

# Optical Metrology and Inspection for Fan-Out Wafer-Level Packaging (FOWLP)

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www.zeta-inst.com



- About Zeta Instruments
- FOWLP advantages and metrology challenges
- WLCSP process flow and the need for multi-mode metrology systems
  - Introduction of Zeta metrology solutions
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## **About Zeta Instruments**

- Multi-mode optical profilers and defect inspection systems for cost effective production monitoring
- Offices in San Jose (HQ) and Shanghai
- Founded in 2009. More than 230 systems installed in 22 countries since 2010
- Focus on advanced semiconductor packaging, HBLED, glass, and solar industries
- World's leading OSATs have adopted the Zeta WLCSP metrology solutions
- www.zeta-inst.com

#### **APPLICATIONS**

Zeta3D<sup>™</sup> metrology systems powered by the ZDot<sup>™</sup> non-contact optical profiler and Multi-Mode Optics are capable of measuring difficult surfaces that white light interferometers and confocal microscopes cannot match.



HIGH BRIGHTNESS LED PSS Metrology & Automated Optical Inspection (AOI)

Zeta3D systems have been adopted by over 20 production PSS fabs for metrology and AOI.



Semiconductor Packaging

2.5D INTERCONNECT

Zeta3D systems have been adopted for production monitoring by leading semiconductor manufacturers and by leading OEMs for R&D and product development.



**UNIVERSITY & INDUSTRY RESEARCH LABS** Fast and Accurate surface metrology instruments

Zeta3D<sup>™</sup> Non-contact Optical Profilers are the tools to get your research done fast, accurately and enabled for multiple applications.



SOLAR CELLS Complete Production Monitoring

With the combination of ZDot non-contact optical profiler technology and application specific software. Zeta3D provides capability unavailable in systemsbased on white light interferometry or confocal microscopy.



LASER INDUCED SURFACE TOPOGRAPHY

Zeta3D<sup>™</sup> Optical Profilers can be used to quantify surfaces created from laser ablation in True Color, irrespective of their roughness, material or dimensions.



MEMS / MICRO-FLUIDICS Multi-surface Microfluidic Device Metrology

Zeta3D with ZDot non-contact optical profiler technology provides unique capability for profiling multi-layer transparent surfaces, enabling complete microfluidic device characterization for both R&D and production.



DATA STORAGE Disk Edge Metrology and Inspection

The Zeta-20CM with ZDot non-contact Optical Profiler technology enables complete, 360 degree characterization of the disk edge.



PCB & FLEX PCB Critical Dimension and Morphology

Zeta3D with ZDot non-contact optical profiler technology and Multi-Mode Optics enables a complete suite of measurements for PCB including critical dimensions (CD) step heights and morphology.



**3D METROLOGY** Non-contact Optical Profile

Zeta3D systems have been adopted by over 20 production PSS fabs for metrology and AOL



### **Multi-Mode Optics for Inspection & Metrology**

Unique capabilities for difficult surfaces

#### Zeta3D<sup>™</sup> Optical Profiler









ZIC Interference Interferometers Contrast

ZX5, ZSI

Transparent and multi-layer Low reflectivity and low-contrast **High roughness** Large height variations High aspect ratio trenches

ZetaScan<sup>™</sup> Defect Inspection



Transparent and thin materials High roughness surfaces Stacked substrates (glass on carrier)



# FOWLP advantages and metrology challenges

- Advantages
  - Thinner package
  - Higher I/O
  - Improved thermal and electrical performance
- Metrology challenges
  - Wafer warpage
  - Smaller RDL critical dimensions
  - Low reflectivity and high roughness of epoxy mold compound (EMC)



# Zeta Metrology Solutions for FOWLP

One system covers all essential measurement needs

### Zeta-500/580

- Probe mark damage
- Seed layer metal reflectivity
- PI and PR film thickness
- PI and PR opening
- RDL thickness, width, and roughness
- UBM height and roughness
- Plated Cu thickness
- Bump height
- TSV fill monitoring
- Bow and stress



#### Zeta-500

Zeta-580



# Application examples LITHOGRAPHY PROCESS MONITORING





#### Full wafer mapping and statistics





# Photoresist opening measurements



Automated feature detection and measurement



Vias in the PR layers are automatically detected and centered within the field of view. The Zeta3D software automatically measures the via diameter as well as the depth.



# Application examples PLATING PROCESS MONITORING





### 5µm RDL height and width

Automated measurement sequence down to 2um RDL





### UBM metrology



#### Measurement of UBM thickness and roughness





# Plated Cu wafer bow and stress



Zeta-500 enables multiple measurements with one tool





# Application examples REFLOWED BUMP HEIGHT MONITORING



## Solder bump metrology

Accurate, automated 3D measurement with peak detection











# Application examples LASER SCRIBE MONITORING





# Application examples FOWLP CARRIER GLASS INSPECTION



Multi-Mode optics for inspecting transparent substrates

#### ZetaScan<sup>™</sup> Defect Inspection





- Multi-Mode Optics
  - High throughput and high sensitivity at low COO
  - Accurate defect classification
  - Separation of topside, backside and interface defects
- Difficult Surfaces
  - Transparent and thin
  - High roughness
  - Stacked substrates
- Irregular shapes and sizes



# Multi-Mode optics enable defect classification

Advanced algorithms compare defect signatures

		Defect Type	ZSS	ZTS	ZSP	ZTP
N NO	ZTS Top Scatter	Top particle	very bright	bright	dark	
ZSS Side Scatter		Bottom particle	bright			
		Top Pit		bright	dark	dark and bright (down-up profile)
		Interface particle		bright		bright and dark (up-down profile)
		Interface bubble		bright	bright	bright and dark (up-down profile)
		Stain			dark	

#### <u>Notes</u>

- This table is Illustrative only
- Other factors are used as necessary (defect size, double image, aspect ratio, intensities, etc.)
- Recipes are developed for accurate defect classification on <u>customer specific samples</u>



## **Carrier glass defect types**

Different signatures in different channels enable detection and classification

Defect	Top Scatter	Side Scatter	Specular	Topography	Unique Characteristic
Pit	-				Top Scatter >> Side Scatter
Scratch	1				High Aspect Ratio
Particle		*			Side Scatter > Top Scatter

# Defect analysis report

ZETA

Includes defect map, report and pareto chart with binning





- FOWLP creates new challenges for metrology and inspection
- Automated multi-mode metrology and inspection systems provide a solution
  - Better process control
  - Cost effective
  - User friendly



# Thank you!

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