



High Efficiency Power Solutions by Chip Embedding

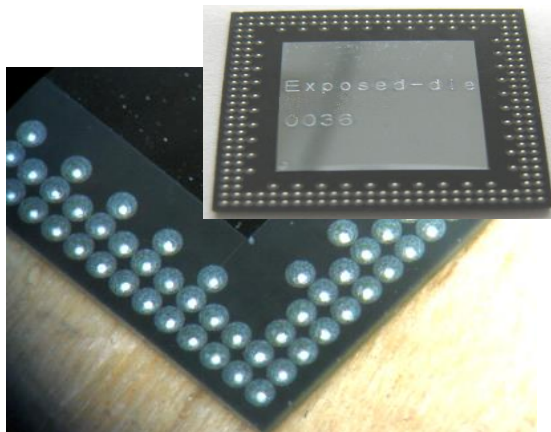
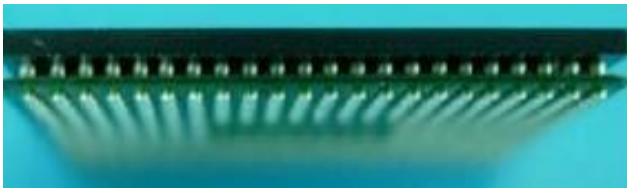
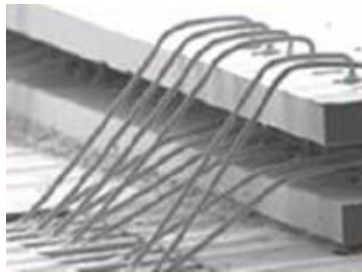
Dr. Kay Essig
ASE
June, 2016



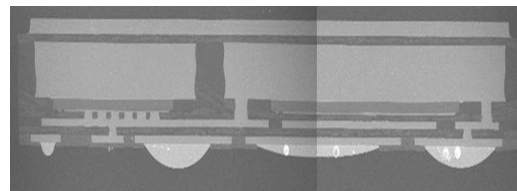
ASE Confidential / Security-B

3D Integration

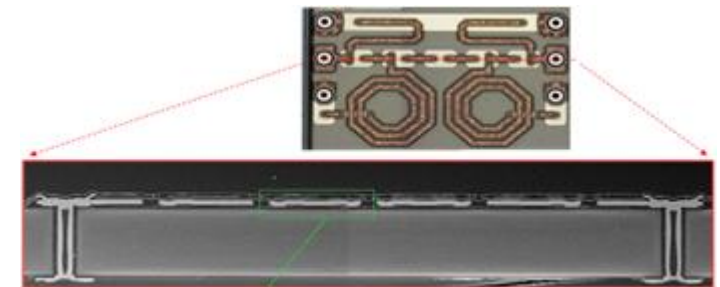
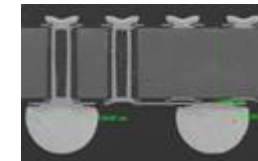
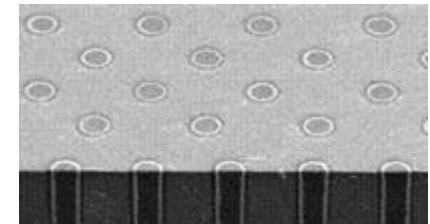
Stacked & PoP



Embedded



TSV



Embedded Technology Introduction

Embedded Components

Passive

Formed

Resistors

Capacitors

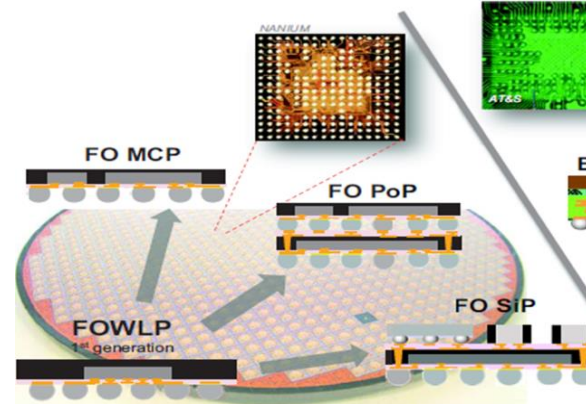
Placed

Materials are added to the printed circuit structure to create the passive element.

Active (Die)

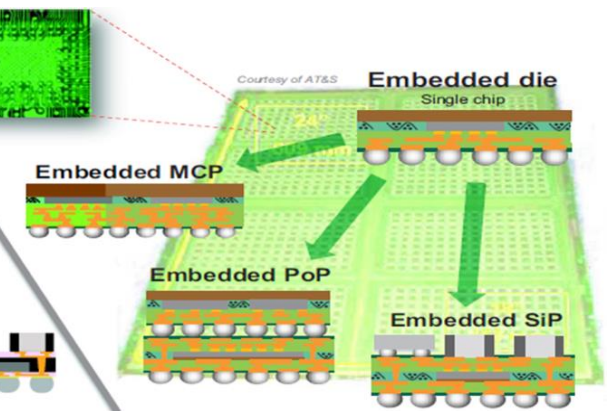
Wafer Level Embedded Die

FOWLP is based on a reconfigured molded wafer infrastructure




Embedded Die in Substrate

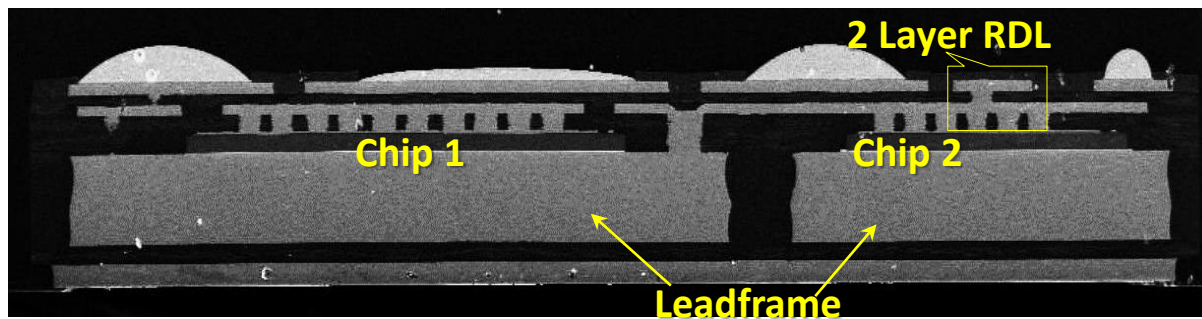
➤ Embedded die in package is based on a PCB type of panel infrastructure



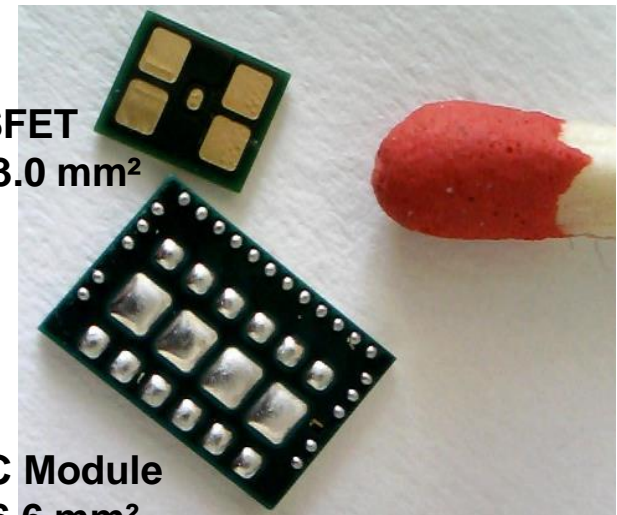
Embedded Die Substrate Technology

• aEASI - Embedded Active System Integration

Type	Schematics	Content	Status
aEASI		EAP - Embedded Active Package Lead Frame based single or multi dies embedded in organic laminate material	1RDL 1Die passed reliability 3RDL 3Die mass production

