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Laser in Battery Production – how, where & why ?

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KUKA makes robots …. But not only !

2/3 = Solution business

- Automotive Solutions
- Advanced Technology Solutions
- Aerospace Solutions
- Logistics Solutions
- Smart production| Industry 4.0

- Arc & Laser Solutions
- Casting Solutions
- Advanced Welding Solutions
- Battery & PV assembly
- Customer Service und Technology Services

- Warehouse & Distribution Solutions
- Healthcare Solutions

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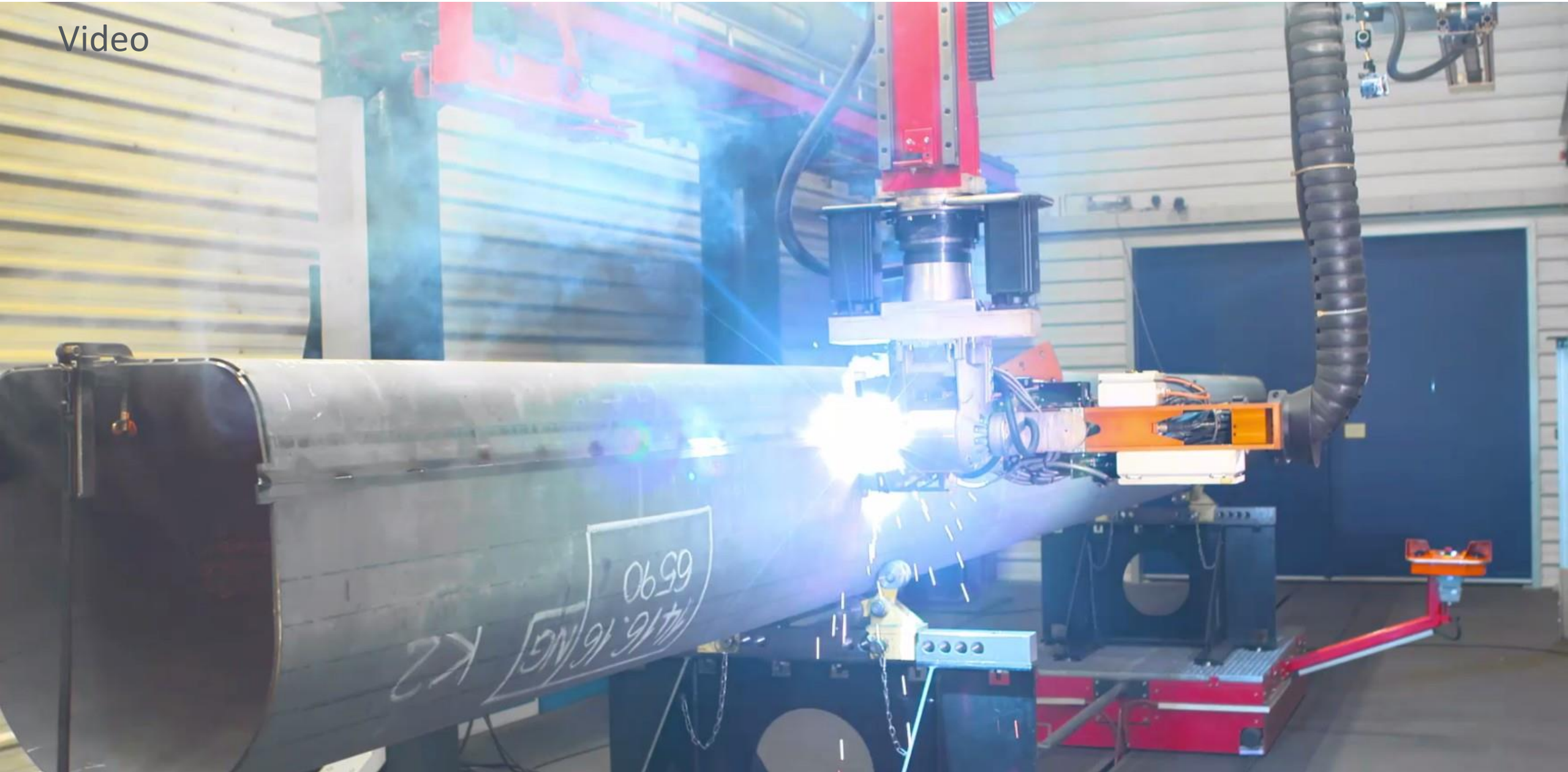
Video



