LASERFERTIGUNG IN XXL

MATERIALS VALLEY WORKSHOP

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Hanau, 26. Februar 2015

materials valley

LZH
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MOTIVATION

Sources: wikimedia.org, wordpress.com, sueddeutsche.de, Graebener Maschinentechnik, Meyerwerft

LZH IN THE SCIENCE PARK MARIENWERDER / HANNOVER

Founded in 1986

Staff / Turn over

- ~ 200 Full time staff
- ~ 100 Students
- ~ 16 Mill. EUR (2014)

Basic data

- Total area ~ 10,000 m²
- Shop floor ~ 1,400 m²
- Clean rooms 300 m²
- 28 Labs

Supported by: Lower Saxony Ministry for Economics, Labour and Transport

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RESEARCH FOCUS

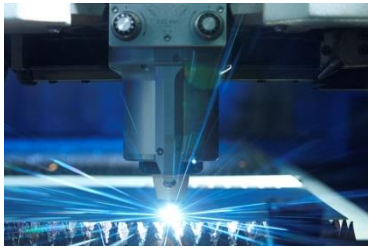
OPTICAL COMPONENTS AND SYSTEMS

- Optical Coating Technology
- Fibre Components
- Lasers

OPTICAL PRODUCTION TECHNOLOGIES

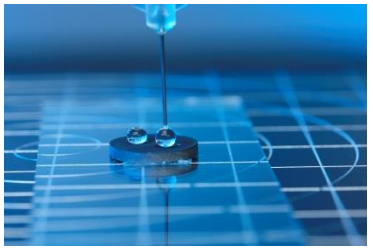
From nano to macro:

- Precise Surface Processing
- Generative Processes
- Joining and Cutting of Metals
- Processing of Non-Metals



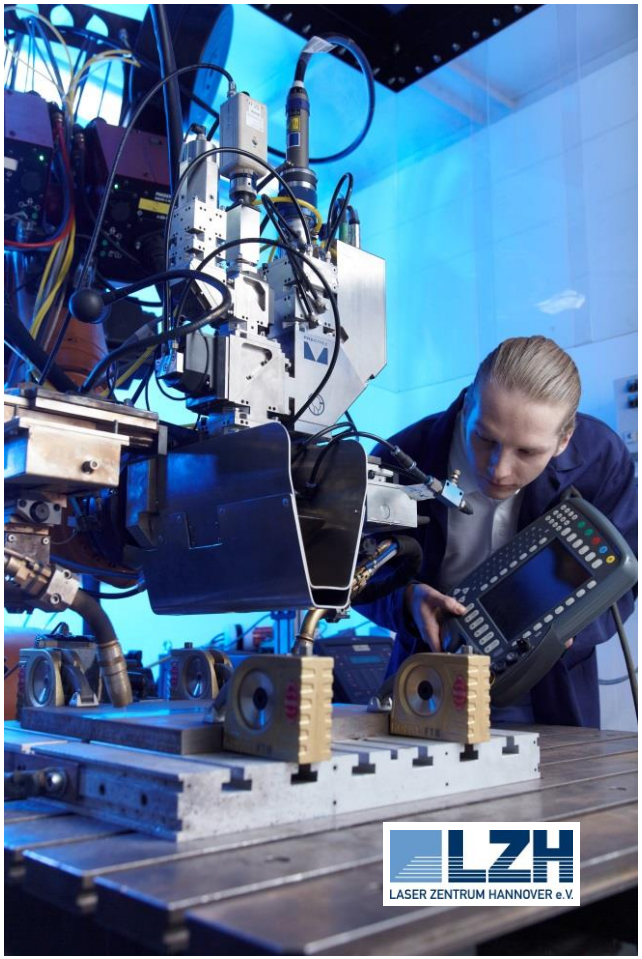
BIOMEDICAL PHOTONICS

- Biomedical Engineering
- Laser Medicine
- Biophotonics



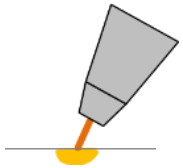
AGENDA

- Laser-GMA hybrid welding overview
- Hybrid welding by using a 16 kW disc laser
  - Steels up to 23 mm
  - Aluminum up to 12 mm
- Induction assisted laser-GMA hybrid welding
- Joining large-sized metal foam sandwiches for shipbuilding
- High Power Diode Laser Welding
- Laser assisted cladding



LASER-GMA HYBRID WELDING

GMA welding



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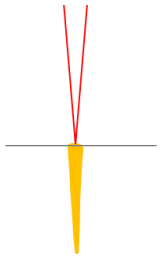
laser beam welding



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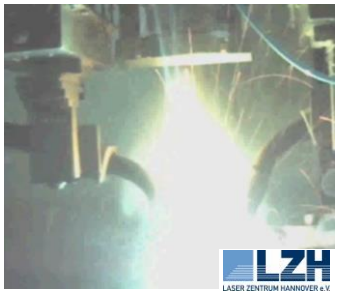
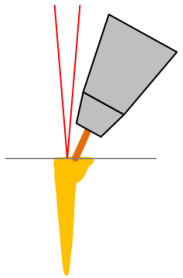
laser-GMA hybrid welding



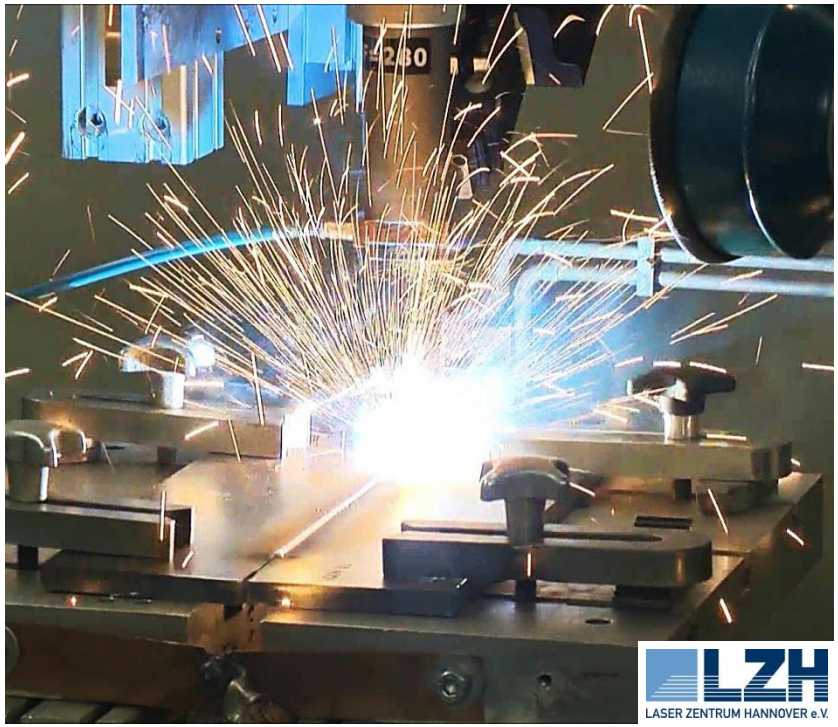


Hybrid process features

- High welding speed
- Robustness against workpiece tolerances (gap bridgeability, vertical edge offset)
- Process stabilization by interaction between the individual processes
- Decrease of edge preparation and filler material consumption
- Joining within a single-pass (single-sided) process step

