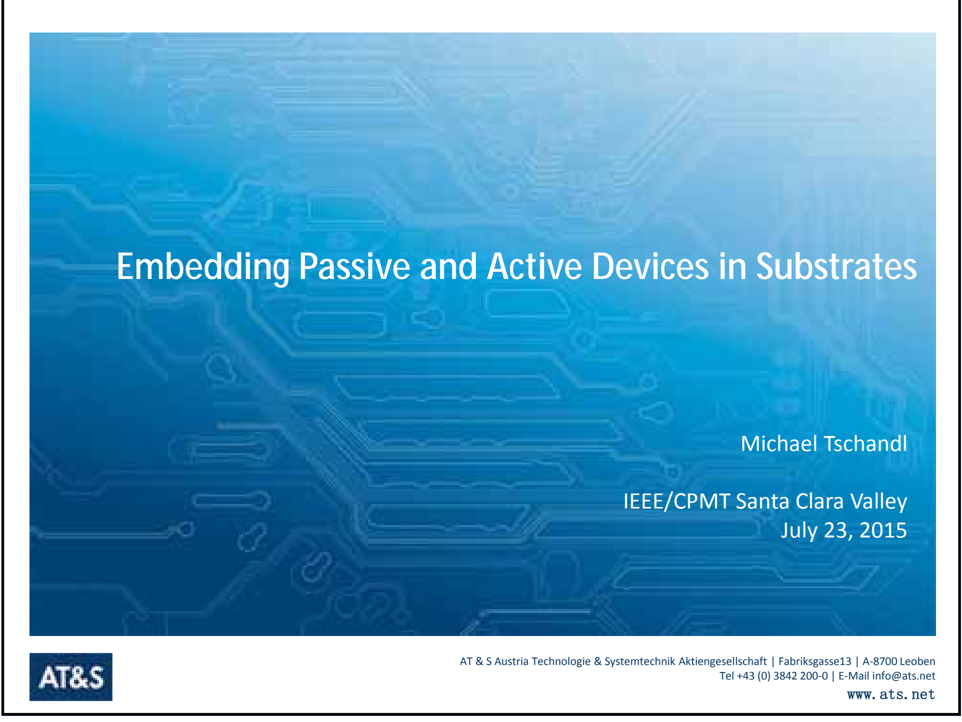
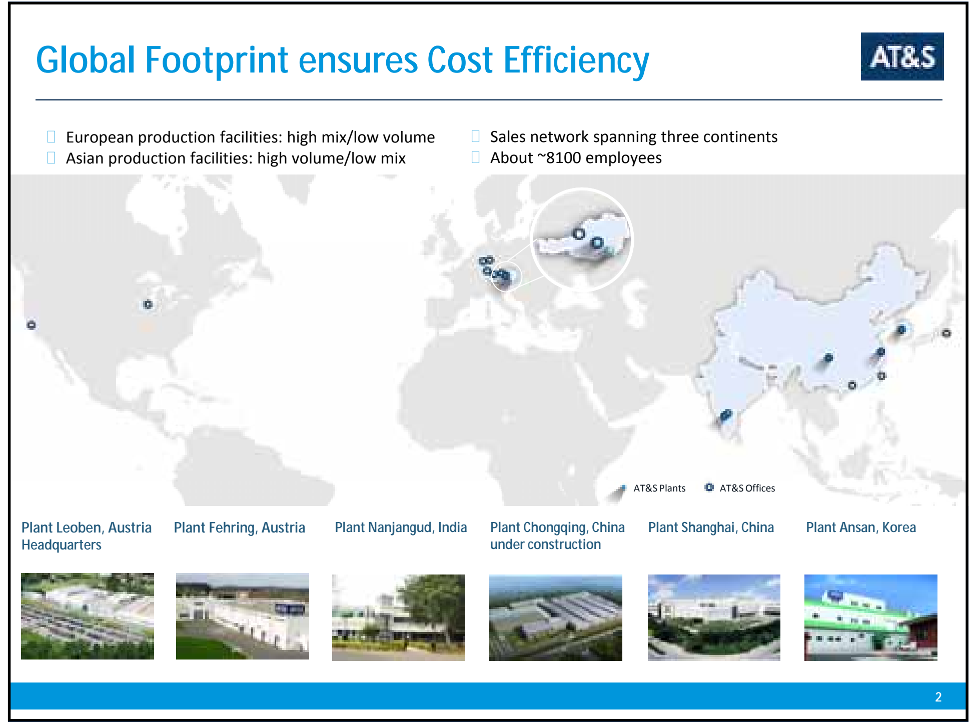


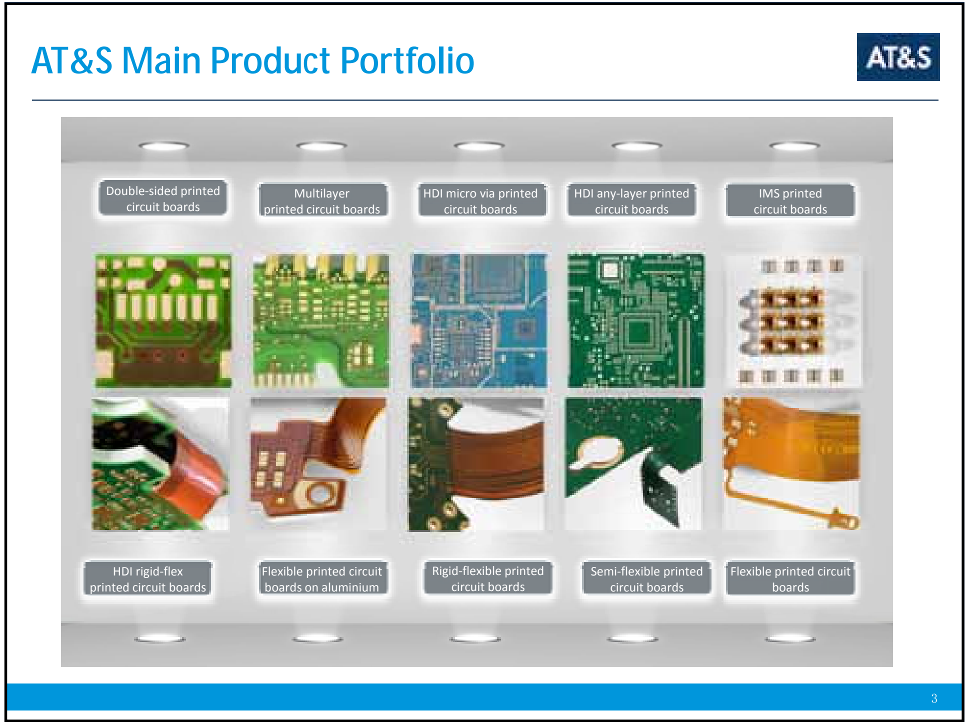
Who is AT&S?

AT&S

- Austria based global technology group focused on High Density Interconnect (HDI) Printed Circuit Boards, Advanced Packaging and IC Substrates.
- AT&S commercializes leading-edge technology for the mobile devices, automotive & aviation, industrial electronics, medical & healthcare and advanced packaging sectors.
- AT&S offers Embedded Component Packaging (ECP®) as a patent protected packaging solution. ECP® embeds active or passive components inside a PCB or IC Package.
- AT&S has 6 manufacturing sites in Austria (2), China (2), India, and South Korea.

1


Global Footprint ensures Cost Efficiency
AT&S
European production facilities: high mix/low volume
Asian production facilities: high volume/low mix
Sales network spanning three continents
About ~8100 employees
AT&S Plants
AT&S Offices
Plant Leoben, Austria
Headquarters
Plant Fehring, Austria
Plant Nanjangud, India
Plant Chongqing, China
under construction
Plant Shanghai, China
Plant Ansan, Korea
2

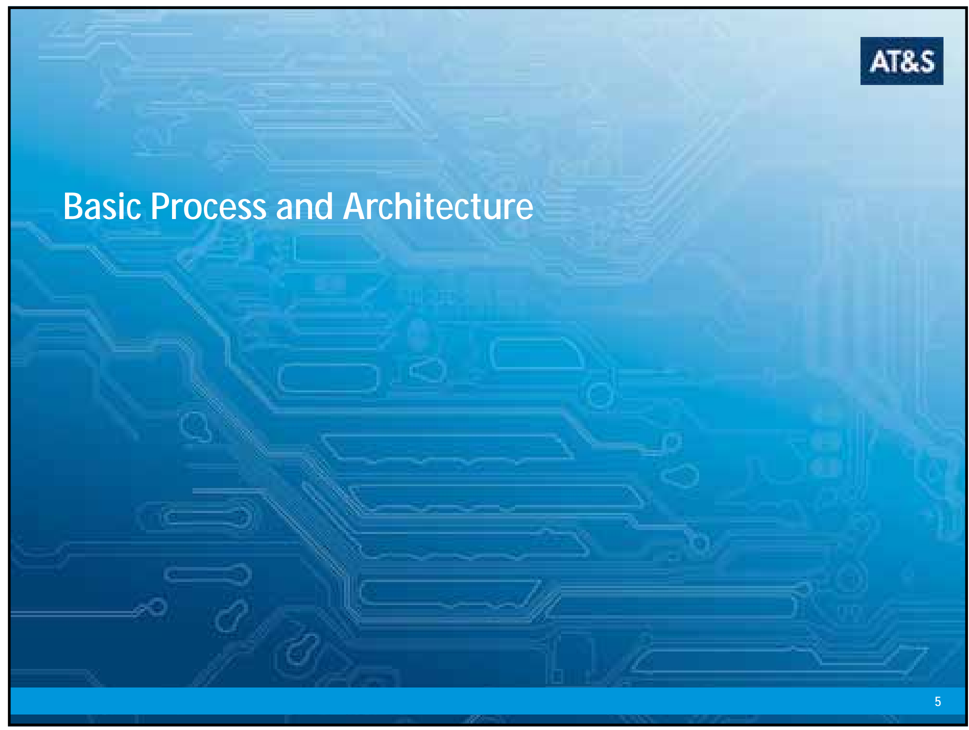

AT&S Main Product Portfolio
AT&S
Double-sided printed circuit boards
Multilayer printed circuit boards
HDI micro via printed circuit boards
HDI any-layer printed circuit boards
IMS printed circuit boards
HDI rigid-flex printed circuit boards
Flexible printed circuit boards on aluminium
Rigid-flexible printed circuit boards
Semi-flexible printed circuit boards
Flexible printed circuit boards
3

