New Package Solutions for Automotive Optical Sensors

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Agenda

Automotive Market Trends

Automotive Imaging Packaging Challenges and Solutions

Cavity Optical BGA Package Development and Results

Summary

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Automotive Market Trends

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Automotive Forecast

Advance Driver Assistance System (ADAS) Level Transition Periods

Vehicle Sales Breakdown Forecast By Autonomy Level (Mu)

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Source: Imaging for automotive, Yole Development, 2024.

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Advance Driver Assistance System Levels

Sensor Quantities Increase Significantly with Autonomous Levels

Sensors – Level 1-2	#
Ultrasonic	4
Rear Camera	1
ADAS	1
Total	6

Sensors – Level 2+	#
Ultrasonic	8
Front Radar	1
Corner Rader	2
Viewing Surround Camera	4
ADAS	1
Total	13

Sensors – Level 2++	#
Ultrasonic	8
Front Radar	1
Corner Radar	4
Viewing Surround	4
ADAS	3
In-cabin	1
Thermal µbolometer	1
Dead Reckoning	1
Total	23

Sensors – Level 3-4	#
Ultrasonic	10
Front Radar	1
Corner Radar	4
Viewing Surround	4
ADAS	6
In-cabin	2
Thermal µbolometer	1
LIDAR	1
Dead Reckoning	1
Total	30

Sensors – Level 5	#
Ultrasonic	10
Front Radar	1
Corner Radar	5
ADAS	9
In-cabin	2
Thermal µbolometer	1
LIDAR	4
Dead Reckoning	2
Total	34

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Source: Computing and AI Technologies for Automotive, Yole Development, 2023.

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Advance Driver Assistance System Levels

Safety Recommendations Become Government Regulation

Organization	2020	2021	2022	2023	2024	2025	2026	2027
C-NCAP (China New Car Assessment Program)		AEB scores point			DMS scores 2 points			
Euro NCAP	AEB scores point			CPD scores point		DMS scores point		
European Commission	UN-R157 permitted at speed limit up to 60 km/h with LKA		General Safety Regulation UN-R157 raising at speed limit up to 130 km/h with lane-changing		General Safety Regulation II		DMS to be mandatory in new vehicles General Safety Regulation III	
JNCAP (Japan New Car Assessment Program)	UN-R157 permitted at speed limit up to 60 km/h with LKA			UN-R157 raising at speed limit up to 130 km/h with lane-changing				
NHTSA (National Highway Traffic Safety Administration)	Publication of the "AV 4.0"		AEB, FCW, and LDW are recommended			Fully automated safety features		

AEB: Automatic Emergency Braking
DMS: Driver Monitoring System
LDW: Lane Departure Warning

CPD: Child Presence Detection
FCW: Forward Collision Warning
LKA: Lane Keep Assistance

Source: Imaging for automotive, Yole Développement, 2024. & Websites

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Automotive Imaging Packaging Challenges and Solutions

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Automotive Imaging and Optical Sensing Challenges

Technology Trend	Market Requirement
Advanced wafer node	Cost competitive
Higher resolution	Fast development (time to market)
Integration	Miniaturization path
Thermal management	Package robustness (automotive grade)

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Automotive Imaging and Optical Sensing Challenges

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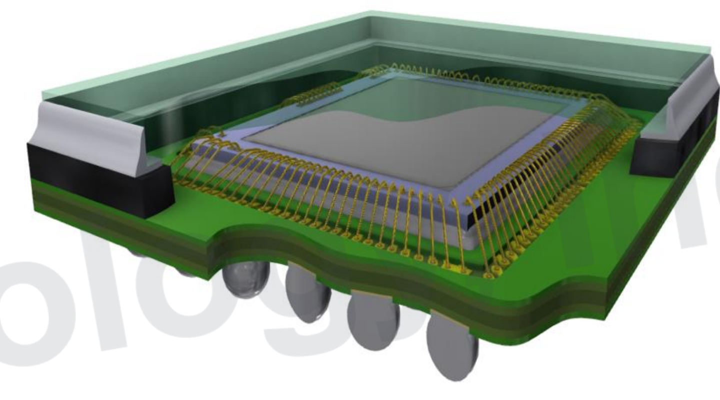