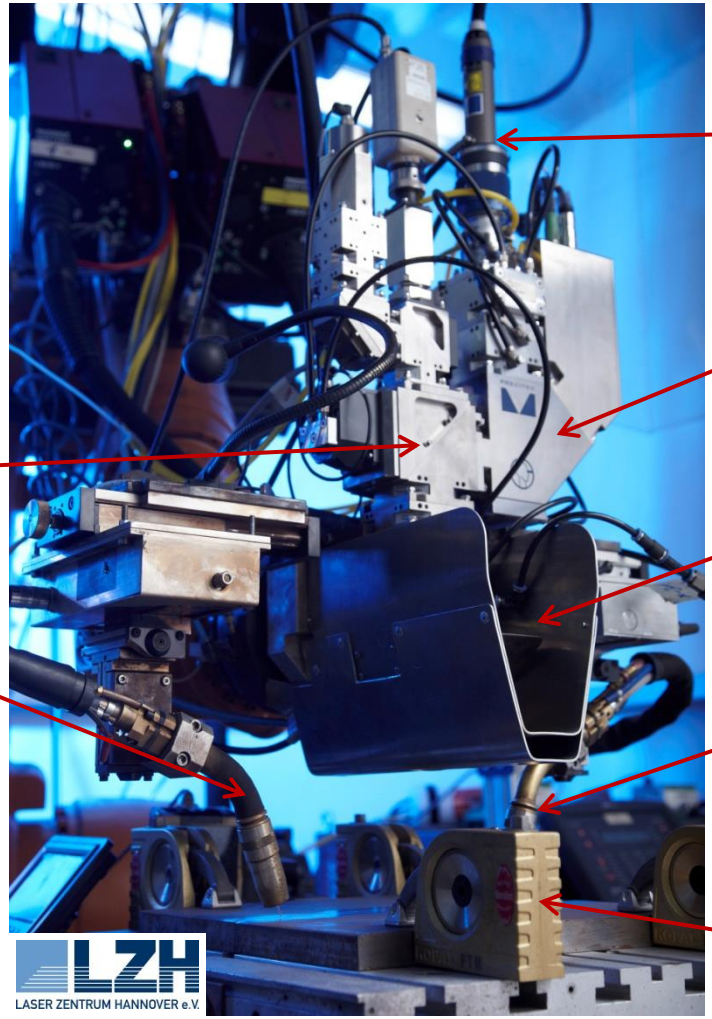
INVESTIGATED MATERIALS AT THE LZH UP TO NOW

- High-strength fine-grain structural steels
  - S1100QL (6 mm)
  - S1300QL (6 mm)
  - S700MC (10 mm)
  - L485MB (13 mm)
  - S690QL (15 mm)
  - S690QL (20 mm)
  - L485MB (23 mm)
  - L450MB (30 mm)
- Aluminum
  - EN AW-6082-T6 (12 mm)



TEST SETUP FOR LASER-GMA HYBRID WELDING

Process with an additional following GMA welding torch



optical fiber
of TRUMPF TruDisk 16.002

scanner

laser welding head

crossjet

following GMA welding torch

trailing GMA welding torch

clamping device

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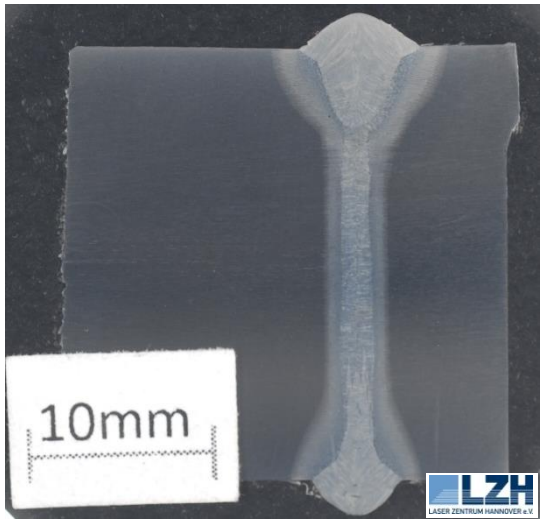
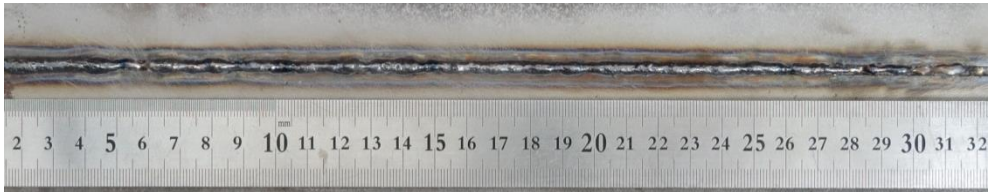
LASER-GMA HYBRID WELDING: STEEL



Cross section

Top layer



Weld root

Material parameters

Material grade: L485MB

Wall thickness: 23 mm

Welding parameters

Welding speed: 1.8 m/min

Laser power: 16 kW

Arc power: 5.6 kW + 5.6 kW

- partial occurrence of hot cracks

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LASER-GMA HYBRID WELDING: STEEL

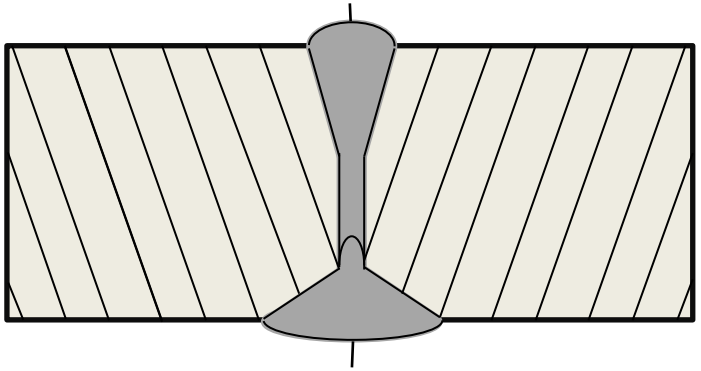
- material: L450MB

- workpiece dimensions
  - wall thickness = 30 mm
  - pipeline length = 1,500 mm
  - external diameter = 1,100 mm

