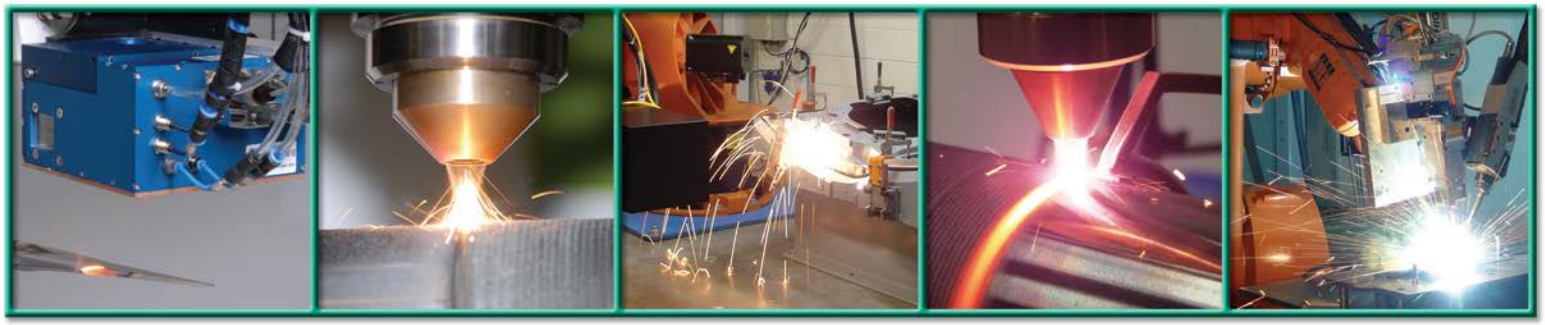
Laser Welding Technology for Lightweight Vehicle Manufacture



Craig Bratt
Fraunhofer USA
Laser Applications Division
Plymouth, Michigan.

Fraunhofer USA

Fraunhofer Worldwide

- 66 Research Institutes
- 22,000 Staff
- 3000 Customers Worldwide (EU / USA / Asia)
- $2.5 Billion Research Budget (1.9bn Euro)
- Research Fields
  - Materials, IT, microelectronics, sensors
  - Energy, environment, molecular biology
  - **Production and process technology, Laser Process Technology**