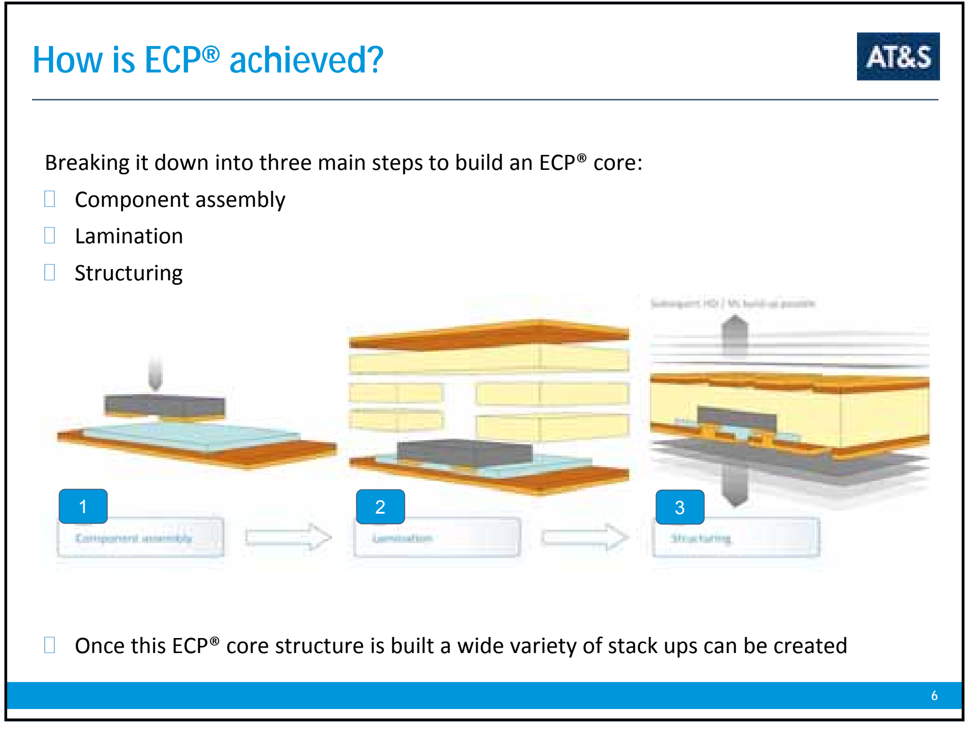
What is ECP®?

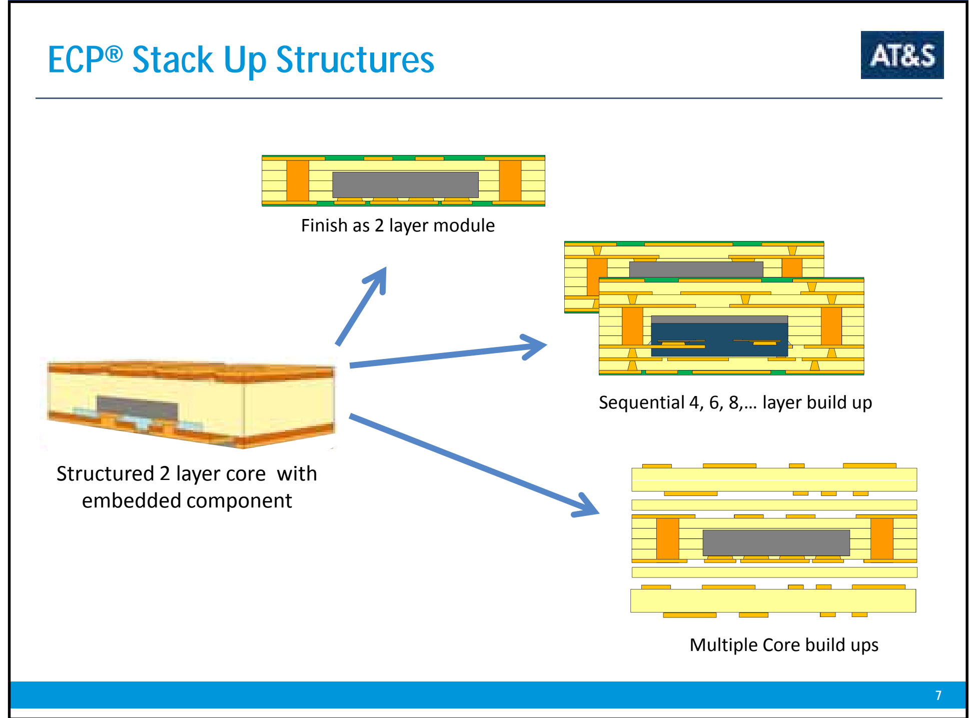
AT&S

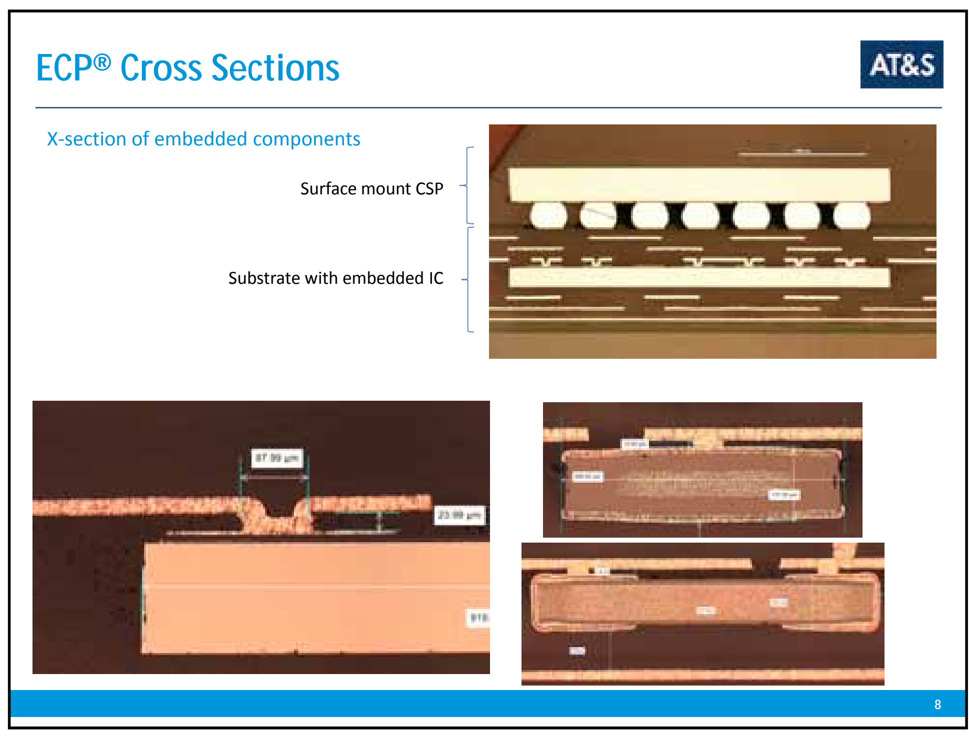
- **ECP® (Embedded Component Packaging)** is patent protected packaging solution.
- ECP® offers miniaturization, performance and reliability benefits.
- ECP® uses the space inside an organic, laminate substrate (Printed Circuit Board) to embed **active and/or passive** components.
- Components will be integrated in the core of the substrate and connected by copper plated micro vias.

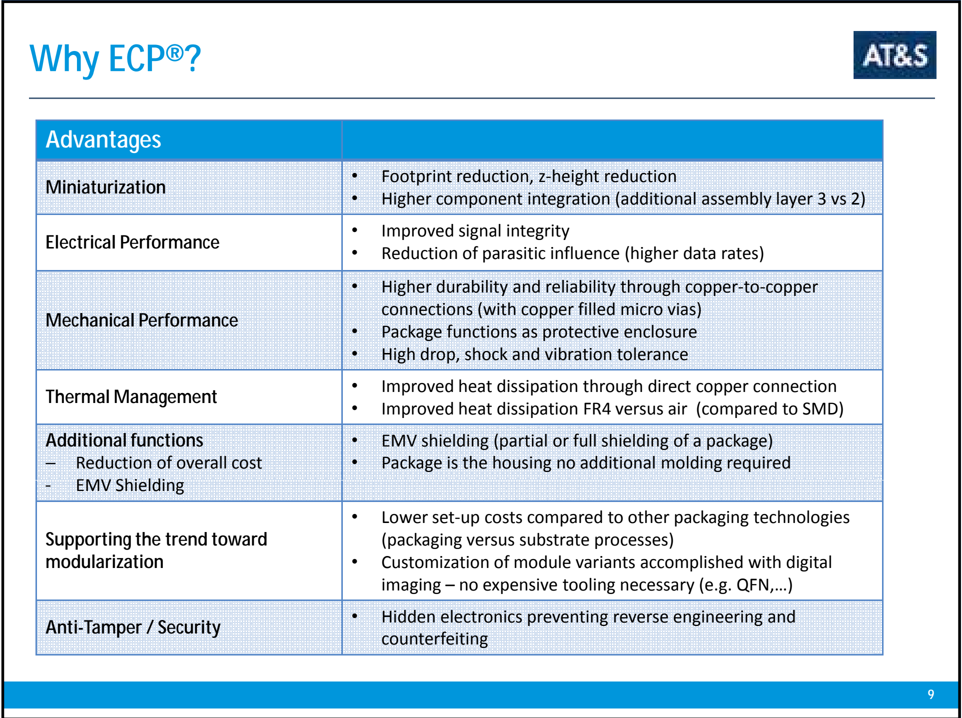
4




How is ECP® achieved?
AT&S
Breaking it down into three main steps to build an ECP® core:
Component assembly
Lamination
Structuring
1
2
3
Once this ECP® core structure is built a wide variety of stack ups can be created
6


