PRECITEC

Success stories in laser welding – the perfect combination of sensor technology with processing optics

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R&D Projects
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EPIC
European Photonics Industry Consortium

EPIC Online Technology Meeting on Laser Beam Welding

NUMBERS & FACTS

PRECITEC IS AN INTERNATIONAL OPERATING COMPANY GROUP

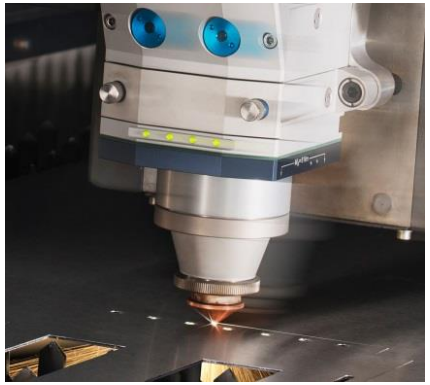
- Headquarters **Gaggenau** and **Neu-Isenburg**, Germany
- Employees **610** worldwide
  315 in Gaggenau
  150 in China
  95 in Neu-Isenburg
- Turnover 2018 **160 million €**
- Growth **10-20%** per year
- **Innovation and market leader** in the core areas of laser material processing and optical measurement
- Independent **family-owned enterprise**
- **High investment** in Research & Development

Gaggenau

Neu-Isenburg

FIVE DIVISIONS

LASER CUTTING

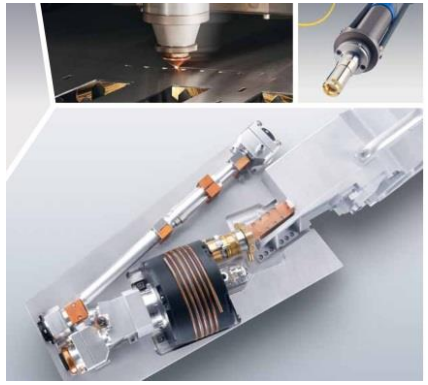


- Processing heads for laser cutting on flatbed, tube and robot machines
- Processing heads for fine, bevel and high speed cutting
- Process monitoring

JOINING TECHNOLOGY

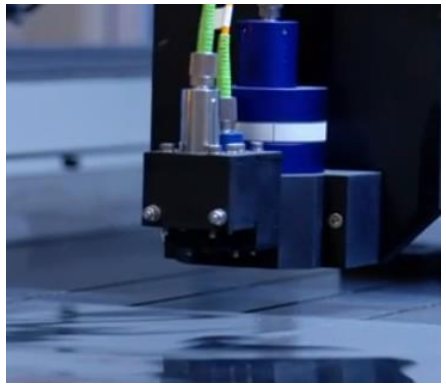
- Processing heads for laser welding and laser cladding
- Monitoring systems for pre, in and post processing

ALL-IN-LIGHT



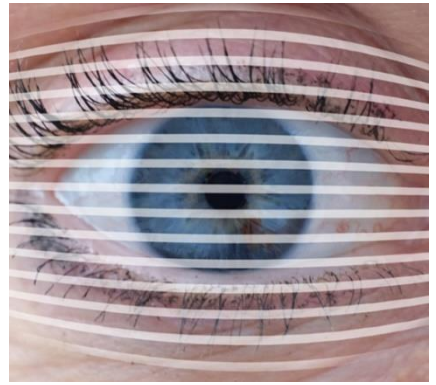
- Complete optical solution from one supplier
- Including laser beam source, cutting head and beam guidance

MEASUREMENT



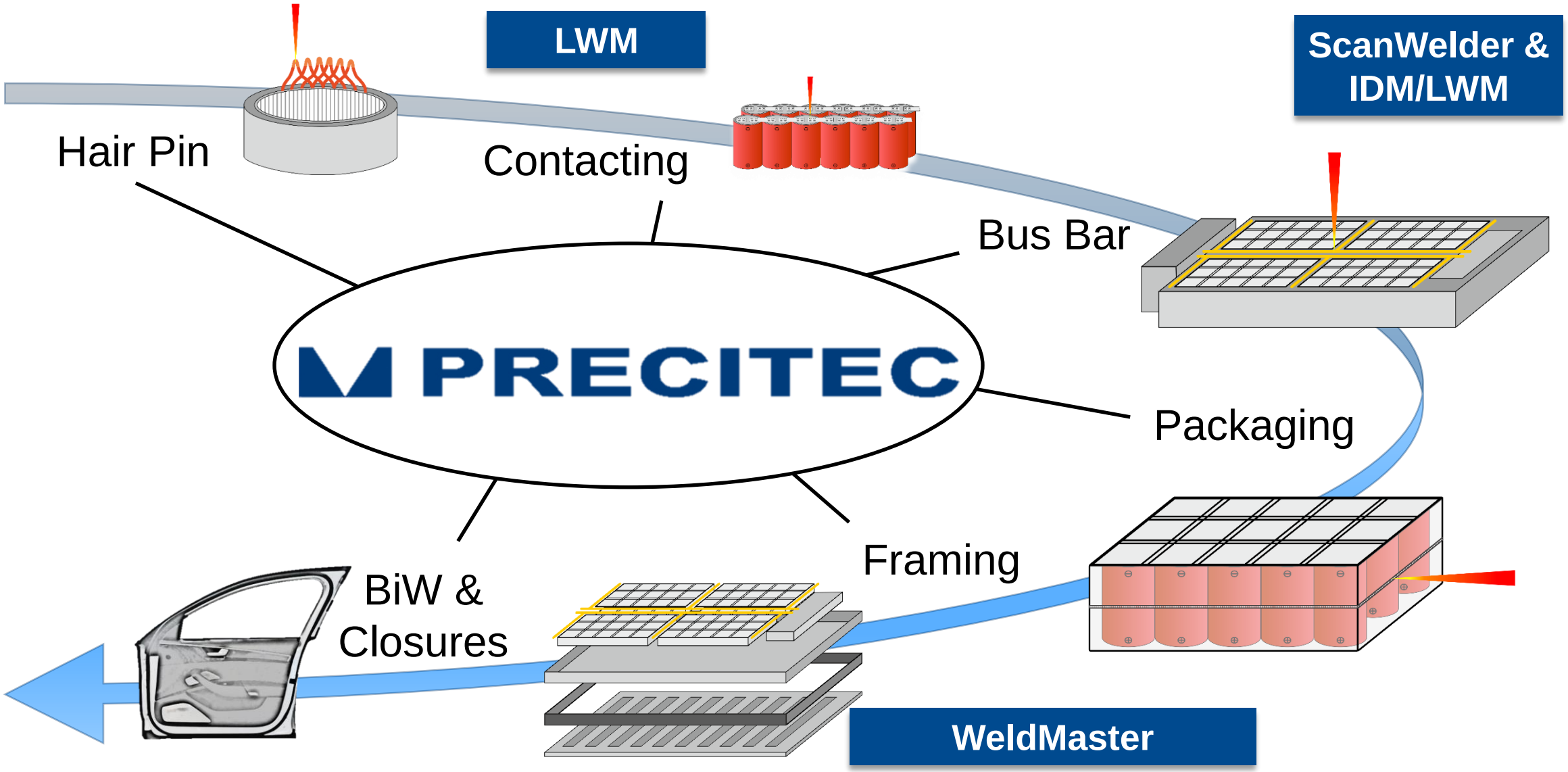
- Chromatic confocal sensors
- Interferometric sensors
- 2D Vision Camera
- Point, Line and Multipoint and Scanning

