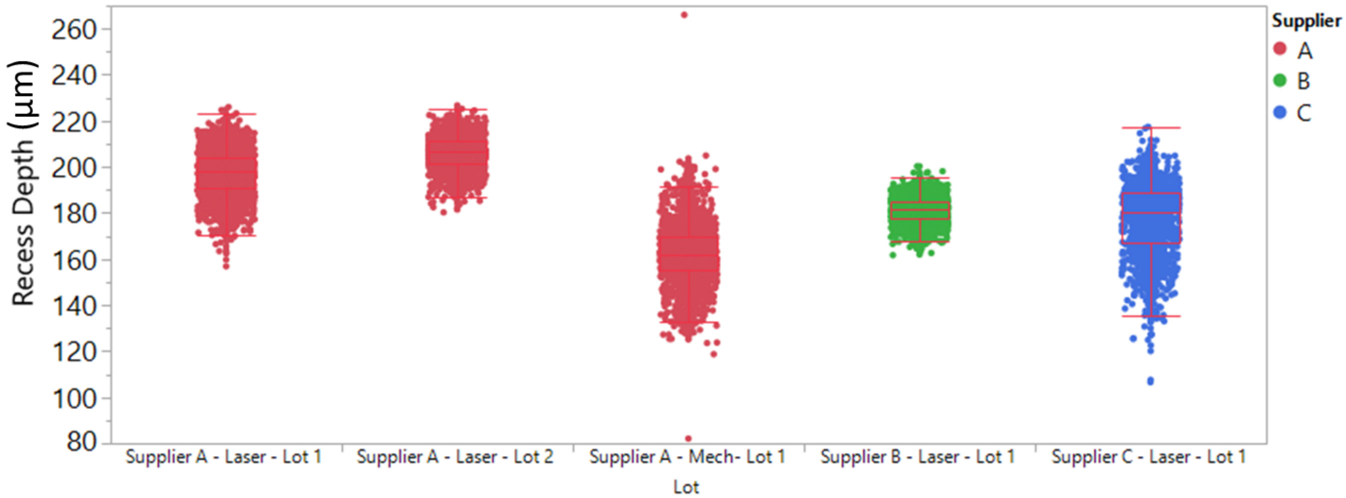

Figure 5: Summary of recess depths by lot

Table 4 – Summary of the Mean Recess Depth and Standard Deviation

Supplier	Formation	Lot	Mean Recess Depth (µm)	Standard Deviation (µm)	Supplier Target Recess Depth (µm)
A	Laser	1	197.4	9.9	198
A	Laser	2	206.4	7.1	198
A	Mechanical	1	162.0	12.6	198
B	Laser	1	181.3	5.3	205
C	Laser	1	177.2	14.9	186

The data in Figure 5 and Table 4 suggests the following:

- Mechanically formed recesses versus laser formed → depth control is more difficult, and recesses tend to be shallower.
- Supplier A → Laser formed recesses tended to be very close to their specified target depth, with the supplier adjusting their process to have a much tighter recess depth in Lot 2.
- Supplier B → had the tightest recess depth range, but their laser formation process had difficulty meeting the target recess depth they specified.
- Supplier C → had the largest recess depth range, and their laser formation process had difficulty meeting the target recess depth they specified.

In order to evaluate: (i) the supplier's capability to meet the target recess depth, and ii) compare each supplier against each other, the recess depths were normalized. The recess depths were normalized using the following equation:

Delta = Supplier Target Recess Depth – OCMM Measured Recess Depth (1)

In equation 1, the Supplier Target Recess Depths uses the values listed in Table 3 and compares them to the recess depths measured using the OCMM. The normalized variability, and Box Plots are provided in Figures 6 and 7, respectively. If the Delta in equation 1 is negative, then the recess depth is deeper, but if the Delta is positive, then the recess depth is shallower (refer to Figure 6).

The normalized delta means are provided in Table 5 and provide further insight on variability between suppliers. This work found that the Supplier A laser formation process tended to be the best at controlling recess depth. They made improvements in their process to reduce the variability between manufacturing Lots 1 and 2. The laser formation process of Suppliers B and C had difficulty controlling the recess depth and produced shallower recesses than they specified in Table 3. This data clearly shows that mechanically formed recess depths tend to be variable, and if there is a tradeoff between cost and quality, laser formed recesses tend to be the optimal choice.

