



Laser Technology in E-Mobility Applications

New Opportunities and Challenges

EPIC Online Technology Meeting

Industrial Laser Processes for Automotive and Electro Mobility | October 21st 2024

Dr. Andreas Heider, Dr. Reiner Ramsayer

Corporate Research, Robert Bosch GmbH, Renningen

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Agenda

- **Sustainable Mobility**
Global Demand, Products and Technologies for a Sustainable Mobility
- **Laser Technology in E-Mobility Applications**
 - Contribution to a Sustainable Mobility
 - Products, Requirements and Challenges
- **Status, Outlook and Summary**

01

Sustainable Mobility

*Global Demand, Products and
Technologies for a Sustainable Mobility*

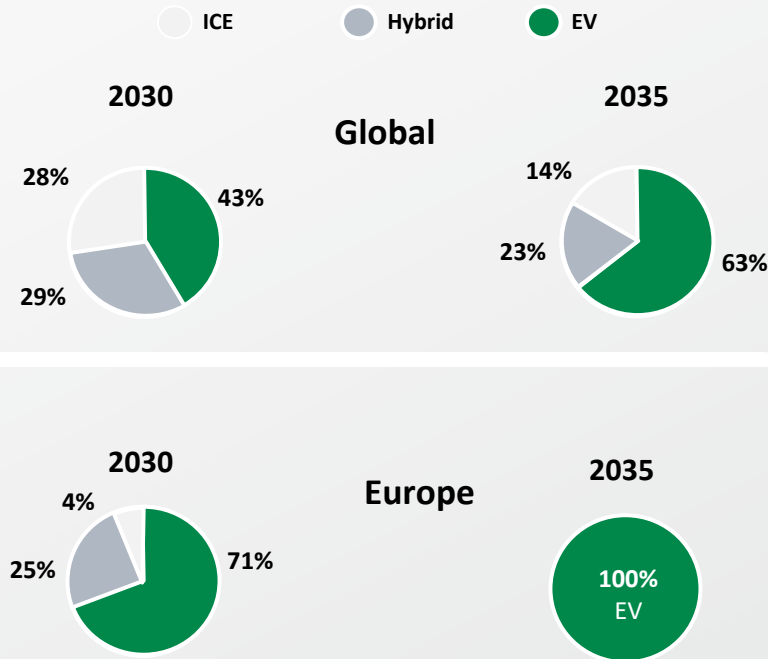
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Global Demand for Sustainable Mobility on the Rise

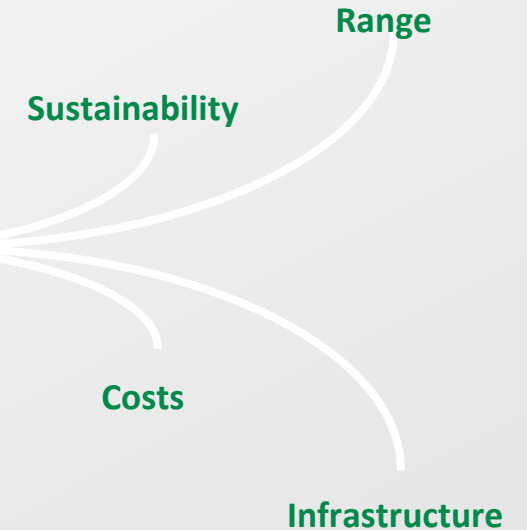
Trends and drivers for electric vehicles



New vehicle sales by powertrain type:*



Solutions from Bosch



800 million Euro invested in electromobility in 2022

Over 5 million vehicles electrified with Bosch Powertrain components

Worldwide CO₂ neutral since 2020 (scope1&2)