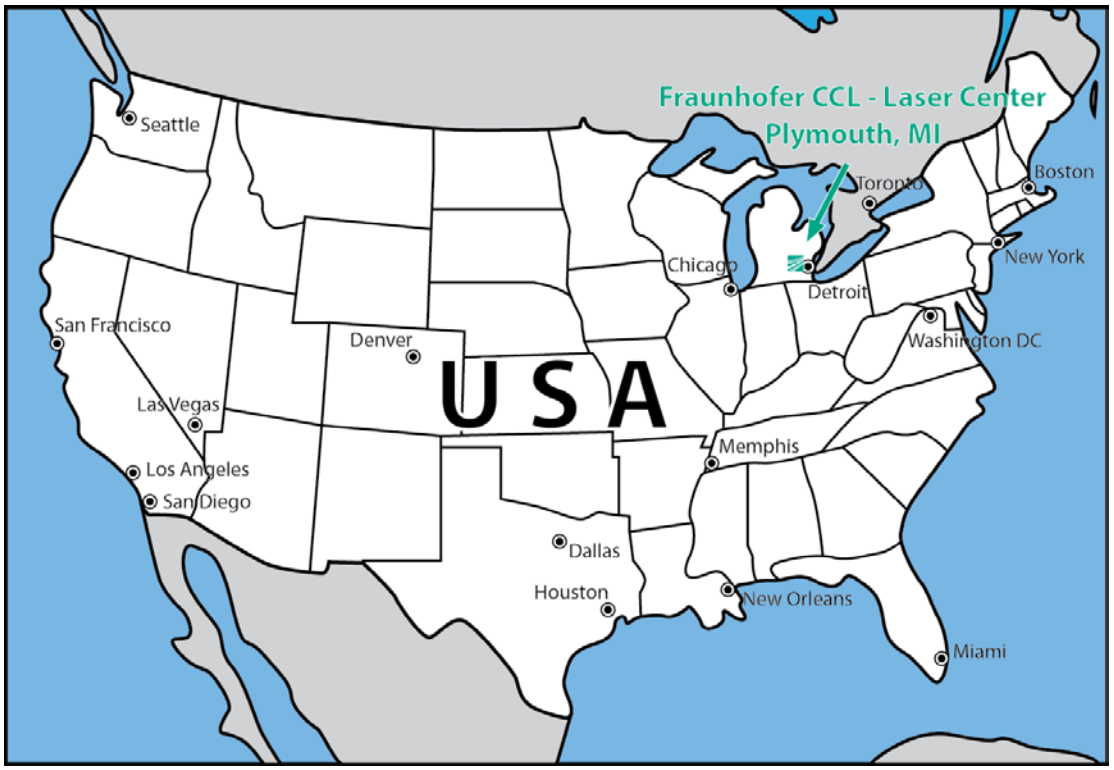
✓ Focus on applied research activities

German Fraunhofer Locations

Fraunhofer USA

Fraunhofer USA

- 20th year in USA (2014)
- High Power Laser Applications Center located in Plymouth MI
- Provide Contract Applications Research and Development for local industry



Fraunhofer CCL Detroit, MI USA

Fraunhofer IWS Dresden, Germany

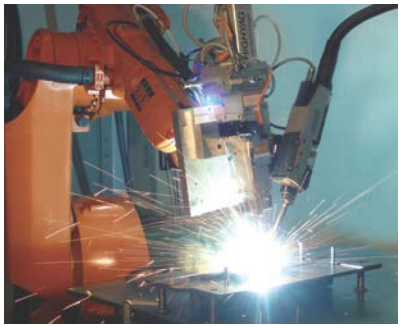
Fraunhofer USA

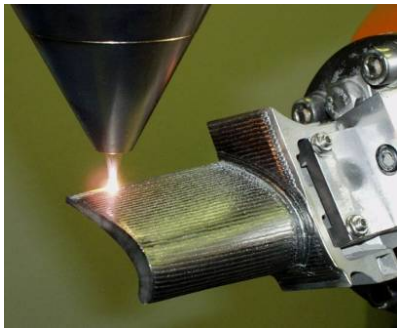
Fraunhofer USA CCL: High Power Laser Applications

High Power Laser Applications from 300W to 10kW power

Processes:

- Welding
- Cutting
- Cladding
- Hardening





Our Aim:

Development of laser technology for production applications
Bridging the gap between research and manufacturing.

Our Services:

From concept phase to implementation

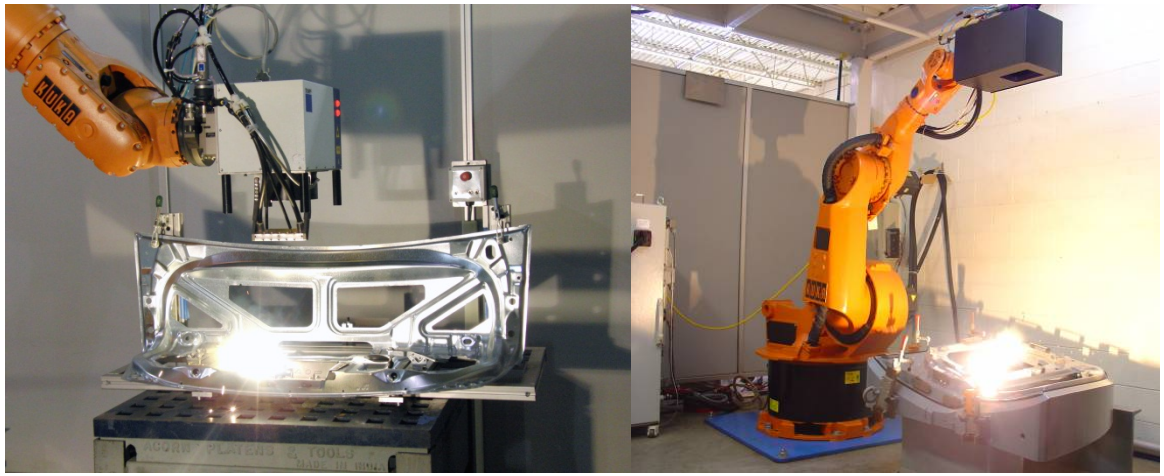
- Consulting, Part design & materials selection,
- Feasibility testing & Process development
- Prototype processing, testing of production equipment
- Process start-up, troubleshooting, pilot production systems

Fraunhofer USA

The best equipped laser applications lab in America!