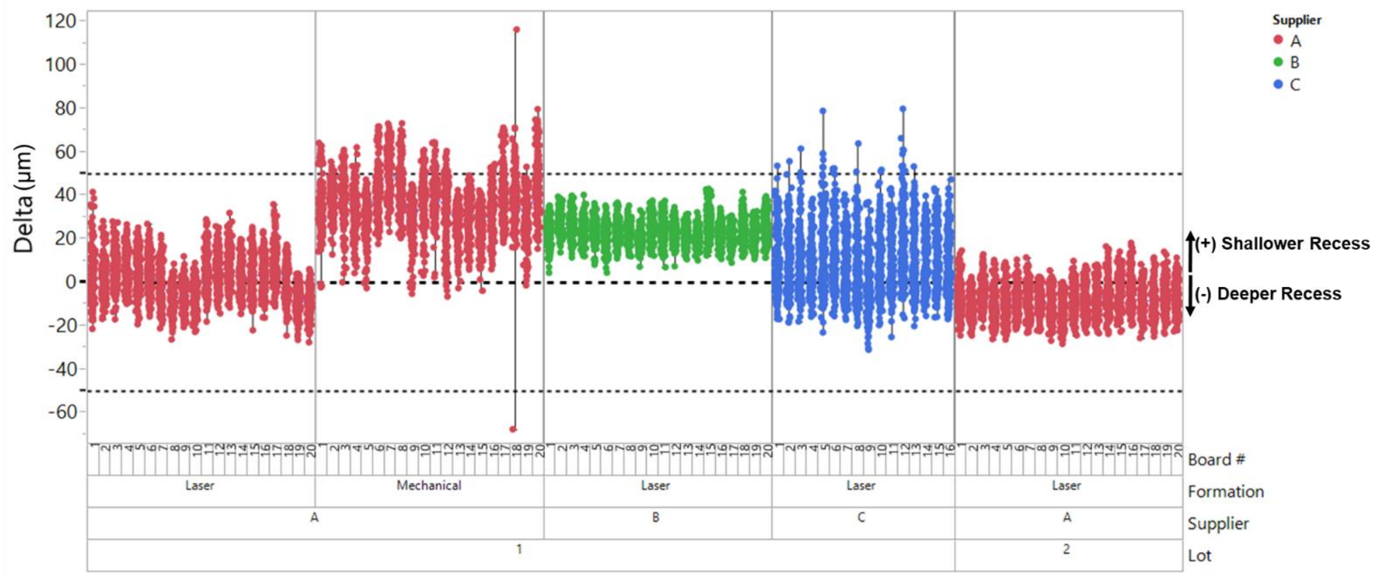

Figure 6: Normalized variability plot

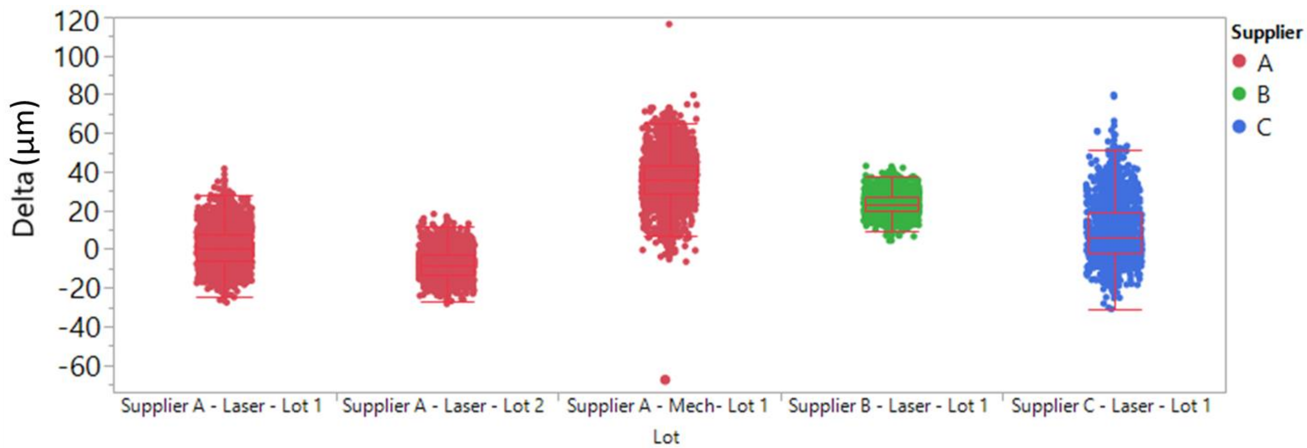

Figure 7: Normalized box plots by supplier

Table 5– Summary of the Mean Delta

Supplier	Formation	Lot	Mean Delta[2] (µm)	Delta[2] 1σ (µm)	4σ Design Tolerance (µm)
A	Laser	1	1.0	9.9	50
A	Laser	2	-8.0	7.1	
A	Mechanical	1	36.4	12.6	
B	Laser	1	23.4	5.3	
C	Laser	1	9.2	14.9	

[2]Note – These values represent that Suppler Target Depth versus the OCMM Depths

From Table 5, the following conclusions can be drawn:

Supplier A and B → For the laser formed recesses, both met the 4σ design requirement.
Supplier B → Had the tightest range, but their recess depths on average were 23.4 µm shallower than the target depth

Supplier C → Did not meet the 4σ design requirement and had quality issues which may have been material or process related.
Supplier A → Mechanically formed recesses did not meet the 4σ design requirement and had poor depth control.

3.2 Metrology Comparison: OCMM, Cross-sections, and White Light Confocal Microscope

For the metrology comparison, each corresponding measurement point was matched and the difference (i.e. delta) between each metrology recess depth was taken for each point. For example, the recess depth measured by both the OCMM and the confocal microscope at point 1 (i.e. P1) as per Figure 4 were matched for each recess location, and the delta was calculated. Both recess depths obtained using the OCMM and cross-section methods were compared to the 'Golden Metrology' (i.e. the white light confocal microscope). The metrologies were compared as follows: a) cross-sections versus OCMM, b) cross-sections versus white light confocal microscope, and c) OCMM versus white light confocal microscope. The delta values are summarized in Figure 8 and Table 6.

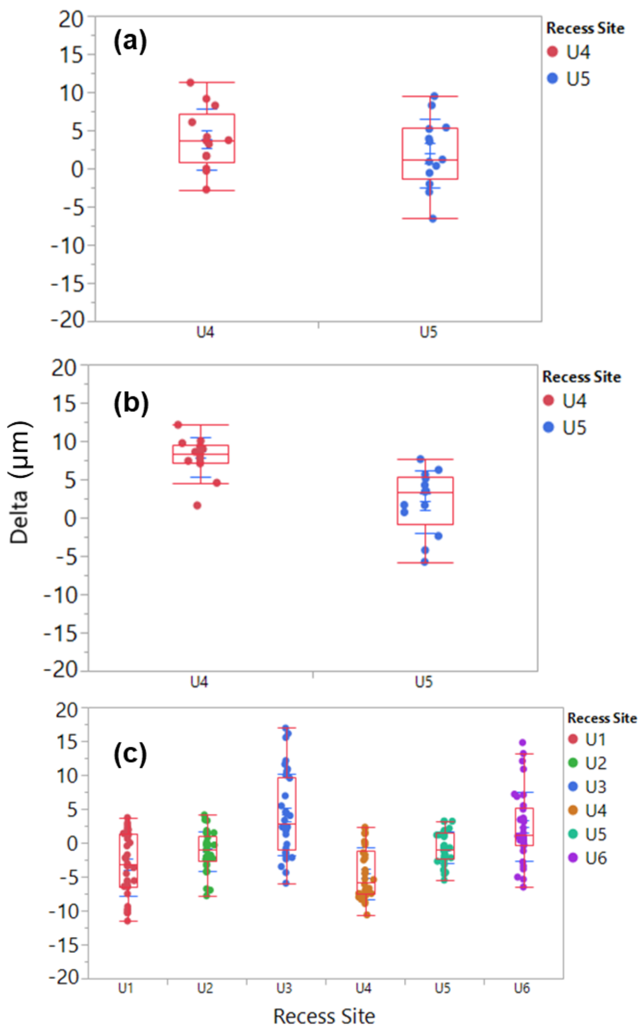

Figure 8: Delta recess depths for: (a) Cross-sections – OCMM, (b) Cross-sections – White Light Confocal microscope, and (c) OCMM – White Light Confocal Microscope versus the recess location.

Table 6 – Summary of Metrology Comparison

Criteria	Cross-sections vs OCMM	Cross-sections vs White Light Confocal	OCMM vs White Light Confocal Microscope
Recess Depth Means (μm)	~197± 9 vs ~194.1± 9	~197± 9 vs ~192 ± 7.9	~194.1± 9 vs ~192 ± 7.9
Delta Recess Depth Mean (μm)	Delta mean → 2 – 4	Delta mean → 2- 8	Delta mean → 2.5-4.5

The data shows that when both the OCMM and cross-section recess depths are compared to the 'Golden Metrology', both metrologies are able to measure recess depths accurately, and are viable metrologies for the incoming inspection of RiMB.

3.3 Typical Recess Contour

The data obtained in this study has found that the deepest recess depths tend to fall along the edges of the recess (dark blue) and the shallowest recess depths tend to fall in the center of the recess (light blue/green) – refer to Figure 9. Obtaining a better understanding of these contour plots requires working with different suppliers to: (i) gain a better understanding of their processes, and (ii) help target specific locations in the recess to better control depth at the different points.

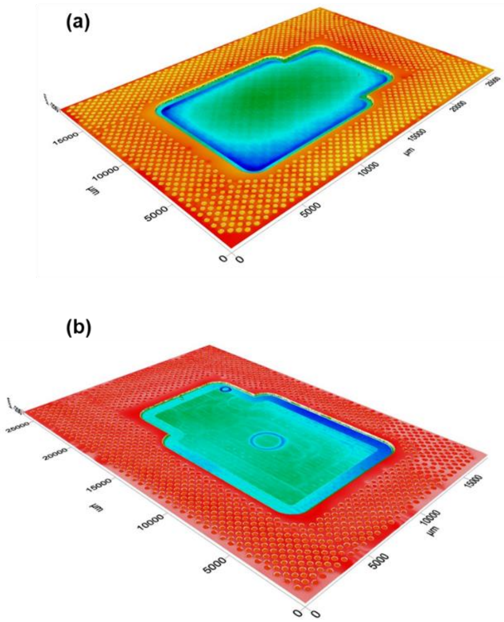

Figure 9: Typical contour of a: (a) laser, and (b) mechanically formed recesses

4 Conclusions

RiMB technology enables reduced z-height ball grid array (BGA) package architectures by removing 3 or 4 layers from the PCB either by laser or mechanical formation. This allows for the placement of larger landside components, greater routing density, compressed PCB designs, no electromagnetic shield, and more space in the electronic package for the placement of the battery.