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EV-batteries – terminology & overview

Cells

cylindrical

prismatic

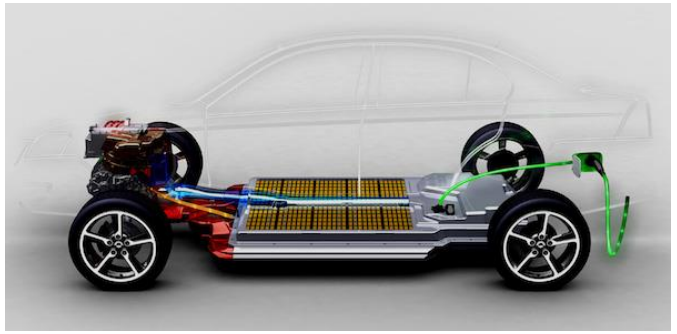
pouch

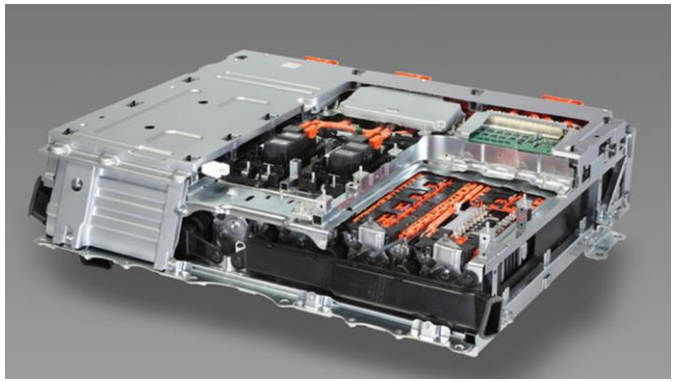
3 basic types

Modules

OEM-specific

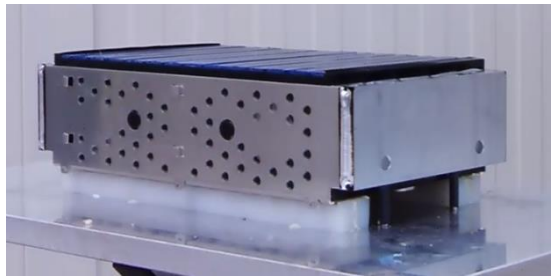
Packs

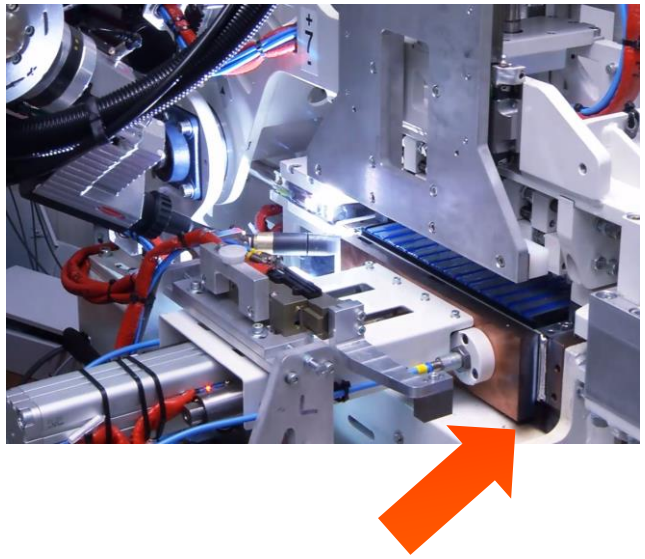




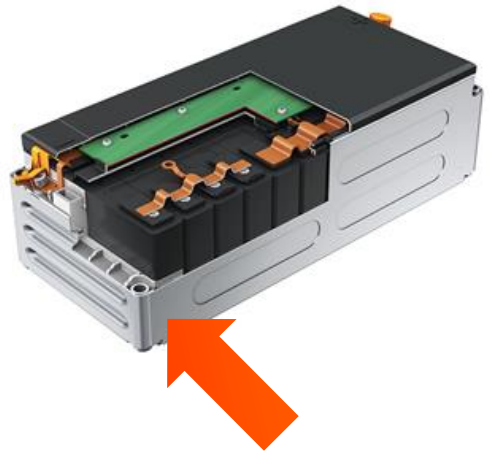
Model-specific

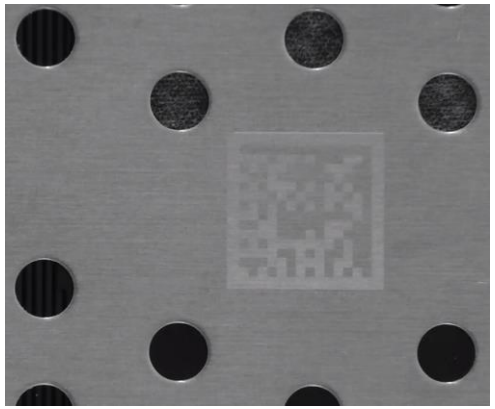