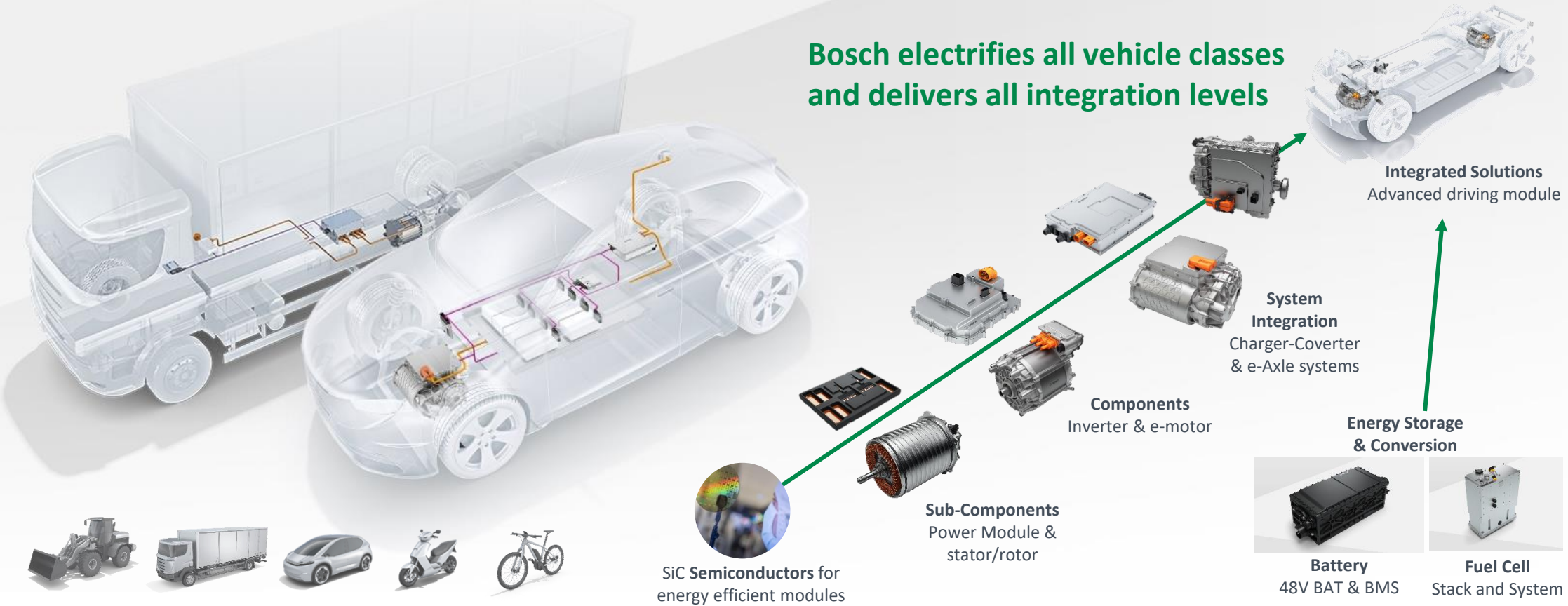
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Product and Technologies for Sustainable Mobility

From passenger cars to commercial vehicles

From silicon carbide chips to drive systems

Bosch electrifies all vehicle classes and delivers all integration levels



02

Laser Material Processing

*Key Technology for todays
and future E-Mobility Products*

Overview and R&D Demands

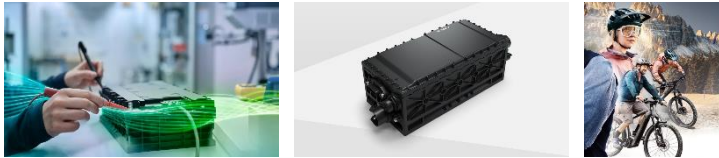
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Contribution to a Sustainable Mobility

Products for Sustainable Mobility and Laser Technology in Production

Products

▪ Batteries



▪ Fuel Cell



▪ Power Electronics



▪ E-Drives



Laser for Production



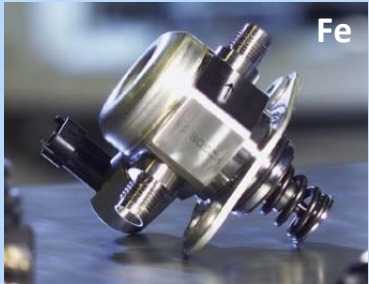
- Enabling Technology for new product features and innovative product designs (e.g. lightweight construction, increase of integration density, use of high-performance materials,...)
- High productive technology
- Highly flexible and automatable
- Low energy consumption (high efficiency)
- ... and many other advantages ...