This study found that different suppliers have different process capabilities to control recess depths. The variability from one supplier to another can result in significant differences in the recess depth. The method used to manufacture recesses plays a vital role. Laser routing methods are superior to mechanical routing methods when manufacturing RiMB. This work found that depth control using mechanical routing is very difficult, and it results in a wide variability in recess depths.

Having the ability to accurately measure the recess depth allows for better process control and provides an incoming quality tool for vendors utilizing this technology. The OCMM is a non-contact, non-destructive and a very promising metrology to measure recess depths. The recess depth data collected using both the OCMM and cross-sections was compared to a 'Golden Metrology'- a white light confocal microscope, and it was found that both are suitable metrologies to measure recess depths. Lastly, this work found that the recess depth contour tends to be deepest at the edges of the recess, and shallowest at the center of the recess.

5 Acknowledgements

The authors would like to thank the following contributors for their assistance in this work: Brett Bennett, Donald Coburn, Pubudu Goonetilleke, Guillermina Iniguez, Do Nguyen, and Dungh Nguyen.

6 References

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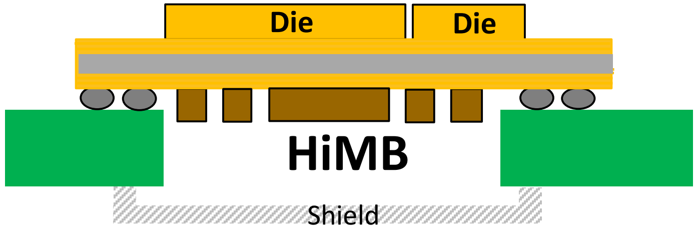
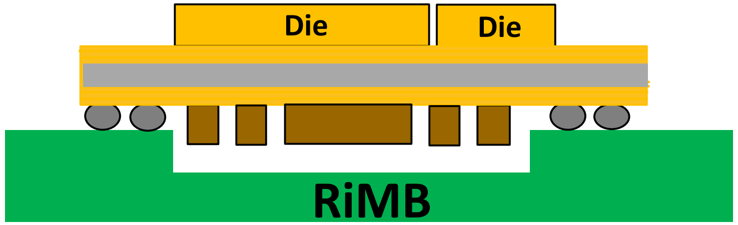
Agenda

- **Introduction to recess-in-motherboards (RiMB)**
  - ✓ RiMB versus Hole-in-motherboard (HiMB)
- **Methods to manufacture RiMB**
  - ✓ RiMB versus Hole-in-motherboard (HiMB)
- **Best known metrologies to measure recess depths**
  - ✓ Optical coordinate measuring machine (OCMM), cross-sections, and confocal microscope ("Golden Metrology")
- **Purpose**
- **The ability of different metrologies to accurately measure recess depths**
  - ✓ OCMM and cross-sections vs the "Golden Metrology"
- **Supplier capabilities to manufacture RiMB**
  - ✓ Depth control capabilities → Laser versus mechanical routing
- **Summary**

Why HiMB/RiMB for small designs?

- Tighter pitch drives smaller BGA solder balls
- Best performance is delivered w/ BGA side decoupling capacitors (LSC)
- On smallest pitch designs, LSC parts would bottom-out during assembly
- Therefore PCB requires either:
  - ✓ Hole routed from the middle of the BGA footprint (HiMB), or
  - ✓ PCB layers removed, creating a recess in the BGA footprint (RiMB)

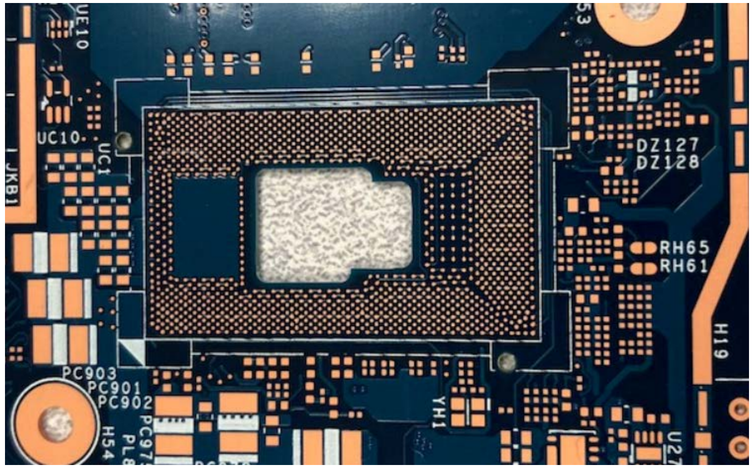




RiMB = Recess in Mother Board
HiMB = Hole in Motherboard

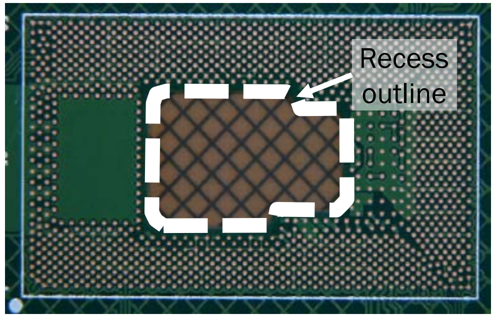
Hole-in-motherboard (HiMB) vs Recess-in-motherboard (RiMB)