ECP® Stack Up Structures
AT&S
Finish as 2 layer module
Sequential 4, 6, 8,… layer build up
Structured 2 layer core with
embedded component
Multiple Core build ups
7

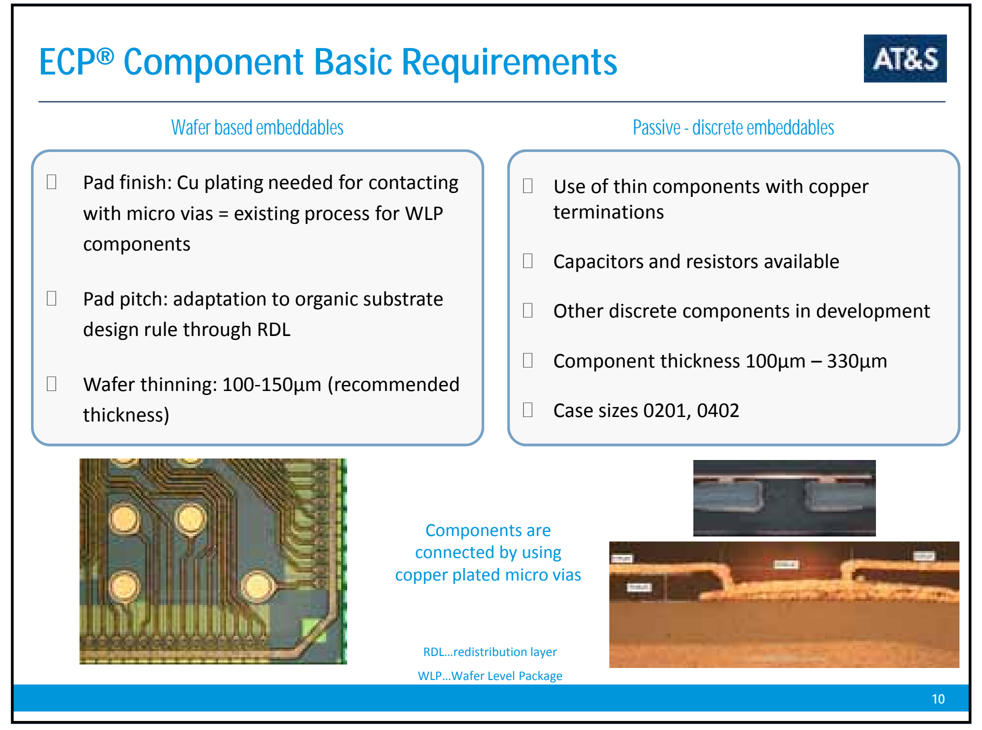


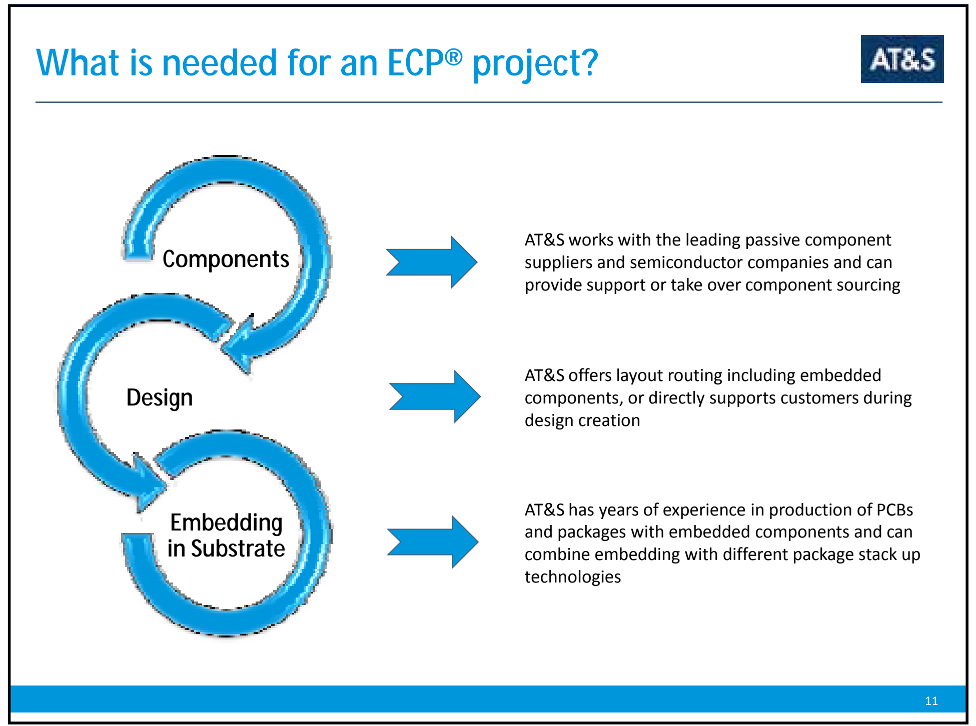

Why ECP®?

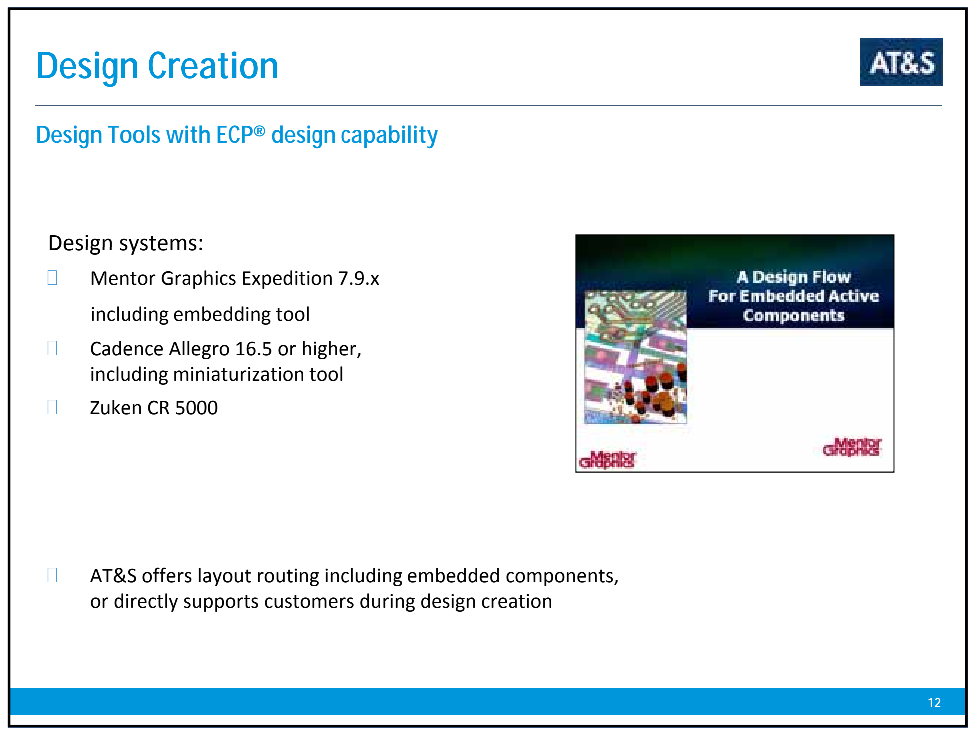
AT&S

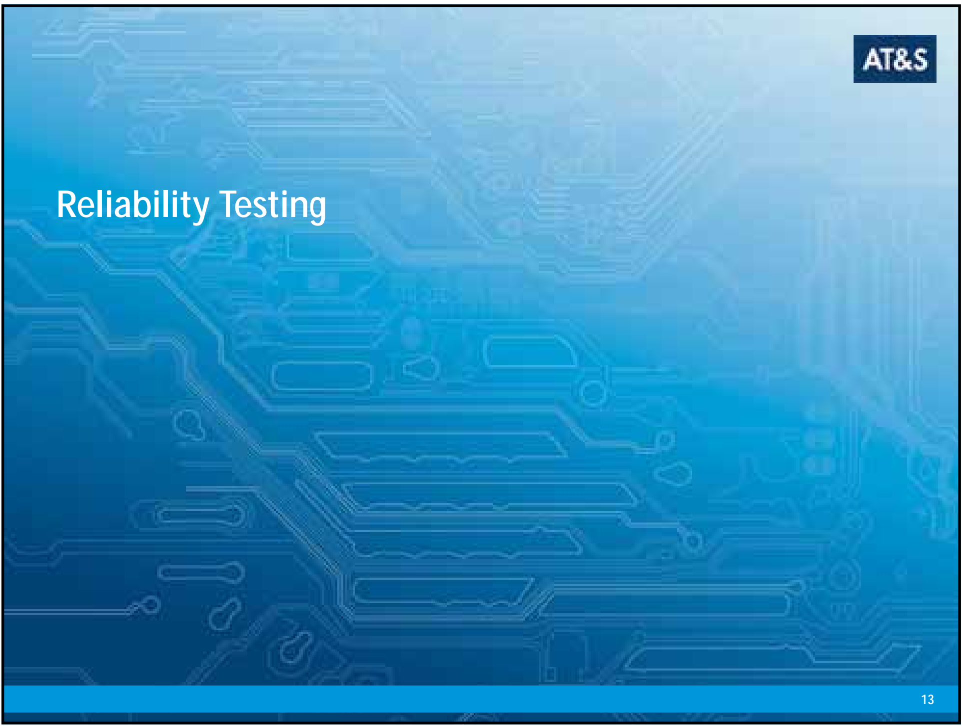
Advantages	
Miniaturization	• Footprint reduction, z-height reduction • Higher component integration (additional assembly layer 3 vs 2)
Electrical Performance	• Improved signal integrity • Reduction of parasitic influence (higher data rates)
Mechanical Performance	• Higher durability and reliability through copper-to-copper connections (with copper filled micro vias) • Package functions as 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 - EMV Shielding	• EMV shielding (partial or full shielding of a package) • Package is the housing no additional molding required
Supporting the trend toward modularization	• Lower set-up costs compared to other packaging technologies (packaging versus substrate processes) • Customization of module variants accomplished with digital imaging – no expensive tooling necessary (e.g. QFN,…)
Anti-Tamper / Security	• Hidden electronics preventing reverse engineering and counterfeiting