Laser-applications in battery module assembly





- **Frame Welding:**
  - Frame is solidly joined, to keep cells under pressure
  - Arc welding or LASER welding (or screwing, riveting, …)



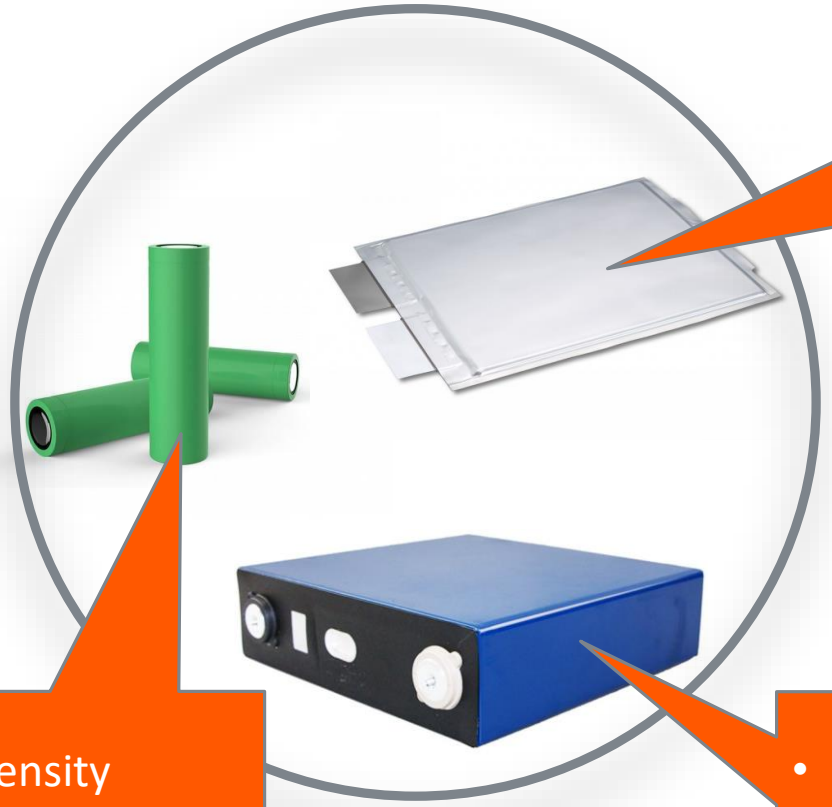


- **Marking:**
  - LASER scribing DMC (data matrix code) onto module frame

- **LASER surface processing:**
  - Removal of Oxides from Al cell housing
  - Surface preparation, e.g. before application of insulating tape or other coating