HiMB

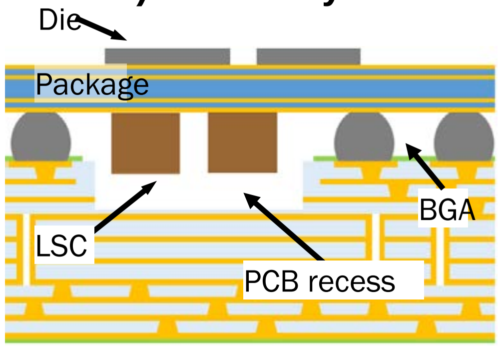


RiMB

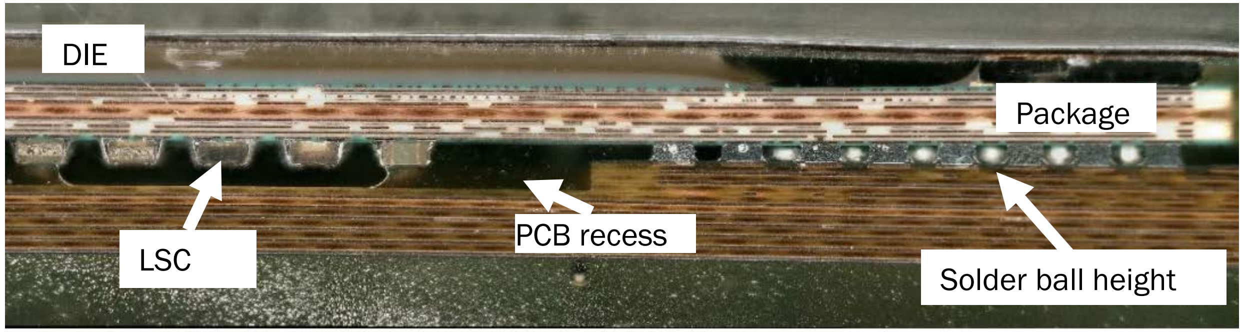
a) Bare PCB w/ center recess



b) BGA array w/ center recess

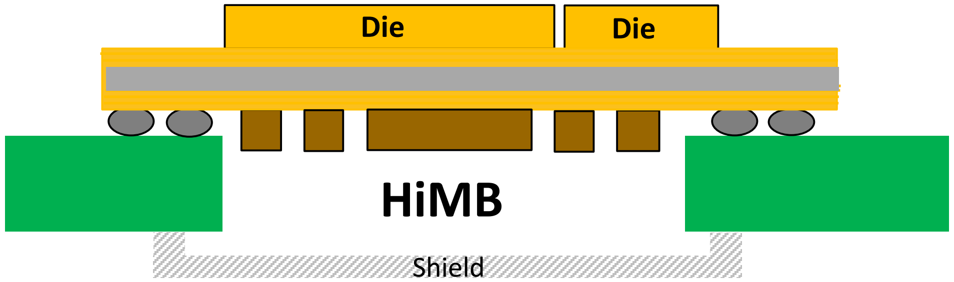


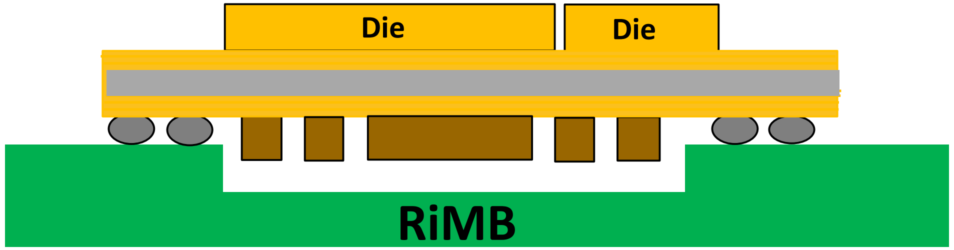
c) Cross section of BGA on a RiMB



RiMB = Recess in Mother Board
HiMB = Hole in Motherboard
LSC = Land Side Components

High Level → RiMB vs HiMB





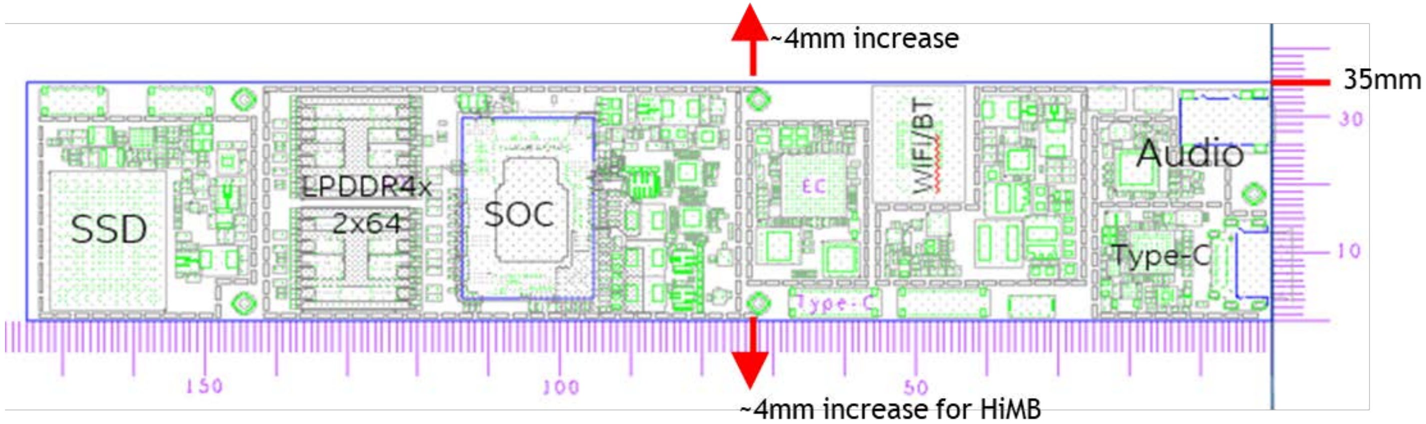
- Completely cuts out board area in package shadow→ No routing under package
- Requires external shield on back side→ SMT cost adder for single sided systems
- ✓ Limited PCB manufacturing risk and manufacturing cost (hole drilled during final routing)

- ✓ Removes 3-4 layers of the design → Ability to route below package (enables smaller systems)
- ✓ Enables single sided design without shield
- Requires more PCB design focus and more expensive for PCB manufacturers to produce

RiMB = Recess in Mother Board
HiMB = Hole in Motherboard

When to use RiMB?

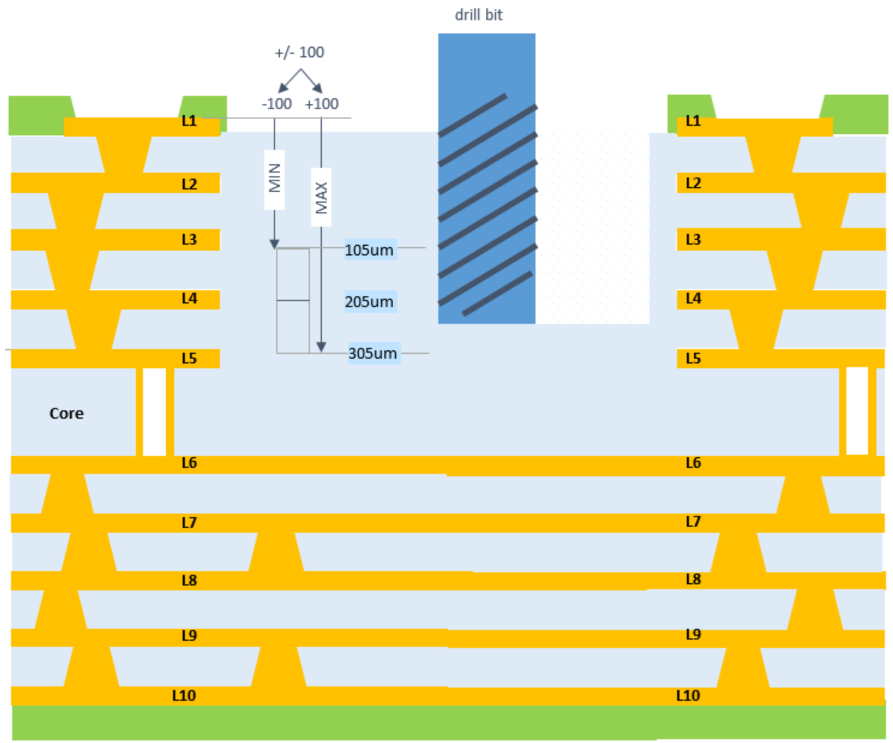
- System form factors targeting small or narrow board designs
  - ✓ Example design below has package to board edge of ~3.5mm (with RiMB). Will be >8mm increase with HiMB