Package Solution

- Standard on the outside, custom on the inside
- Faster introduction of new products
- Lower development cost
- Flexible for new technology

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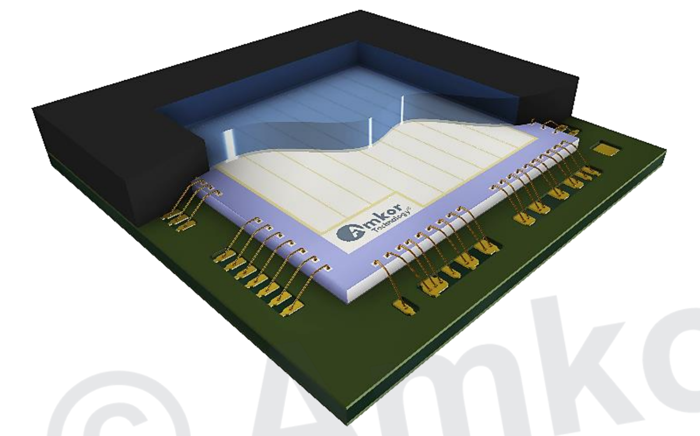
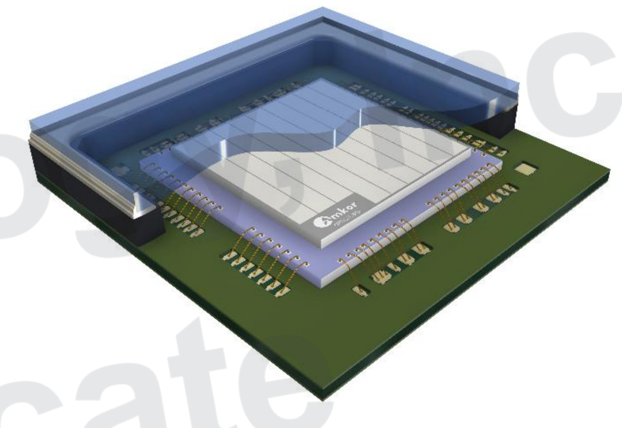
Cavity Optical BGA Platform

For Various Optical Imaging, Optical MEMS and Sensing applications





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Overmolded Packages

- Ambient Light

- InfraRed (IR)

- Temperature

- Fingerprint Sensors

Cavity Packages

- Temperature

- Gas/Particle Sensors
- Proximity & Ambient

- Bio-Health Sensor (Blood O_2)
- Multi-Spectral

Molded Cavity Packages

- Visible (ambient)

- InfraRed
- Beam-Steering

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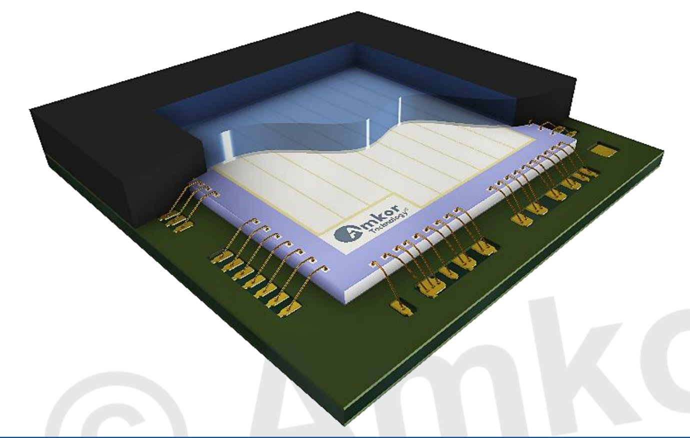
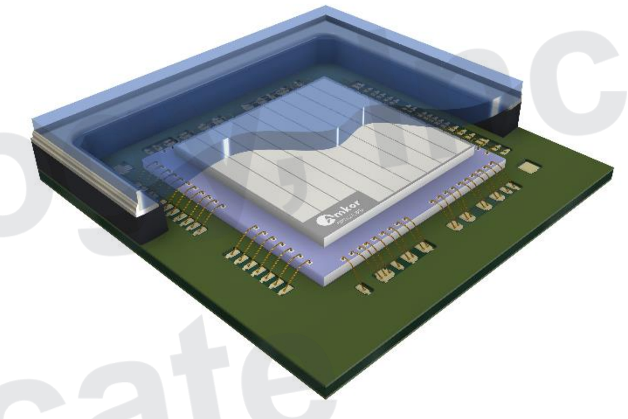
Cavity Optical BGA Platform Features

