I PROCESSI DI SALDATURA LASER NELLE LINEE DI ASSEMBLAGGIO SVILUPPATE DA MANZ PER LA PRODUZIONE DELLE BATTERIE A LITIO

Luca Di Silvio  MANZ ITALY

Lavorazioni Laser nel Settore E-Mobility: Stato dell’Arte e Prospettive Future
## GLOBAL PRESENCE

### Facts and Figures

<table>
<thead>
<tr>
<th>HEADQUARTERS</th>
<th>GERMANY</th>
</tr>
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<tbody>
<tr>
<td>R&amp;D AND PROTOTYPING</td>
<td>GERMANY, ITALY, TAIWAN</td>
</tr>
<tr>
<td>PRODUCTION</td>
<td>SLOVAKIA, HUNGARY, CHINA</td>
</tr>
<tr>
<td>SALES &amp; SERVICE</td>
<td>ASIA, EUROPE, USA</td>
</tr>
</tbody>
</table>

- **Year of Establishment**: 1987
- **Employees**: 1,500
- **Floor Area**: 55,000 m²
- **Revenue**: 264 m €
SEGMENTS AND TECHNOLOGIES

OUR SEGMENTS ARE BASED ON OUR 5 CORE TECHNOLOGIES

SEGMENTS
- SOLAR
- ENERGY STORAGE
- ELECTRONICS
- CONTRACT MANUFACTURING
- SERVICE

TECHNOLOGIES
- AUTOMATION
- LASER PROCESSING
- METROLOGY
- ROLL-TO-ROLL
- WET CHEMISTRY
SEGMENT ENERGY STORAGE

ELECTROMOBILITY

» Production solutions for lithium-ion batteries, super-caps and capacitors for hybrid electric and electric vehicles

STATIONARY STORAGE

» Production solutions for lithium-ion batteries and capacitors for stationary energy storage for private homes and large-scale photovoltaic plants

CONSUMER ELECTRONICS

» Production solutions for lithium-ion batteries for consumer electronic products like tablet computers, mobile phones and notebooks
SEGMENT ENERGY STORAGE
Production equipment for all current lithium-ion battery cell geometries

- Cylindrical cells (winding)
- Prismatic cells (winding/stacking)
- Pouch cells (winding/stacking)

» One of the leading suppliers, setting standards for > 30 years
» Machines for different production volumes: from lab & pilot production to turnkey

PRODUCTION EQUIPMENT FOR LITHIUM-ION BATTERY MODULES AND PACKS:
SEGMENTS AND TECHNOLOGIES

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SOLAR  ENERGY STORAGE  ELECTRONICS  CONTRACT MANUFACTURING  SERVICE

SEGMENTS

AUTOMATION  LASER PROCESSING  METROLOGY  ROLL-TO-ROLL  WET CHEMISTRY

TECHNOLOGIES
TECHNOLOGY: OVERVIEW OF LASER PROCESSING APPLICATIONS

Ablation
- Solar
- Electronics
- Energy storage

Cutting
- Energy storage
- Electronics

Drilling
- Solar
- Electronics

Welding
- Energy storage
- Al/Cu

novel processes
Laser welding using high-frequency spatial modulation of laser beam

- High-frequency spatial modulation/oscillation of laser beam
- 3 additional parameters in addition to the previously known parameters (Power, feed velocity, etc.)
  - the geometry
  - the amplitude $a$
  - the frequency $f_p$

Usage of single-mode laser sources

Keyhole-welding with high aspect ratio

Very stable in coupling – control of the welding depth

Lower thermal input into the work piece (< 60°C inside the cell)
LASER WELDING USING SPATIAL MODULATION OF LASER BEAM

Laser welding using high-frequency spatial modulation of laser beam

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Free selectable weld seam geometry

Free selectable cross section shape
LASER WELDING USING SPATIAL MODULATION OF LASER BEAM

Laser welding using high-frequency spatial modulation of laser beam

- Usage of single-mode laser sources
- Keyhole-welding with high aspect ratio
- Very stable in coupling – control of the welding depth
- Lower thermal input into the work piece (< 60°C inside the cell)
- Free selectable weld seam geometry
- Free selectable cross section shape
- Significant reduction of intermetallic phases

Light microscopy

SEM

EDX Cu

EDX AI
High quality welding of numerous material combinations and material thicknesses

Overlap welding and butt joint welding possible

Welding strength up to 36N/mm achievable

Throughput: up to 800 welds/min
LASER WELDING USING SPATIAL MODULATION OF LASER BEAM