Plymouth, Michigan Facility Equipment Capabilities (high power):

- 4kW & 10kW Laserline Fiber delivered diode laser
- Qty 2 x 6kW TRUMPF Disk Laser 6001 & 6002
- 5kW & 6kW IPG Fiber Laser / 1kW JK Fiber Laser
- 4.4kW Rofin Sinar Nd. YAG & 6kW Slab CO_2 Laser
- 6 robot and CNC workstations
- Remote Welding and Hybrid Arc welding equipment
- Laser Powder and Wire Deposition equipment for Cladding / & Additive Manufacturing



Remote Welding using Scanners at CCL

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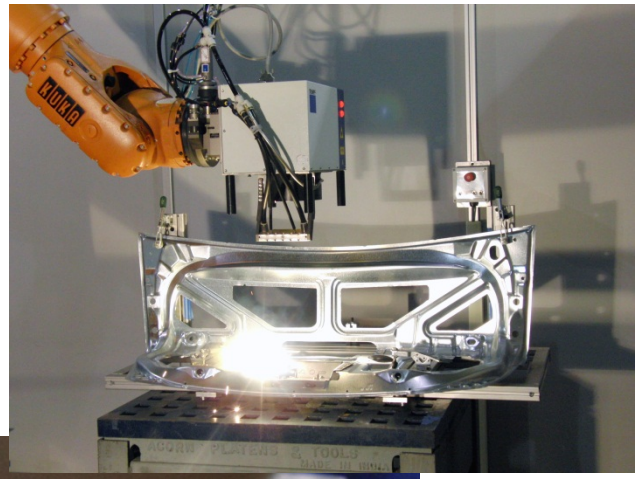
Fraunhofer Welding & Joining Capabilities

Lasers and Equipment:

- 9 High power laser sources
- 3D Remote Welding Head
- 3 State of the art Aluminum wire feeders (push pull)
- 7 Work Cells (4 Robots and 3 CNC workstations)



Processes:

- Autogenous Laser Welding
- Welding with cold wire feed
- Welding with hot wire feed (new)
- Hybrid Welding (Laser + MIG / Plasma)
- Fixed optic and remote (scanner welding)

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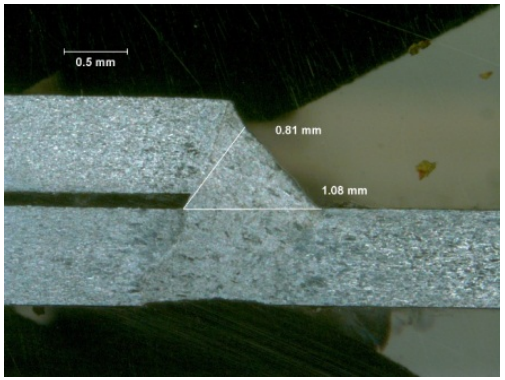
Technology Areas – Automotive Laser Welding & Brazing

Automotive Applications:

- Body in White
- Closures
- Powertrain
- Batteries



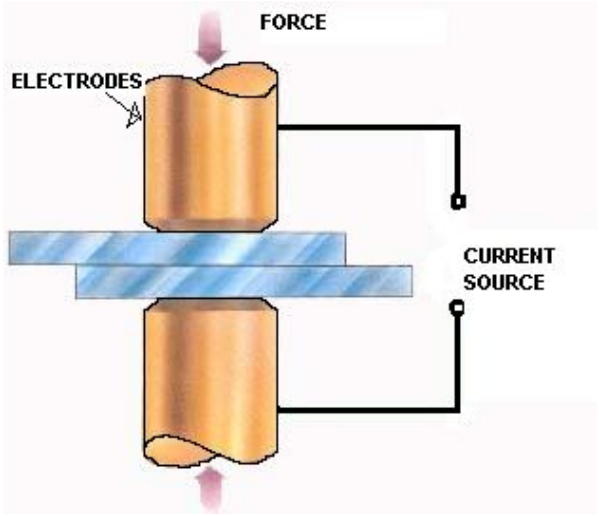
Remote welding of automotive tailgate assembly using 6kW Disk laser

- Fraunhofer CCL was awarded the Henry Ford Technology Achievement Award:
- F150 Truck roof laser welding development project.

Fraunhofer USA

Why Laser Welding?