Overall: Laser is a cost-effective process with a high unique selling proposition and essential for e-Mobility products

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Changes in Products, Requirements, Materials and Processes

Conventional Power Train *(with an Internal Combustion Engine)*



High-pressure pump



Injection valve HDEV4



Injection valve EV14

Electrified Power Train



Fuel Cell



Power Electronics



Electric Motor

Requirements on Welds (typically)

Mechanics
(high loaded component, distortion, hard to weld materials,...)

- $300 \mu m \leq t \leq 1 \text{ mm}$
- $150 \mu m \leq s \leq 1 \text{ mm}$
- $1 \leq a \leq 20$
- $< 20 \text{ €}$
- $10 \text{ mm} \leq l \leq 100 \text{ mm}$

- Thickness of parts
- Welding depth
- Welds per part
- Costs per part
- Weld length per part

Electrics
(contact resistance, inductance, high voltage, conductive materials,...)

- $10 \mu m \leq t \leq 5 \text{ mm}$
- $50 \mu m \leq s \leq 10 \text{ mm}$
- $1 \leq a \leq 600$
- $>> 20 \text{ €}$
- $100 \text{ mm} \leq l \leq 2 \text{ km}$

New materials / products and strong increase in complexity require new strategies, new system technology and a robust process for welding

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E-Mobility Products with Laser Inside

Requirements & Challenges: Laser welding processes in...

Fuel Cell BiPolarPlates



Steel

Thin steel sheets

Long and narrow weld seams

Fast welding speeds

High tightness requirements

Overlap joint and clamping

Weld distortion

...

Power Electronics



Copper

Many connection points

Short weld seams

Spatters and dust

From thin to thick copper parts

Accessibility

Sensitive components

...

E-Drives



Copper

Many connection points

Short weld seams

Spatters and dust

Copper bar welding (Hairpins)

Process chains & geometry influences

Electrical & mechanical requirements

...

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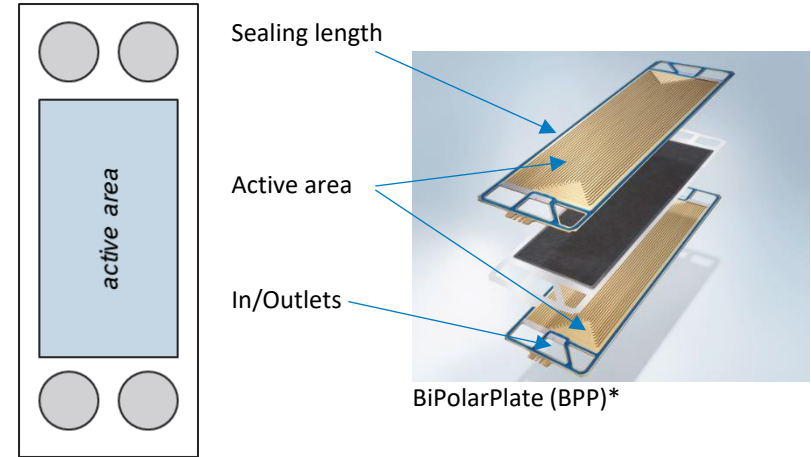
“Fuel Cell BiPolarPlates” – Welding Steel @High Speed

Rough Estimation*



Fuel cell stack

- ▶ Dimension ~ 150x250 mm² (375cm²)
- ▶ Sealing length ~ 1,2 m (800mm + 400mm)
- ▶ Active area ~ 250 cm² (excl. connections,...)
- ▶ Output Power per BPP (1...1,5 W/cm²) ~ **320 W/BPP**



For a 100 kW fuel cell stack

- ▶ ~ 320 BPP needed
- ▶ ~ **384 m welding (reliable and tight over lifetime) per stack**