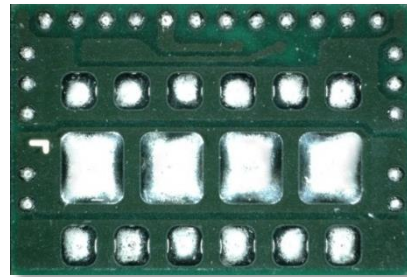


MOSFET
3.4x3.0 mm²

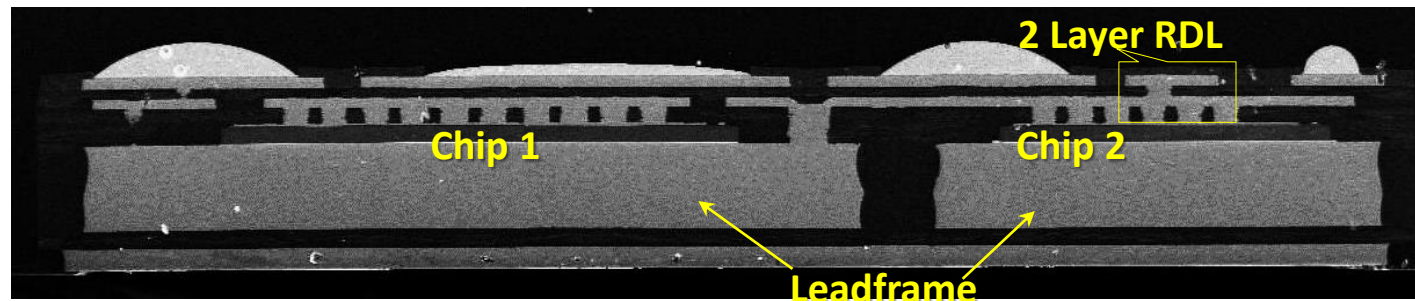


DC/DC Module
4.5x6.6 mm²

a-EASI Product: DC/DC Converter

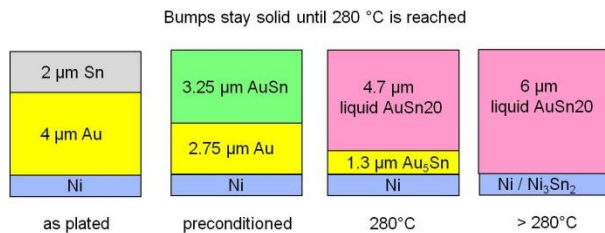


- Package: 6.65 x 4.55 x 0.8 mm³, 38L
- Chip Information: 2 MOSFETs + 1 Driver Chip
- Max. average current: 60 A
- Input Voltage range: 4.5 V to 16 V
- Fast switching > 750 kHz
- Power up Blade Server



Die Attach on L/F - TLPB

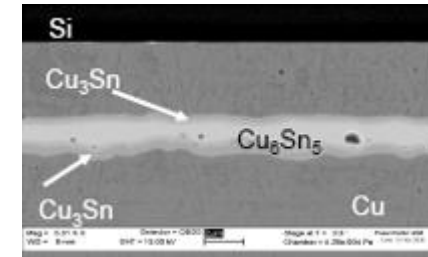
Transient Liquid Phase Bonding



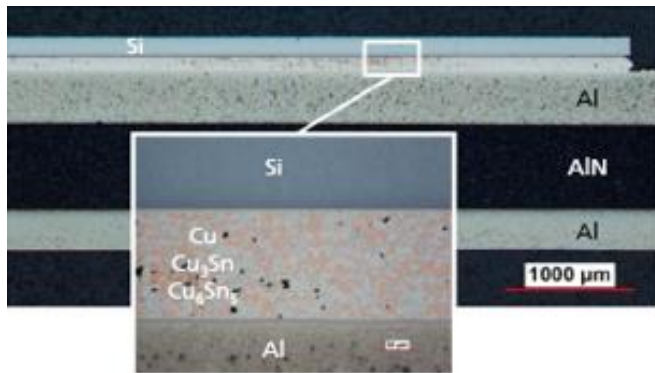
Die Bond preparation on Die side



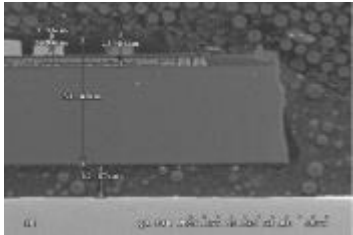
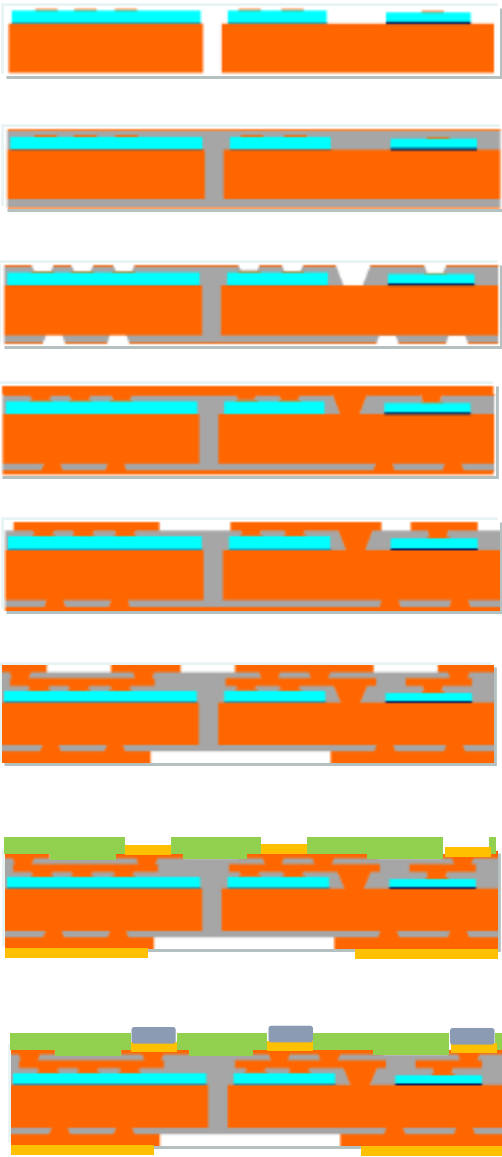
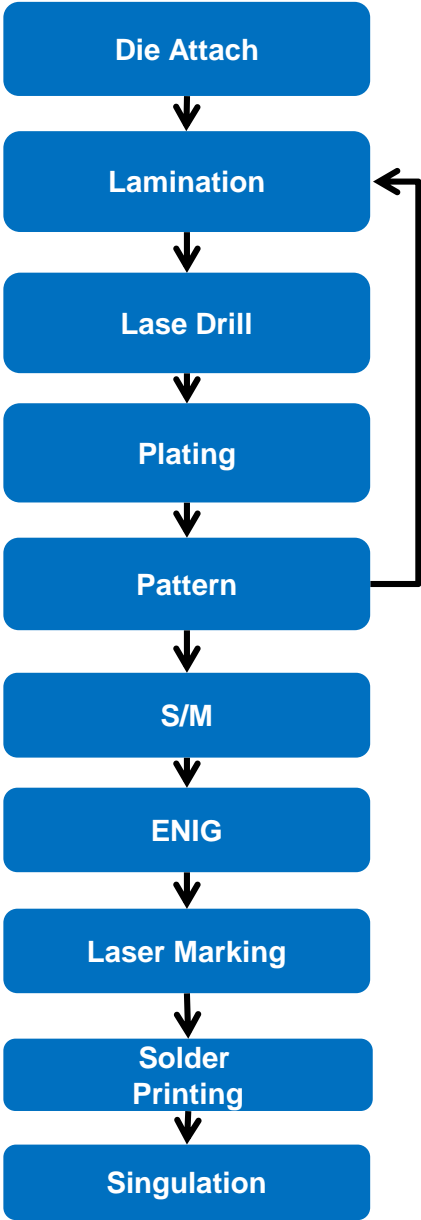
TLPB process