MEDICAL TECHNOLOGY



- Control for corneal and refractive surgery
- Eye tracking systems

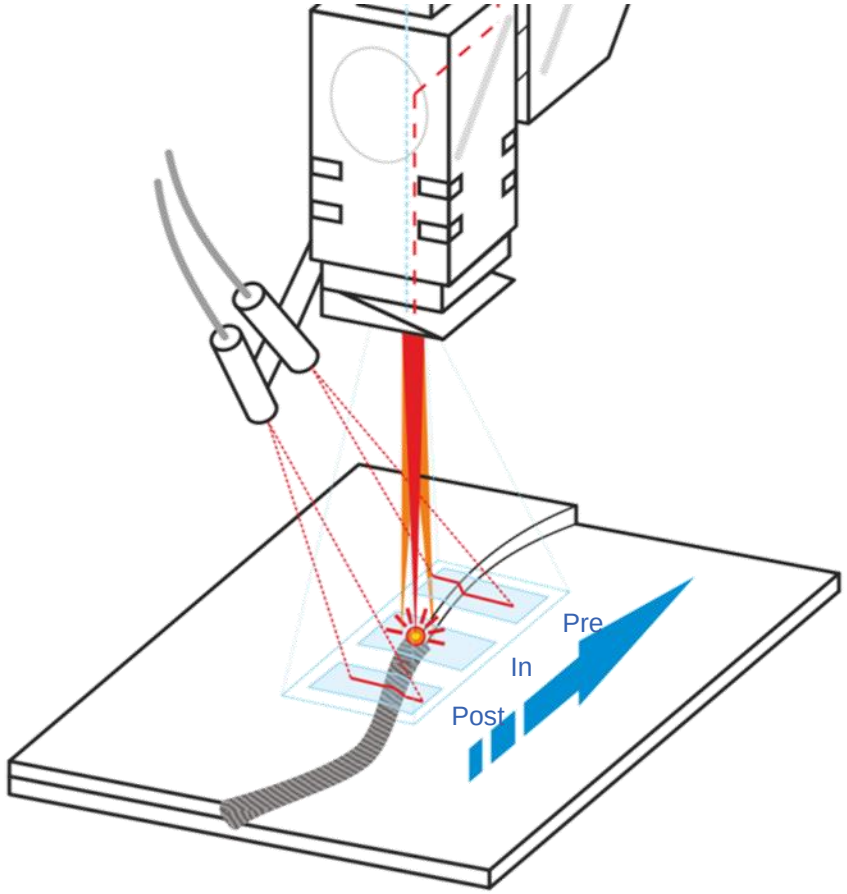
PROCESSING TOOLS AND MONITORING DEVICES



PROCESS MONITORING

Introduction

- Pre-Process → **WeldMaster**
  - Joint position, gap width, mismatch
- In-Process → **IDM, LWM**
  - Welding depth, seam position
  - Holes, pores, spatters
- Post-Process → **WeldMaster**
  - 3D measuring of seam profile
  - 2D texture analysis for seam width
  - Insufficient fill, undercut notches
  - Cracks, holes, pores, seam position



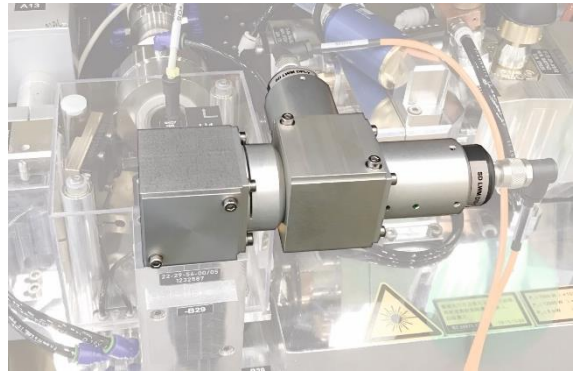
LASER WELDING MONITOR (LWM)

FLEXIBILITY

Sensors

- Easy retrofit into existing welding systems
- Suitable for welding processes with a duration of milliseconds up to several minutes
- Suitable for various welding processes (deep penetration welding, heat conduction welding, pulsed-, cw-mode)
- Power and time-sharing possible
- Can be mounted inside laser sources or on any kind of processing head (fixed optics, scanner, …) with camera / process monitoring flange
- Flexible sensor setup depending on your application