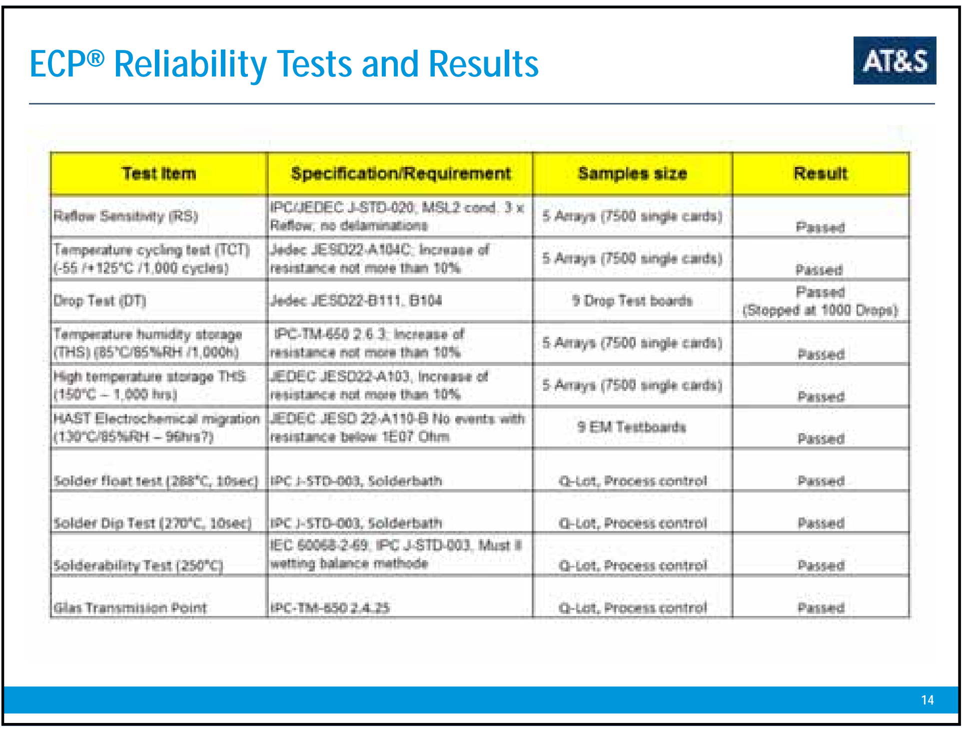
9


ECP® Component Basic Requirements
AT&S
Wafer based embeddables
Pad finish: Cu plating needed for contacting with micro vias = existing process for WLP components
Pad pitch: adaptation to organic substrate design rule through RDL
Wafer thinning: 100-150µm (recommended thickness)
Passive - discrete embeddables
Use of thin components with copper terminations
Capacitors and resistors available
Other discrete components in development
Component thickness 100µm – 330µm
Case sizes 0201, 0402
Components are connected by using copper plated micro vias
RDL...redistribution layer
WLP...Wafer Level Package
10


What is needed for an ECP® project?
AT&S
Components
Design
Embedding in Substrate
AT&S works with the leading passive component suppliers and semiconductor companies and can provide support or take over component sourcing
AT&S offers layout routing including embedded components, or directly supports customers during design creation
AT&S has years of experience in production of PCBs and packages with embedded components and can combine embedding with different package stack up technologies
11


Design Creation
AT&S
Design Tools with ECP® design capability
Design systems:
Mentor Graphics Expedition 7.9.x including embedding tool
Cadence Allegro 16.5 or higher, including miniaturization tool
Zuken CR 5000
A Design Flow For Embedded Active Components
Mentor Graphics
AT&S offers layout routing including embedded components, or directly supports customers during design creation
12