Die Bond on Lead Frame



Process Flow

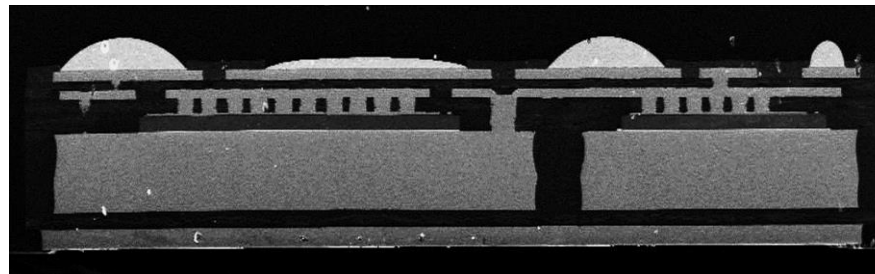


Embedded Power Module Manufacturing



Capacity & Yield

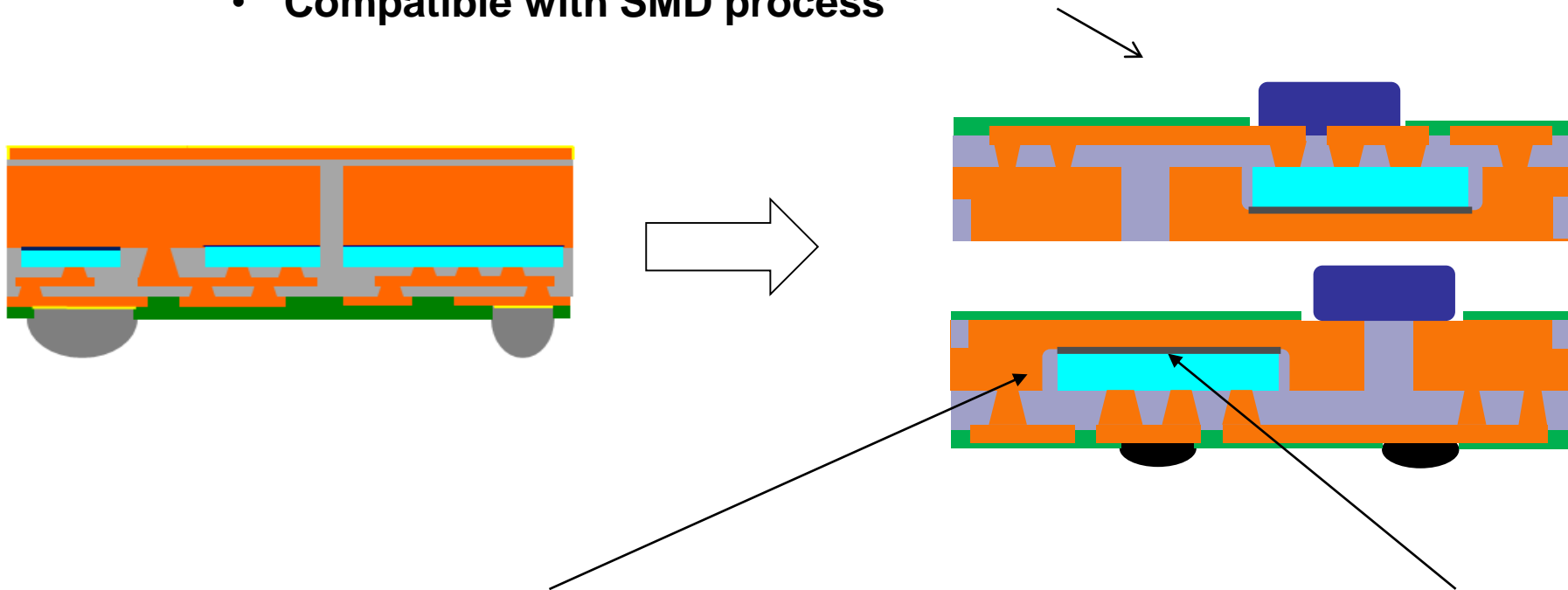
- Yield = 97.6% in May '16. Targeting 99% in Q4 '16.
 - Important because of 3 KGD are embedded per device
- Capacity of 3.3M unit/month (5x6 mm) today.
- More than 40 M units delivered



aEASI - 2nd Generation (P2 Structure) Patent pending



- Support BGA, QFN foot print
- Marking on Solder Mask
- Compatible with SMD process



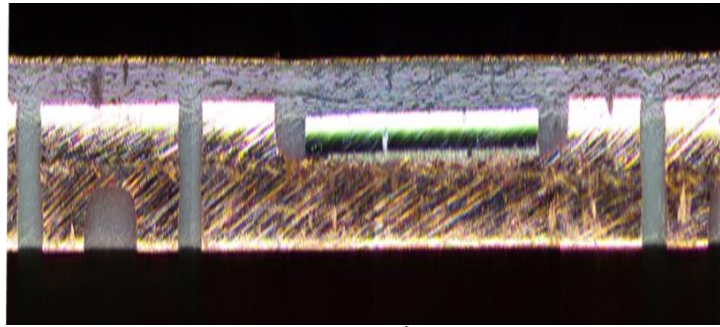
Cavity Lead Frame

- Avoid die crack risk
- Uniform via depth for better laser & plating process control

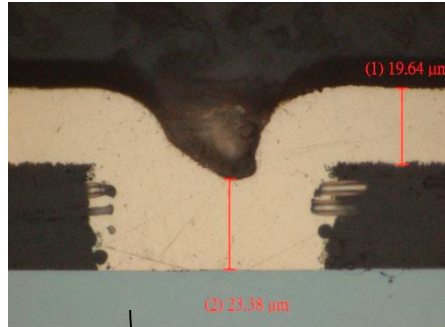
Ag Sintering bond

- Compatible with conventional bonder

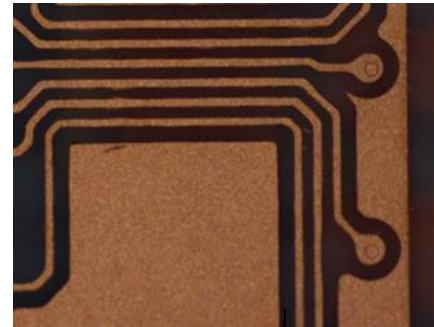
aEASI - P2 Results Patent pending



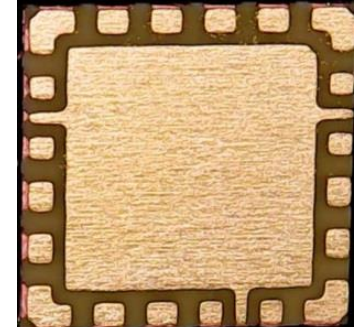
Die attach



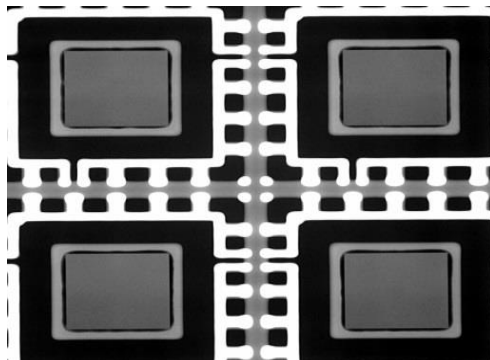
Laser drill



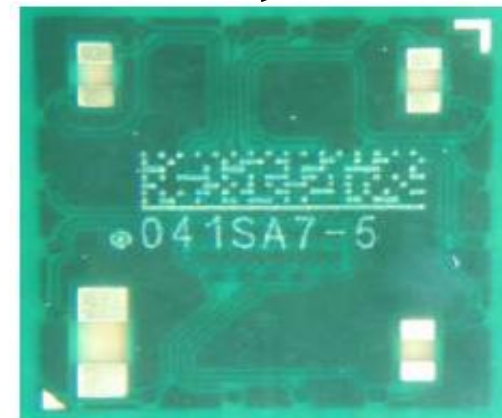
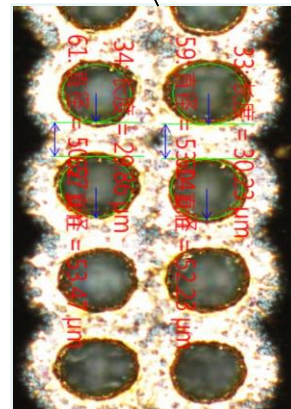
Plating & Patterning