Installation on 2D scanner

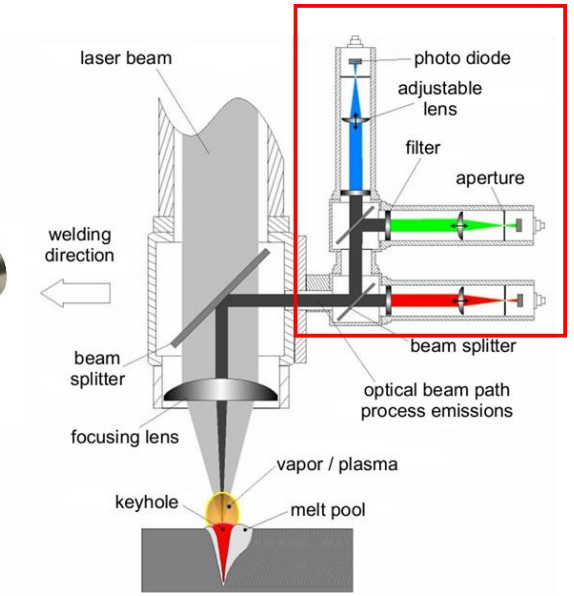


Installation inside the laser source

Modular sensors

Compact sensor

LWM 4.0 Sensor

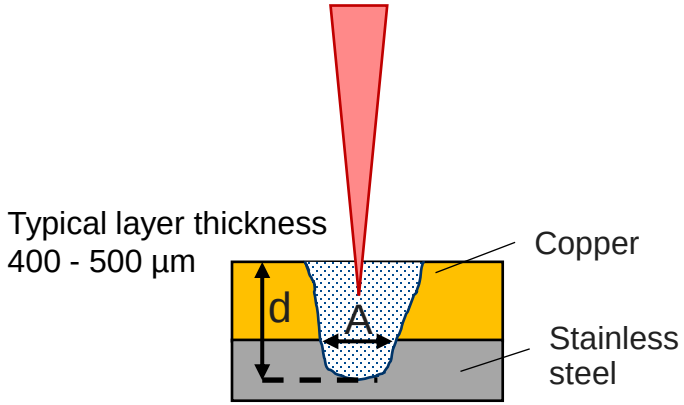


Modular sensors

LWM APPLICATION EXAMPLES – BATTERY CONTACT WELDING

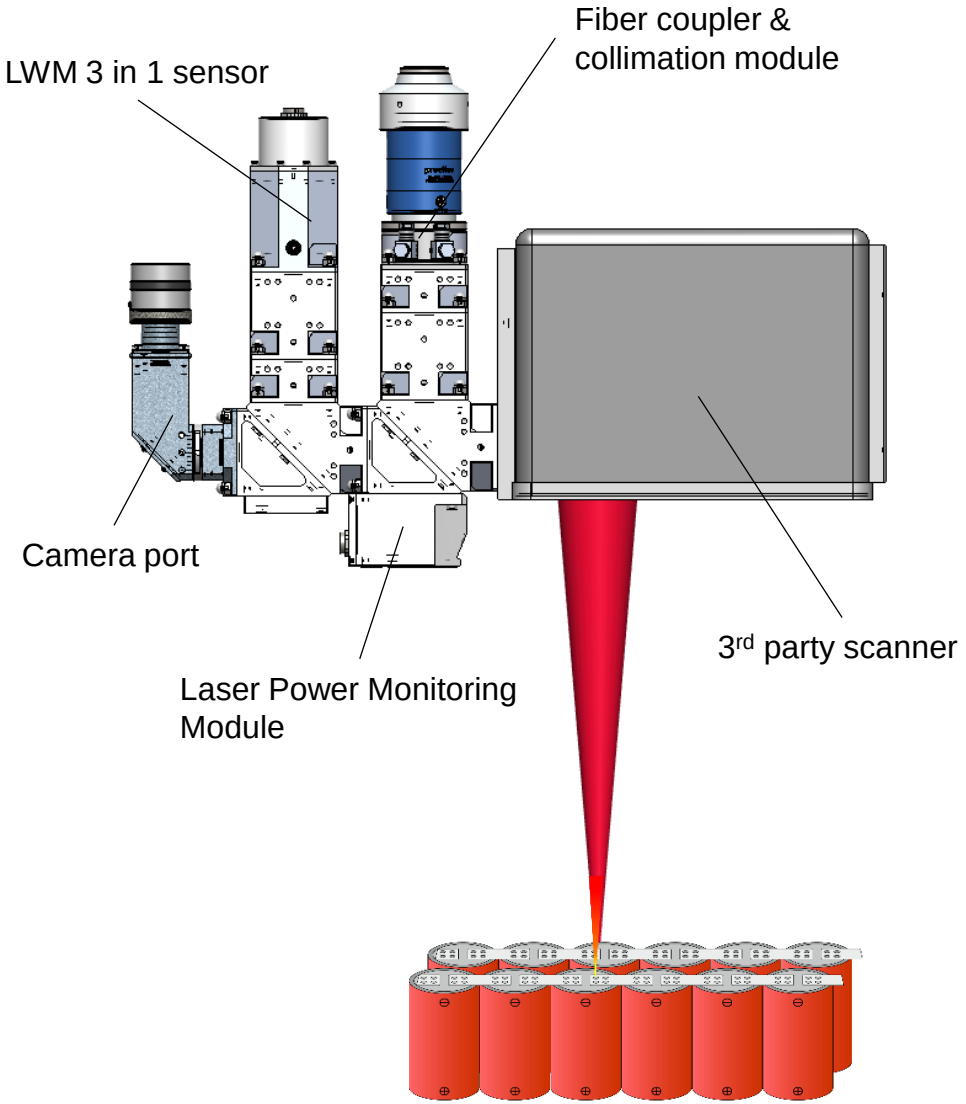
Application

- Battery contact welding
- In production since 2018
- Pilot customer CONFIDENTIAL



Challenges

- Contacting welding of materials such as:
  - Copper to aluminum
  - Copper to stainless steel
  - Aluminum to copper
- Ensuring maximum possible connection width (A) with minimum penetration depth (d)
- Risk of penetrating through battery top layer



LWM APPLICATION EXAMPLES – BATTERY CONTACT WELDING

Application

- Battery contact welding
- In production since 2018
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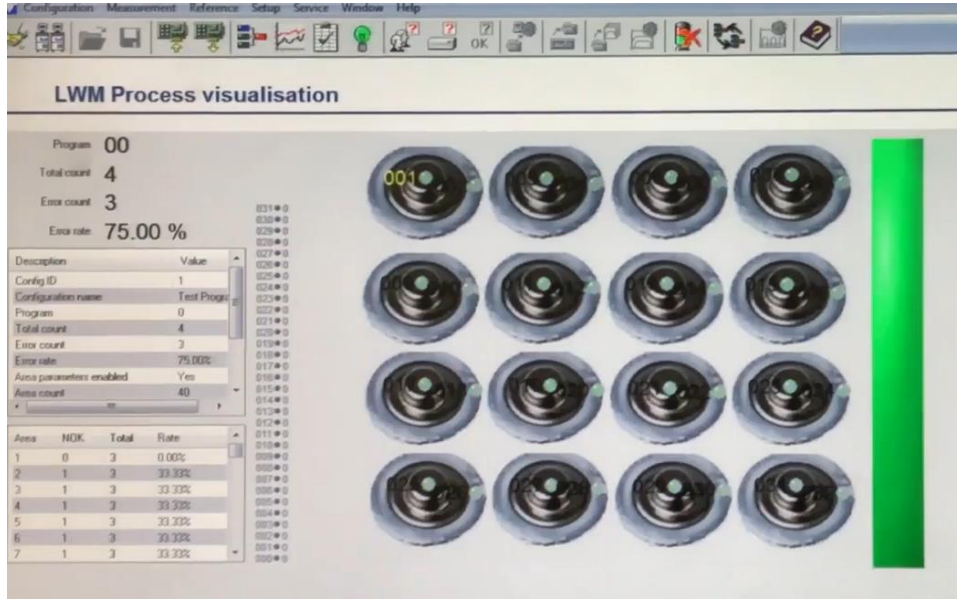
LWM

- Scanner based laser welding processes
  - numerous seams
  - very short laser-off times
- LWM is able to handle…
- the acquisition of several signals
- numerous weld seams

…within one cycle.