AT&S
Reliability Testing
13

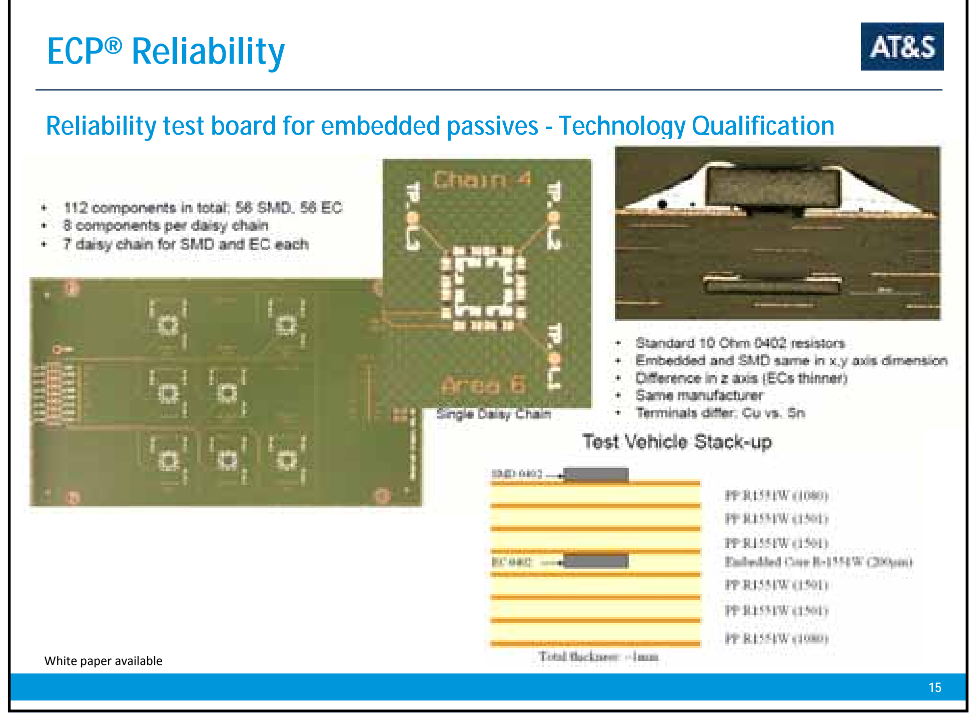


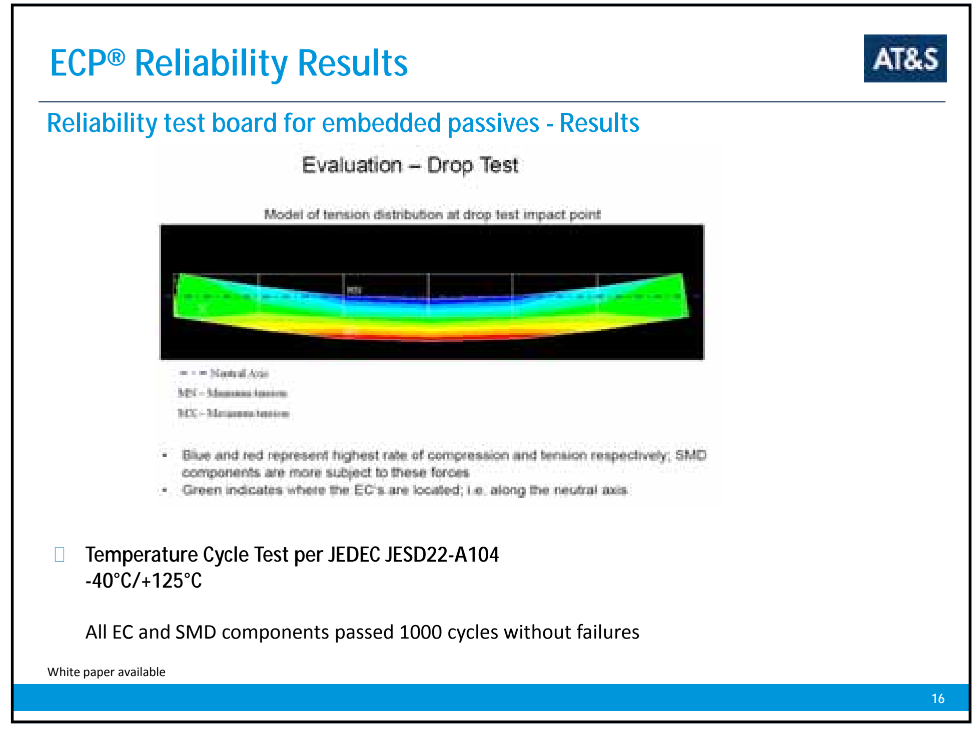
ECP® Reliability Tests and Results

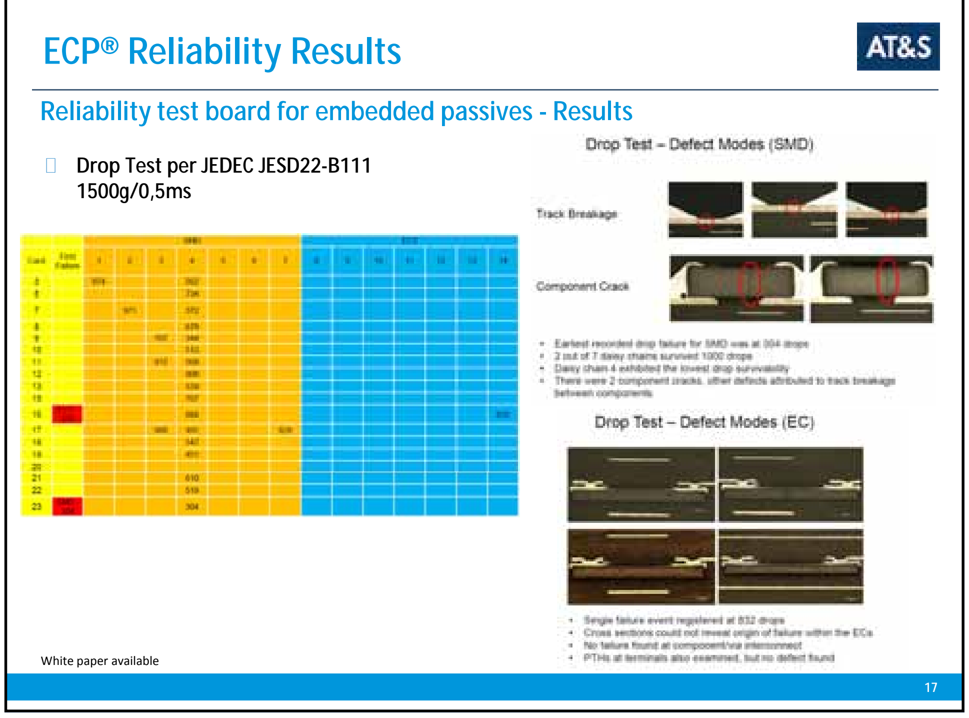
AT&S

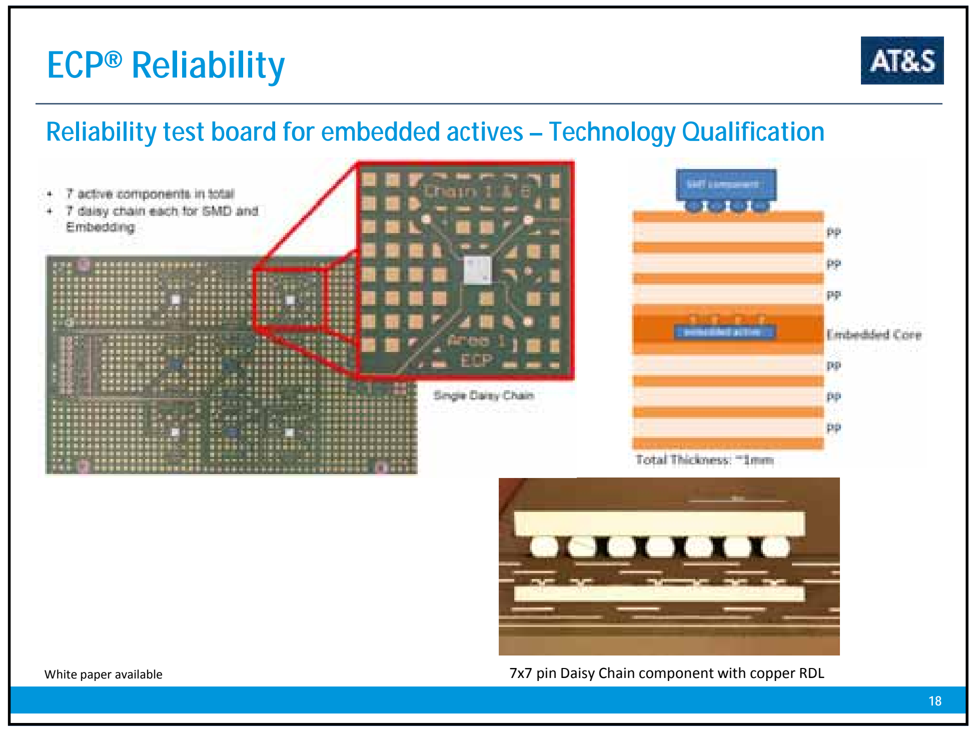
Test Item	Specification/Requirement	Samples size	Result
Reflow Sensitivity (RS)	IPC/JEDEC J-STD-020; MSL2 cond. 3 x Reflow; no delaminations	5 Arrays (7500 single cards)	Passed
Temperature cycling test (TCT) (-55 /+125°C /1,000 cycles)	Jedec JESD22-A104C; Increase of resistance not more than 10%	5 Arrays (7500 single cards)	Passed
Drop Test (DT)	Jedec JESD22-B111, B104	9 Drop Test boards	Passed (Stopped at 1000 Drops)
Temperature humidity storage (THS) (85°C/85%RH /1,000h)	IPC-TM-650 2.6.3; Increase of resistance not more than 10%	5 Arrays (7500 single cards)	Passed
High temperature storage THS (150°C – 1,000 hrs)	JEDEC JESD22-A103, Increase of resistance not more than 10%	5 Arrays (7500 single cards)	Passed
HAST Electrochemical migration (130°C/85%RH – 96hrs?)	JEDEC JESD 22-A110-B No events with resistance below 1E07 Ohm	9 EM Testboards	Passed
Solder float test (288°C, 10sec)	IPC J-STD-003, Solderbath	Q-Lot, Process control	Passed
Solder Dip Test (270°C, 10sec)	IPC J-STD-003, Solderbath	Q-Lot, Process control	Passed
Solderability Test (250°C)	IEC 60068-2-69; IPC J-STD-003, Must II wetting balance methode	Q-Lot, Process control	Passed
Glas Transmision Point	IPC-TM-650 2.4.25	Q-Lot, Process control	Passed

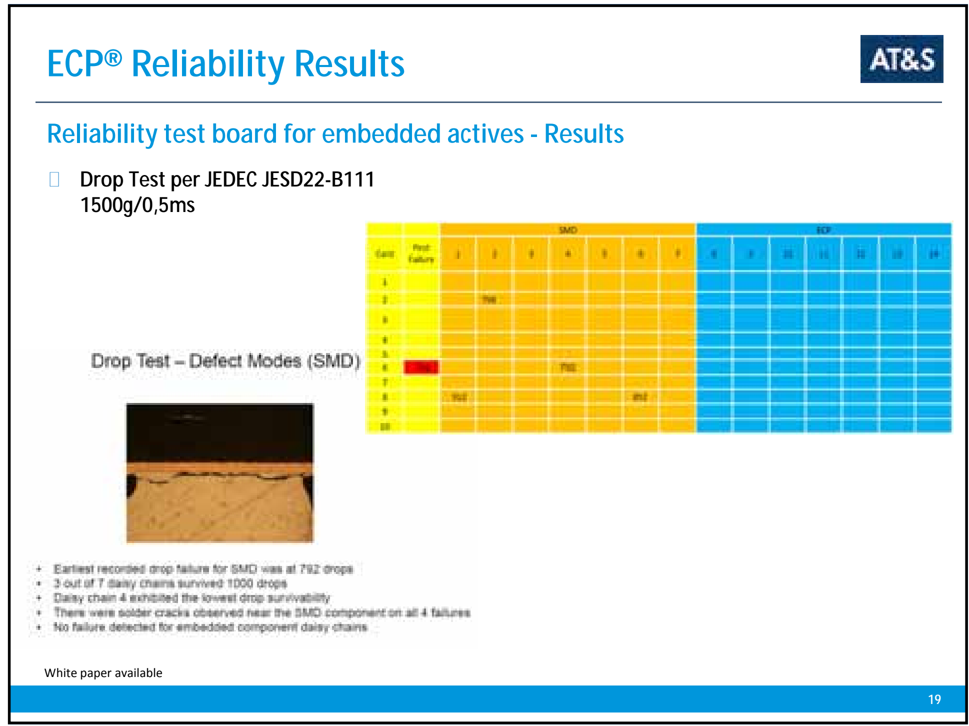
14

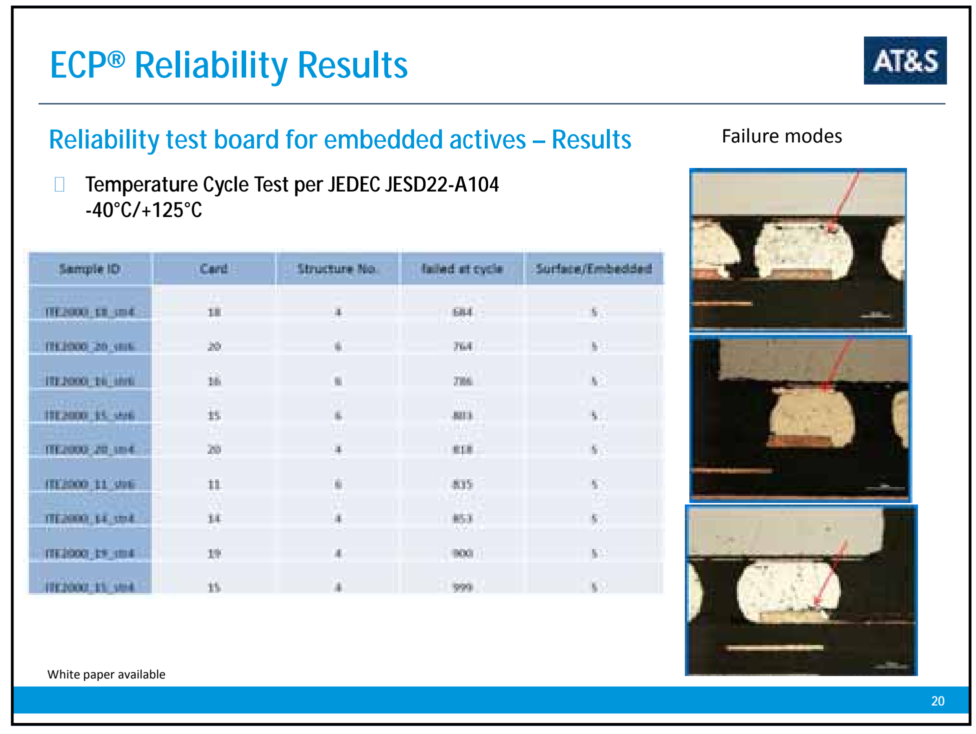



ECP® Reliability Results
AT&S
Reliability test board for embedded passives - Results
Evaluation – Drop Test
Model of tension distribution at drop test impact point
Blue and red represent highest rate of compression and tension respectively; SMD components are more subject to these forces
Green indicates where the EC's are located; i.e. along the neutral axis
Temperature Cycle Test per JEDEC JESD22-A104
-40°C/+125°C
All EC and SMD components passed 1000 cycles without failures
White paper available
16