S/M, Marking, Singulation



X-Ray result



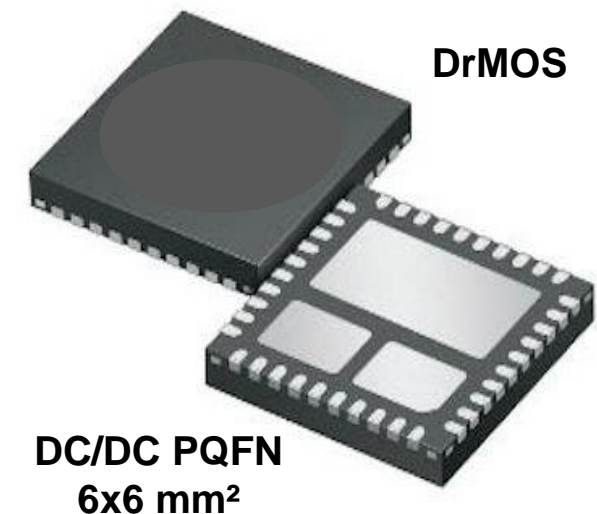
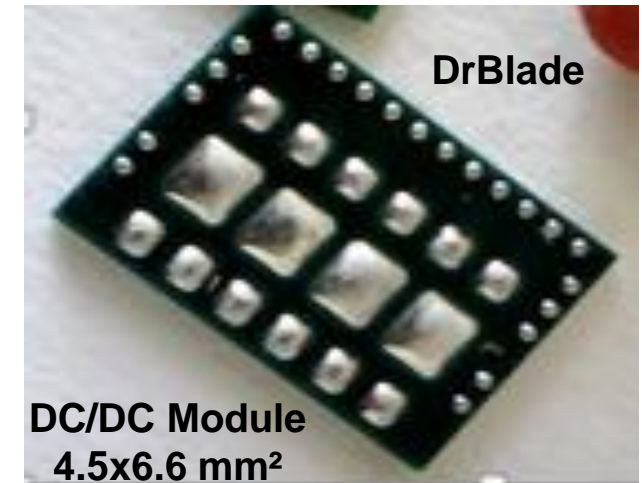
Embedded Die Power Module

➤ Advantages

- Smaller & Thinner package
- Excellent Thermal Dissipation
 - 2 sides cooling areas
- Excellent Electrical Performance
 - μ -via for Gate and Source, full surface Drain
 - Low resistance & inductance, good shielding
- Enhanced Reliability

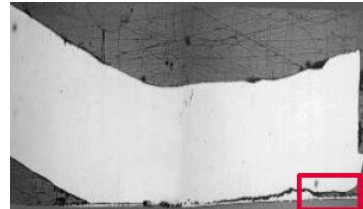
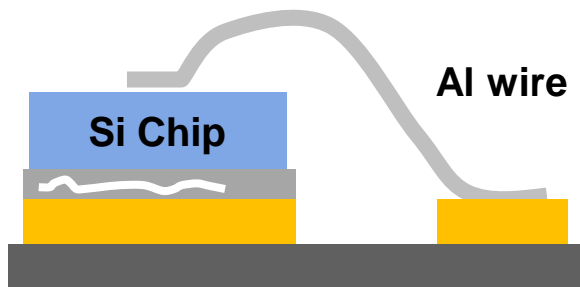
➤ Markets

- Power Devices, MOSFET
- DC/DC Converter Modules
- Fast switching Power & IGBT



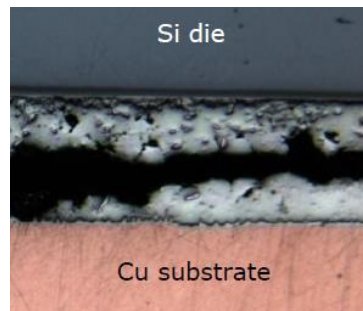
Power Die - Reliability

Power Electronic Packages



Al wire

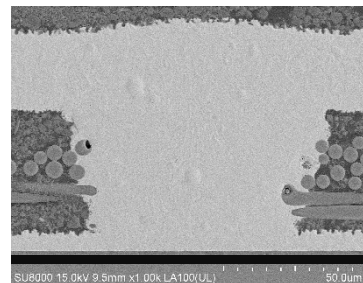
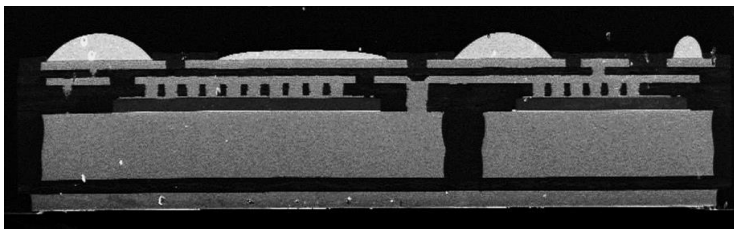
Crack propagates through Al wire matrix
Increases electrical/thermal resistance



Soft Solder

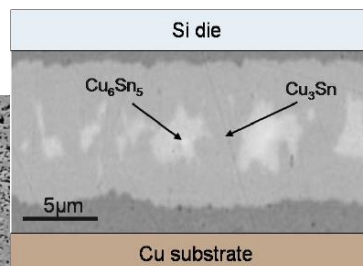
Crack formation in solder volume
Increases thermal / electrical resistance

Embedded Power Packages



μ -via

Copper filled micro vias on Cu die pad
No crack expected



TLPB / Ag Sintering

High melting point > 300°C
Stable against thermal stress

Reliability Tests

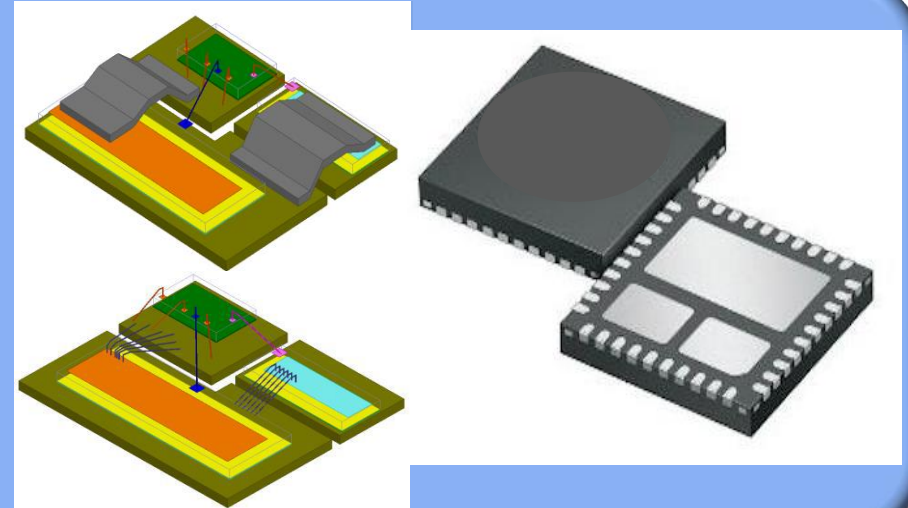


Test description	Abbr.	Condition	Readout	Result
Pre-Conditioning J-STD-020D	PC	MSL3, 3x260°C, Reflow		Pass
Biased Highly Accelerated Stress Test JESD22 A110	HAST	Ta=130°C RF=85%	0 h precon 96 h	Pass Pass
Temperature Cycling JESD22 A104	TC	T = - 55°C to 150°C	0 c precon 500c 1000c	Pass Pass Pass
High Temperature Storage Life JESD22 A103	HTSL	Ta = 150°C	0 h precon 168 h 500 h 1000 h	Pass Pass Pass Pass
High Temperature Operating Life JESD22 A108	HTOL	Ta = 125°C Tj = 150°C	0 h 168 h 500 h 1000 h	Pass Pass Pass Pass
Power Temperature Cycling JESD22 A105	PTC	T = - 40°C to 125°C	0 c precon 500c 1000c	Pass Pass Pass