- ✓ Fast
- ✓ Flexible
- ✓ Precise
- ✓ Minimal heat input / distortion
- ✓ Highly suitable for welding Aluminum and Magnesium
- ✓ No contact required
- ✓ No electrical resistance required
- ✓ Single sided access only required
- ✓ Remote welding possible
- ✓ High point to point positioning speed



Conventional Spot Welding


Remote Laser Welding

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Fraunhofer USA New Remote Welding Capabilities

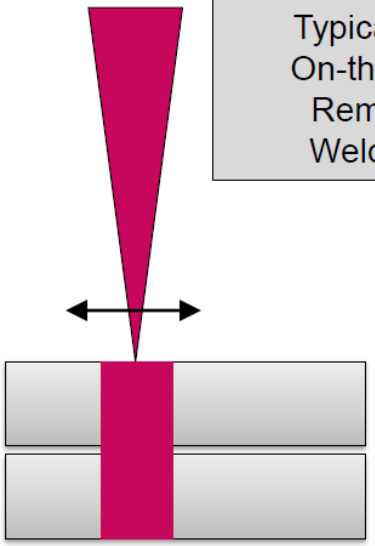
Task description

Remote laser welding of fillet joints

BLACKBIRD

Overlap Joint

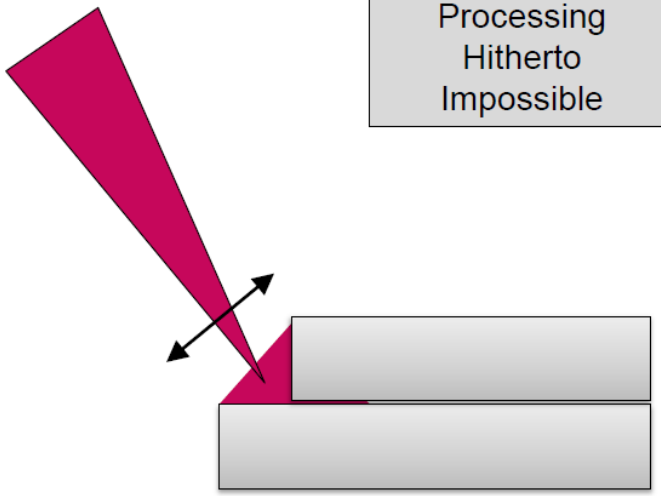
Typical for On-the-Fly Remote Welding



- Larger flanges required
- Requires controlled gap for gas release if steel is galvanized (=> dimpling)
- Only indirect quality assessment
- Higher laser powers required
- **Lower accuracy is tolerable**

Fillet Joint

On-the-Fly Processing Hitherto Impossible



- Smaller flanges enabled
- No additional measures required to release zinc gas
- Geometric quality evaluation possible
- Less laser power required
- **High accuracy required (~0,1mm)**

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Fraunhofer USA New Remote Welding Capabilities

Application example
Car doors with fillet seams

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- Door Welding for BMW / Mini
- Multiple systems implemented in serial production