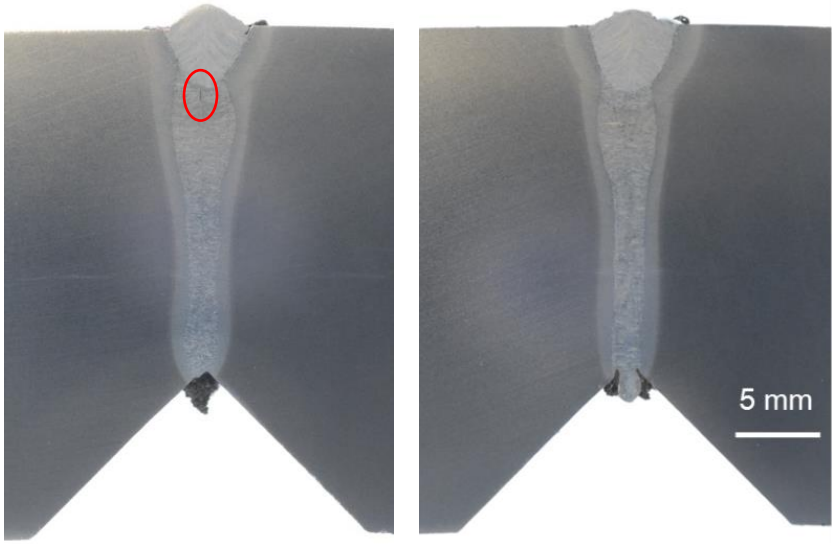
LASER-GMA HYBRID WELDING: STEEL

- height of the hybrid welding seam: 20 mm
- consistent seam appearance on a length of 1,500 mm
- high welding speeds of 1.6 m/min–2.0 m/min
- utilized laser beam power: 16 kW
- partial occurrence of cracks

layer 1 (laser-GMA hybrid welding)



backing run (submerged arc welding)



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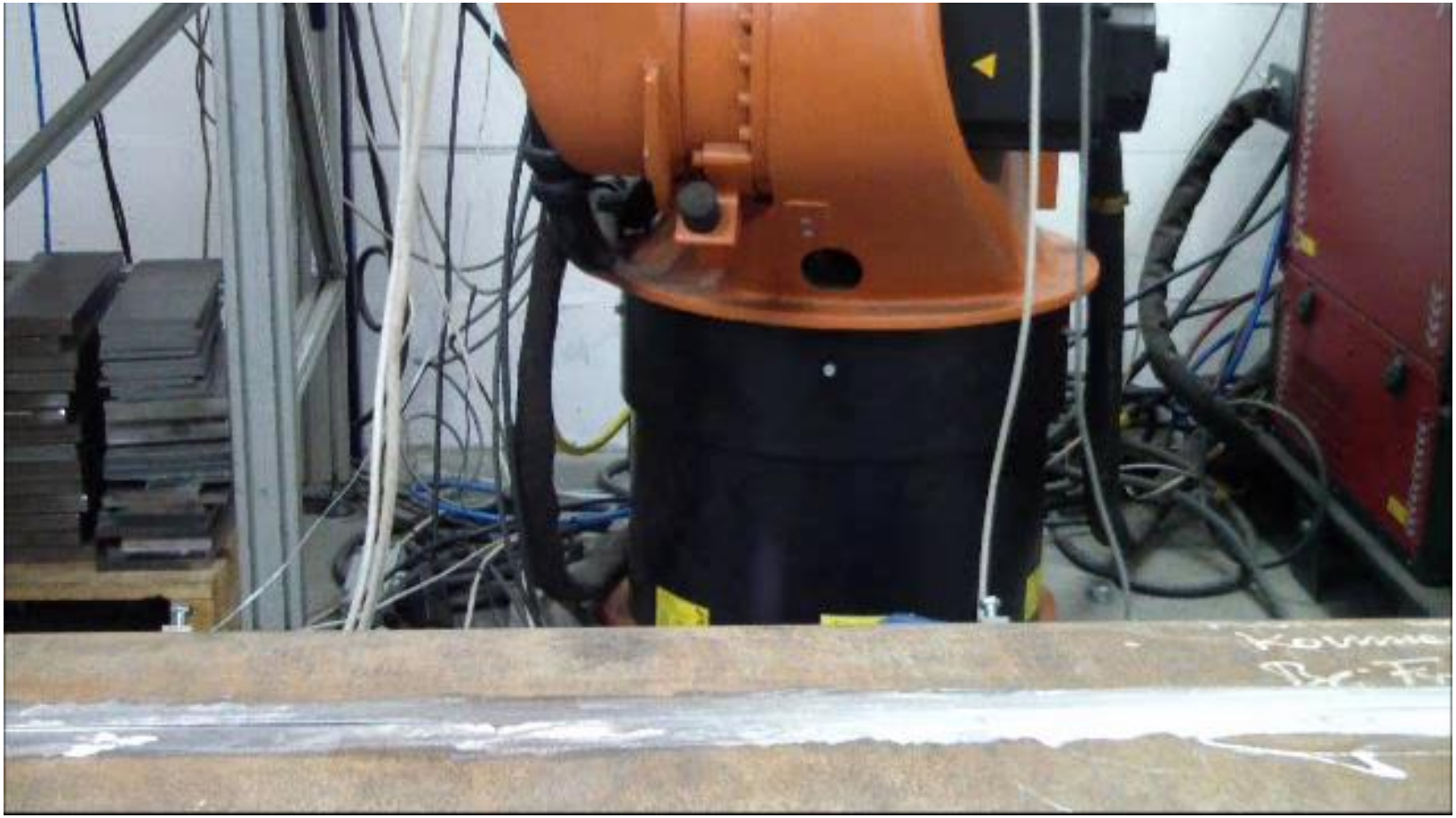
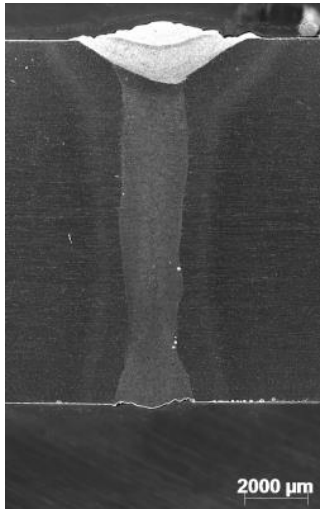
LASER-GMA HYBRID WELDING: STEEL