- All cells and sensor signals are independently analyzed



LWM process visualisation battery cells

LWM APPLICATION EXAMPLES – BUS BAR WELDING

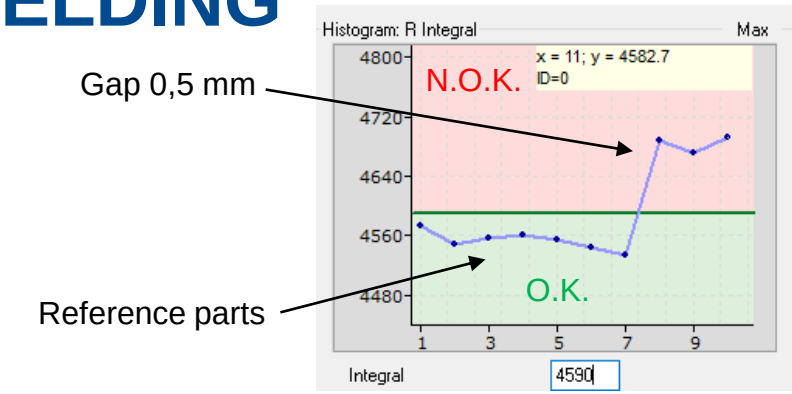
Application

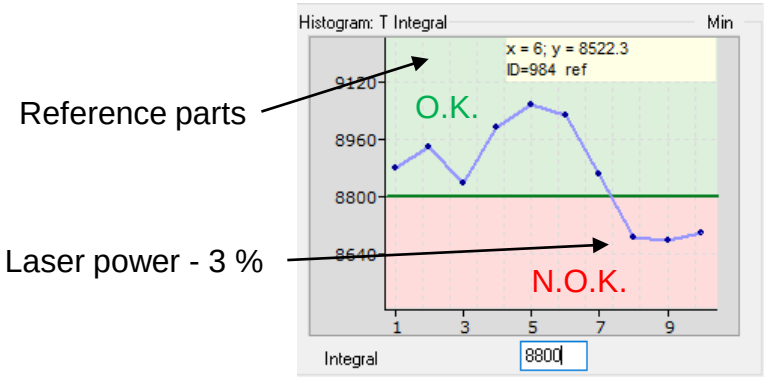
- Bus bar welding (Al-Al)
- Material thickness 1,5 mm – 3 mm
- Scanlab Intelliweld with attached LWM sensors
  - 3 sensors
    - Temperature
    - Back reflection
    - Plume

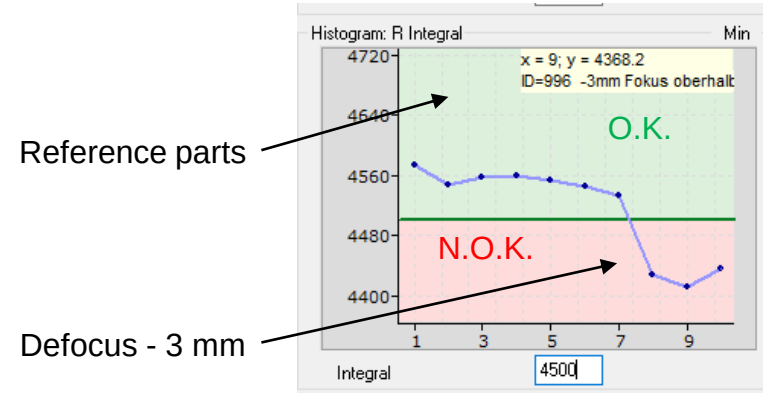
LWM Process Monitoring

- Reliable Detection of
  - Gap
  - Defocused working position
  - Power loss

Precitec LWM system attached to Intelliweld







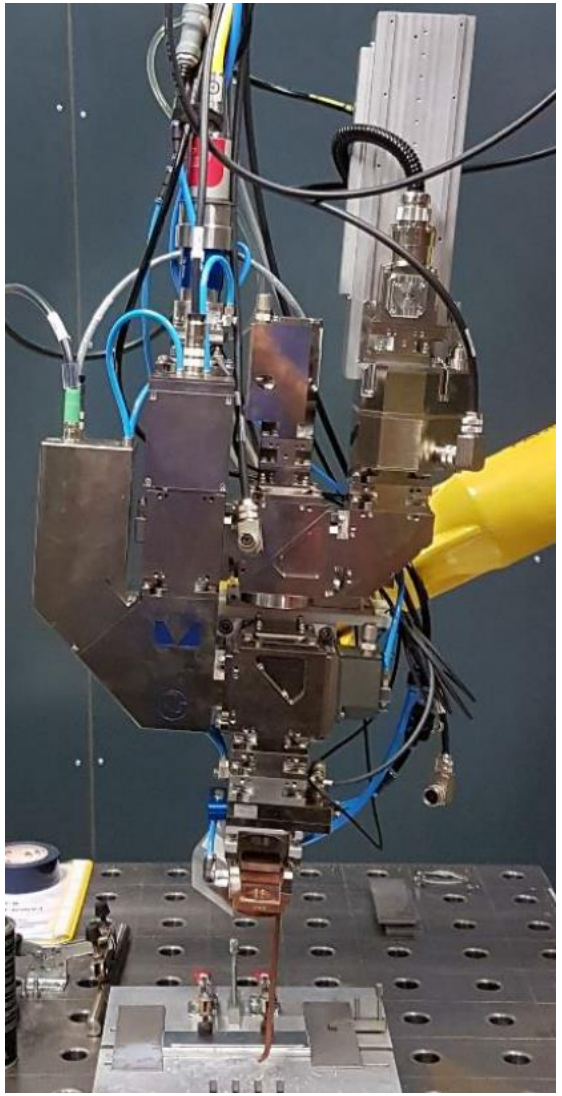
LWM APPLICATION EXAMPLES – BUS BAR WELDING (CU-CU)

Application

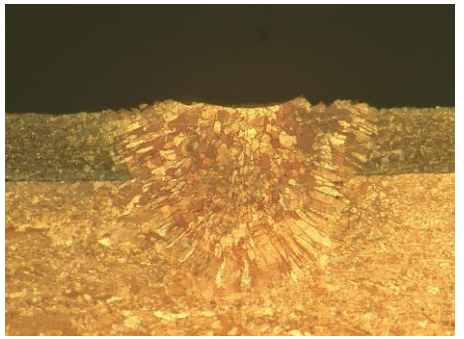
- Bus bar welding (Cu-Cu)
- Material thickness 0,4 mm – 3 mm
- Precitec ScanWelder with attached LWM sensors
  - 3 sensors
    - Temperature
    - Back reflection
    - Plume

LWM Process Monitoring

- Reliable Detection of
  - Gap / Pollution
  - Power loss
  - Incoupling problems into copper material



