



3D SiP with Embedded Chip Supply Chain Integration

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Agenda

- Introduction of UTAC and AT&S
- Trends, Applications & Trade offs for 3D SiP w/ Embedded Chip
- AT&S ECP[®] Technology and Performance Summary
- Examples of Embedded Chip Product Solutions
- 3D SiP with Embedded Chip UTAC / AT&S Collaboration
- Summary





UTAC at a Glance

- Outsourced Semiconductor Assembly and Test services (OSAT) provider in support of Analog, Mixed-Signal, Logic, Power and Memory products
- UTAC 2015 Revenue \$878M; Ranked 6th in the Top Ten OSATs; 12k employees strong; Sales offices located worldwide
- Focus Assy, Test and Full Turnkey; Test comprises 35% of sales in 2015
- Est. 1997 Singapore; ten factories w/ 260K M²; operations in six countries Singapore, Taiwan, Malaysia, Indonesia, Thailand, China
- 3 Factories with SiP capability
- Markets: Mobile, Automotive, Security, Wearable's, Industrial & Medical



AT&S at a Glance

High-end interconnection solutions

for Mobile Devices, Automotive, Industrial, Medical Applications and Semiconductor Industry

> 9,452 employees

Continuously outperforming market growth

One of the most profitable players in the industry*

* In terms of EBITDA margin

1 manufacturer in Europe # 3 in high-end technology worldwide

€ 762.9m revenue in FY 2015/16; 5.2% organic growth

Cost-competitive production footprint with

6 plants in Europe and Asia



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AT&S ECP® Platform Technology

ECP® (Embedded Component Packaging) uses the space in an organic laminate substrate (PCB) for active and passive components integration.



Components embedding into the PCB core with copper plated microvia connections.





Applications for 3D SiP with Embedded Chip

EMBEDDED DIE POTENTIAL APPLICATIONS MATRIX

	Stand-Alone active die packages	Embedded SiP Modules
Cell phones Portable media players Notebooks Digital cameras	 IPD - ESD protection IPD - RF DC/DC converters IC Drivers: Audio codec, battery charger, display interface, LED driver) Power Management Unit Transceivers Bluetooth/GPS/FM: Processor 	 Cellular Radio: IPD-RF, Transceiver, PA WLAN Module: IPD-RF, DC/DC converter Bluetooth/GPS/FM: DC/DC converter, processor CPU/GPU: Embedding of stacked ICs in PoP Memories: Embedding of stacked ICs in PoP Baseband: Embedding of stacked ICs in PoP Audio Module: IPD-ESD, IPD-Capa, Audio codec/driver Digital TV Module: IPD-Capa, Video decoder, DC/DC converter Camera Modules: Sensor, DC/DC ISP, AF driver MEMS/Sensor Modules: Sensor(s), ASIC > Oscillators, Si-microphones, pressure sensors, inertial sensors, magnetic Hall sensor, RFID LED Modules: LED driver, MOSFET
Medical & industrial	 Power Applications: MOSFET, IC drivers, Thin- film batteries 	 Hearing Aids: IPD-ESD, IPD-Digital, processor, memory Pacemakers: IPD-ESD, IPD-RF, IPD-Digital, processor, memory Wireless Sensor Node applications: RFID, thin-film battery, magnetic hall sensor
Automotive	 IPM "Intelligent Power Modules" MOSFET, IGBT, IC driver, Sensor 	 Engine Control Module: MCU, memory, IPD Telematics/Car information units: GPS, NFC MEMS/Sensor Modules: Sensor(s), ASIC Camera Modules, Hall Sensors, TPMS, IMU modules, RFID



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Embedding Technology Milestones



Why Chip Embedding?

Unique Selling Propositions	in detail	
Miniaturization	 Footprint reduction Higher component integration (additional assembly layer) 	
Electrical performance	Improved signal performance (higher data rates)Reduction of parasitic effects	
Mechanical performance	 Higher durability and reliability through copper-to-copper connections (copper filled microvias) Package enables protective enclosure High drop, shock and vibration tolerance 	
Thermal management	 Improved heat dissipation through direct copper connection Improved heat dissipation FR4 versus air (compared to SMD) 	
 Additional functions Reduction of overall cost EMI shielding 	 EMV shielding (partial or full shielding of a package) Package is the housing → no additional molding required 	
ECP is supporting the trend towards modularization	 Lower set-up costs compared to other packaging technologies (packaging versus PCB processes) Customization of footprint and module versions can be done due to digital imaging - no separate tooling necessary (e.g. QFN) 	
Anti-Tamper and Security	Hidden electronics preventing reverse engineering and counterfeiting	