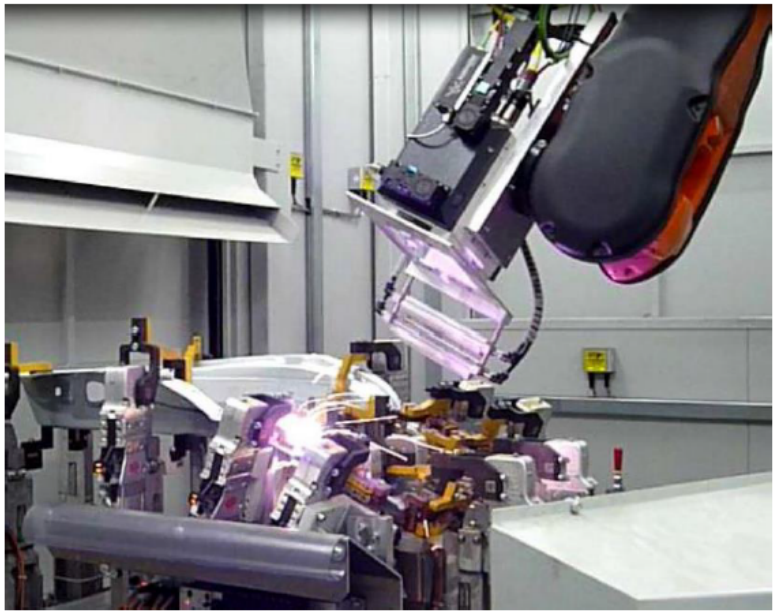

Image by courtesy of BMW Group

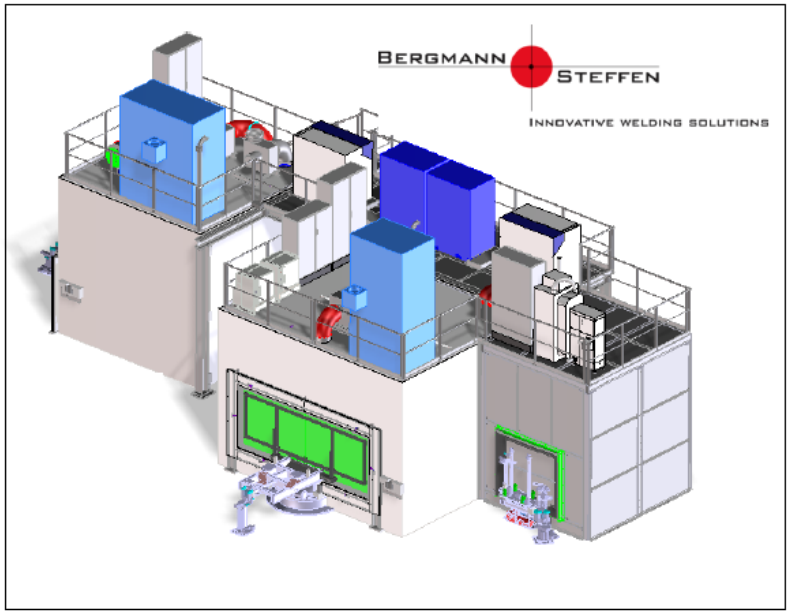

Image by courtesy of Bergmann & Steffen GmbH

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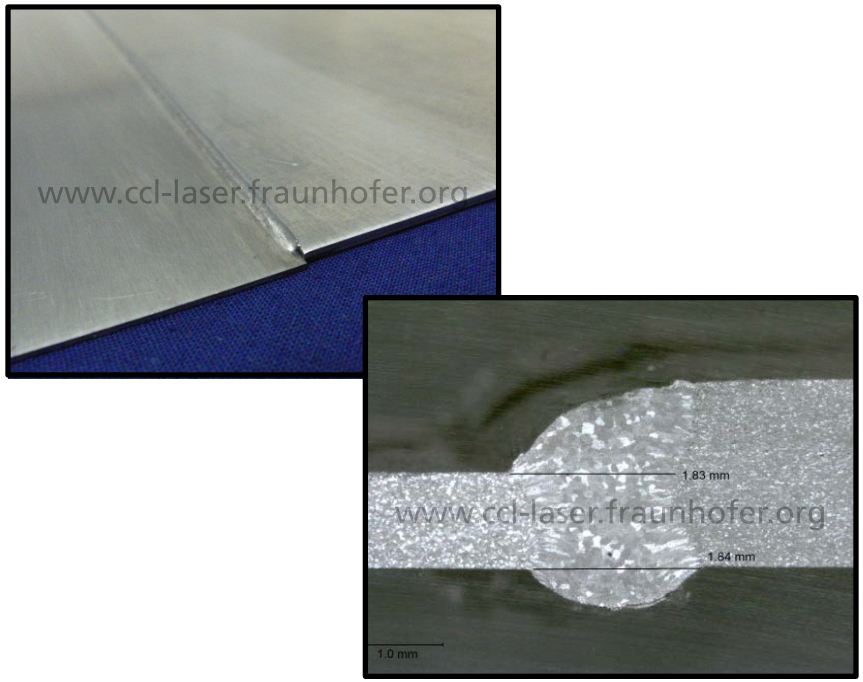
Application Examples

- Tailor Welded Aluminum Blanks
  - Up to 2 m long continuous welds
  - Up to 8 m/min travel speed
  - Thickness combinations from 0.8/1.0 mm to 1.5/2.0 mm



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Aluminum Tailor Welded Blanks

Aluminum 5182 – TWB Example

TWB Test, Aluminum 5182

- Thickness = 1.0mm to 1.5mm
- Robot Speed = 8.1 m/min
- Laser Power = 2.8 kW

Aluminum 6014

TWB Test, Aluminum 6014

- Thickness = 1.5 to 2.0mm
- Robot Speeds = 6 to 9 m/min
- Laser Powers = 3 to 4 kW

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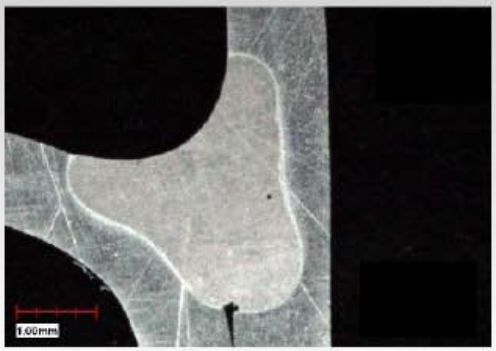
Aluminum Deck Closure Welding