LASER-MIG HYBRID WELDING: ALUMINUM



Cross section

Top layer

Weld root

Material parameters

- Material grade: EN AW-6082-T6
- Wall thickness: 12 mm

Welding parameters

Welding speed:	6 m/min
Laser power:	16 kW
Arc power:	2.7 kW + 1.8 kW

- **meets the requirements for rating B according to EN ISO 13919-2:2001 and FprEN ISO 12932:2012.**

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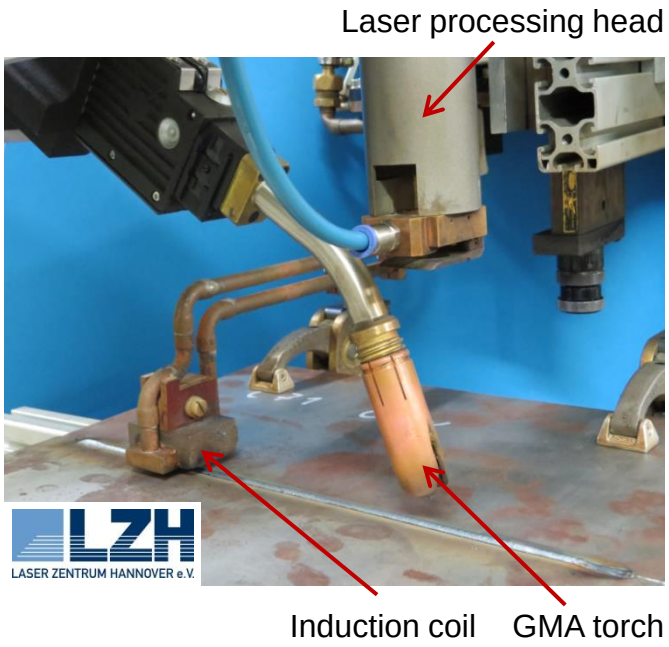
INDUCTION ASSISTED LASER-GMA HYBRID WELDING: STEEL

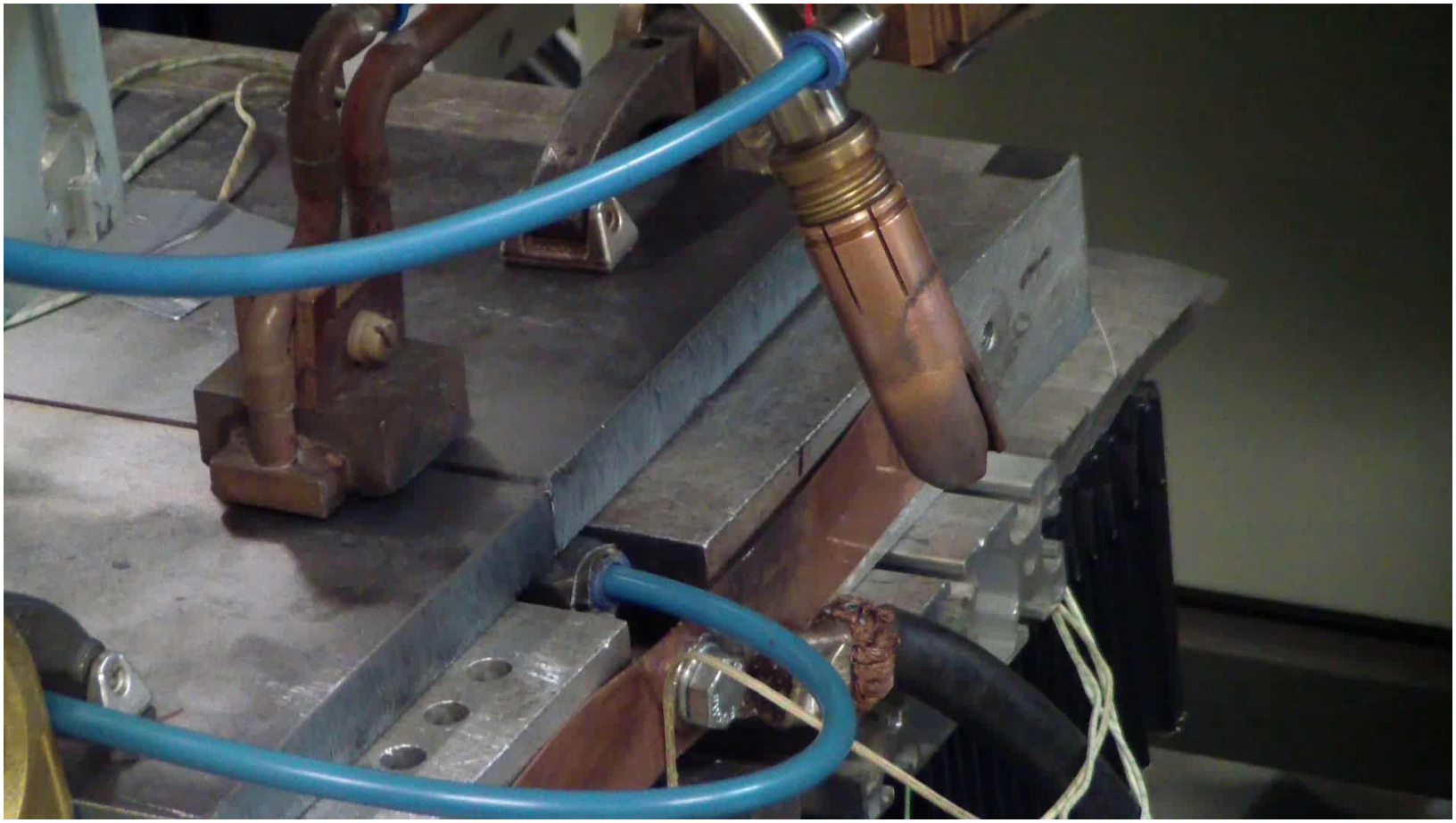
Laser-MAG hybrid welding of S690QL (t = 20 mm) with the use of an inductive preheating



Process features

- Increase of the welding speed and the welding penetration depth
- Homogeneous mechanical properties in the vicinity of the welding seam
- Regulation of the hardness using variable induction power

INDUCTION ASSISTED LASER-GMA HYBRID WELDING: STEEL



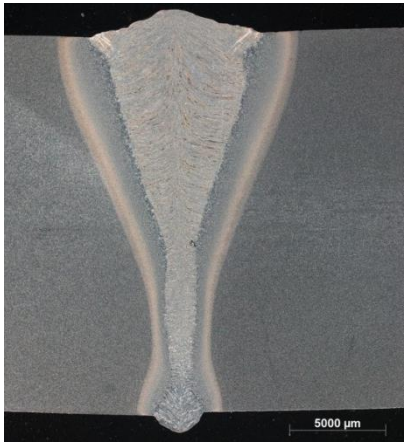
INDUCTION ASSISTED LASER-GMA HYBRID WELDING: STEEL