PMIC Package Comparison

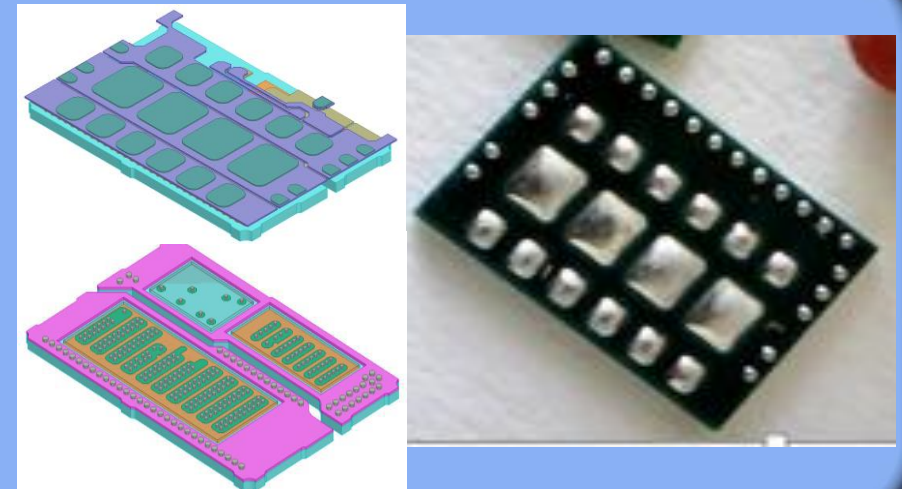
Standard PQFN Types

- PQFN 6x6 mm² Cu Clip
- PQFN 6x6 mm² Cu Wire Bond



Embedded Die Packages

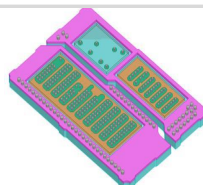
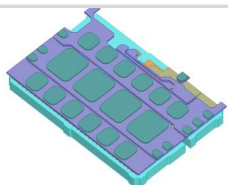
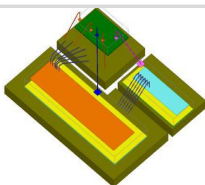
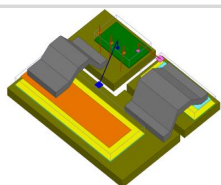
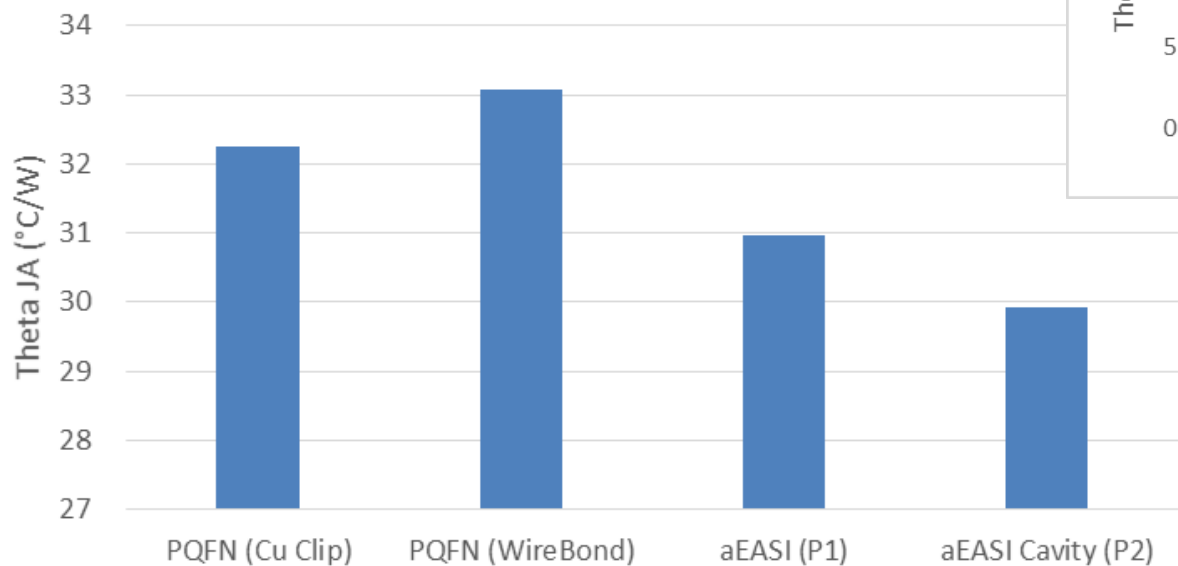
- aEASI 4.5x6 mm²
- aEASI 4.5x6 mm² cavity
Patent pending



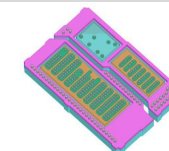
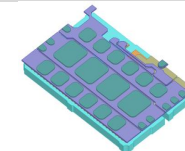
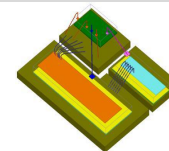
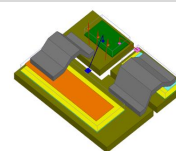
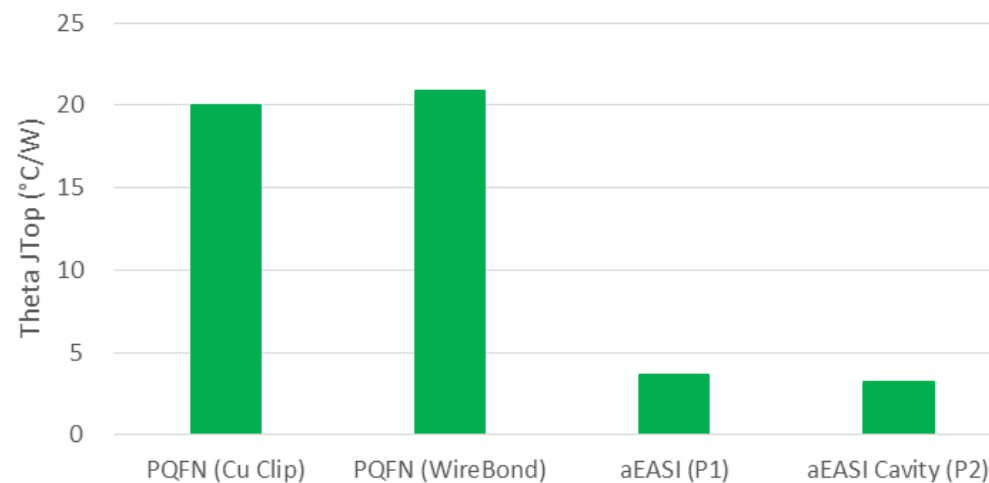
PMIC Comparison - Thermal Resistance