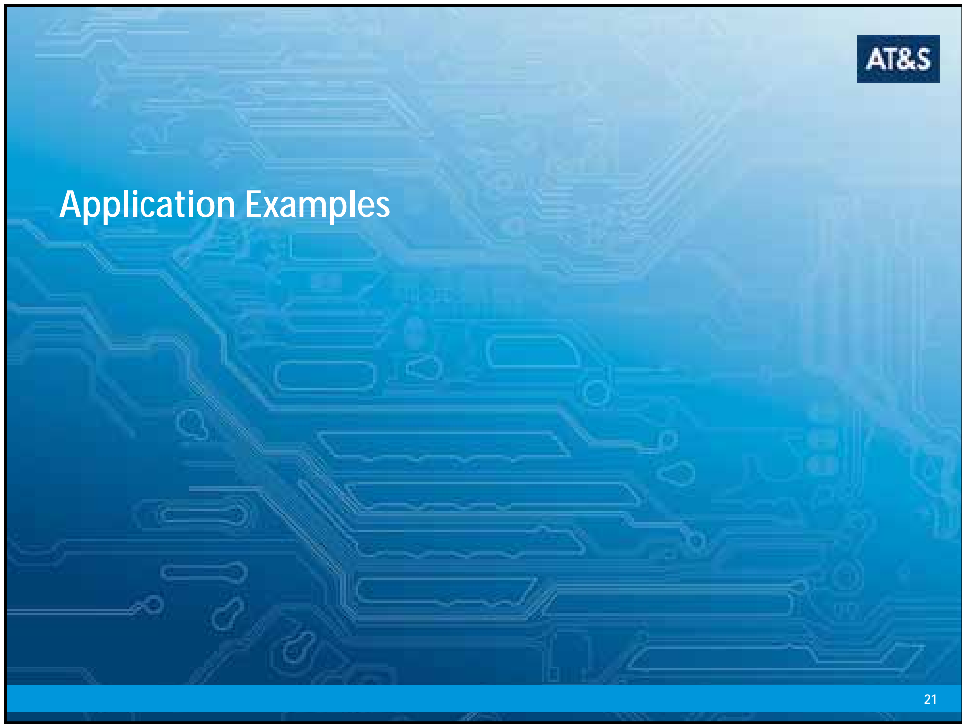

ECP® Reliability Results
AT&S
Reliability test board for embedded passives - Results
Drop Test per JEDEC JESD22-B111
1500g/0,5ms
Drop Test – Defect Modes (SMD)
Track Breakage
Component Crack
Drop Test – Defect Modes (EC)
White paper available
17

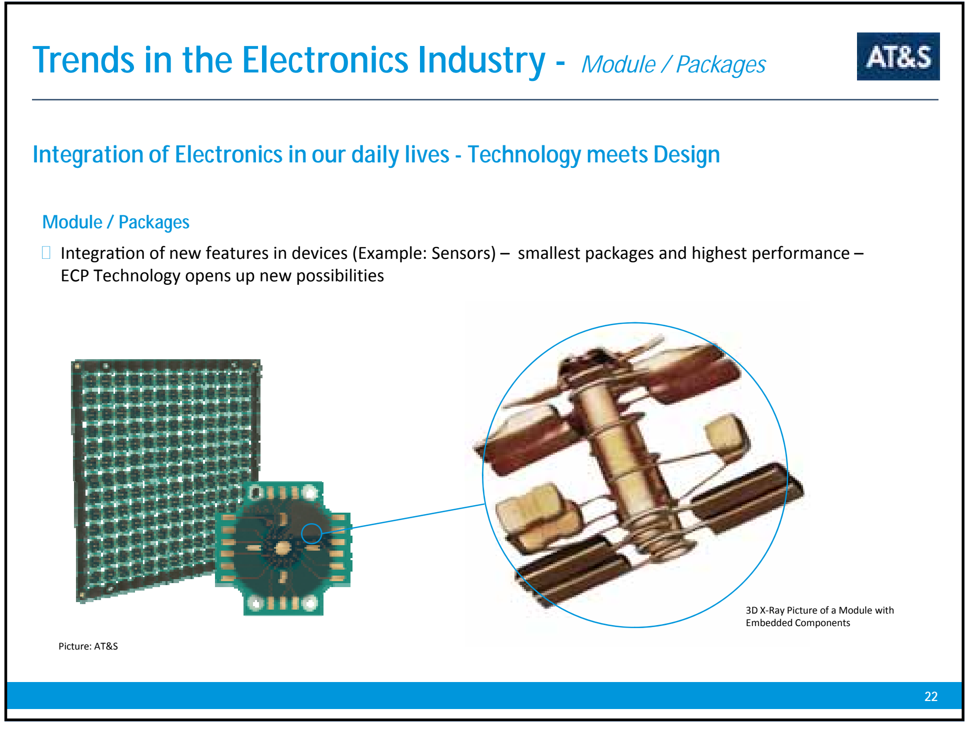

ECP® Reliability
AT&S
Reliability test board for embedded actives – Technology Qualification
• 7 active components in total
• 7 daisy chain each for SMD and Embedding
Chain 1 & 8
Area 1
ECP
Single Daisy Chain
SMT component
PP
PP
PP
Embedded Core
PP
PP
PP
Total Thickness: ~1mm
White paper available
7x7 pin Daisy Chain component with copper RDL
18

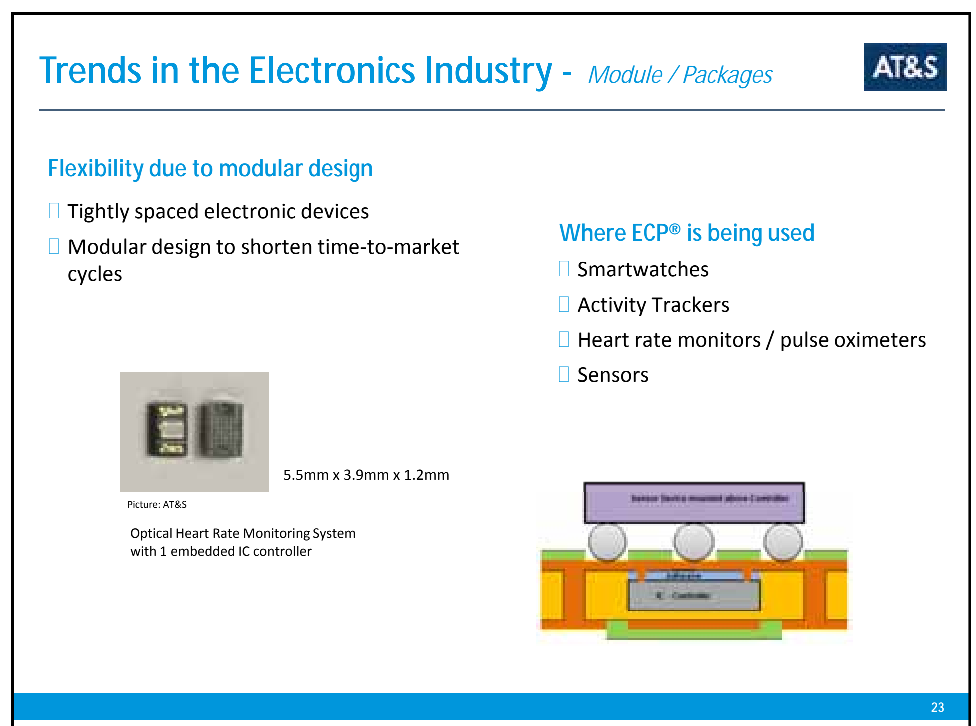

ECP® Reliability Results
AT&S
Reliability test board for embedded actives - Results
Drop Test per JEDEC JESD22-B111
1500g/0,5ms
Drop Test – Defect Modes (SMD)
SMD
ECP
• Earliest recorded drop failure for SMD was at 792 drops
• 3 out of 7 daisy chains survived 1000 drops
• Daisy chain 4 exhibited the lowest drop survivability
• There were solder cracks observed near the SMD component on all 4 failures
• No failure detected for embedded component daisy chains
White paper available
19