Lead-in area

Lead-out area

Material parameters	
Material grade	S690QL
Wall thickness	20 mm
Welding parameters	
Laser power	6 kW
Welding speed	0,75 m/min
Wire feed rate	14 m/min
Edge preparation	20°Y9mm
Filler wire material	CrNiMo

- Secure root formation in the stable area (middle of the welding seam)
- Without weld imperfections (with exception of partial root concavity), **without hot cracks**
- Consistent seam appearance, but **disadvantageous hardness profile**
  → **usage of an inductive preheating**



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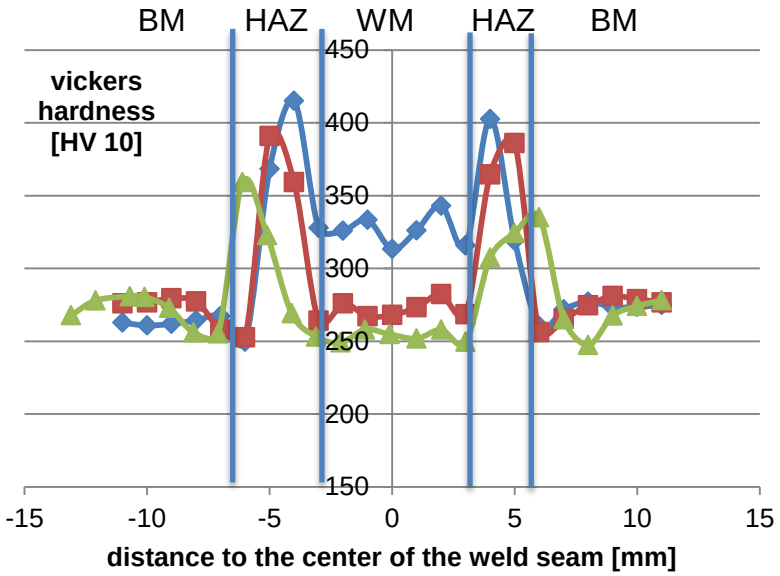
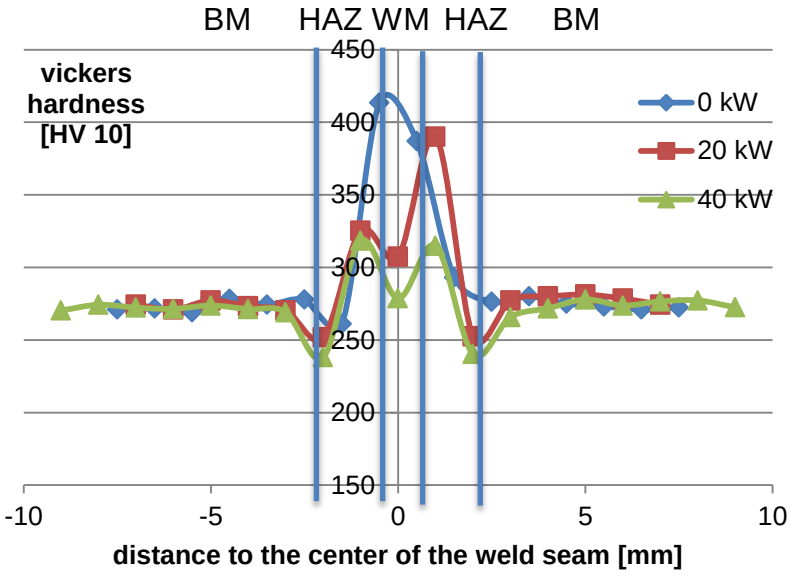
INDUCTION ASSISTED LASER-GMA HYBRID WELDING: STEEL

- Influence of the inductive power on the hardness of the welding seam
- Hardness series were determined 2 mm above and below the plate edges





- Reduction of the hardness by increasing inductive power

  → Hardness of 410 HV 10 (0 kW) to 350 HV 10 (40 kW) in the HAZ

Material parameters	
Material grade	S690QL
Wall thickness	20 mm

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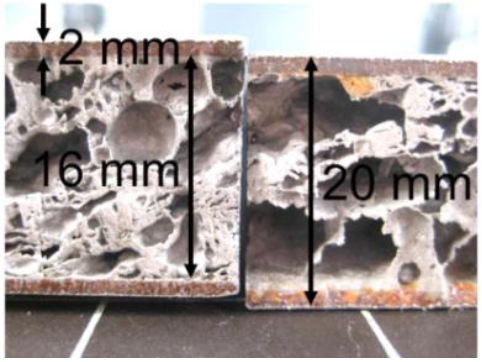
JOINING LARGE SCALE METAL FOAM SANDWICHES FOR SHIPBUILDING

- Sandwiches:

  2 mm steel + 16 mm aluminum foam + 2 mm steel

- The mixing of aluminum and steel has to be prevented (formation of intermetallic phases)

- Partial use of robots for joining large scale components



Steel-aluminum sandwich structure

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XXL- DEMONSTRATION PARTS

Demonstrators: gear unit foundation (3.6 t) and rudder structure

- 125 m laser welded seam, ca. 40 m (32 %) finished
- adequate planarity is required for Butt and T-joints
- laser welding is efficient practicable for ideal prepared panel edges
- weight reduction over 20 %

XXL-SURFACING IN HEAVY INDUSTRY

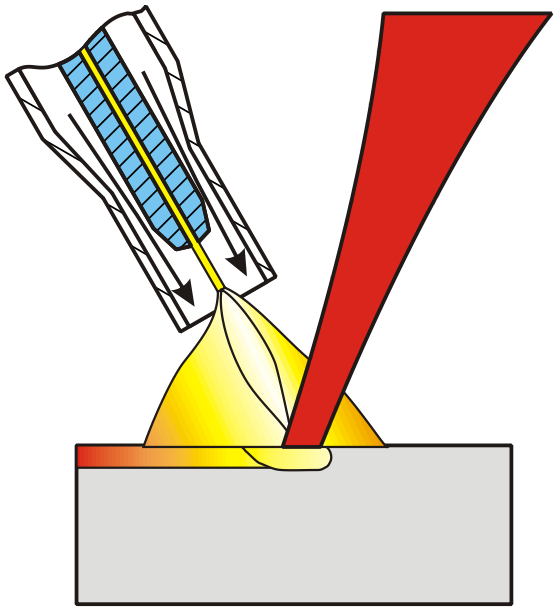
Source: http://www.terracompactorwheel.com

Source: Lincoln Electric

LASER-GUIDED AND STABILIZED WELDING

Properties

- Low laser intensities (~10^4 W*cm^{-2})
- ~10-20% contribution to total power
- **Only usage of the laser for guidance and stabilization**
- Cost-effective laser systems
- Increased conductivity in the electric arc