For Various Optical Imaging, Optical MEMS and Sensing applications





Overmolded Packages

Glass-on-Sensor

- Glass attached on die
- No air cavity interface
- Use DAF with high transmittance (>90%, λ: 400-700 nm)
- Single/Multi-die stacking

Cavity Packages

Glass-on-Cavity

- Air-cavity created by LCP or substrate
- Single/Multi-die stacking

Molded Cavity Packages

Glass-on-Mold

- Air-cavity created by mold process
- Compatible for standard cavity & film assisted molding
- Single/Multi-die stacking

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Molded Cavity Optical BGA Development and Results

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Cavity Optical BGA Package Platform Development

Package Information – Pre-molded Cavity + Glass on Top

Package	COBGA
Body Size	6.9 x 7.6 mm
Mold Cap	Transfer Mold
Die Thickness	Senser: 200 µm Glass: 400 µm
Die Adhesive	Standard
EMC Type	OMC-2
Glass Adhesive	NGA-2
Wire Type	25 µm (1.0 mil) Au
PCB Thickness	4 Layers/0.6 mm

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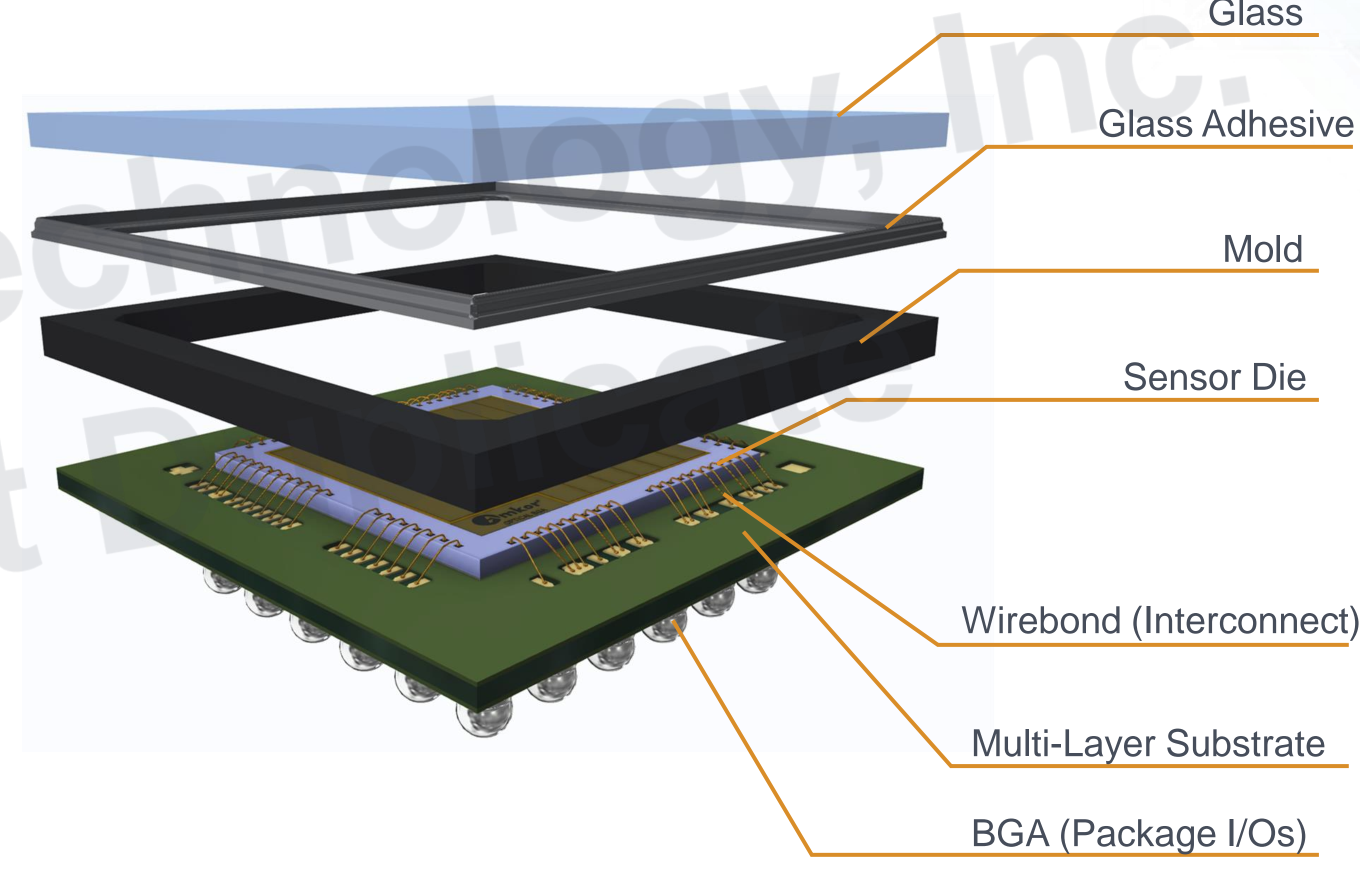