Precitec ScanWelder with attached LWM system



Cross section reference part:
penetration depth app. 1,5 mm

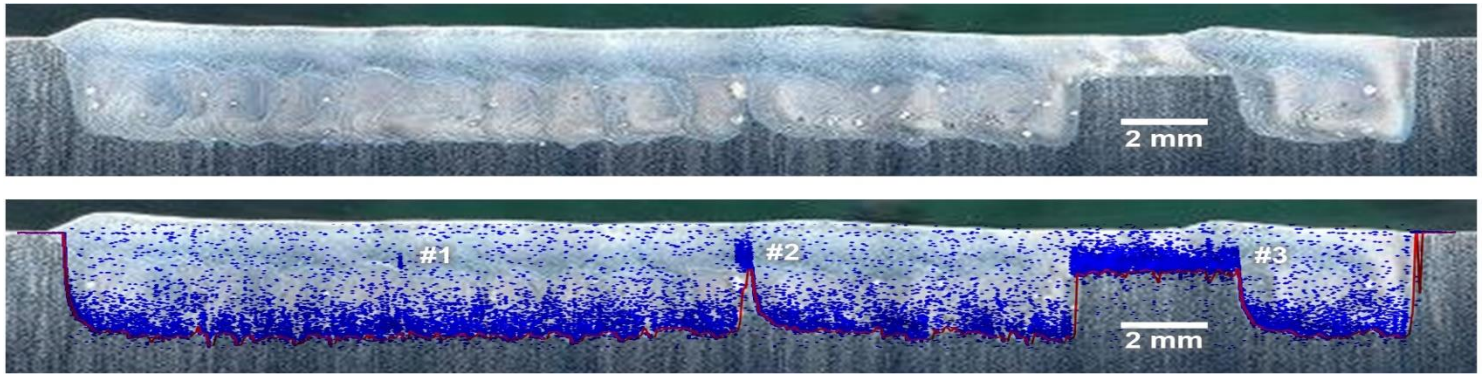
Top view reference parts

IN-PROCESS DEPTH METER (IDM) – OCT TECHNOLOGY

INTRODUCTION

System overview

- Penetration depth measurement up to 10mm
- Keyhole laser welding required
- In-situ data acquisition
- Works coaxially
- Measurement immune to process emissions



Application example: IDM signal extraction for a weld in stainless steel and three intentional interruptions of the laser power (#1: 1 ms; #2: 10 ms; #3: 100 ms)

Applications

- Powertrain
- Seat manufacturing
- E-mobility
- Body in-white
- Steel ☑ Aluminium ☑ Copper ☑

Automotive application examples

IDM APPLICATION EXAMPLE – BUS BAR WELDING

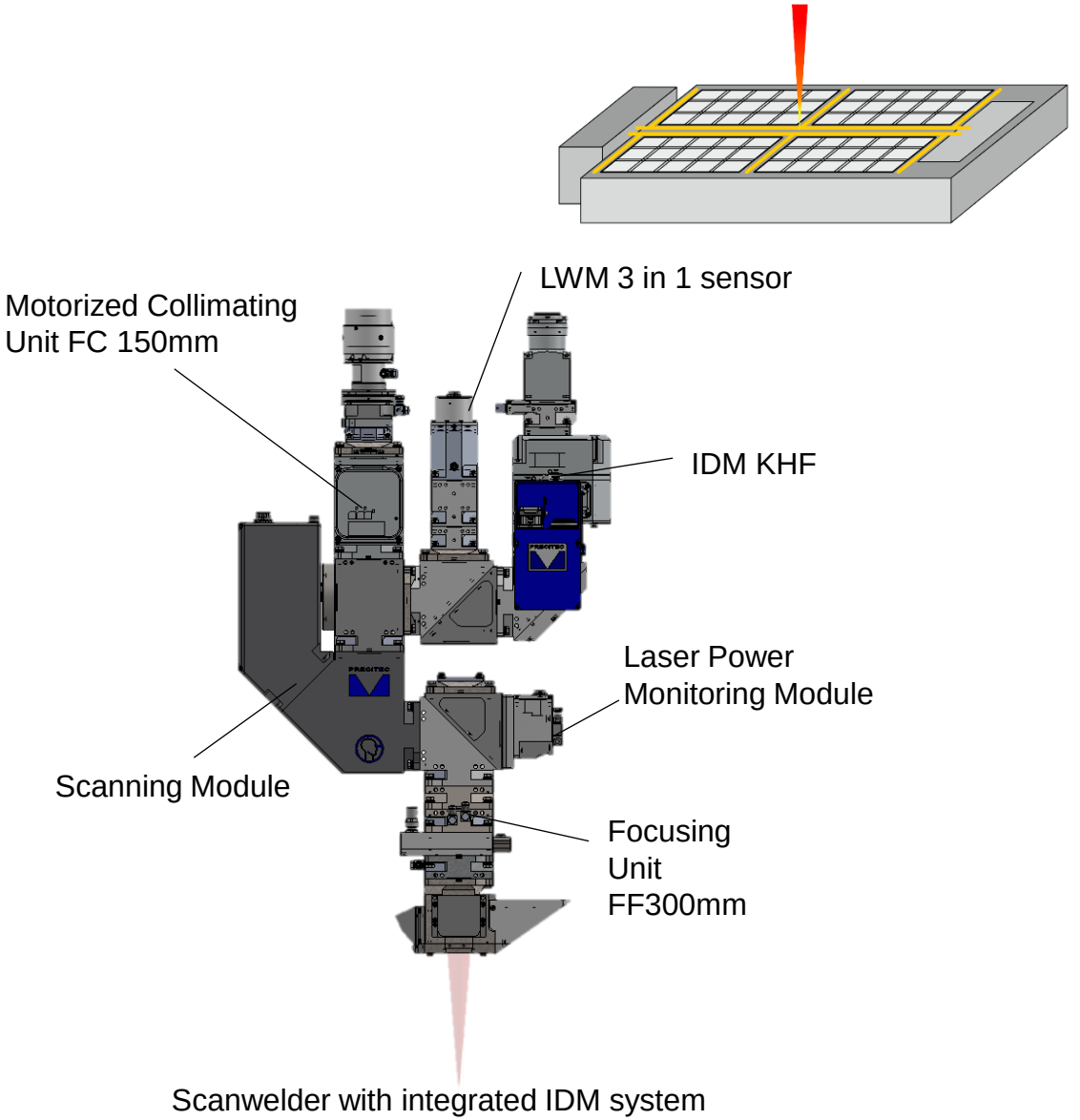
Application

- Bus bar welding (Al-Al, Cu-Cu)
- Pilot customer:
- In production since:

CONFIDENTIAL

Challenges

- Large cross section with low porosity for optimum conductivity required
- High welding speeds required to achieve customer tact times
- Low spatter process to avoid contamination and damage of cells
- Battery packs can be charged up to 80% at this stage requiring a minimum thermal stress (low heat input)