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Comparison of Package Area vs. Thermal Resistance





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Package Inductance Ranking

Source: GaN Systems / AT&S IMAPS 2014



TI MicroSiP™

(Introduced 2011 > 20 products)







Thermal Evaluation



Thermal Image of MicroSiPTM when IC is dissipating 0.45W. Ambient temperature is 22°C, max junction temperature is 72°C. For thermal modeling, a value of Θ_{JA} =125°C/W provides an excellent initial estimate of thermal performance.

Board-Level Reliability Data

8-pin MicroSiP™				
	Test Parameters	Results (t _{first fail})		
Drop	1500G/1.0ms pulse	> 100 drops		
Temp Cycle	-40/125°C, 2 cycles/hr	> 1000 cycles		

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TDK's SESUB Technology shrinks power mgmt section 60% in Blackberry ™ Z10 Phone (2013)





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Embedded Chip Technology – adoption accelerating in Power Applications



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UTAC & AT&S Collaboration

- System in a package (SiP) is a strategic focus area for UTAC and AT&S
- 3D SiP with Embedded Chip provides integration, size and performance benefits over 2D planar SiP solutions
- 3D Embedded Chip technology adoption is accelerating in Power and High Density Interconnect Applications
- Supply chain collaboration for emerging 3D SiP solutions with embedded chip technology will advanced the technology and provide full turnkey (FTK) supply solutions for customers.
- Flexible business models available to fit to customer requirements





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3D SiP Supply Chain UTAC / AT&S Collaboration



April 2015 - Joint marketing / supply chain agreement Between AT&S and UTAC for 3D SiP with embedded chip technology. Collaboration press release April 2016. AT&S over 5 years production embedding experience.

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UTAC / AT&S 3D SiP Process Flow



3D SiP w/ Embedded Collaboration Example

Package Type: 4.5 x 7.2mm LGA-SIP Highlights: 2 embedded die + 24 passive components on substrate top side

Package size / Type	4.5 x 7.2 mm LGA-SIP
Substrate Thickness	560 um \pm 10% 320um core
Die thickness	200 um Max.
Surface finish (Die DAP)	Electrolytic NI/AU
Surface finish (Land Pad)	Electrolytic NI/AU
# of Passive Component (Top of substrate surface)	24 Passives
Component Sizes	10ea 01005 10ea 0402 4 ea 0201
# of embedded chip	2
Strip Size	188x64mm
Substrate Metal layers	4 Layer

Assembly Layout







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Courtesy of Sarda Technologies, Inc.





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3D SiP w/Embedded Chip Business Models

1.UTAC provides full turnkey with AT&S as strategic supplier for embedded chip in substrate. Customers place 1 PO to UTAC -full responsibility for quality. Since embedding is a chips 1st process KGD supply is critical to yield. Customers consign wafers. Substrate design complexity has yield complexity so Yield ranges need to be agreed based on KGD quality level and embedded substrate density / yield.

- 2.AT&S provides FTK with UTAC as strategic supplier for wafer to die processing, assy / test. This applies where customer is better fit for AT&S due to level of current biz relations. AT&S and UTAC have guides in place and discuss in good faith who best positioned to serve a customer requiring FTK. Above items still apply.
- 3.Split business with customer providing a PO to AT&S for embedding and UTAC for assy / test. This model often applies in development phase, but in some cases may apply for production.

In some cases a **3 way NDA** may be executed to enable AT&S, UTAC and customer to exchange confidential information to **enable Co-design to optimize a design for:** *Performance, Cost, Reliability, Test and Mfg yield*





Summary

- System in a package (SiP) is a strategic focus area for UTAC and AT&S
- 3D SiP with Embedded Chip provides integration, size and performance benefits over 2D planar SiP solutions
- 3D Embedded Chip technology adoption is accelerating in Power and High Density Interconnect Applications
- Supply chain collaboration with AT&S for emerging 3D SiP solutions with embedded chip technology will advanced the technology and provide full turnkey (FTK) supply solutions for customers.







Follow Ups:

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