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Cavity Optical BGA Package Platform Development

Ensuring Package Robustness – Finite element (FE) Modeling Simulation

Glass

Pressure

3D Quarter Model

Glass

Die

Mold

Substrate

Pressure Direction

Glass

Epoxy

Die

Interface①

Interface②

Mold

Substrate

Detailed View

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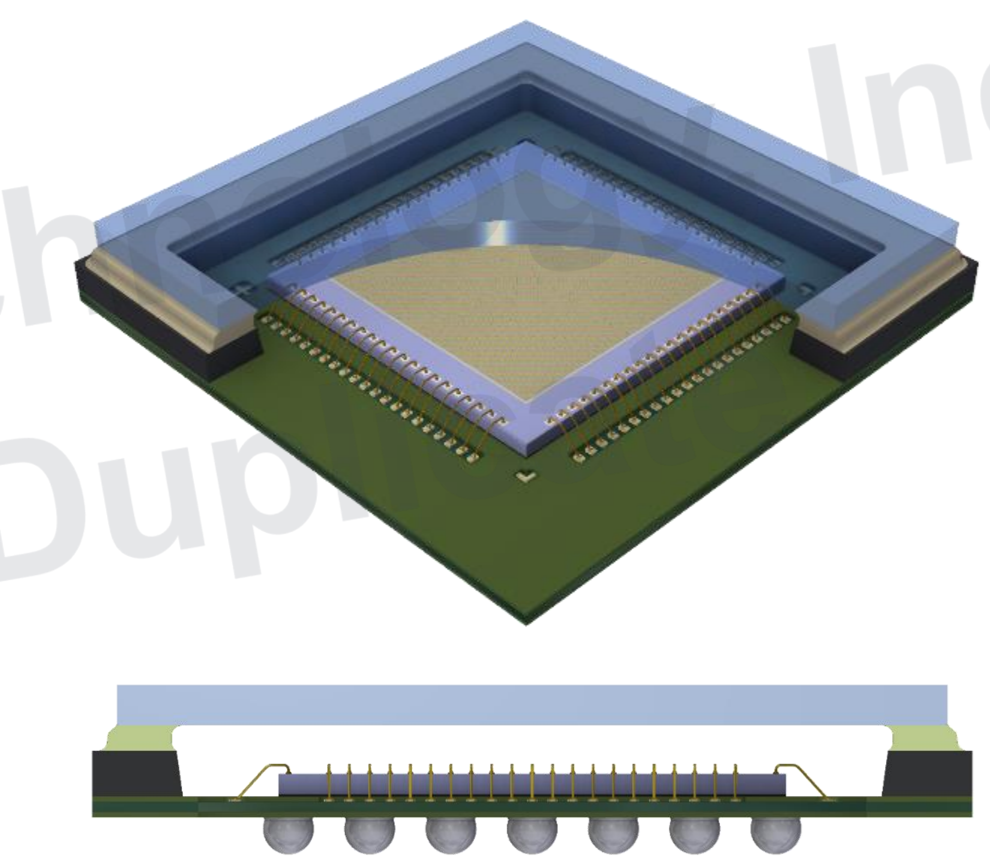
Cavity Optical BGA Package Platform Development