Deck Closure Welding at Audi A8 – New Application

Innovations in detail
laser-welding of divided tailgate

parameter and equipment of laser process

- installation parameters:
  - cycle time: 300 sec
  - volume: 10,8 parts per hour
  - laser source: diode laser
- zero-gap joint:
  - welding-speed: 3.0 m/min
  - filler-wire: 2.4 m/min
  - seam-length:
    - zero-gap joint: 760 mm
    - overlap-joint: 4 steps á 35 mm
  - shielding-gas: helium
  - tactile guided laser-welding
  - no finish of welding-seam needed



14

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Aluminium application – Divided tailgate

- 1. Step Preparation of the aluminium surface with laserclean
- 2. Step Welding of the divided tailgate

Q5

Divided tailgate Q5 with zero gap joint

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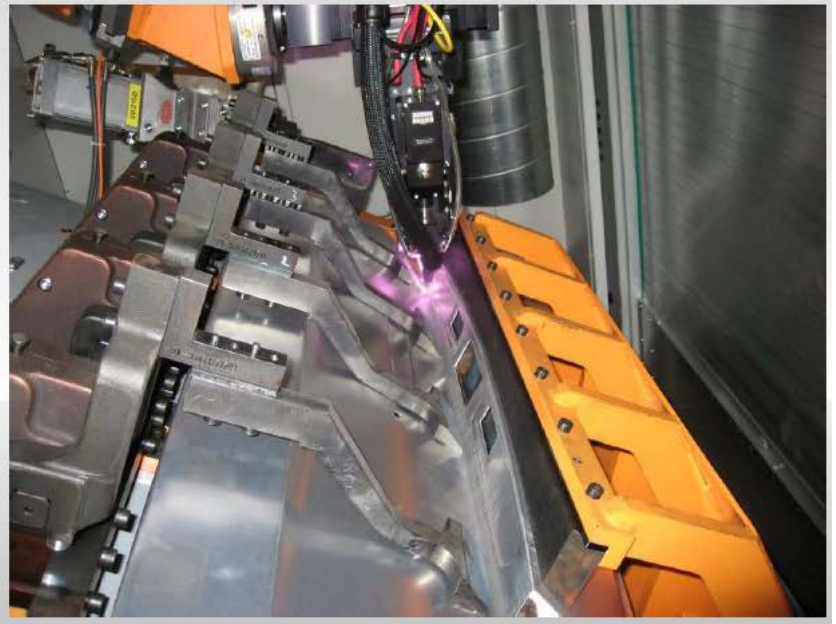
Aluminium application – Divided tailgate

Parameter and equipment of laser process

- Installation parameters:
  - Laser source: 4 kW diode laser
    - Laserline LDF 400 – 4000
  - Optic: Scansonic ALO 3

- Zero-gap joint:
  - Welding-speed: 2,4 m/min
  - Filler-wire: 2,6 m/min
  - Seam-length:
    - Zero-gap joint: 756 mm
  - Shielding-gas: He
  - Tactile guided laser-welding
  - No finish of welding-seam needed