Source: https://cdn1.img.sputniknews.com/images/104492/37/1044923772.jpg

Cell geometry: one origin, three concepts



- Flexibility
- Weight
- Flat electrodes

- Energy density
- Maturity
- Thermal properties

- Safety
- Form factor
- Capacity

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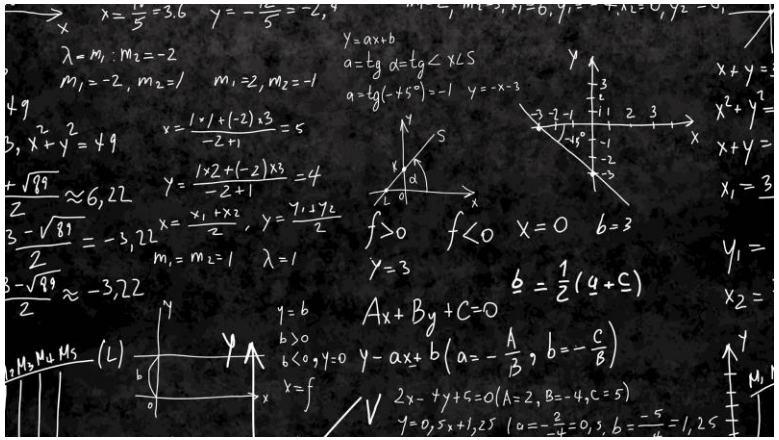
Electrical contacting of cells in EV battery (I)

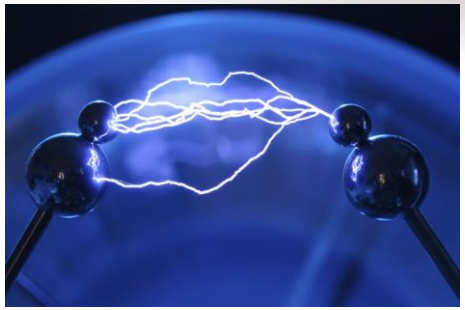


Specific requirements

1. Trend to HV-batteries for EVs (electrical vehicles): 400 - 800 V

– Li-Ion cell voltage: ca. 3.6 V → 1-200 cells in series (one bad joint impacts complete string!)

→ **need for very robust, reliable process**



2. Trend to high power EVs: up to 750 kW (1000 PS)

– with 375V HV battery → currents up to 2.000 A

– depending on cell type & battery capacity: 5 – 150 strings → 15 – 400 A in one string

→ **need for minimal contact resistance**

3. Trend to high capacity batteries: up to > 100 kWh

– depending on cell-type: several 100 to about 10.000 individual cells

– up to ca. 40.000 welding points per battery (e.g. wire/tab bonding)

→ **need for fast & cost efficient contacting process**

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Electrical contacting of cells in EV battery (II)

Specific requirements

4. Contacting of different materials

– for pouch cells, Cu and Al electrodes must be contacted

– different conductor materials must be joined

→ **need for process capable of intermetallic joints**

5. Heat impact reduces battery life

→ **process must minimize heat influx to cell**

6. Batteries are subject to mechanical stress:

– thermal cycles, vibrations, …

→ **process must create mechanically solid bond**

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Electrical contacting of cells in EV battery (III)

Specific requirements

7. Cost

– investment cost (purchase cost, write-off period, overall system cost, …)

– operational cost (maintenance, consumables, energy)

→ **need for competitive, cost efficient process equipment**

8. Safety

→ **process equipment must be safe to use**

9. Flexibility

– evolution of welding process details

– varying material combinations & joint topologies

→ **process parameters must be easily adjustable**

10. Availability

– minimized maintenance & repair needs

– maximized duty cycled

→ **process equipment must ensure high, reliable availability**

Typical welding processes

- **Resistance welding (gap welding, projection welding)**
  - **+:** established, cheap technology;
  - **-:** Accessibility; surface requirements; contact area; heat influx; limited material combinations;
- **Ultrasonic welding**
  - **+:** Small heat impact; lower surface requirements;
  - **-:** Sensitive to surface quality; small contact area; limited material combinations; cycle times;
- **Friction Welding (liner, rotational, FSW)**
  - **+:** Material combinations possible; good contacting; not sensitive to surface properties;
  - **-:** Forces; cycle times;
- **EMP Welding (electro-magnetic pulse welding)**
  - **+:** Larger contact areas;
  - **-:** Forces, process control;
- **LASER**
  - **+:** Fast (using scanning technology, no need for physical position); flexible; material combinations;
  - **-:** Cost; safety;
- **Other technologies (Clamping, screwing, gluing, …)**
  - **+:** Avoiding heat impact; potentially fast; benefits for recycling;
  - **-:** Joint quality / robustness;

Tactile versus scanner based bonding

Tactile welding technologies
(e.g. wire bonding, resistance / gap welding, etc.)