Ensuring Package Robustness – AECQ100 Reliability Results

- Reliability results
  - MSL 3: **SAT & Open/Short Test Passed**
  - TC (-55~125°C)
    - 500 cycles: Open/Short **Passed**
    - 1000 cycles: Open/Short **Passed**
  - HTS (150°C) w/o pre-con
    - 500 hrs: Open/Short **Passed**
    - 1000 hrs: Open/Short **Passed**
  - uHAST (130°C/85%RH)
    - 96 hrs: Open/Short **Passed**
  - Thermal & humidity (85°C/85%RH)
    - 500 hrs: Open/Short **Passed**
    - 1000 hrs: Open/Short **Passed**



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Cavity Optical BGA Package Platform Development

Ensuring Package Robustness – Integrity Check After Reliability

Reliability	Cross Section		Remark
MSL3			**No abnormality**
TCB 1000X			**No abnormality**
HTS 1000H			**No abnormality**

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Cavity Optical BGA Package Platform Development

Ensuring Package Robustness – Shadow Moire Measurement

	25 C°	150 C°	200 C°	217 C°	260 C°	217 C°	200 C°	150 C°	25C
Top	-2.8	1.2	-4.6	4.2	8	7.6	2.8	0.2	-3.8
Bottom	8.8	6.4	-4.4	-6.6	-8	-7.8	6.2	11.4	17.4

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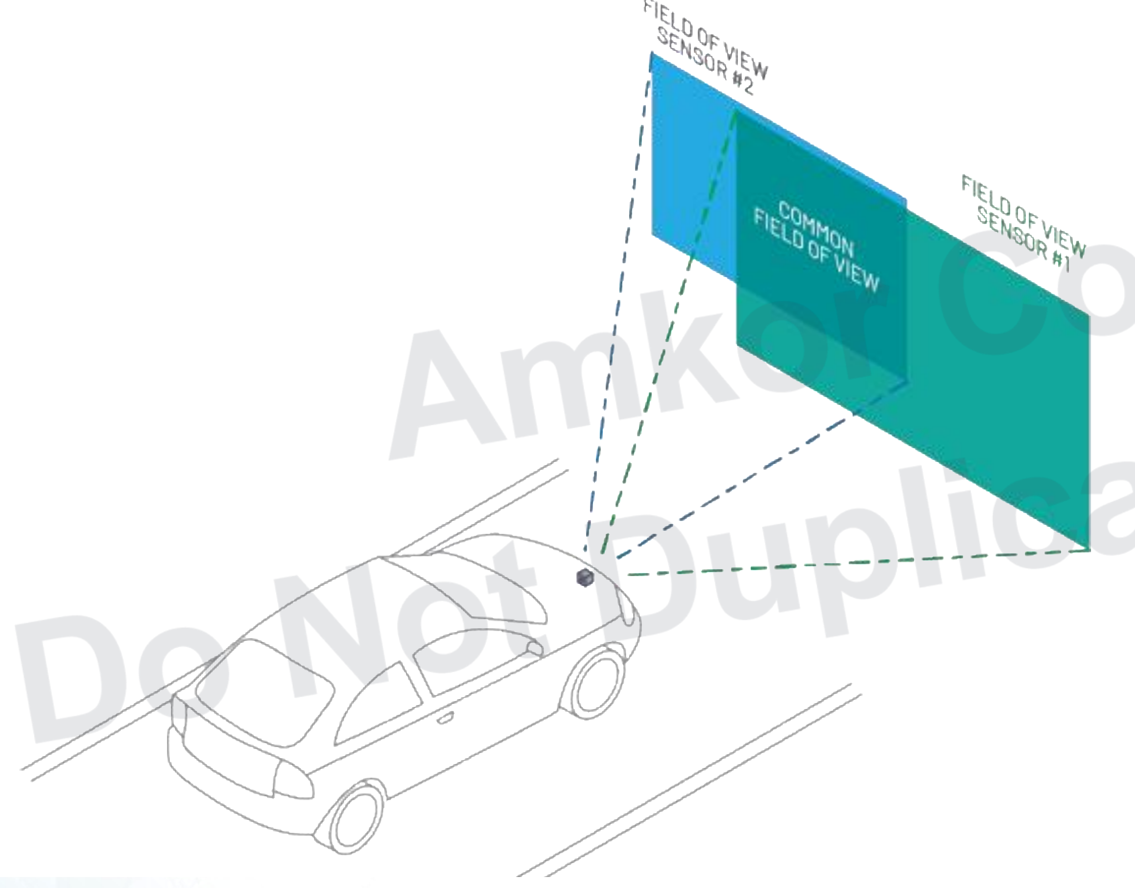
What's next? - Sensor Fusion in Cavity Optical BGA