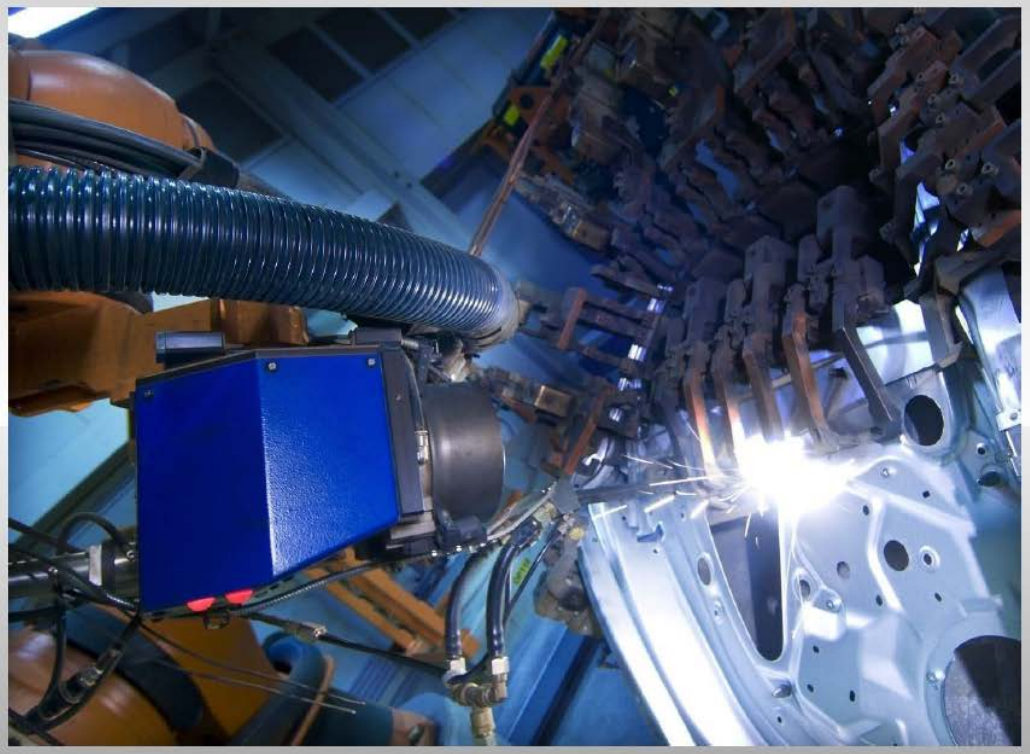
Clamping divided tailgate Q5

Remote Welding of Door Assemblies at Audi

Laser application in the body shop - Laser remote door-application

Performance:

- No. of seams: 45-49/door
- stitches in total with a length of 25 – 40mm
- Welding time: 19,5sec.
- Cycle time: 32,4sec (arrangement, handling and joining included)



Film: remote welding of Q5 door

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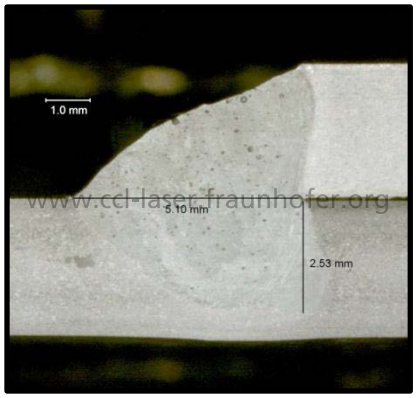
Laser Welding Processes with Filler Wire

- Laser Hybrid welding
  - GMAW-Laser Hybrid welding
    - Al 6061 sheets in lap fillet configuration, Al4047 filler wire
    - Less dependent on work piece tolerances

Laser- GMAW Hybrid Welding process



Al6061 sheet and Al4047 wire

Laser Power: 3 kW
Travel Speed 3.0 m/min
Wire Feed Rate: 8.0 m/min

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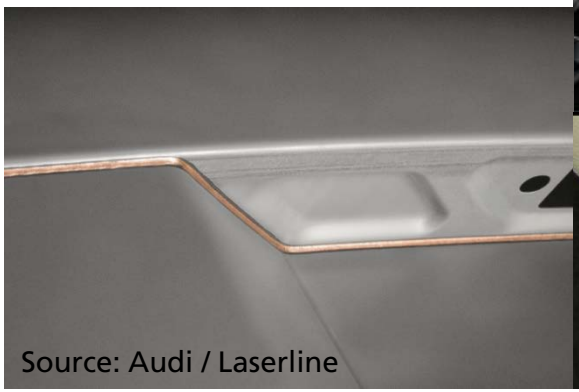
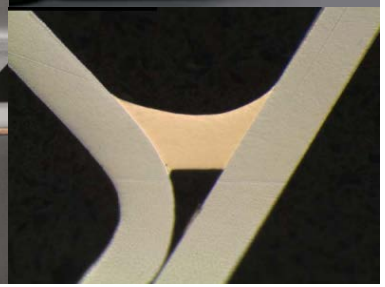
Typical Body in White Brazing Applications

Tailgate / Liftgate (License plate) / Roof

Has been Implemented by:
BMW (various models inc Liftgate)
Chrysler Sebring (Liftgate)
Ford (Mondeo – Roof development)
GM – Cadillac CTS (Roof and Liftgate)
Mercedes (Liftgate)
VW / Audi / SEAT (various)
Renault (Roof)
Peugeot (Roof)