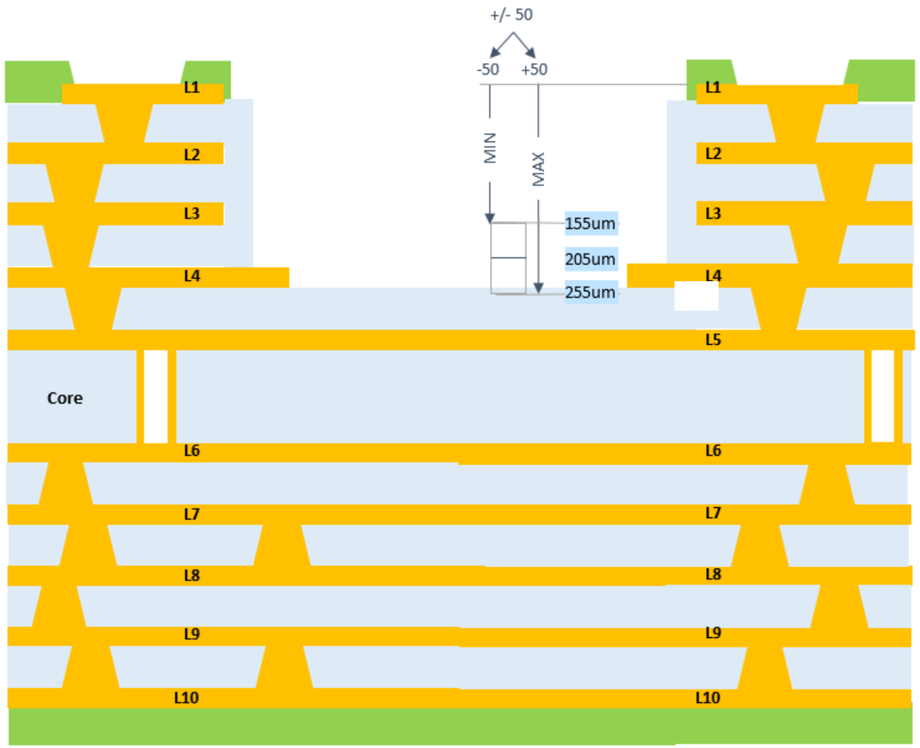
Minimum board width with HiMB: ≥43mm
Minimum board width with RiMB: 35mm

Key Point → HiMB restricts power planes and signal routing, it drives ~8mm growth in the narrowest dimension of the motherboard vs RiMB.

Common Manufacturing Methods



Mechanically Milling



Laser Routing

Best Known Metrologies to Measure Recess Depths

	Confocal Microscope (“Golden Metrology”)	OCMM	Cross-sections
Method	-Non-contact -Uses a confocal microscope with white light	-Non-contact -Image capture camera	-Two reference pads are used as a reference to cut a section of the recess. -This section is then potted in an epoxy material and polished.
Resolution	-Depth resolution: 0.2 µm -Spatial resolution: 1 µm	-Depth & spatial resolution: 5X magnification: 2 µm/pixel	-This will be dependent on the optical microscope used, but the magnification ranges from 100X – 1000X.
Accuracy	-Depth: ±0.2 µm -X & Y: ±10 µm over a 200 mm travel distance	-Depth: ±1.5 µm -X & Y: ±1.5 µm	-This will be dependent on the operator and microscope. -Typically → ±10 µm
Vacuum	Yes	No	No

Key Points

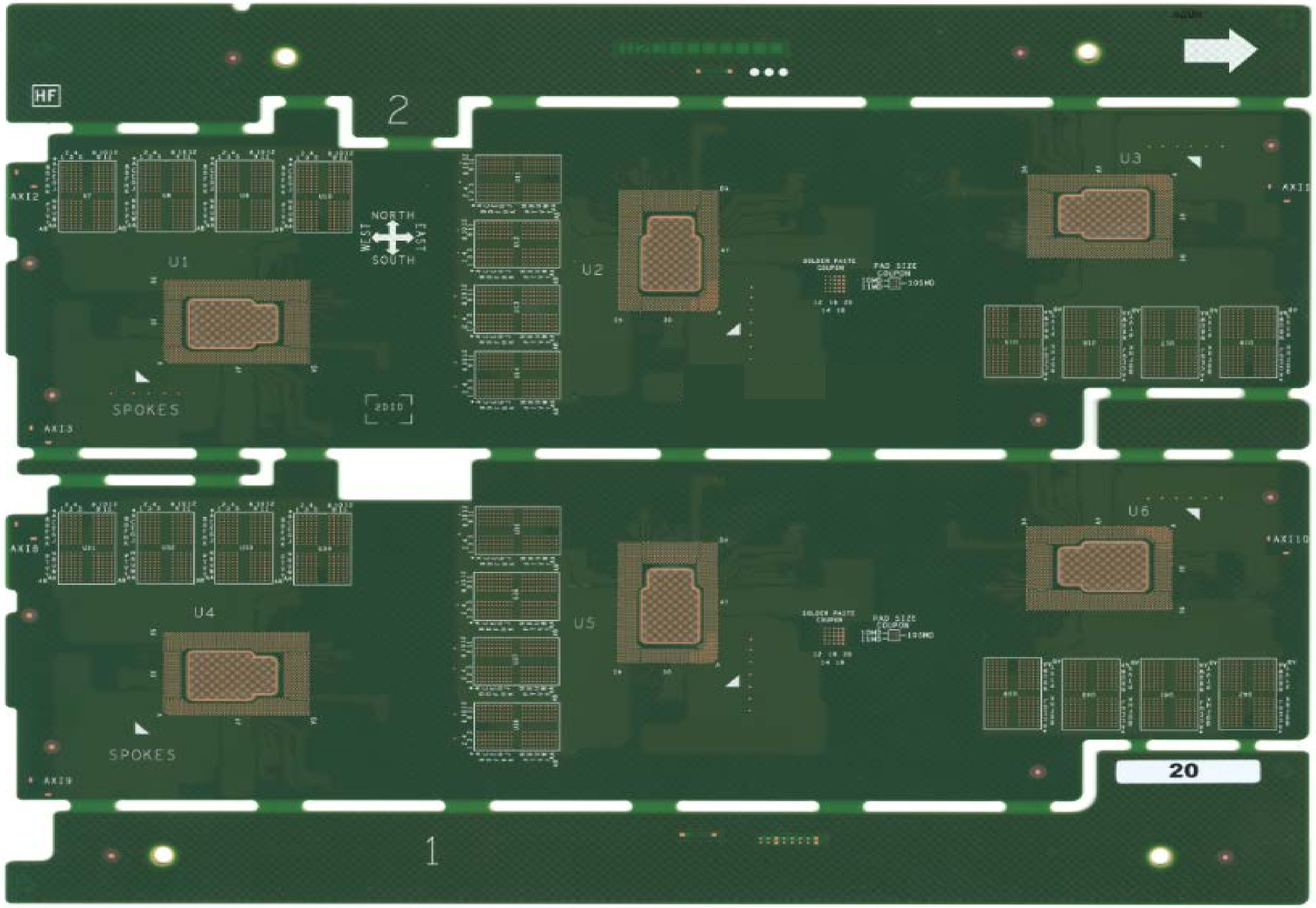
- ✓ There is more PCB design focus, and different suppliers have different processes to manufacture RiMB.
- ✓ Depth control is a crucial factor → ensuring that suppliers meet target depth → requires suitable metrologies to accurately measure recess depths.

OCMM = Optical coordinate measuring machine

Purpose

- To determine if the OCMM and cross-section methods are viable metrologies to accurately measure recess depths.
- The depth control variability between laser versus mechanical routing.
- The capabilities of suppliers to manufacture RiMB using laser routing.