Minimizes the parallax issue by positioning sensors close to each other



Source: Sensor fusion for ADAS and autonomous vehicles, Yole Développement, 2021.

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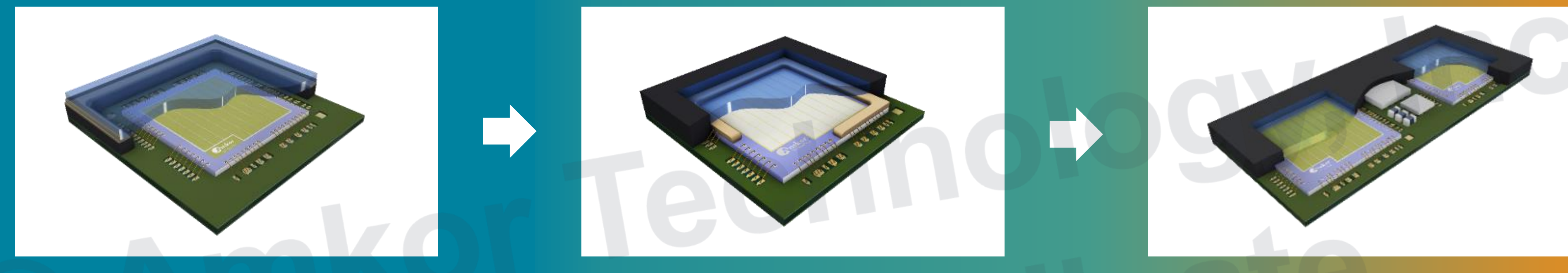
Standardization to High Integration

Future Development Using Advanced Packaging Technologies



Discrete Package

- Glass-on-Mold

Miniaturization

- Glass-on-Wire

Sensor in Package

- Differentiated by MEMS/sensor silicon content
- Standard platform extension
- Sensor module and automotive sensor suites

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Established Process Technologies from MEMS Toolbox