For 1 Mio. cars per year

- ▶ ~ 1,4% of all cars are fuel cell
- ▶ ~ 320 Mio. BPP per year
- ▶ ~ **384.000 km weld per year**



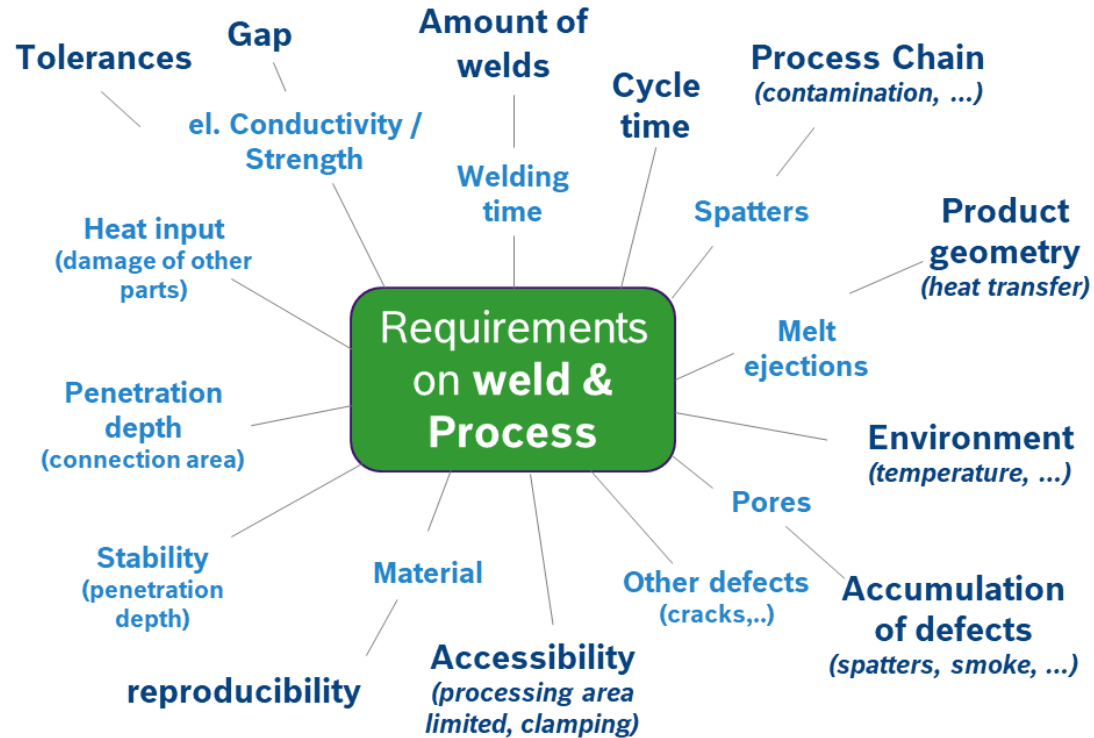
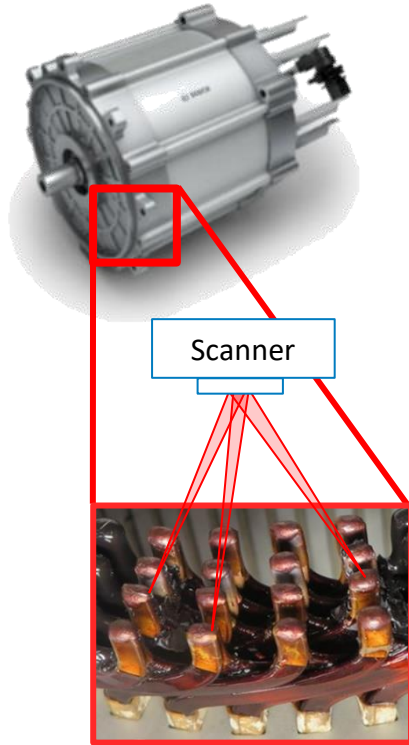
Distance Earth to Moon