Experimental Method



- Recess test vehicle (TV)
- Number of recess test boards (RTB) = 2
- Number of recesses per RTB = 3
- Number of recesses per TV = 6

Summary Of The Number of Samples Evaluated

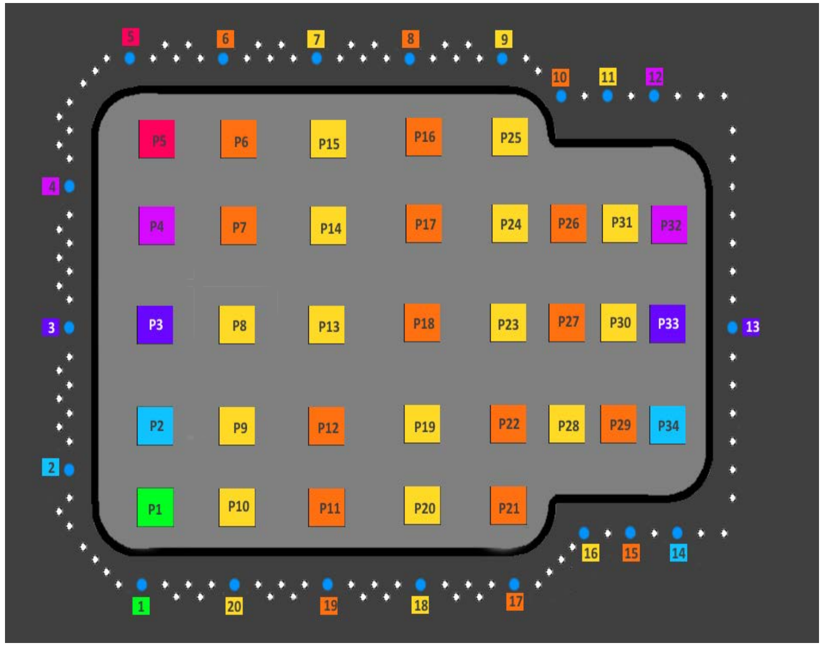
Supplier	Lot	Manufacturing Method	Number of TVs Measured	Number of RTBs	Number of recess sites
A	1	Laser Routed	20	40	120
A	2	Laser Routed	20	40	120
A	1	Mechanically Routed	20	40	120
B	1	Laser Routed	20	40	120
C	1	Laser Routed	16	32	96
Total	NA	NA	96	192	576

Optical Coordinate Measuring Machine Recipe

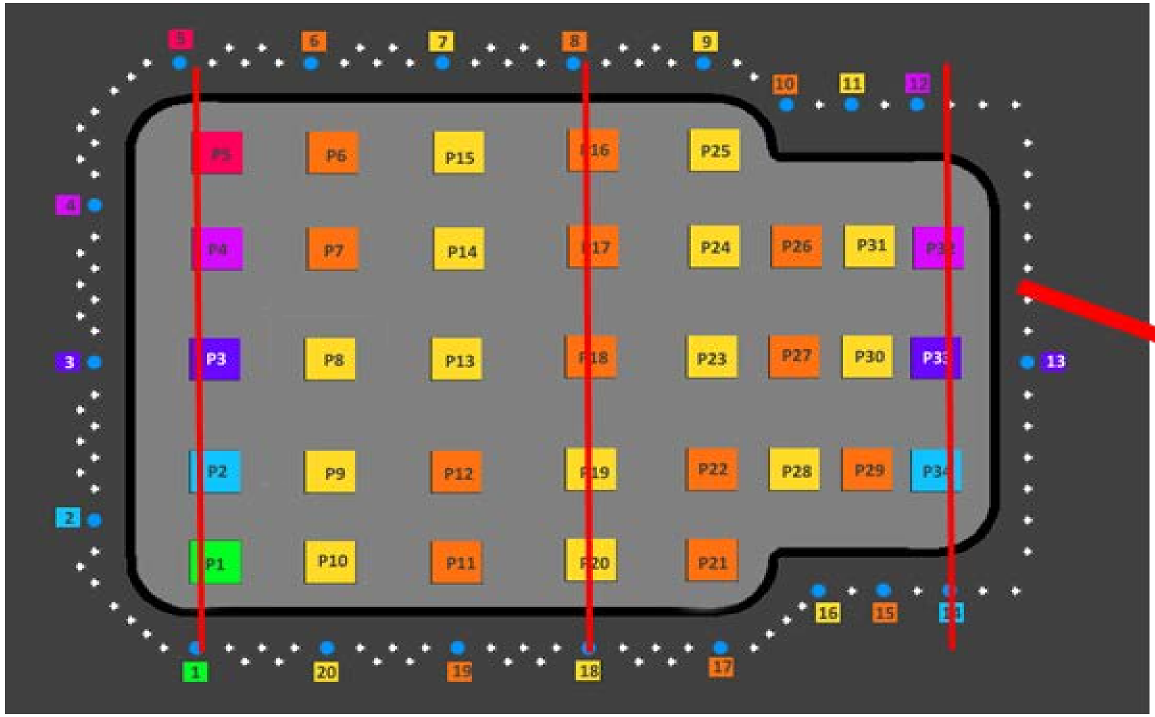
- **Recess points**
  - ✓ 34 recess points were selected
- **Reference pad selection**
  - ✓ 20 reference pads were selected nearest the recess points
- **The recess depth is calculated as follows:**

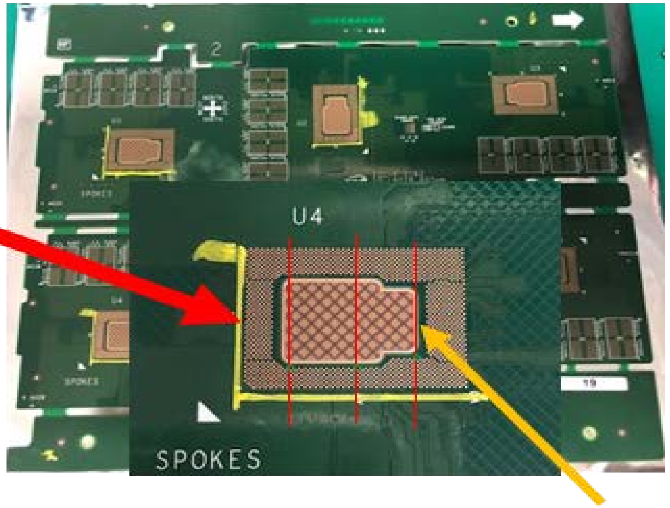
  Recess Depth = |Reference Pad – Recess Point|

- The reference pad nearest the recess point using the matching color scheme is used to calculate the recess depth. For example, for P6, the recess depth = |6-P6|, for P15, the recess depth = |7-P15|. Repeat this for all 34 recess points.
- **Note** → the same reference pads and recess measurement locations were used to determine the recess depths using the confocal microscope.