To Enable Heterogeneous Packaging Solutions

Lid/Glass Attach

Chip-on-Chip Bonding

Overmold/FAM Cavity Mold

Environment Media Protection

Laser Singulation

Multi-Die Wirebond & Flip Chip Assembly

Top/Bottom Side SMT

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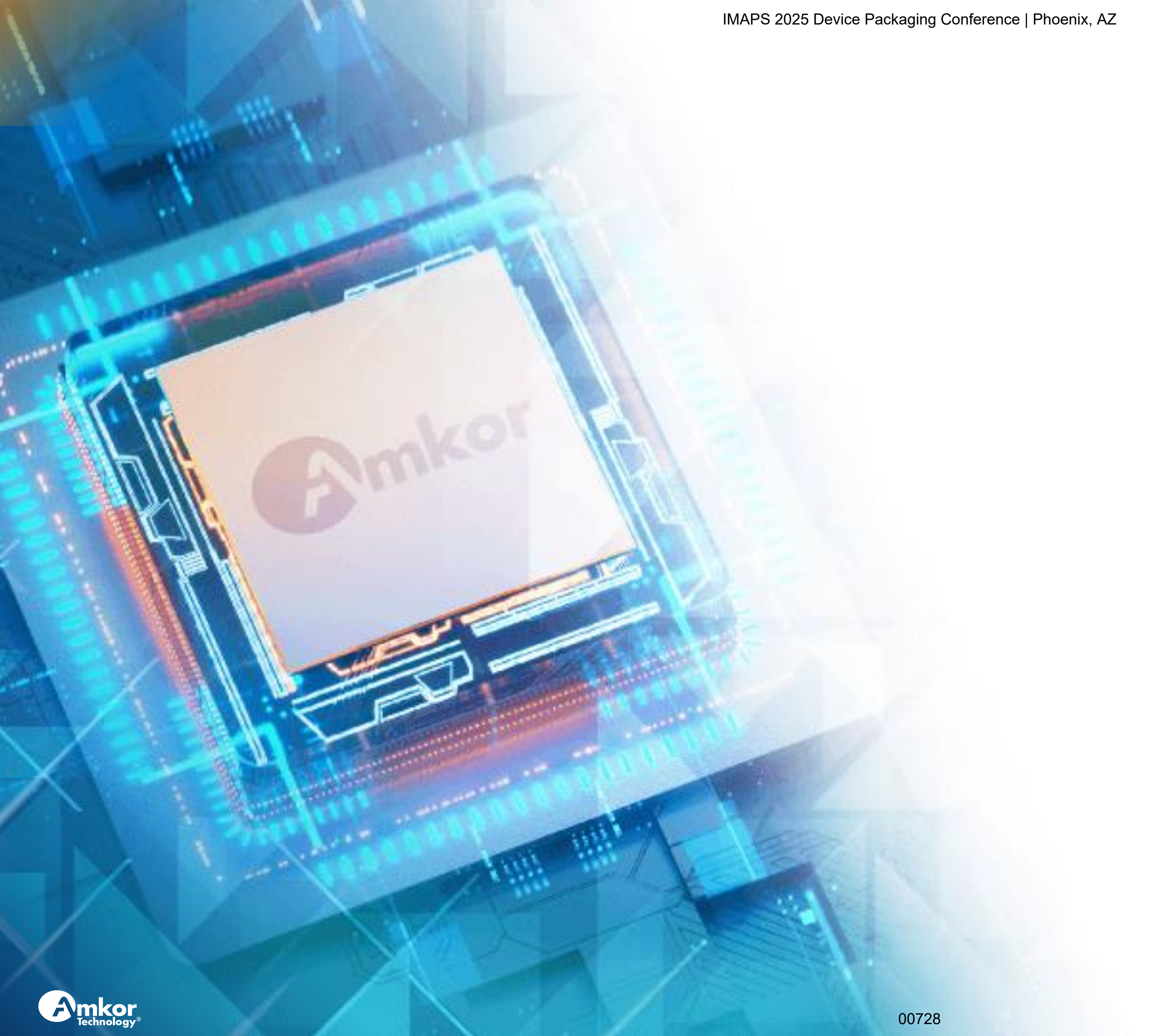