* Based on data from literature: <https://www.zbt.de>; <https://fuelcellsworks.com>; <https://www.energy.gov>; www.bosch.com; <https://www.greencarcongress.com>; <https://www.zmescience.com>; <http://www.daimler.com>

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“Hairpin Welding” – Copper Laser Welding for E-Drives



For capable serial production: Developing “only the welding process” is not sufficient
Relevant influencing effects have to be understood → Deep understanding

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“Hairpin Welding” – Copper Laser Welding for E-Drives

Transfer from Lab to Production

In the Lab
(simplified
samples)



Hundreds
welds/part

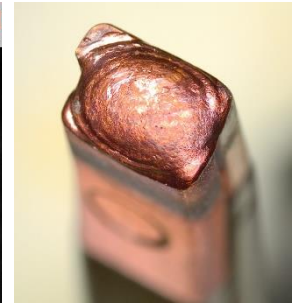
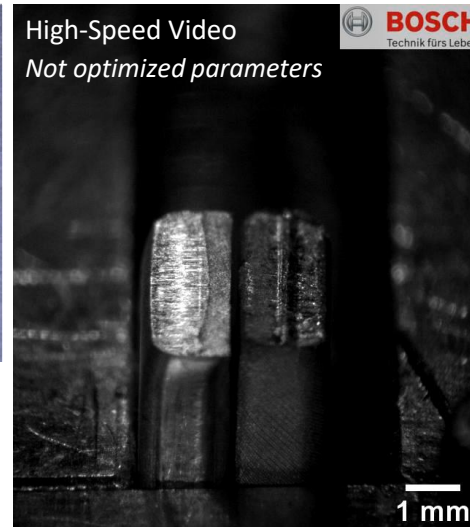
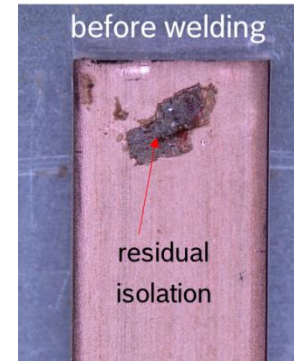


In Production
(Process chain,
batches,
tolerances,
suppliers,...)

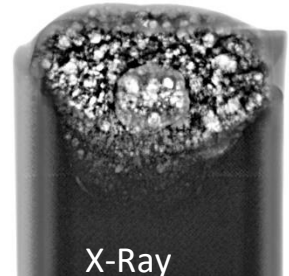
Challenges

- ▶ High number of joining processes in one product
- ▶ High requirements on process stability
- ▶ Determine root-cause of very rare, sporadic defects with limited experiments
- ▶ Transfer Lab-process to high volume production process

Example: Influence of Process Chain Effects



Weld defects **not** visible
after welding!



Sporadic contaminations on the parts can lead to
„not visible“ defects

“Stable“ welding process in the Lab is not sufficient

We have to work out a deep understanding of influencing factors and process chain effects

04

Status, Outlook and Summary

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Summary



Global Demand for **Sustainable Mobility** on the rise.

Bosch offers **innovative products** and **technologies** to make sustainable mobility a reality.

Bosch drives sustainability on all levels (reduce CO2 footprint of products and production chains, enhance efficiency,...) **by innovations**



Bosch electrifies all vehicle classes and delivers all integration levels for our customers **worldwide**

Laser Technology is a key for today's and future electrified products.

There will be no **fuel cell**, no **battery**, no **power electronic** & no **e-drive** without **laser technology**.



Fundamental **process understanding** in combination with a **deep technological understanding** (product & manufacturing) is basis for a stable, robust and cost-effective production

Transfer of processes from lab to industrial applications is a **challenging** task



There is still a **great demand** for **novel laser technologies** to **enhance productivity** and **costs**.

Innovative solutions in process development and product design will come hand-in-hand to **master future challenges**.

Laser Technology has great potential in all future mobility products if we can transfer the technology USPs in real product USPs

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Laser Technology in E-Mobility Applications
New Opportunities and Challenges

Thank You!

Dr. Reiner Ramsayer

Robert Bosch GmbH

Corporate Research, Renningen