Cross-section Locations Used to Determine the Recess Depths





- Three cross-sections were prepared per recess → cross-section 1: P1-P5, cross-section 2: P16-P20, cross-section 3: P32-P34.
- Two recesses were cross-sectioned → 6 cross-sections in total

Metrology Comparison: OCMM, Cross-section Method, and Confocal Microscope

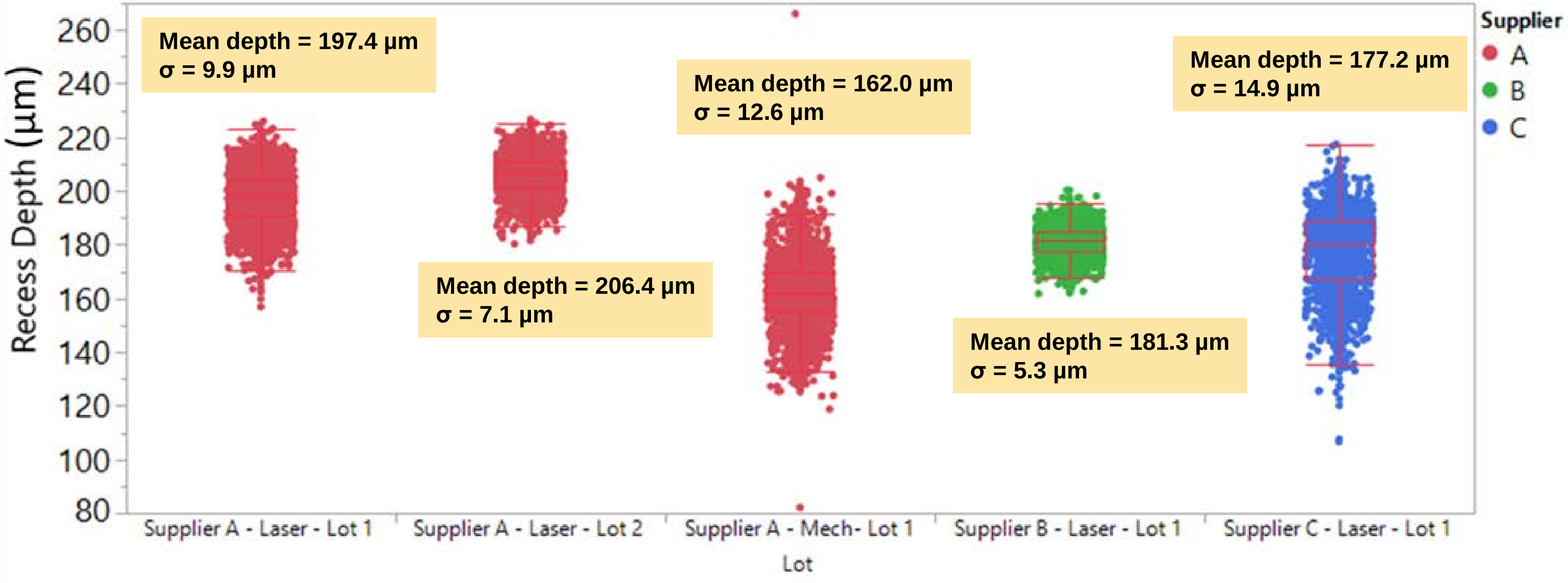
Summary of Meteorology Comparison

Criteria	Cross-sections vs OCMM	Cross-sections vs Confocal Microscope	OCMM vs Confocal Microscope
Recess Depth Means (µm)	~197± 9 vs ~194.1± 9	~197± 9 vs ~192 ± 7.9	~194.1± 9 vs ~192 ± 7.9
Delta Recess Depth Mean (µm)	Delta mean → 2 - 4	Delta mean → 2 - 8	Delta mean → 2.5 - 4.5

- One Laser routed board from Vendor A was measured using both the OCMM & confocal microscope
- Two recesses were cross-sectioned using the same board measured using the OCMM and confocal microscope
- **Conclusion**
  - ✓ **Both the OCMM and Cross-section vs the confocal microscope range from 2 µm – 8 µm**
  - ✓ **Both the OCMM and Cross-section measure recess depths accurately**

Depth Control Variability: Laser vs Mechanically Formed Recesses

Depth Control Variability: Laser vs Mechanically Formed Recesses



Supplier A: Specified Target Depth = 198 µm

Supplier B: Specified Target Depth = 205 µm

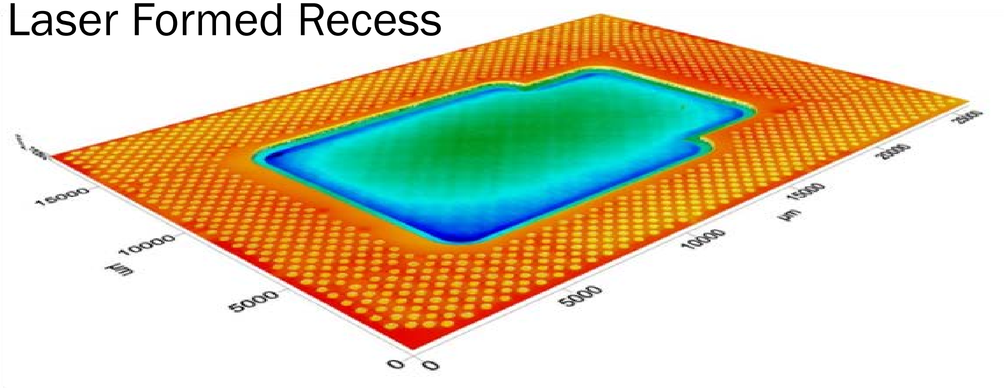
Supplier C: Specified Target Depth = 186 µm

Key Point

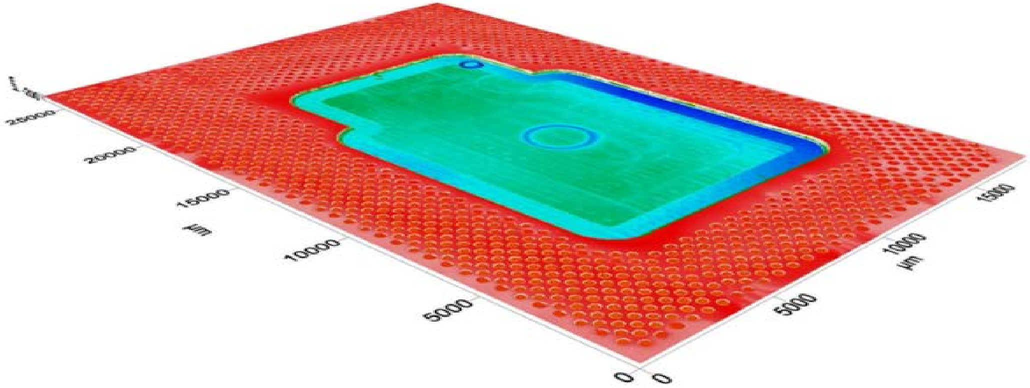
✓ Different Suppliers specified different recess depths and had different process capabilities to meet these target depths.