- Summary of welding applications using thick upper materials

<table>
<thead>
<tr>
<th>Upper material</th>
<th>Lower material</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al 750 µm</td>
<td>Al &gt; 1 mm</td>
<td>Stitch seam – can to cover</td>
</tr>
<tr>
<td>Al 1.5 mm</td>
<td>Cu 1.8 mm</td>
<td>Stitch seam – ring to tab</td>
</tr>
<tr>
<td>Cu 1 mm</td>
<td>Cu 1 mm</td>
<td>Stitch seam – tab to tab</td>
</tr>
<tr>
<td>Cu 2.5 mm</td>
<td>Cu 2.5 mm</td>
<td>Stitch seam – wire to tab</td>
</tr>
<tr>
<td>Cu 0.5 mm</td>
<td>Al 1 mm</td>
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</tbody>
</table>
Laser welding with high peak power laser radiation

- Limitations of P2-welding process (spatial modulation of laser beam)
  - Materials with very high surface reflectivity
  - Challenging material combinations (Cu-SS)

Cu-connector
Li-Ion-cell
Minus-pole-welding
Cell damage
LASER WELDING USING SHORT PULSED LASER SOURCES

Usage of laser sources with high laser peak power

Stable in coupling even by high reflective materials e.g. Cu

Very stable and easy to control welding depth even at inconvenient material combinations

Reduction of intermetallic phases in comparison to state of the art welding processes

Predestinated for welding of Cu-connectors to cylindrical cells
LASER WELDING USING SHORT PULSED LASER SOURCES

Unbuttoned seams

Linear relationship between tensile strength and seam cross section

Robust and reproducible process in reply to tensile strength and ductility

![Graph showing linear relationship between tensile strength and seam cross section.](image)
FIELD OF APPLICATION – CELL2CELL WELDING

Cell2Cell

1. BUSBAR
2. CELL TO BUS BAR INTERFACE
3. CELL NEST
4. CYLINDRICAL CELLS
5. CELL NEST
6. CELL TO BUS BAR INTERFACE
7. BUSBAR
BATTERY MODULE ASSEMBLY

BLS500 Battery Laser System

» Standardized modular machine platform for various laser applications
» Scalable from lab-tool to mass production
» High accuracy system incl. camera, exhaust, chiller
» Flexible clamping solution with finger clamping
» Various options available
  » Different laser sources, optics
  » Robot loading
  » Laser process monitoring
MASS PRODUCTION MACHINES FOR LI-ION BATTERY PRODUCTION:
BLS500 AND CYLINDRICAL CELLS BATTERY PACK

BLS 500
ONE MACHINE PLATFORM,
NUMEROUS LASER APPLICATIONS
BATTERY MODULE ASSEMBLY

BLS500 Battery Laser System

» Online laser process monitoring
» Sensor detection of optical emissions of laser welding
» Integrated into laser beam path
» Immediate reaction on anomalies during welding
  » Non zero-gap detection
  » Contamination and defocus detection

Algorithm detects anomalies in comparison to taught reference signals
TECHNOLOGY MATRIX MODULE ASSEMBLY

Input
- Laser Cutting Circuit Board

Prepare
- Pre-Assembly One-Sided
  - Pre-Assembly

Assembly
- Cell
  - Tab Bending
  - Cell stacking

Joining Process
- Laser Welding Positive and Negative Terminal
  - Laser Welding Positive
  - Laser Welding Flipping
  - Laser Welding Negative
  - Laser Welding Screwing
  - Laser Welding

Output
- Hard case CAN Pouch
BATTERY MODULE ASSEMBLY PROCESSES

- **Cell preparation**
  - Cell feeding
  - Cell orientation

- **Terminal preparation**
  - Terminal cutting
  - Terminal bending

- **Sub-module assembly**
  - Surface cleaning
  - Dosing, cell gluing
  - Submodule assembly
  - Terminal welding

- **Module assembly**
  - Submodule stacking
  - Module assembly

- **Final assembly**
  - Module contacting
  - Contact welding

- **Module testing**
  - Ele. module testing
ASSEMBLY LINE FOR CELL CONTACTING SYSTEM
Partecipazione di MANZ a progetti di Ricerca e Innovazione in ambito Europeo

Horizon 2020

Horizon Europe
FP 9 Program

LiPlanet
Coordination of EU Research activities
On batteries

IPCEI* on Batteries
"Summer" IPCEI

European Battery
Alliance

IPCEI* EuBatIn
"Autumn" IPCEI

Batteries Europe

Battery 2030+

Industrial Approach
→ State Aid Budget

Research Approach
→ EC Budget

* Important Project of Common European Interest
Progetto 29 – AREA 7  Automazione per Assemblaggio di Celle e Batterie al Litio
IPPSAL : Integrazione Processo Prodotto Servizio per Accumulatori al Litio

- Alma Mater Studiorum – Università di Bologna
- Università degli Studi di Ferrara

• Integrazione da cella a pacco
• soluzioni di monitoraggio delle batterie
• Collegamento delle attività di sviluppo prodotto ‘integrazione celle’ con l’attività di sviluppo ‘processo di saldatura laser’ e controllo del ‘processo di saldatura’
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