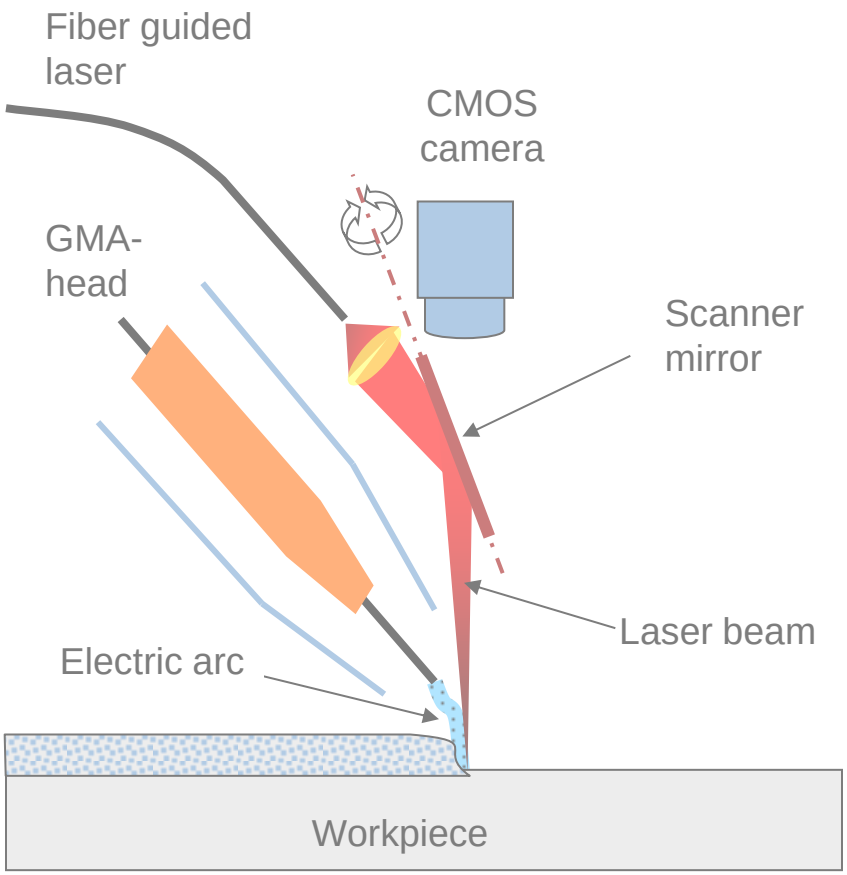


Possibilities

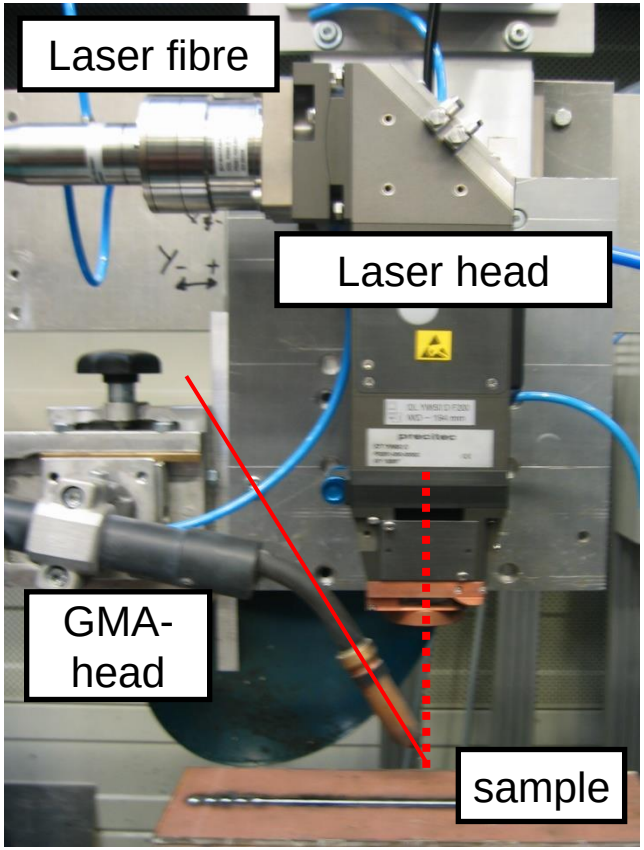
- No keyhole, no deep welding effect
- **Different seam geometries may be welded**
- **Higher feed rates possible**
- Active positioning of the electrical arc, oscillation
- Decrease of thermally induced distortion

CONCEPT

Schematical Setup



Test Setup



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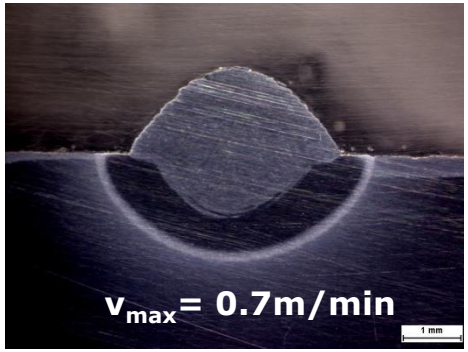
STABILIZATION OF GMA PROCESS

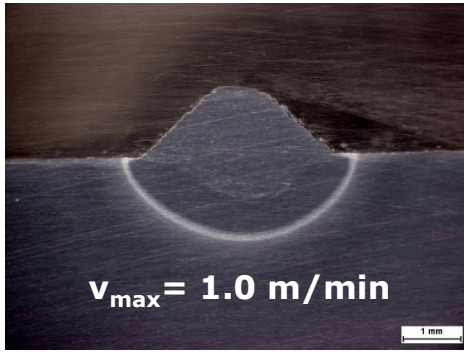
GMA reference weld



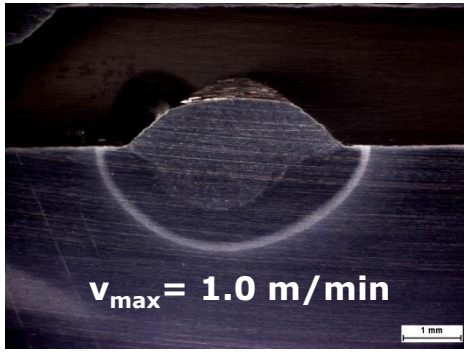
Process parameters:

Wavelengths:	1064 / 808 / 811nm (cw)
Beam diameters:	0.9mm / 2 mm / 1.3mm
Focus positions:	+4mm / +7mm / +3mm
Laser power:	400 / 360 / 250W
Welding power:	1600 W
Material:	Steel
Gas:	Corgon