Scanwelder with integrated IDM system

IDM APPLICATION EXAMPLE – BUS BAR WELDING

Application

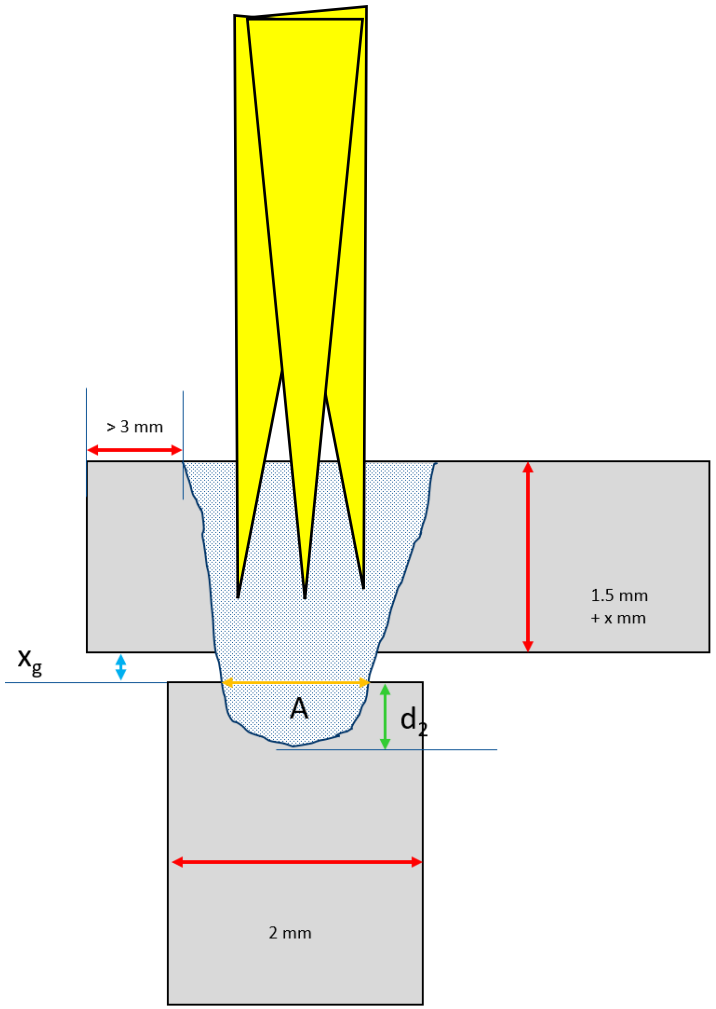
- Bus bar welding (Al-Al, Cu-Cu)
- Pilot customer:
- In production since:

Solution

- Laser beam remote welding utilizing:
  - small key whole size (0.3 mm)
  - beam oscillation
  - synchronized laser power modulation
- Process monitoring with real-time measurement of penetration depth
  - Laser weld process monitoring
  - Control of penetration

Scanwelder

IDM / LWM



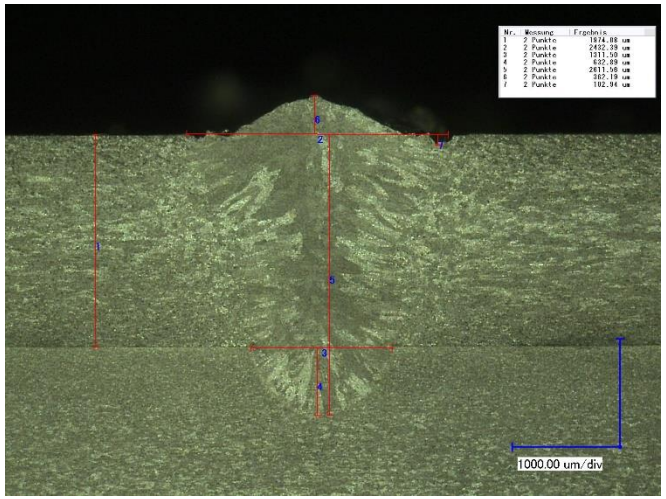
IDM APPLICATION EXAMPLE – BUS BAR WELDING

Application

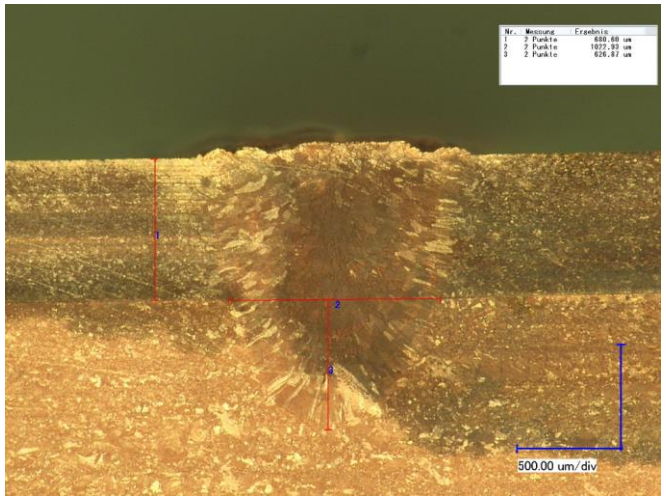
- End cap welding (Al-Al, Cu-Cu)
- Pilot customer:
- In production since:

Solution

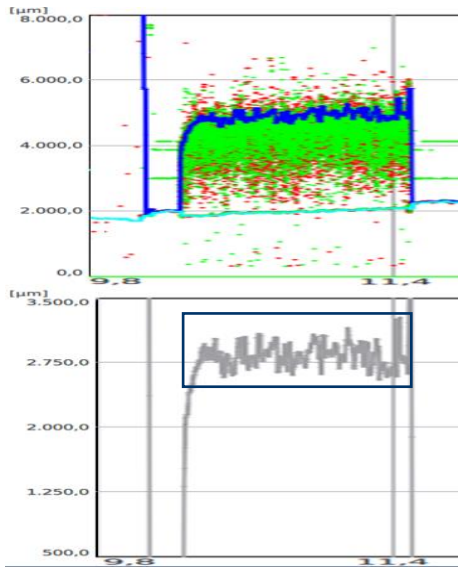
- Scanwelder ensures stable welding process without additional filler wire material
- IDM Keyholefinder ensures in-situ penetration depth measurement