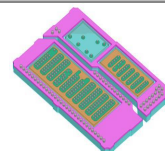
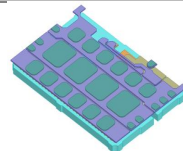
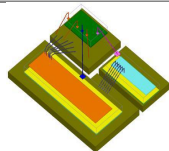
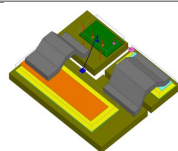
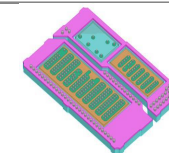
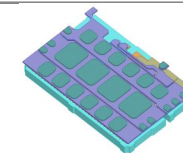
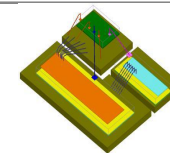
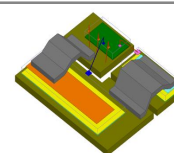
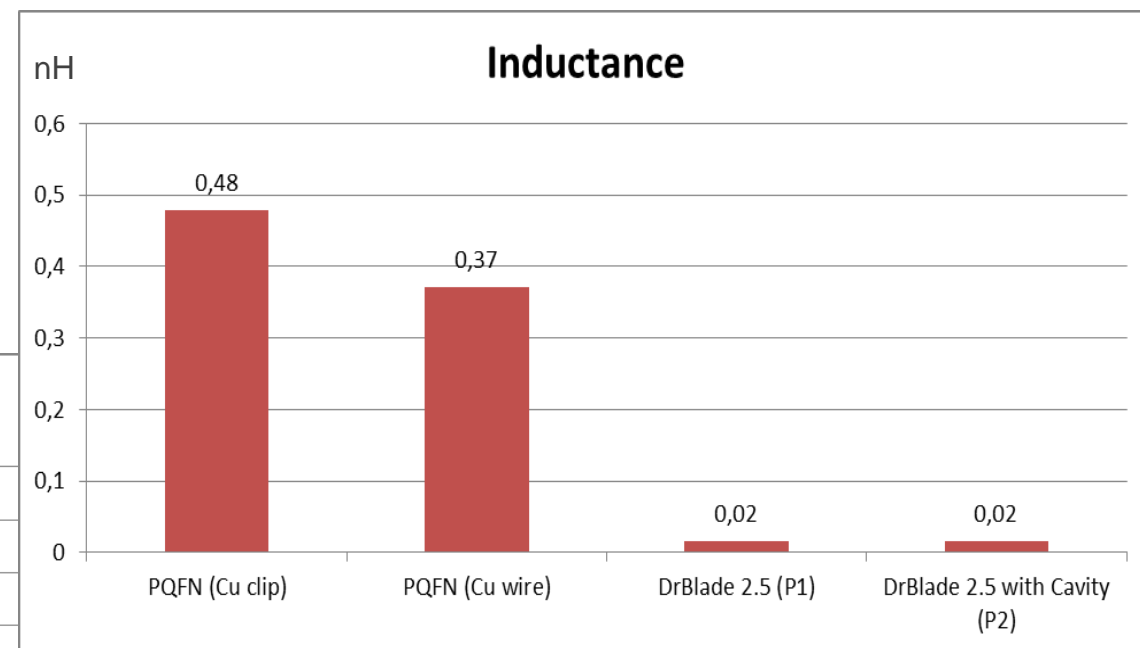
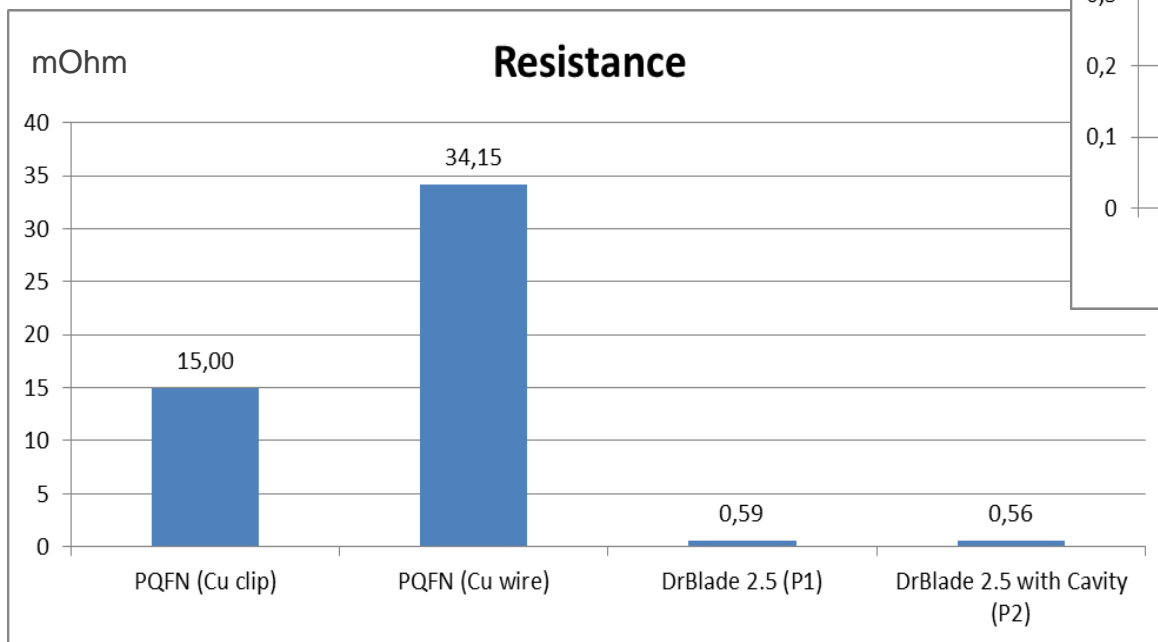
Thermal Performance
Theta Ja simulated



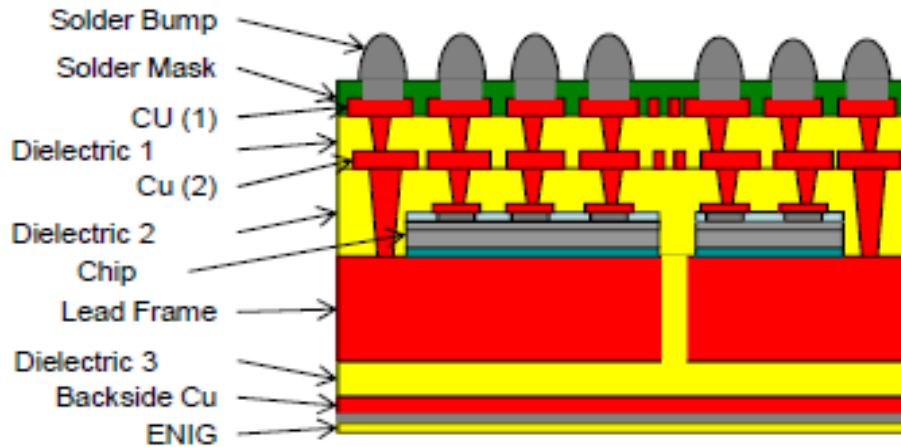
Thermal Performance
Theta JTop Data Sheets



PMIC Comparison - Electrical Performance

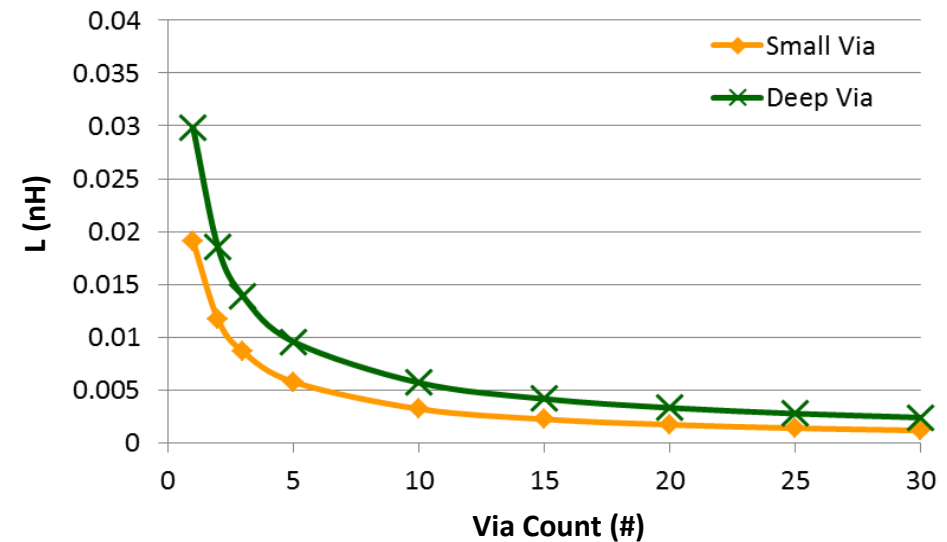
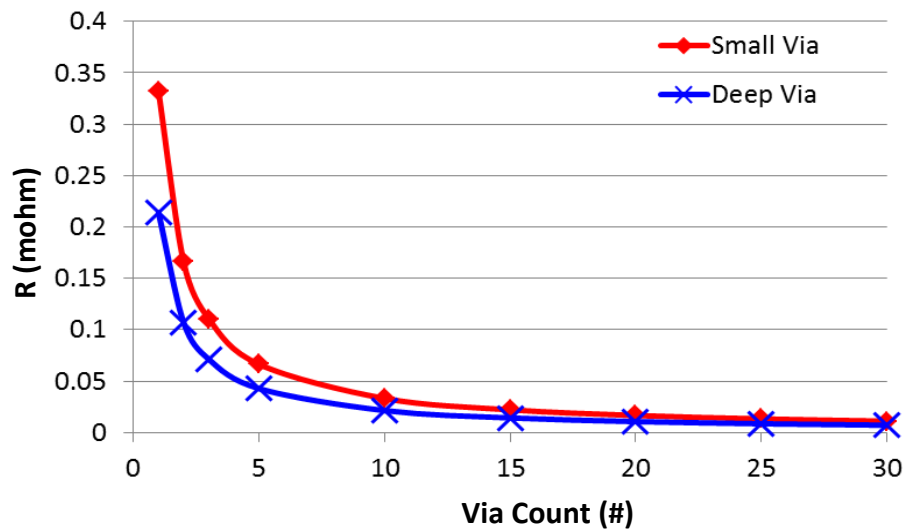