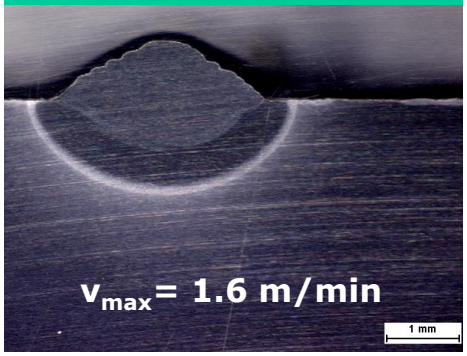
GMA+Nd:YAG-Laser



GMA+Diode-laser 808nm



GMA+Diode-laser 811nm

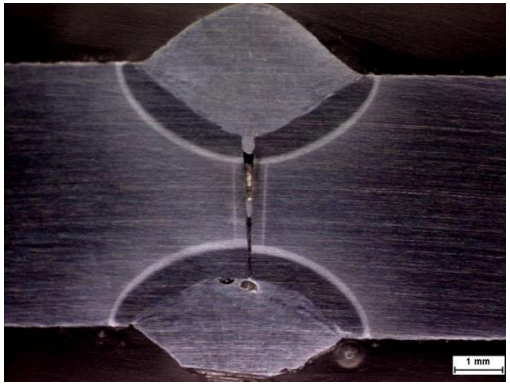


Result: 120% increase of the welding speed because of laser stabilization

LASER STABILIZED GMA BUTT WELDS

Laser stabilized butt weld:

Stable GMA weld

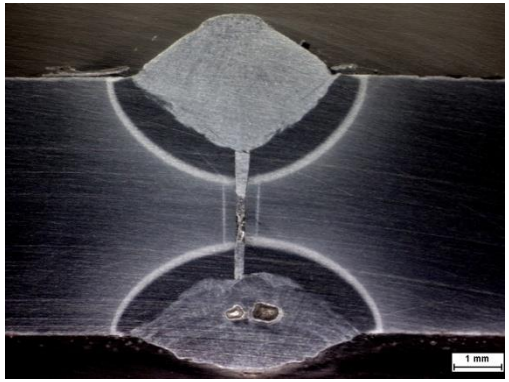


Without laser

With Laser

0.6 mm increased penetration with Laser

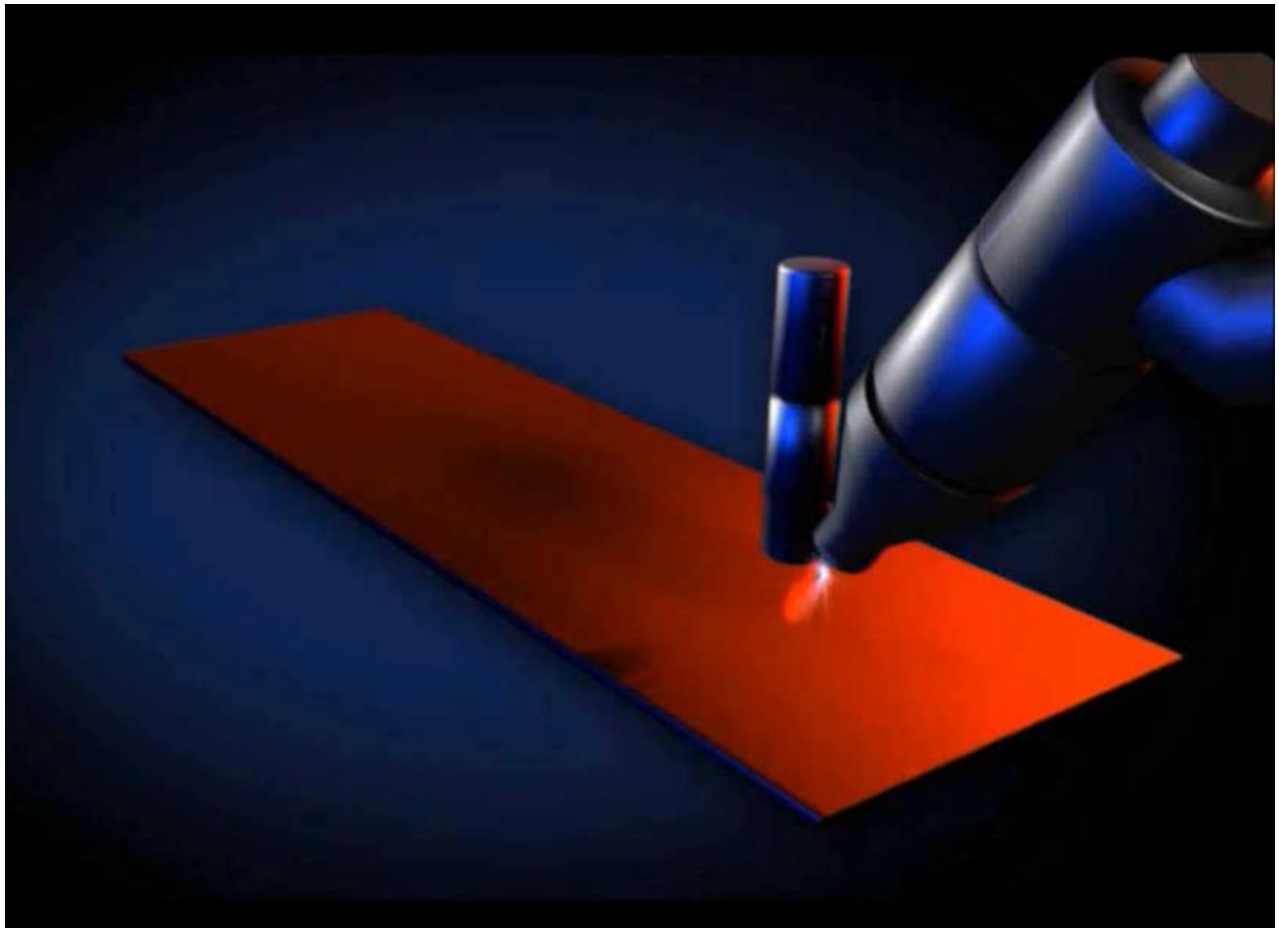
Laser + GMA weld



Wavelength:	811 nm (cw)	**Welding power:**	3690 W
Beam diameter:	1.3 mm	**Material:**	Steel
Focus position:	+3mm	**Speed:**	1.7 m/min
Laser power:	380 W	**Gas:**	Corgon

