Automotive joining of light-weight materials enabled by fiber lasers

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The Power to Transform™
Contents

- IPG Photonics - Company Overview
- 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

- Optical Preform
- Fiber Draw
- Optical Components
- Active Fiber Block
- Beam Switches
- Collimators
- Final Assembly
- Modules
- Process Heads
- Fiber Beam Delivery
- Diode Assembly
- Fab Operation
General data IPG Photonics

- Founded in 1991
- 17% year-over-year increase
- 3800 employees in 2015
- Total net sales 901 million $
- 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

- Asia: 15%
- Europe, CIS: 31%
- Americas: 54%
- Advanced Applications, Medical, Telecom: 6%
- Materials Processing: 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
- Welding
- Brazing
- Ablation/Cleaning
- Micro machining
- Cutting
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

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

\[ P_L = 4.1 \, \text{kW} \]
\[ P_{\text{Side}} = 2 \times 360 \, \text{W} \]
\[ V_{\text{Rob}} = 4.0 \, \text{m/min} \]
\[ V_{\text{Filler Wire}} = 4.2 \, \text{m/min} \]
Key Applications:
ROOF JOINING & Trunk/Boot-lid joining

Tri-focal - Brazing of hot dipped Zn coated steel

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

Brazing of Hot-Dipped Zn coated
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

\[ P_L = 1.7 \text{ kW} \]
\[ P_{\text{Side}} = 1 \times 320 \text{ W} \]
\[ V_{\text{Rob}} = 3.0 \text{ m/min} \]
\[ V_{\text{Wire}} = 3.3 \text{ m/min} \]
Filler Wire: \( \phi \) 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](image1.jpg)

![Aluminum](image2.jpg)

![Copper/Stainless Steel](image3.jpg)
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
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
Monofocal laser welding of Aluminum
Real part from production

Top view

Cross section

Bottom view
Tri-focal Welding of Aluminium

Trifocal laser welding of Aluminum
Real part from production

\[ P_L = 4.0 \, \text{kW} \]
\[ P_{\text{Side}} = 2 \times 400 \, \text{W} \]
\[ V_{\text{Rob}} = 3.6 \, \text{m/min} \]
\[ V_{\text{Filler Wire}} = 4.2 \, \text{m/min} \]
Material: Al6016
Thickness: 1.1 mm
Filler Wire: AlSi12
Diameter: \( \phi \) 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