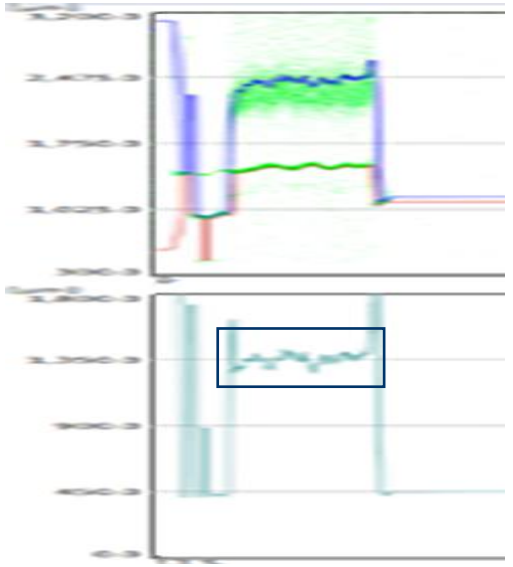
Al-Al: Penetration depth 2,61 mm



Cu-Cu: Penetration depth 1,31 mm



IDM measurement: 2,8 mm



IDM measurement: 1,35 mm

WELDMASTER

SYSTEMS SOLUTIONS

WeldMaster ScanTrack

- Seam tracking system with coaxial sensor, scanner unit and laser power control

WeldMaster Track

- Seam tracking system with coaxial and external sensor

WeldMaster Monitor

- Keyhole and melt pool position and geometry

WeldMaster Inspect

- Seam inspection during laser welding and laser brazing

Combination of functions

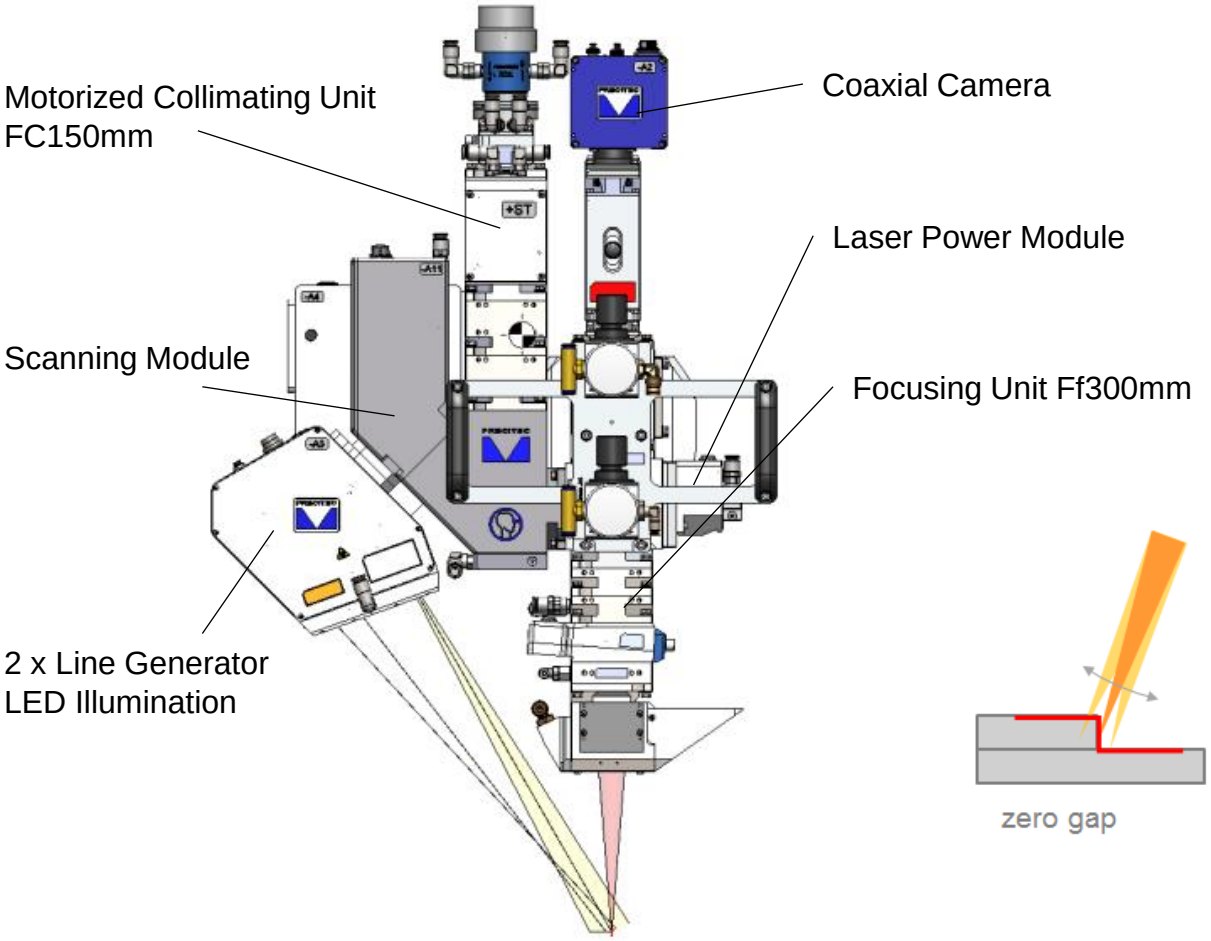
Seam Tracking

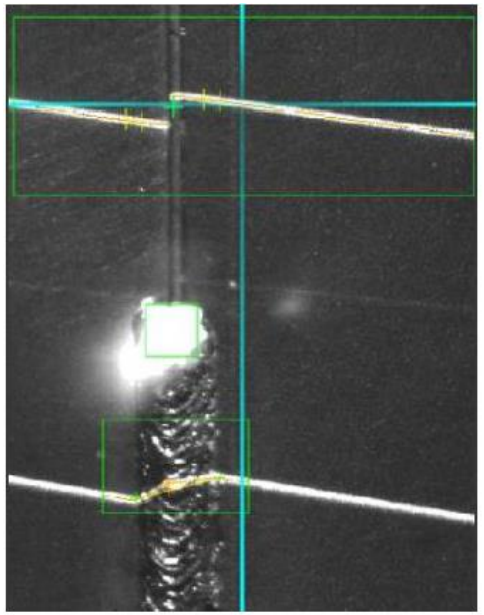
Keyhole Detection

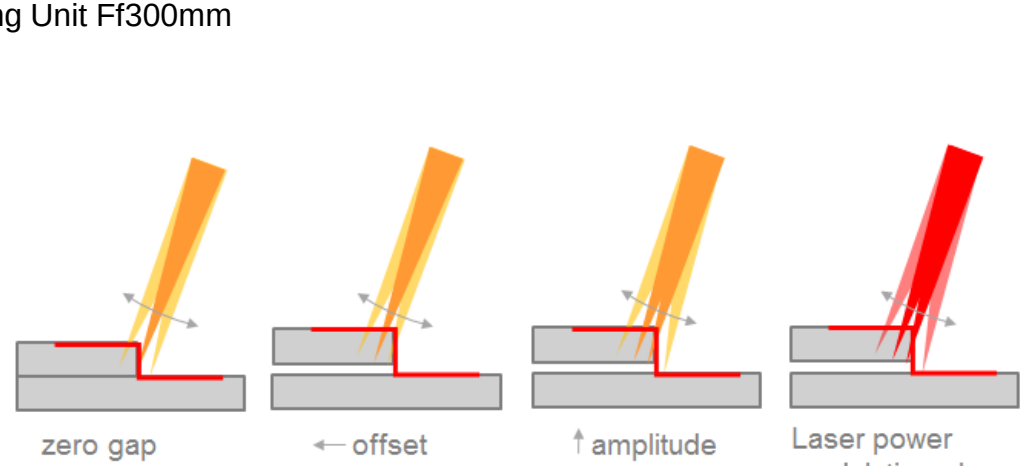
Weld Quality

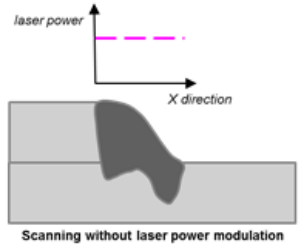
WELDMASTER SCANTRACK & INSPECT

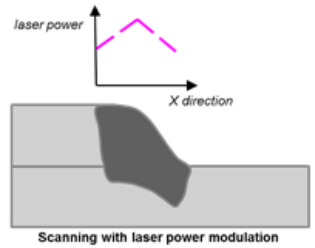
SYSTEM CONFIGURATION











WELDMASTER APPLICATION EXAMPLE – FRAMING

WELDMASTER SCANTRACK & INSPECT

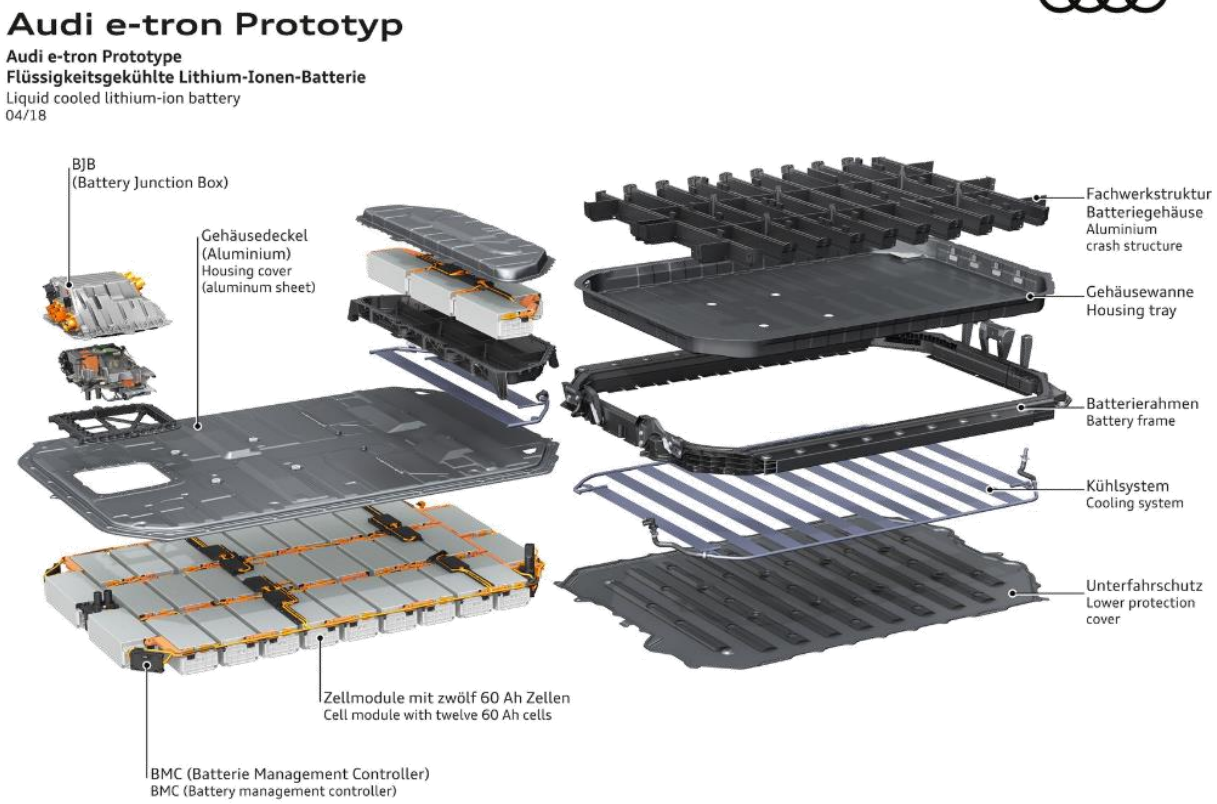
Application

- Welding of lower protection plate
- Production reliably running since 2017
- Exact placement of 10 reinforcement rails / 260 step seams
- High material thickness of the upper sheet
- Low failure rate of single seams
- Fillet weld good connection cross section

Challenges

- Crack and pore free welding of 5xxx / 6xxx series aluminum required
- Low heat input and controlled process to avoid overheating of already charged battery pack
- Placement of welding exactly in place
- Fillet weld with good connection cross section

Source: www.audi.de



WELDMASTER APPLICATION EXAMPLE – AUDI A8 DOORS

Source: www.audi.de

WELDMASTER SCANTRACK & INSPECT

Application

- Audi A8 door
- Production reliably running since 2014

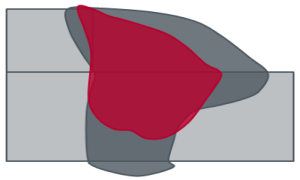
Challenges