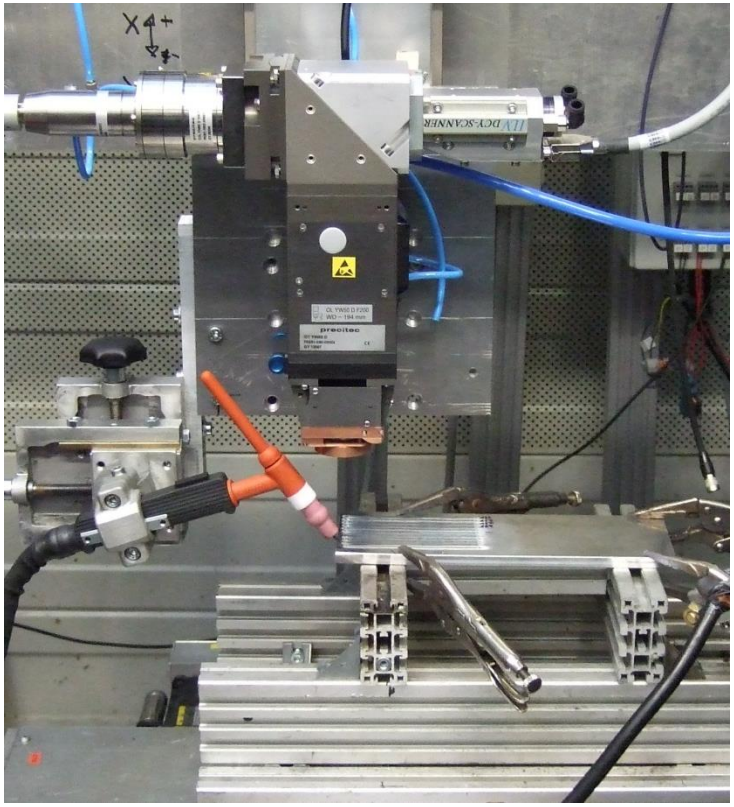
Result: Higher welding speed and deeper penetrations of butt welds due to laser stabilization

INTERACTION BETWEEN LASER RADIATION AND ELECTRIC ARC



GUIDING OF A TIG ELECTRIC ARC

Setup:



Process parameters:

Wavelength:	811 nm (cw)
Beam diameter:	ca.1.2 mm
Focus position:	+3mm
Laser power:	280 W
Welding power:	1050 W
Material:	Aluminium

3 Hz; 1.5m/min

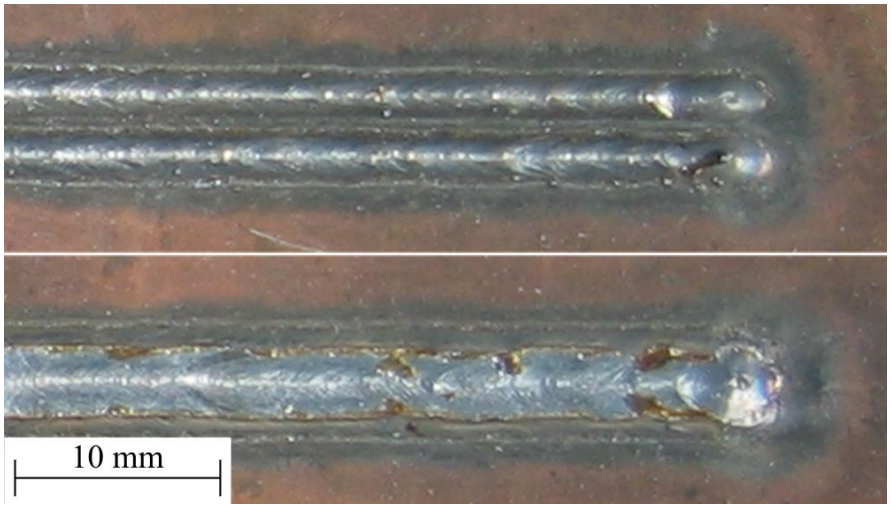
3 Hz; 5 Hz; 0.5m/min

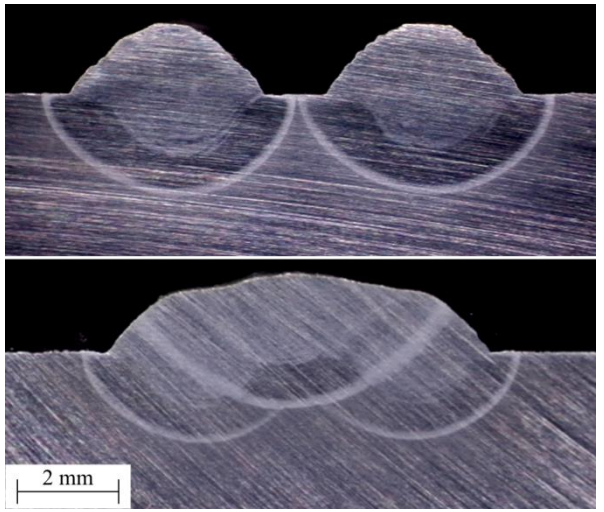
Result: Guiding of a TIG electric arc with low laser power is possible

LAYER BETWEEN TWO EXISTING LAYERS

Problem: **Self positioning of the electric arc on the highest position**

⇨ **No contact to both layers**





Beam diameter:	1 mm	**Process speed**	900/ 800mm/min
Focus position	+3mm		

Result: Placing a middle layer in between two weld clads is possible.

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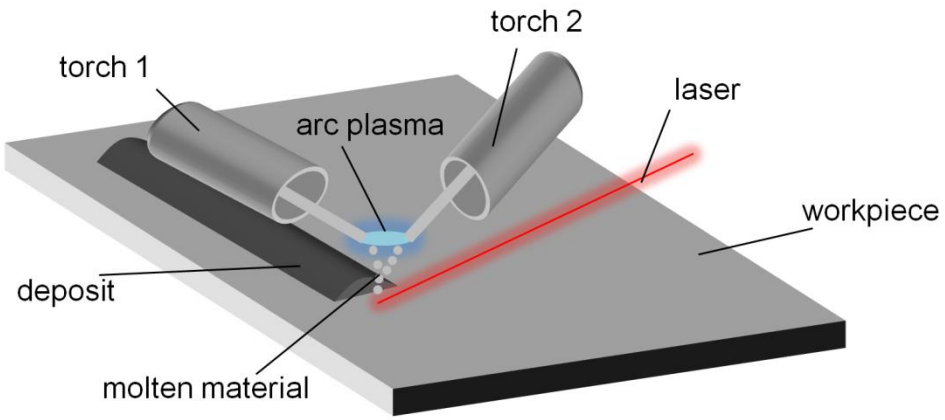
XXL-SURFACING

laser assisted double wire surfacing



Advantages:

- minimal heat input
- low dilution
- high deposition rate

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XXL-SURFACING

welded surface, not machined

THANK YOU FOR YOUR ATTENTION

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