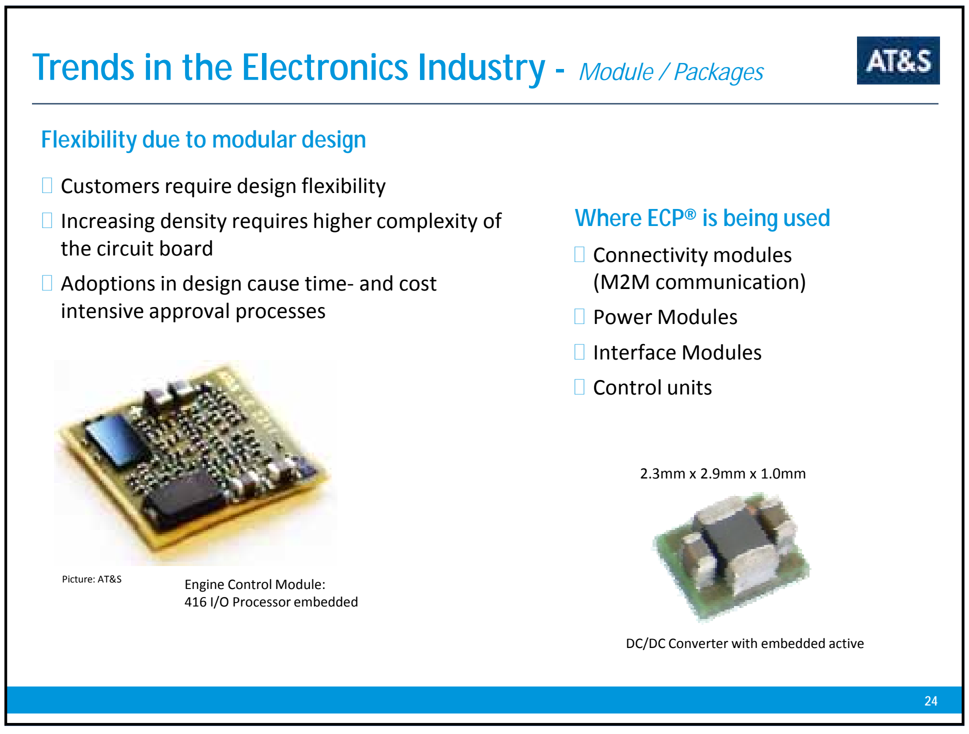


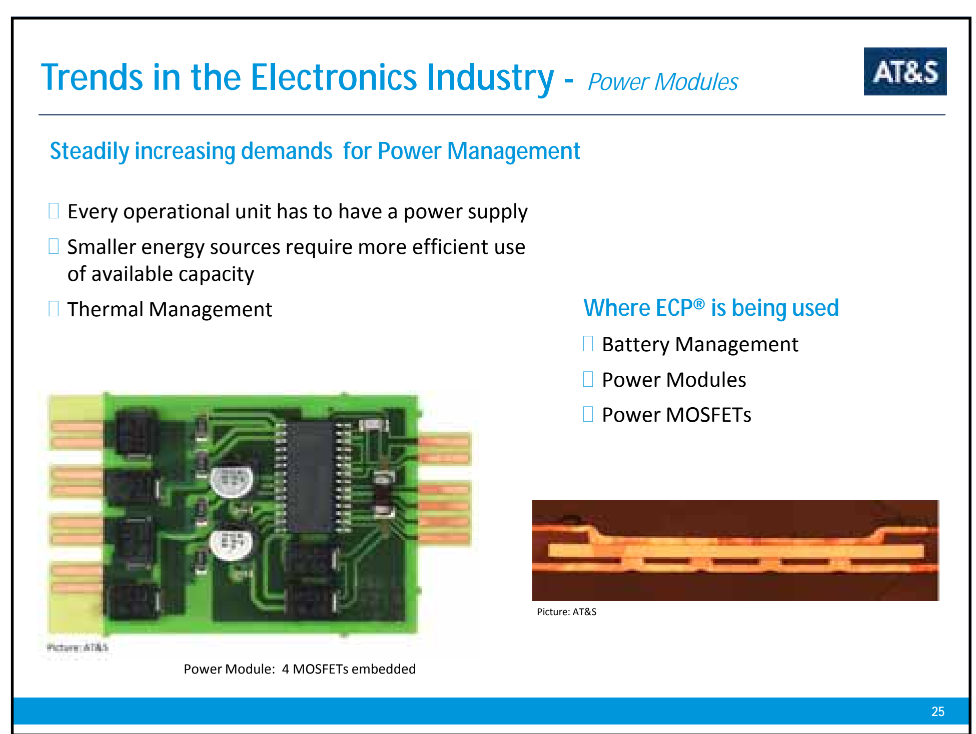
Sample ID	Card	Structure No.	failed at cycle	Surface/Embedded
ITE2000_18_str4	18	4	684	5
ITE2000_20_str6	20	6	764	5
ITE2000_16_str6	16	6	786	5
ITE2000_15_str6	15	6	803	5
ITE2000_20_str4	20	4	818	5
ITE2000_11_str6	11	6	835	5
ITE2000_14_str4	14	4	853	5
ITE2000_19_str4	19	4	900	5
ITE2000_15_str4	15	4	999	5

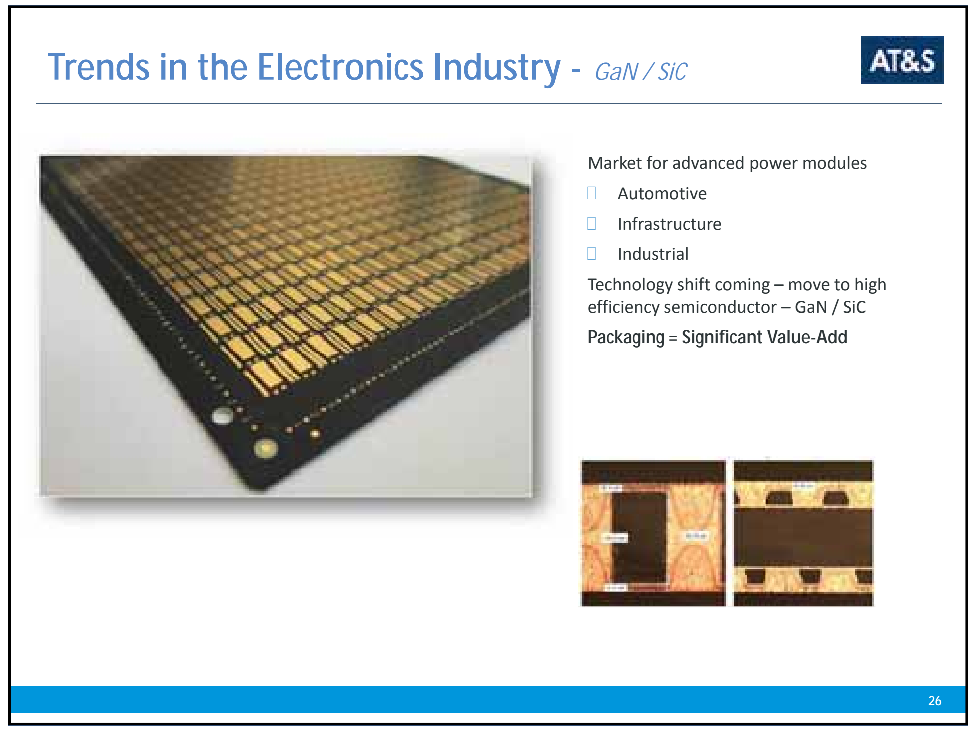


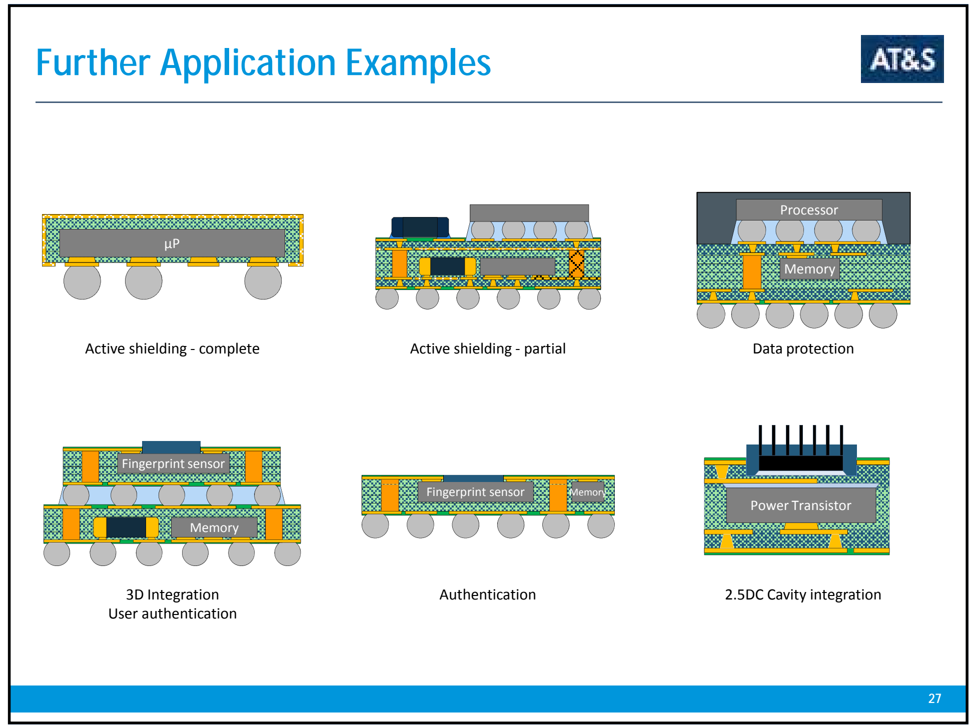

Trends in the Electronics Industry - Module / Packages
AT&S
Integration of Electronics in our daily lives - Technology meets Design
Module / Packages
Integration of new features in devices (Example: Sensors) – smallest packages and highest performance – ECP Technology opens up new possibilities
3D X-Ray Picture of a Module with Embedded Components
Picture: AT&S
22


Trends in the Electronics Industry - Module / Packages
AT&S
Flexibility due to modular design
Tightly spaced electronic devices
Modular design to shorten time-to-market cycles
Where ECP® is being used
Smartwatches
Activity Trackers
Heart rate monitors / pulse oximeters
Sensors
5.5mm x 3.9mm x 1.2mm
Picture: AT&S
Optical Heart Rate Monitoring System with 1 embedded IC controller
23