Via Resistance & Inductance

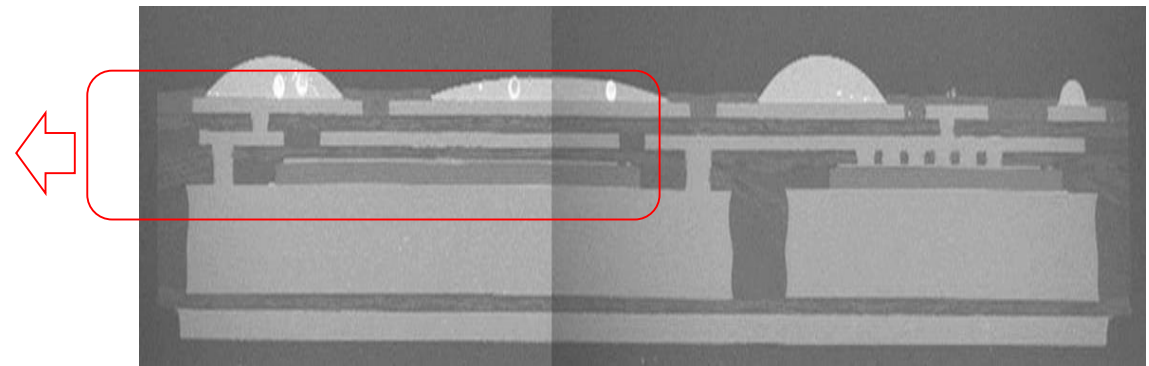
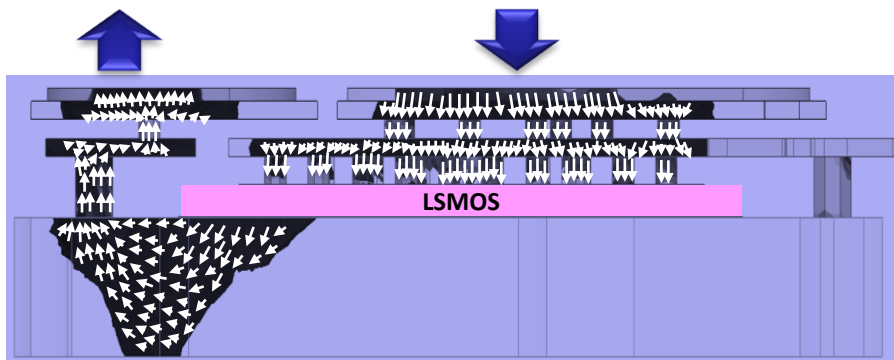
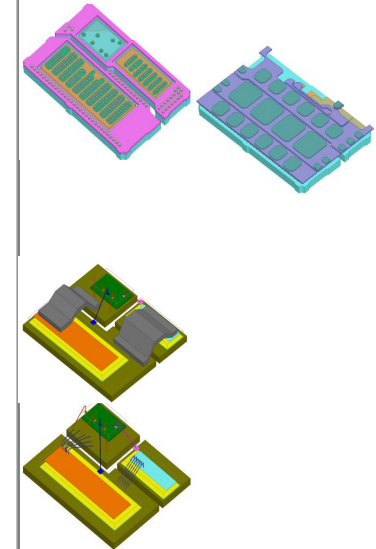
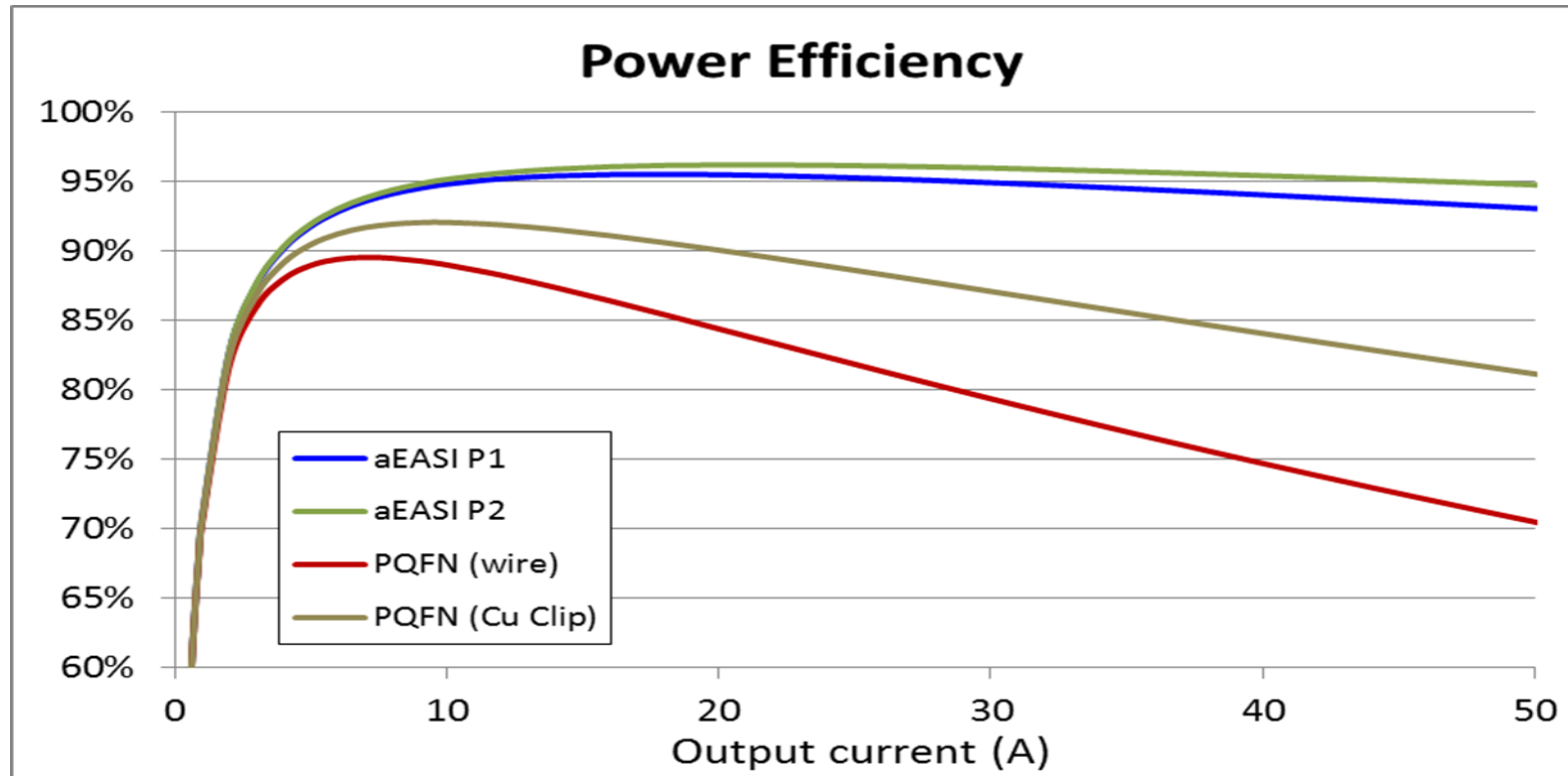


aEASI 4 layers Structure

- Resistance is analyzed at 0 Hz.
- Inductance is analyzed at 100 MHz.
- Conclusion: More via in parallel to share the current density introduce lower R & L interconnection