Summary

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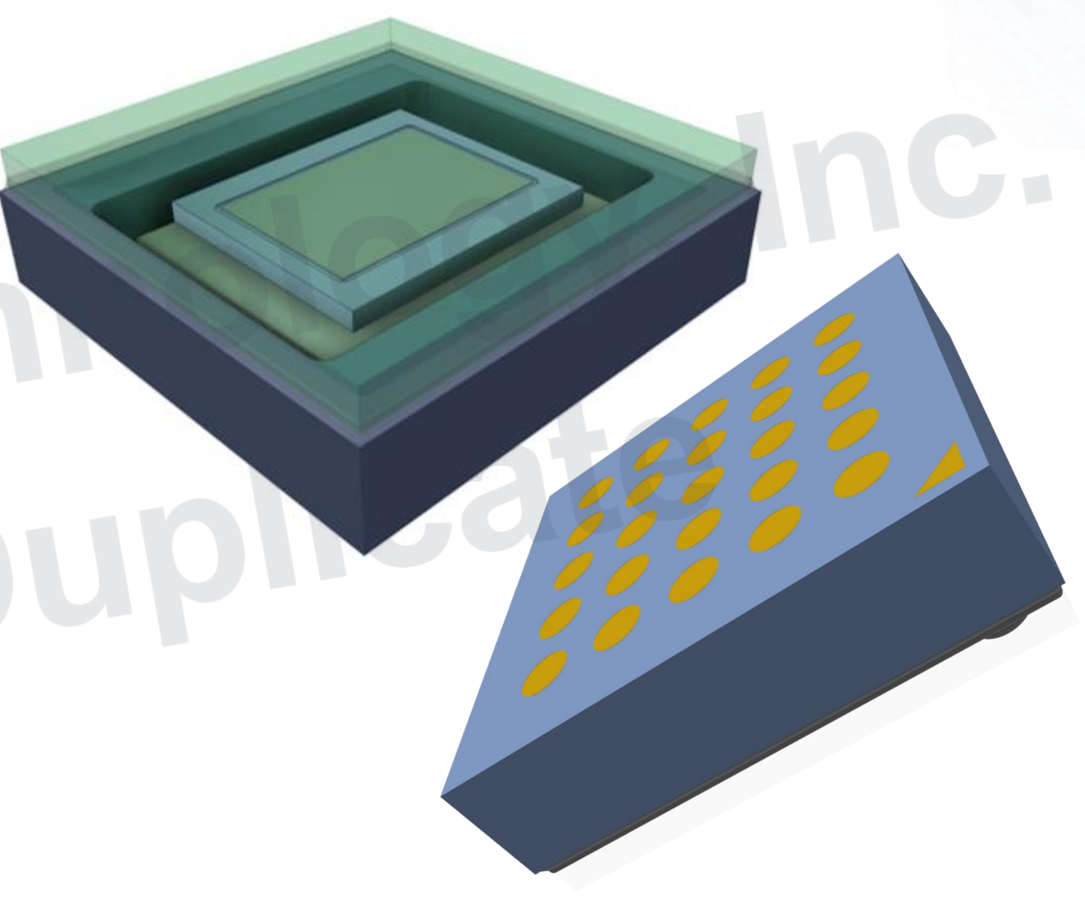
Amkor's MEMS, Sensor & Imaging Experience

- Over 25 years of MEMS and sensor assembly and test (non-optical)
  - 1st high volume device was qualified for automotive application
  - over billions of parts shipped
  - Long term partnership with suppliers
- Over 15 years of imaging, optical MEMS and Sensor Assembly and Test
  - Over 75 Million parts shipped (high end image sensors and optical MEMS)
  - Enhanced particle control for super cleanrooms



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Excellence in Cavity Optical BGA Manufacturing

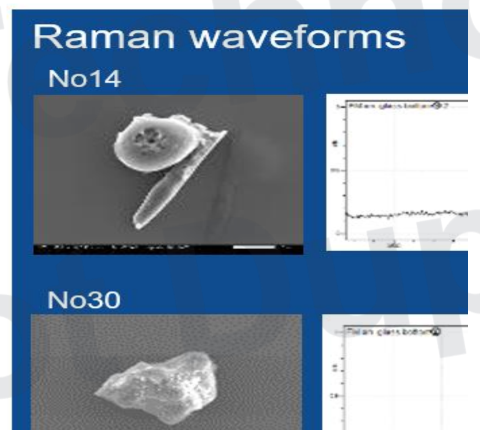
Automotive Quality System

Zero-defect mindset

Automotive certification

AECQ100 qualification

Foreign Material Management



High yield of large size CIS

Super cleanroom management

Foreign material know-how

Automotive Supply Chain Ecosystem

Geographic footprint for collaboration

Well positioned to enable reginal supply chains

Long-term strategic partnerships

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Foreign Material Management Know-How

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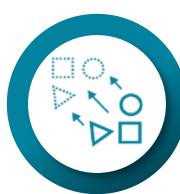

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In Closing

- Standard package platforms enable faster development time
- Available technology toolbox for heterogeneous package integration
  - Flip chip, flip stack, wirebond
  - TSV, Cu pillar, TMV®
- Comply Amkor Automotive Golden Rule to enable automotive optical product
  - Automotive certificate
  - Automotive Supplier Quality Management (SQM)
  - Automatic optical inspection
  - Unit Level Traceability (ULT)
- We want to collaborate and be the trusted and reliable innovation partner

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ENABLING the FUTURE

Thank You