Typical Recess Contours for Laser and Mechanically Formed Recesses

(a) Laser Formed Recess



(a) Mechanically Formed Recess

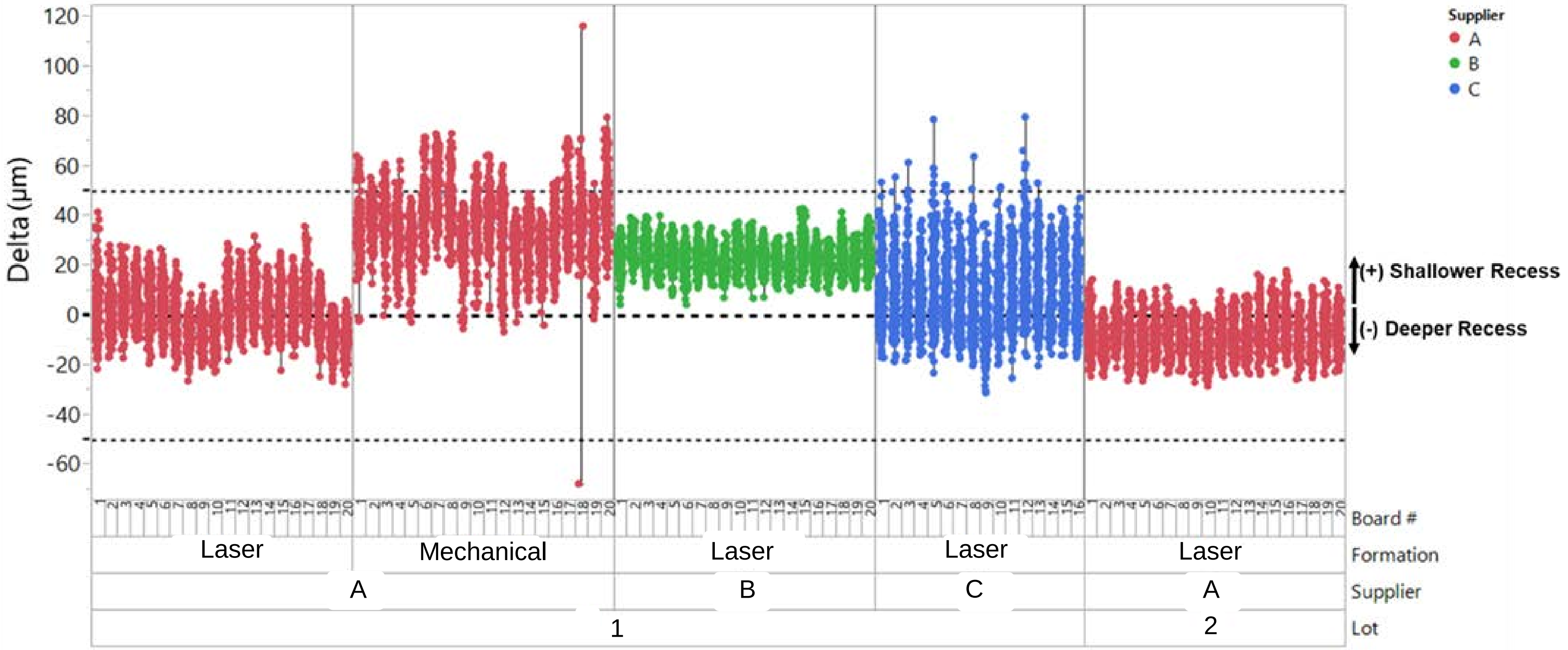


Key takeaways from the contour plots:

- The deepest recess depths tend to fall along the edges of the recess (dark blue).
- The shallowest recess depths tend to fall in the center of the recess (light blue/green).

Supplier Capability To Manufacture RiMB Using Laser routing

Normalized Variability Plot[1]



Supplier A: Specified Target Depth = 198 µm

Supplier B: Specified Target Depth = 205 µm

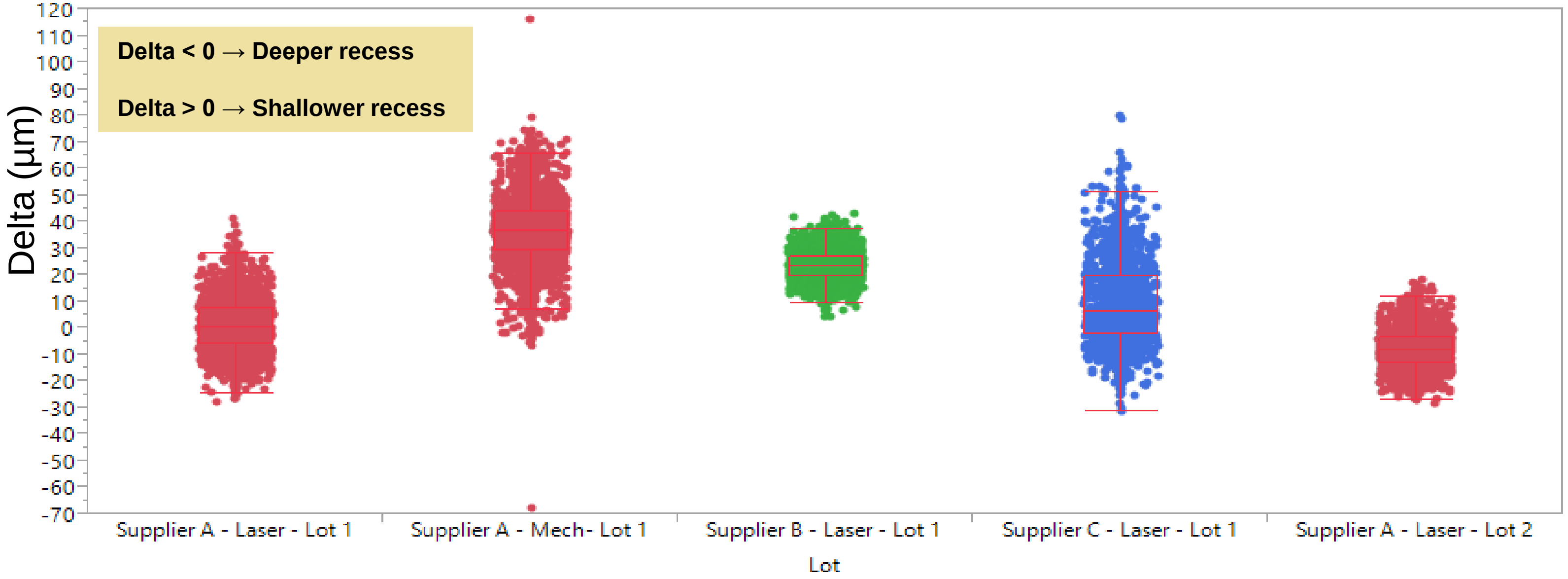
Supplier C: Specified Target Depth = 186 µm

Key Point

Different suppliers specified different target depths → to compare the capabilities of different suppliers versus each other, the data was normalized.

[1]**Note: Delta = Supplier Target Recess Depth – OCMM Measured Recess Depth**

Normalized Box Plots and Mean Delta Values



Supplier	Formation	Lot	Mean Delta (µm)	Delta 1σ (µm)	Met the 4σ Design Requirement (µm)	4σ Design Tolerance (µm)
A	Laser	1	1.0	9.9	Yes	50
A	Laser	2	-8.0	7.1	Yes	
A	Mechanical	1	36.4	12.6	No	
B	Laser	1	23.4	5.3	Yes	
C	Laser	1	9.2	14.9	No	

Key Points

- ✓ **Laser routed board** → Supplier A & B met the 4σ design requirement, while Supplier C did not meet the 4σ & had quality issues.
- ✓ **Mechanically routed board** → Supplier A did not meet the 4σ design requirement & had depth control issues.

Table Legend
Red = Supplier did not meet the **4σ Design Requirement.**
Green = Supplier met the **4σ Design Requirement.**

Summary

- Recess-in-motherboard (RiMB) technology enables reduced z-height ball grid array (BGA) package architectures by removing 3 or 4 layers from the PCB by either mechanical or laser formation.

- The ability of having metrologies that accurately measure recess depths is crucial for new-product integration and incoming quality inspection. The optical coordinate measuring machine (OCCM), and cross-section method were compared to a ‘Golden Metrology – confocal microscope’, and it was found that both the OCMM and cross-section method are both viable metrologies to measure recess depths.

- Laser **vs** Mechanically formed recesses → depth control using mechanical routing is very difficult, and it results in a wide variability in recess depths.

- The recess depths that were formed by laser routing were compared for three different suppliers, and it was found that there was supplier to supplier variability in the recess depths.

- Typical contour of a recess → i) deepest depth is along the edge of the recess, and ii) shallowest depth is along the center of the recess.

Thank You!