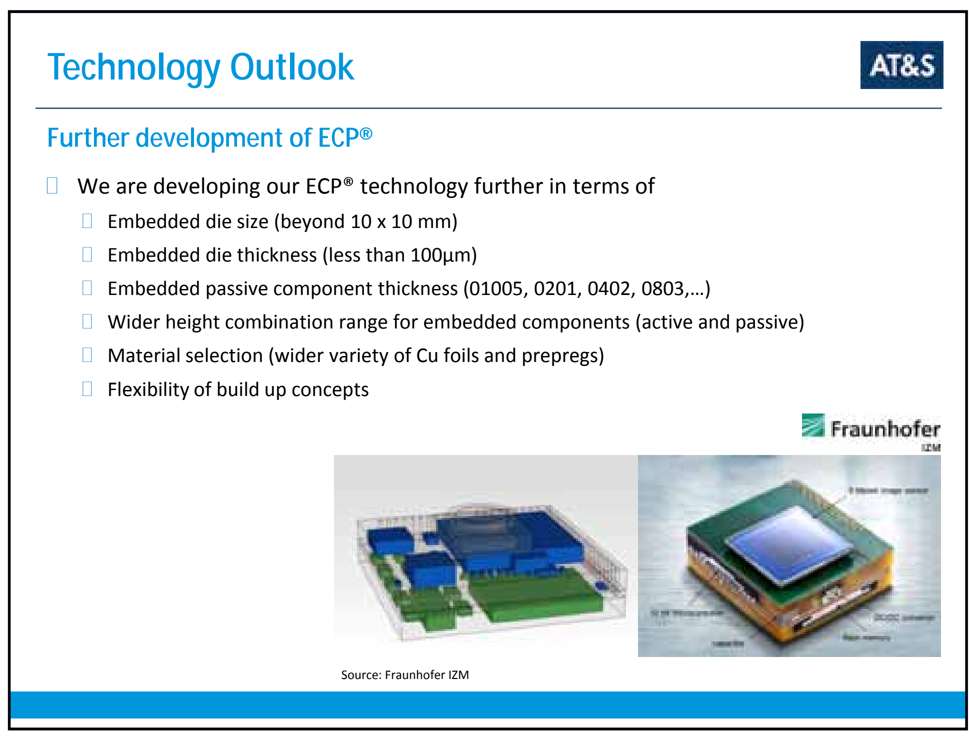

Trends in the Electronics Industry - Module / Packages
AT&S
Flexibility due to modular design
Customers require design flexibility
Increasing density requires higher complexity of the circuit board
Adoptions in design cause time- and cost intensive approval processes
Where ECP® is being used
Connectivity modules (M2M communication)
Power Modules
Interface Modules
Control units
2.3mm x 2.9mm x 1.0mm
Picture: AT&S
Engine Control Module:
416 I/O Processor embedded
DC/DC Converter with embedded active
24

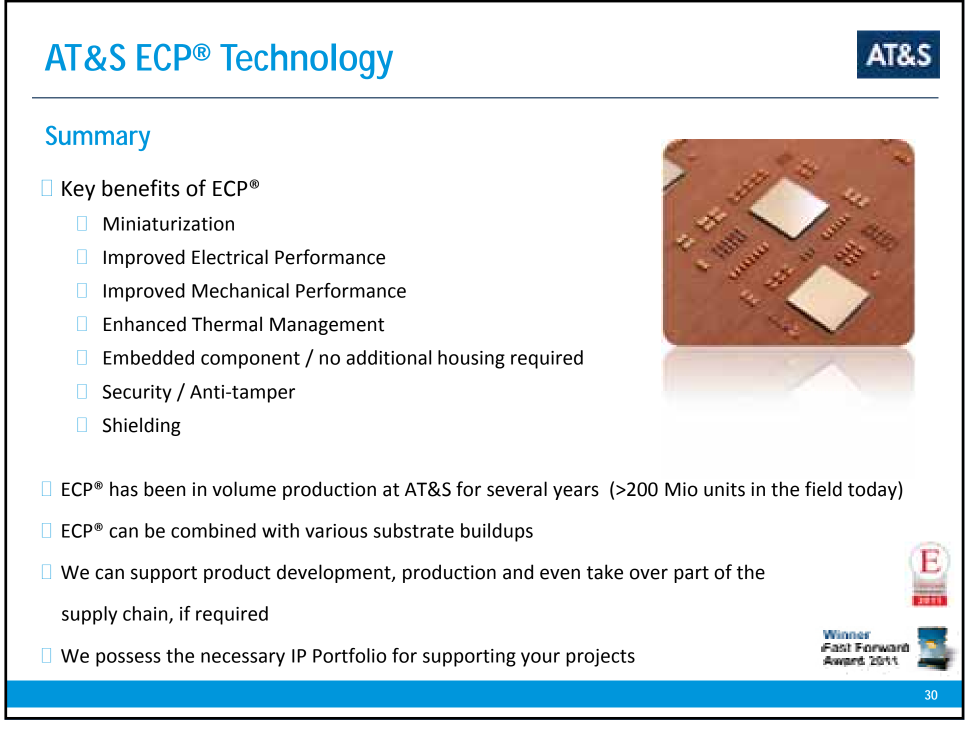

Trends in the Electronics Industry - Power Modules
AT&S
Steadily increasing demands for Power Management
Every operational unit has to have a power supply
Smaller energy sources require more efficient use of available capacity
Thermal Management
Where ECP® is being used
Battery Management
Power Modules
Power MOSFETs
Picture: AT&S
Picture: AT&S
Power Module: 4 MOSFETs embedded
25

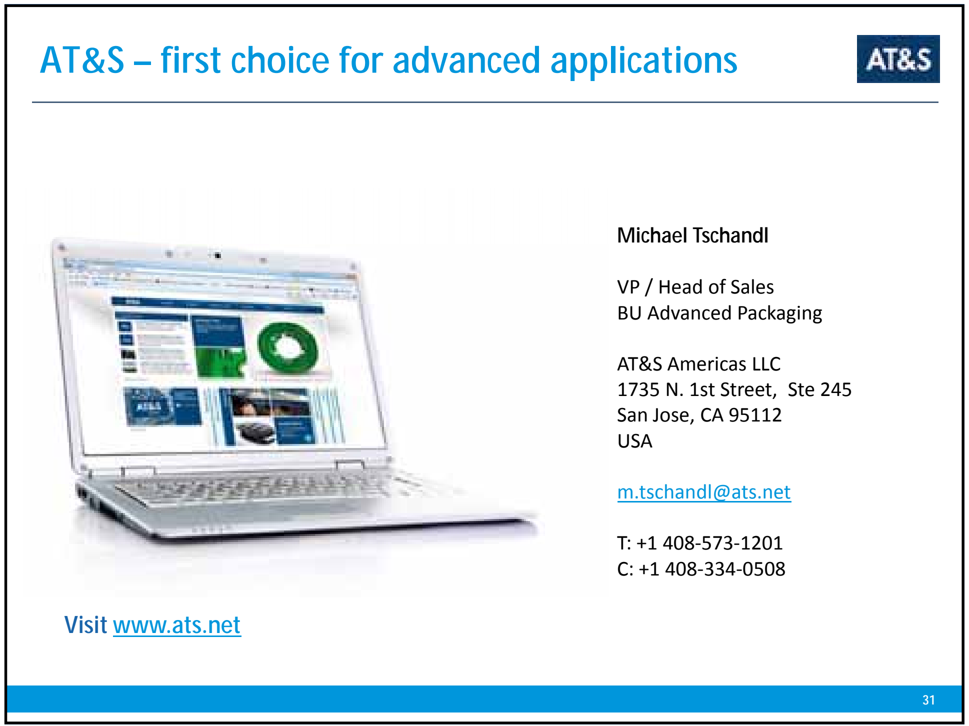

Trends in the Electronics Industry - GaN / SiC
AT&S
Market for advanced power modules
Automotive
Infrastructure
Industrial
Technology shift coming – move to high efficiency semiconductor – GaN / SiC
Packaging = Significant Value-Add
26


Further Application Examples
AT&S
µP
Active shielding - complete
Active shielding - partial
Processor
Memory
Data protection
Fingerprint sensor
Memory
3D Integration
User authentication
Fingerprint sensor
Authentication
Power Transistor
2.5DC Cavity integration
27

Standardization
AT&S
System-in-Package
ECP as Package
Standard qualification process
AEC Q100, JESD-22, MIL-STD-883…
System-in-Board
ECP as Substrate
No standard in place yet
AT&S working with IPC Committee
Embedding-specific standard (IPC-7092)
IPC / FED Conference on Embedded Components
Frankfurt Germany 4-5 June 2013
IPC-7092
Design and Assembly Process Implementation for Embedded Components
D-55 subcommittee members:
28


Technology Outlook
AT&S
Further development of ECP®
We are developing our ECP® technology further in terms of
Embedded die size (beyond 10 x 10 mm)
Embedded die thickness (less than 100µm)
Embedded passive component thickness (01005, 0201, 0402, 0803,…)
Wider height combination range for embedded components (active and passive)
Material selection (wider variety of Cu foils and prepregs)
Flexibility of build up concepts
Fraunhofer
IZM
Source: Fraunhofer IZM


AT&S ECP® Technology
AT&S
Summary
Key benefits of ECP®
Miniaturization
Improved Electrical Performance
Improved Mechanical Performance
Enhanced Thermal Management
Embedded component / no additional housing required
Security / Anti-tamper
Shielding
ECP® has been in volume production at AT&S for several years (>200 Mio units in the field today)
ECP® can be combined with various substrate buildups
We can support product development, production and even take over part of the supply chain, if required
We possess the necessary IP Portfolio for supporting your projects
Winner
Fast Forward
Award 2011
30


AT&S – first choice for advanced applications
AT&S
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VP / Head of Sales
BU Advanced Packaging
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