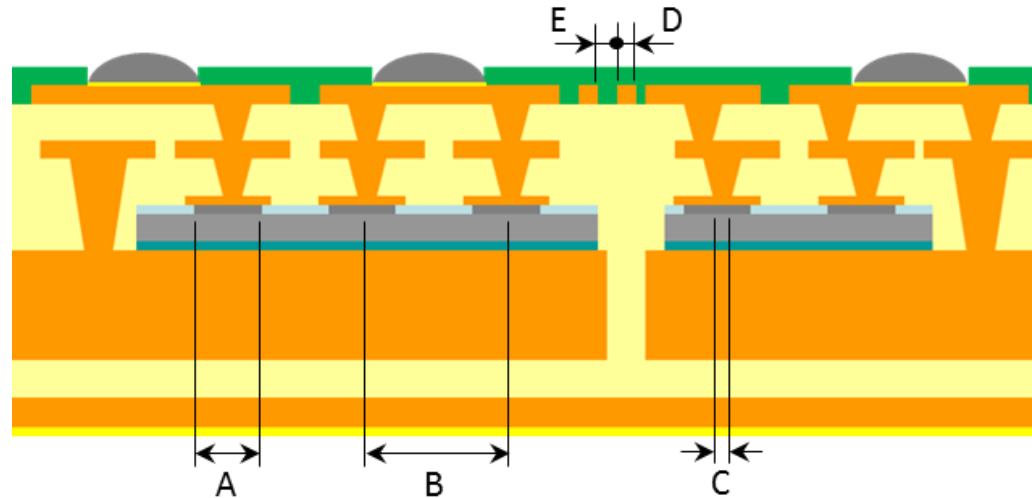


Electrical & Thermal Performance



Design Rule

- Detail design rule is available today for customer design study



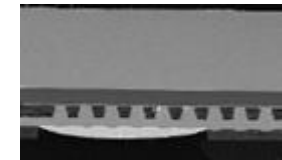
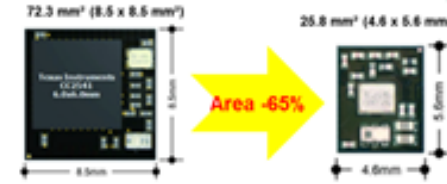
Unit: um

Symbol	Description	Normal	Advance	Prototype
A	Die Pad Size	120	110	100
B	Die Pad Pitch	180	150	135
	Die Pad Material (Cu Thickness)	5	4	3
C	Via Diameter (Top Diameter)	70	60	50
D/E	Line width/space	60/60 *35um Cu	40/40 *15um Cu	35/35 *12um Cu
	RDL Layer	2		
	Via aspect ratio	1.1		1.2

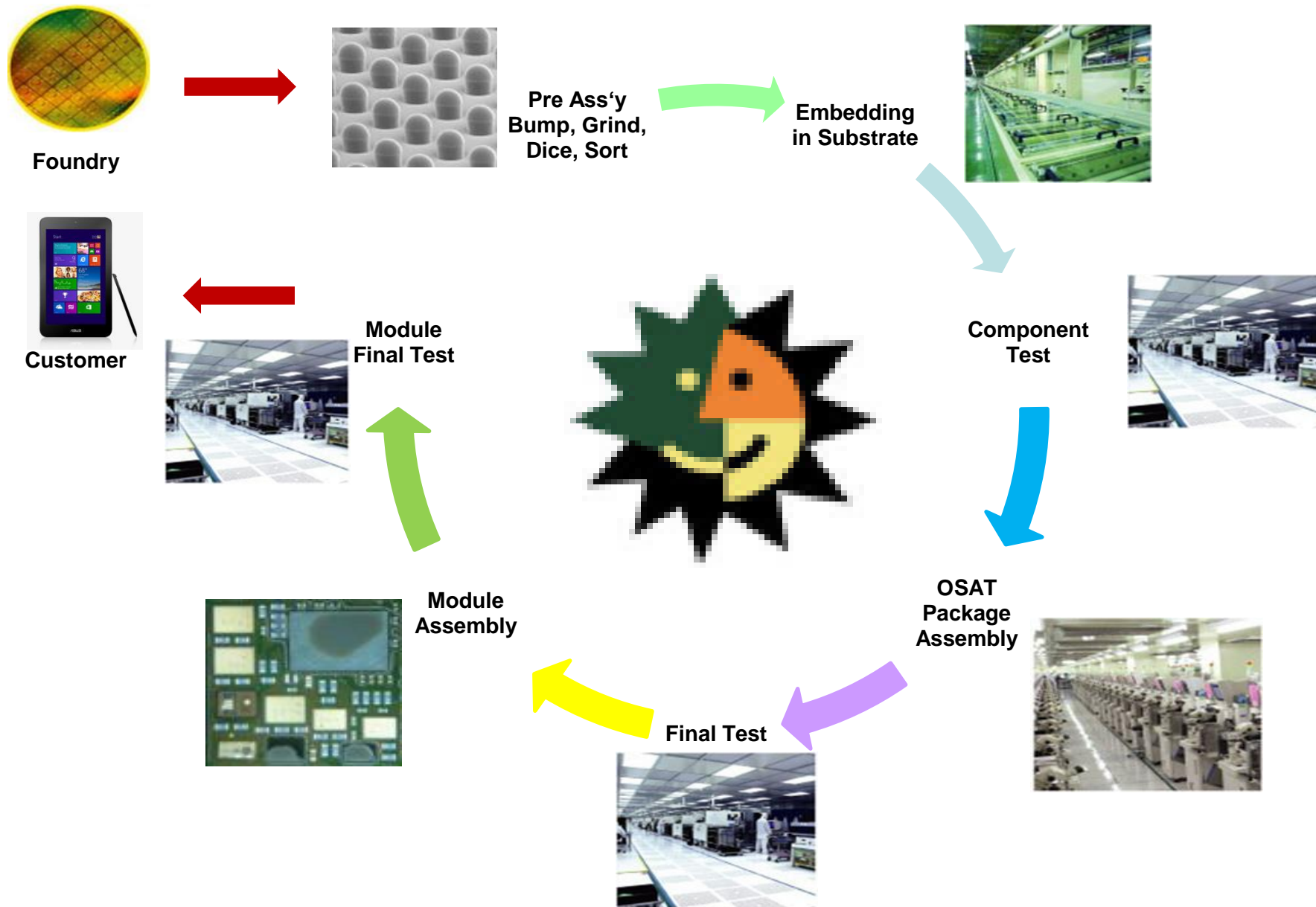


Embedding Benefits

- Smaller Outline
- Lower Thickness
- Electrical Performance
 - Shorter Tracks
 - Lower Resistance & Inductance
 - Shielding
- Thermal Performance
 - More Cooling Areas
- Less Delamination (similar materials)
- Enhanced Reliability
- Less Plagiarism



Embedded packaging business model



Summary



- Embedded Components can have more and more important benefits than smaller outline
- Embedded Power Modules show advantages in Thermal and Electrical Performance
- ASE brought aEASI – Embedded Die Power Modules to HVM
- Next Gen. aEASI shows enhanced manufacturability and flexibility

Thank You

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