- Increase use of aluminum for automotive body in white to extend range of electric vehicles
- Crack and pore free welding of 6xxx series aluminum required
- Traditional (tactile) laser welding process have major disadvantage
  - Slow processing speed (< 2.5 m/ min)
  - Relatively high heat input
  - Shielding gas and wire required

WELDMASTER APPLICATION EXAMPLE – AUDI A8 DOORS

CUSTOMER BENEFITS

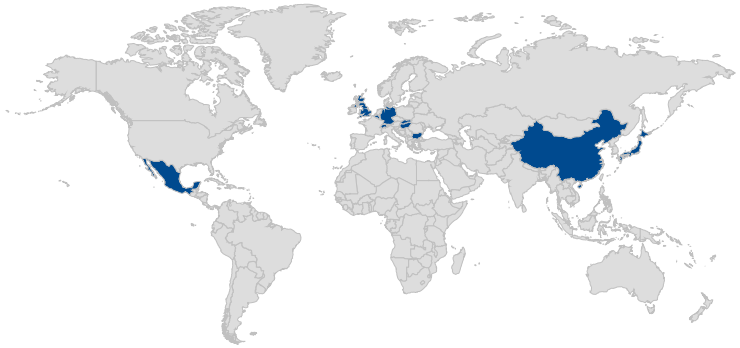
No Filler Wire, No Hot Cracks, Standard Aluminium



Reduction of heat input
~ 47 %

Source: Audi AG, EALA 2015, Dr. Jan-Philipp Weberpals

Industry Proven Solution



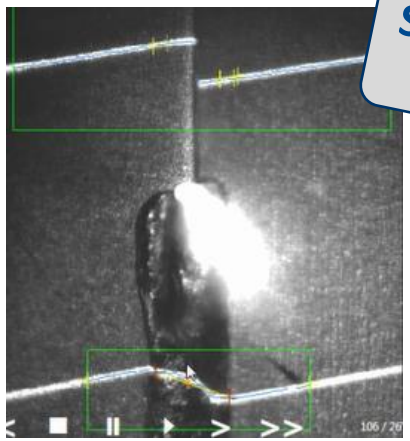
Cost Efficiency

- Reduction of investment costs ~ 26%
- Saving of running costs ~ 95%
- Time Saving ~ 53%

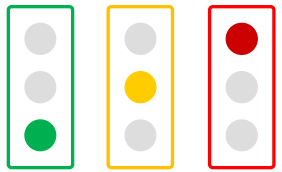
Source: Audi AG, EALA 2015,EALA 2016, Dr. Jan-Philipp Weberpals

Inline Quality Control

- No Additional Station for Quality Check



Systems for Customized Quality Control



PRECITEC

TAKE AWAY MESSSAGES

- **High diversity of laser concepts will induce application specific laser usage and will ask for flexible and application specific processing components**
- **Modular design is the turnkey solution to provide customer, machine and application specific solutions, not only with regards to processing heads**
- **Fully implemented sensor technology for Pre-, In- and Post Process monitoring/ control enables continuous compliance to the specific quality standards and meets Industry 4.0 requirements**
- **Precitec is a reliable and curious partner providing the required solutions at the end of the optical fiber for cutting, welding and additive manufacturing**

Thanks to EPIC for having me!
Any questions?

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