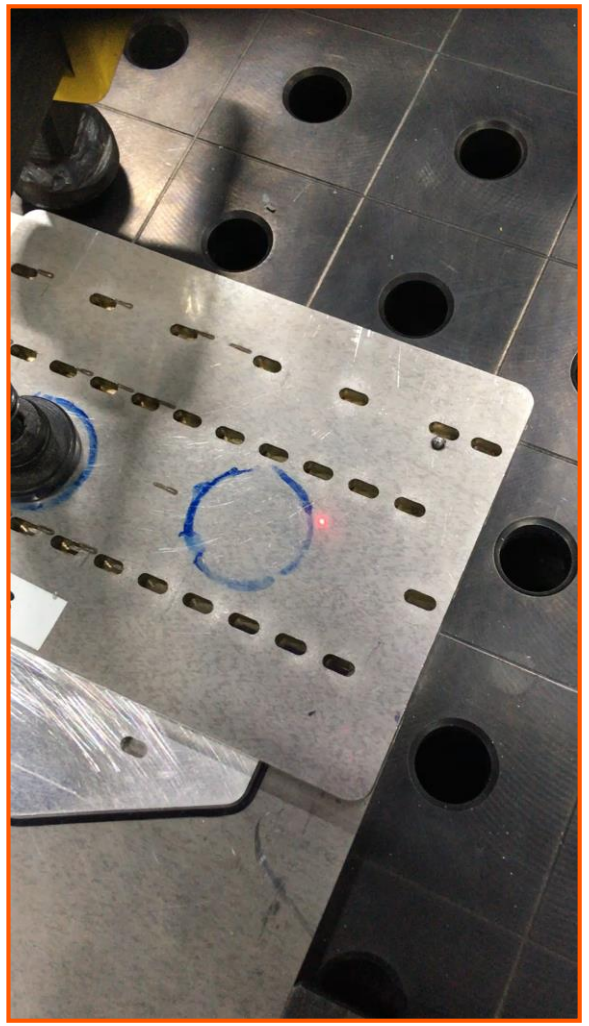
+ well established, robust, "cheap"

- slow, spacious, prone to wear

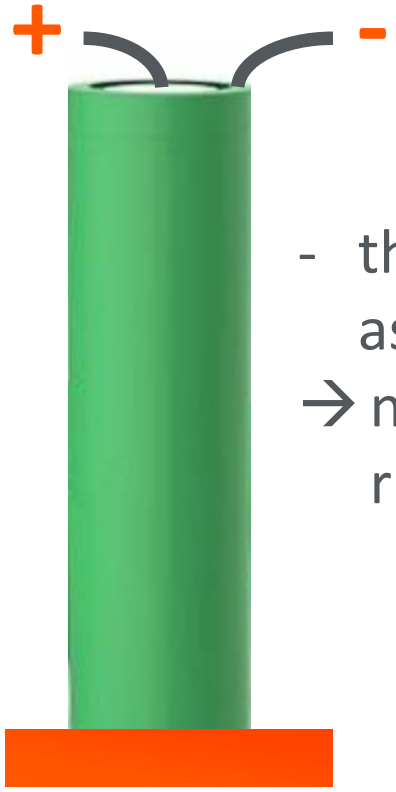
Scanner based welding technologies
(e.g. laser, electron beam, …)

+ very fast, scalable contact area, optional "on the fly" process, minimal maintenance

- demanding fixturing, more complex,



Contacting cylindrical cells



- cell size / capacity
  → huge number of welds

- thermal contacting, assembly process
  → negative contact on top rim

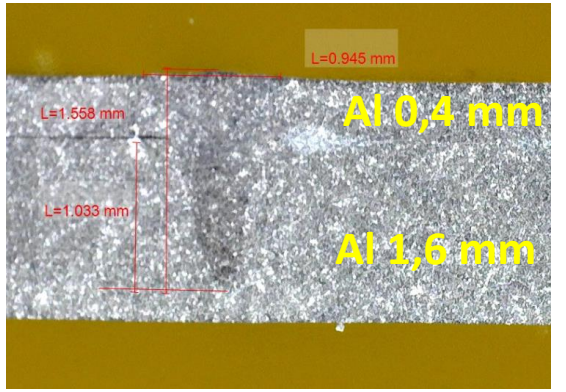
The ideal candidate for laser welding ?

