Automotive joining of light-weight materials enabled by fiber lasers

GALM 29 Nov 2016, Vox Centre, Birmingham, UK

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- Static Beam forming for brazing and welding
- Dynamic beam forming for body joining
- Laser Seam Welding – an RSW alternative
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**General data IPG Photonics**

- Approx. 3800 employees
- Development and Production of Fiber Lasers
- Service and Sales Departments
- 10 Application Labs

**Vertically Integrated Production**

- Final Assembly
- Modules
- Laser Diodes
- Active Fiber Block
- Process Heads
- Collimators
- Fiber Beam Delivery
- Beam Switches
- Optical Components
- Fiber Draw
- Optical Preform
- Fab Operation
- Diode Assembly
IPG Photonics Corporation – Nasdaq IPGP

General data IPG Photonics

- Founded in 1991
- 17% year-over-year increase
- 3800 employees in 2015
- Total net sales $ 901 M
- Over 4700 High Power Lasers in 2015

High Power Laser Sales (in millions)

- 2011: $222.1
- 2012: $263.4
- 2013: $344.1
- 2014: $426.1
- 2015: $499.6

2015 Sales by Geography and End-Use

- 31% Americas
- 54% Asia
- 15% Europe, CIS
- 6% Advanced Applications, Medical, Telecom
- 94%

• Source: IPG Photonics Annual Report 2015
Overview

All IPG Product Lines

Leadership in Automotive Joining & Cutting

Low Power CW Fiber Lasers
Mid Power CW Fiber Lasers
High Power CW Fiber Lasers
Quasi-CW Fiber Lasers
Nanosecond Fiber Lasers
Pico & Femtosecond Fiber Lasers
Mid-IR Hybrid Lasers
CW Fiber Amplifiers
Diode Lasers
Automotive Product Lines

Products for mainstream automotive applications

Remote processing

Ablation/Cleaning

Micro machining

Cutting

Welding

Brazing
Static beam forming – tri-focal fiber delivery

**Motivation/ Requirements**
- High Reliable Process stability
- Increased Speed
- Increased Strength
- High quality seam appearance at Hot-Dipped Zn coated Materials
- Inline Cleaning process
- Dynamic power modulation

![Trifocal Process fiber](image)

Main spot

2 side spots

Trifocal Process fiber
Tri-focal Fiber Laser

3 beams in a single cable with independent power control

Ablation side spots (2x 150W)
Welding centre spot (1500W)
Trifocal process (1500W + 2x150W)
Welding of Zn-coated material @ Zero Gap

Monofocal welding
galvanized + hot dipped

Trifocal welding
galvanized + hot dipped
Car roof welding Aluminium – Tri-focal welding

\[ P_L = 4,1 \text{ kW} \]
\[ P_{\text{Side}} = 2 \times 360 \text{ W} \]
\[ V_{\text{Rob}} = 4,0 \text{ m/min} \]
\[ V_{\text{Filler Wire}} = 4,2 \text{ m/min} \]

Side Spot
Key Applications:
ROOF JOINING & Trunk/Boot-lid joining

P = 2.4 kw + 2 x 340 W
v = 3.6 m/min

Brazing of Hot-Dipped Zn coated steel
Welding of Aluminium Roof - Comparison

Mono-focal welding of Al
Real part from production

Tri-focal welding of Al
Real part from production

Standard Cross section

Improved Cross section
Litecor  Brazing @ New Materials

metal

polymer

PL = 1,7 kW
PSide = 1 x 320 W
VRob = 3,0 m/min
VWire = 3,3 m/min
Filler Wire: Ø 1,2 mm CuSi3

Only 1 side spot on galvanized material!!!
→ Individual controlable laser spots
Dynamic beam forming with fiber laser

Principle of a wobbling head

General Specifications
- Max Wobble frequency 300 kHz
- Laser Power up to 8 kW
- Max focal length 500 mm
- Full Scanning Range +/- 7.5 mm
Dynamic beam forming improves joint quality

- Higher frequencies and low welding speed to generate large melting pool
- Controlled thermal input
- Intermetallic properties matched to need

Example: 20 Hz 15mm/sec.
Dynamic beam forming with fiber laser

Example: Corner welding

- Less heat input compared to big spot welding
- High process stability compared to big spot welding

Stainless Steel

Aluminum

Copper/Stainless Steel
Combining static & dynamic beam forming

**Laser Seam Welding**

**Applications:** Automotive (Body-in-white), Marine vessels, Railway Vehicles, Furniture

- Laser Power range from 1 to 4 kW

- Less minimum distance
- Less abrasion of mechanical parts
- Less influence of sheet coating
- No problems on asymmetric sheet combination

**KEY BENEFIT**
- Welding dissimilar material combinations
Laser seam welding with Tri-focal for Zn-coated @ Zero Gap

Top view

Bottom view
Fiber LSS: Video overview
Summary

Tri-focal Fiber Laser shows for **brazing**:
- Higher speed: +30% | Higher strength: +30% | Higher surface quality
- Production Energy savings > 60%

Tri-focal Fiber Laser shows for **welding**:
- Higher speed for Aluminum | Improved surface quality without cleaning
- Welding of 6000 alloys without filler wire
- Spatter free Overlap welding of Zn-coated materials @ zero gap

Dynamic beam forming – enables dissimilar materials **welding**
- Wobble head welding matches materials properties to requirements
- Laser Seam Welding enables new light-weighting design

**CHALLENGE US TO JOIN YOUR MATERIALS OF CHOICE:**
Thank you for your attention!

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Appendices
Welding of Al Roof – Previous method

Monofocal laser welding of Aluminum
Real part from production

Top view

Bottom view

Cross section
Tri-focal Welding of Aluminium

Trifocal laser welding of Aluminum
Real part from production

- $P_L = 4.0$ kW
- $P_{\text{Side}} = 2 \times 400$ W
- $V_{\text{Rob}} = 3.6$ m/min
- $V_{\text{Filler Wire}} = 4.2$ m/min
- Material: Al6016
- Thickness: 1.1 mm
- Filler Wire: AlSi12
- Diameter: $\varnothing 1.2$ mm
- Protective Gas: 10 l/min Ar 4.8
Static beam forming with fiber laser

Applications with a tri-focal fiber laser

Result with tri-focal fiber laser

Welding of Aluminium

P = 3,5 kw + 2 x 440 W
v = 4,5 m/min
Principle of a tri-focal fiber laser

General Specifications
• Compact footprint design
• High WPE > 50%
• Integrated water-water chiller
• Replaceable three-core Process Fiber
• Independent power control via ProfiNet interface
• Advanced IPG Power Supply with integrated safety
• Excellent for brazing and welding applications
• Total efficiency incl. chiller: 42%
Static beam forming with fiber laser

Principle of a tri-focal fiber laser