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AT&S at a Glance

ECP® - The Embedding Technology

Applications
AT&S – A WORLD LEADER IN HIGH-TECH PCB & IC SUBSTRATES

- High-end interconnect solutions for Mobile Devices, Automotive, Industrial, Medical Applications and Semiconductor Industry
- Continuously outperforming market growth
- #1 manufacturer in Europe
- €991.8m revenue in FY 2017/18
- Cost-competitive production footprint with 6 plants in Europe and Asia

#3 in high-end technology worldwide

10,039 employees

GLOBAL FOOTPRINT ENSURES PROXIMITY TO SUPPLY CHAIN & COST EFFICIENCY

Staff, Average, FTE, Q1-3 2017/18, 73 employees in other locations
MARKET SEGMENTS & PRODUCT APPLICATIONS SERVED BY AT&S

Computer, Communication, Consumer
Smartphones, Tablets, Wearables, Ultrabooks, Solid State Drives, Microserver

IC substrates
High Performance Computer, Microserver

Automotive
Advanced Driver Assistance Systems, Emergency-Call, X2X Communication

Industrial
M2M Communication, Robots, Industrial Computer, X2X Communication

Medical
Patient Monitoring, Hearing Aids, Pacemaker, Neurostimulation, Drug Delivery, Prosthesis

Segment Mobile Devices & Substrates

Segment Automotive, Industrial, Medical

HDI: high density interconnect, meaning laser-drilled connections (microvias). HDI is first step towards miniaturization. AT&S can produce 4-layer laser PCBs up to 6-n-6 HDI multi layer PCBs.

IMS: insulated metal substrate. Primary function: heat dissipation for use mainly with LEDs and power components.

Further technological enhancement to HDI microvia: All electrical connections in HDI any-layer boards consist of laser-drilled microvias. Advantage: further miniaturization, and higher performance and reliability. AT&S produces HDI any-layer in 4 to 12 layers.

Production site
Shanghai, Leoben, Nanjiangud, Fehring

Applications
Smartphones, Tablets, Notebooks

Used in all electronic applications including automotive (navigation, infotainment and driver assistance systems)
### Flexible printed circuit boards
- Used to replace wiring and connectors, allowing for connections and geometries that are not possible with rigid printed circuit boards.

### Semi-flexible printed circuit boards
- More limited bend radius than flexible printed circuit boards. The use of a standard thin laminate makes them a cost-effective alternative.

### Rigid-flex printed circuit boards
- Combine the advantages of flexible and rigid printed circuit boards, yielding benefits for signal transmission, size and stability.

### Flexible printed circuit boards on aluminum
- Used when installing LEDs in car headlights, for example, where the printed circuit board is bonded to an aluminum heat sink to which the LEDs are then attached.

### Insulated Metal Substrate PCB
- Thick metal substrate PCB used for heat dissipation for LED applications or power components which generate a lot of heat.

### Production site
- Ansan, Fehring
- Ansan
- Ansan
- Fehring

### Applications
- Nearly all areas of electronics, including measuring devices and medical applications
- Automotive applications
- Industrial electronics, such as production machines and industrial robots
- Lighting, automotive, building lighting
- Lighting, automotive, industrial power applications

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What is ECP®?
AT&S ECP® - Embedded Component Packaging

ECP® (Embedded Component Packaging) uses the free space in an organic, laminate substrate (Printed Circuit Board) for active and/or passive components. Components are integrated in the core of the PCB and connected by copper plated micro vias.

Key Facts
Possibilities and requirements for an embedding project

- Active and/or passive components
- Copper surface on IO’s
- Component (body) thickness 60µm - 300µm (min/max values)
- Laser drilled micro vias
- Electrolytic plated copper
- HDI PCB processes
- PCB material and processes
- Various combination of stack-ups possible
- Details on next slide
Why ECP®?

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 micro vias)  
  • 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 | • EMV shielding (partial or full shielding of a package)  
  • Package is the housing → no additional molding required
ECP is supporting the trend towards modularization | • 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

ECP®: Embedded Component Packaging
Produced volumes since 2011

<table>
<thead>
<tr>
<th>Packages</th>
<th>Modules</th>
<th>Boards</th>
</tr>
</thead>
<tbody>
<tr>
<td># of shipped units</td>
<td>&gt; 247 million</td>
<td>&gt; 9 million</td>
</tr>
<tr>
<td># of shipped m² (gross)</td>
<td>&gt; 3.900</td>
<td>&gt; 700</td>
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<tr>
<td># of HVM projects</td>
<td>55</td>
<td>10</td>
</tr>
<tr>
<td># of prototypes</td>
<td>64</td>
<td>114</td>
</tr>
<tr>
<td># of assembled components</td>
<td>&gt; 247 million</td>
<td>&gt; 15 million</td>
</tr>
</tbody>
</table>

Mainly low voltage applications (<20V)
**Process Flow Center Core ECP®**

Main process steps

- Core preparation
- Cavity cutting
- Carrier lamination
- Component assembly

- Soft lamination
- Carrier removal
- Final lamination

- Laser drilling
- Mechanical drilling
- Plating and structuring
- Testing

**Possible Architectures**

Embedded core combined with standard PCB technology

- Finish as 2 layer module
- Sequential 4, 6, 8, 10 layer build up
- Multiple core build up
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ECP® Application Examples

<table>
<thead>
<tr>
<th>Application</th>
<th>GaN based multilevel inverter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package size / Type</td>
<td>10 x 10 mm Single-die board</td>
</tr>
<tr>
<td>Substrate Construction/Thickness</td>
<td>2 layer (double side connection) 350 um</td>
</tr>
<tr>
<td># of embedded components</td>
<td>1</td>
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<tr>
<td>Voltage</td>
<td>150V</td>
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</tbody>
</table>

Paper presentation at CIPS 2018
EmPower
Integration of Electric Power Components for Electromobility
EmPower: Application fields

› BT microelectronic:
  Power discrete package on base of D²PAK
  → power schottky rectifier

› Continental Transmission
  Pedelec → BLDC motor control with power module

› Continental Hybrid & Electric Vehicle:
  DC/DC inverter

Source: AT&S

EmPower

Miniaturization x,y,z – 500W Demonstrator

• Size reduction in x,y of 50% in power area
• z – dimension of Power core around 350µm

Source: AT&S
Switching performance – 500W Demonstrator

- close positioning of single components results in a minimization of inductance of the switching cell
- reduction of the overvoltage indicates less switching losses and finally faster switching is possible

Ferrite embedding for Power Converter Applications

Toroidal Inductor

N = 16
R1 = 1.5 mm
R2 = 5.25 mm
h = 300 µm

Magnetic field lines distribution at 2.5 A

- No air gap
- Air gap 500µm
- Air gap 350µm

European funded GaNonCMOS project

The combined embedding of magnetic material, active and passive components allows the production of highly integrated modules exploiting all possible advantages
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