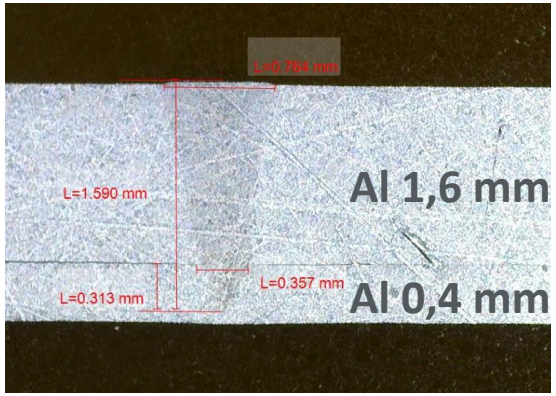
Unfortunately …..

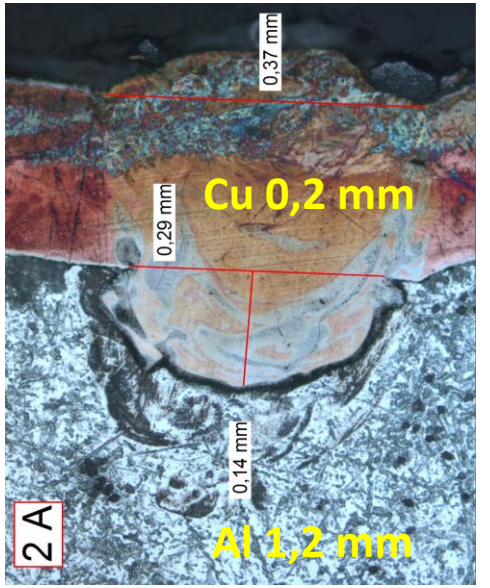
Challenging special applications: electrode contacting for pouch cells

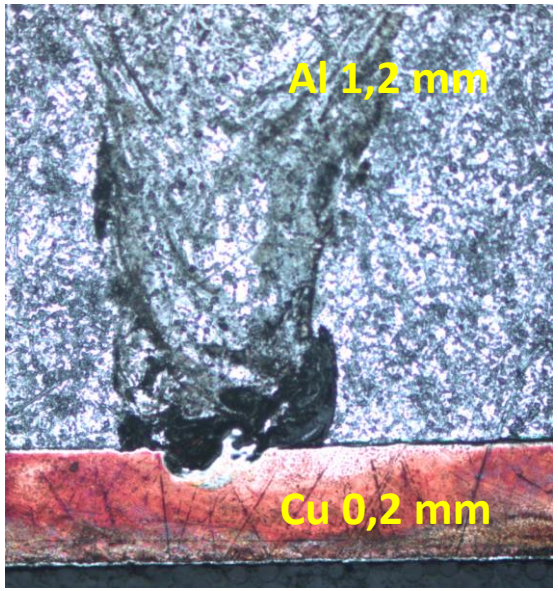
Success factors:

- Laser equipment / selection
- Process expertise / implementation
- Fixtures / tooling
- Product design









Specific challenge:

- Contacting of thin Al & Cu electrodes ….
- … to each other
- … and/or to thick current collectors
- … with minimal space consumption
- … and high reliability

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Conclusion

- Mass production challenges (“6 sigma”):
  - Tolerances (dimensions, positioning, thickness, surface properties, …)
  - Technical availability (wear parts, process drifts, ...)
  - Robustness (maintenance & calibration needs)

require ***team work***

Process & Concept (→ research / academia)

x **Tool & Fixture Design** (→ machine builder / integrator)

x **Product Design** (→ cell / battery producer)

= **Result**

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Thank you !
Questions ?

Thank you !

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