Source: Audi / Laserline



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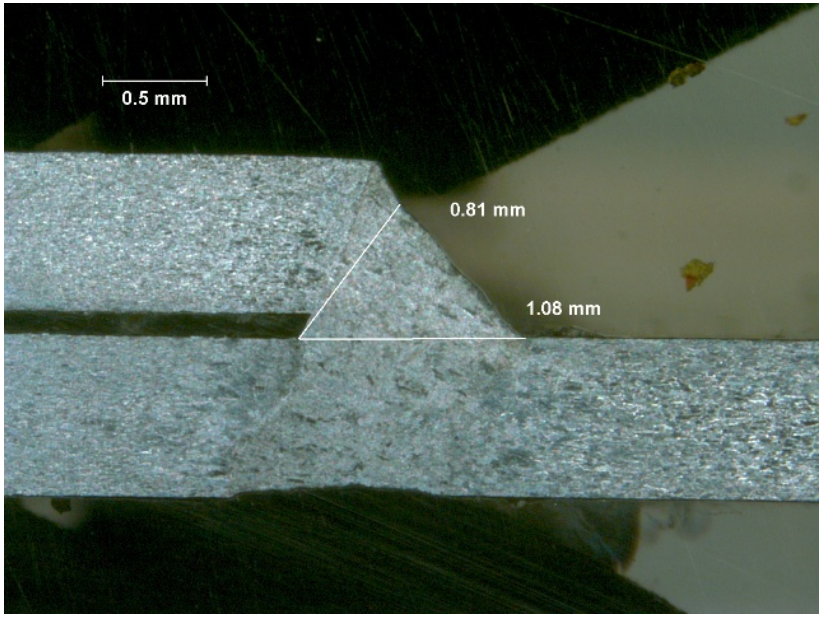
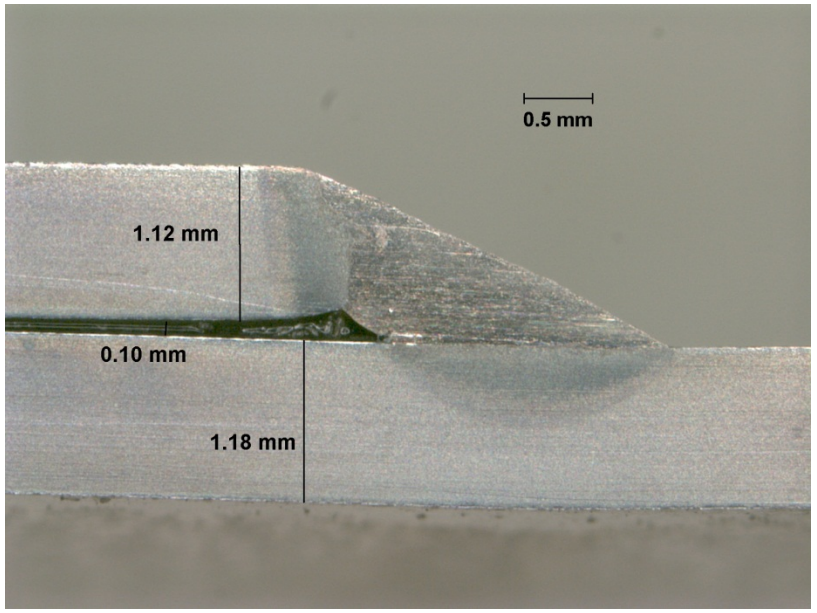
Laser Weld (Fusion) vs. Laser Braze (Metallic Bond)

Laser edge lap weld



Laser brazed lap joint



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Laser Brazing

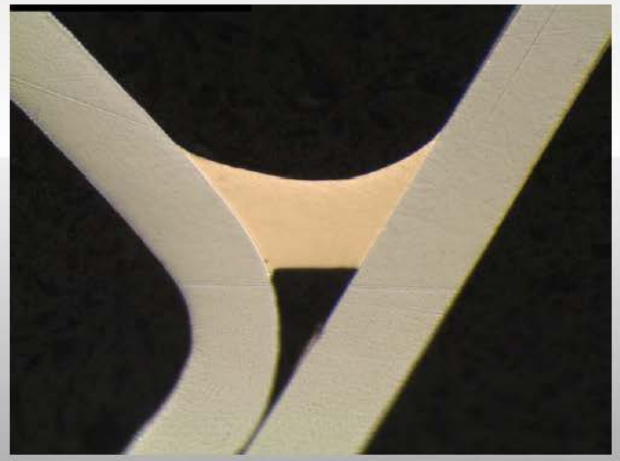
Laser Brazing

Steel application – Divided tailgate

Laser brazing with direct diode laser:

- joint directly visible to customer:
  - Highest demand on optical appearance
  - Highest demand on corrosion

A4 Limousine



Polished section:
Zero gap joint divided tailgate

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42

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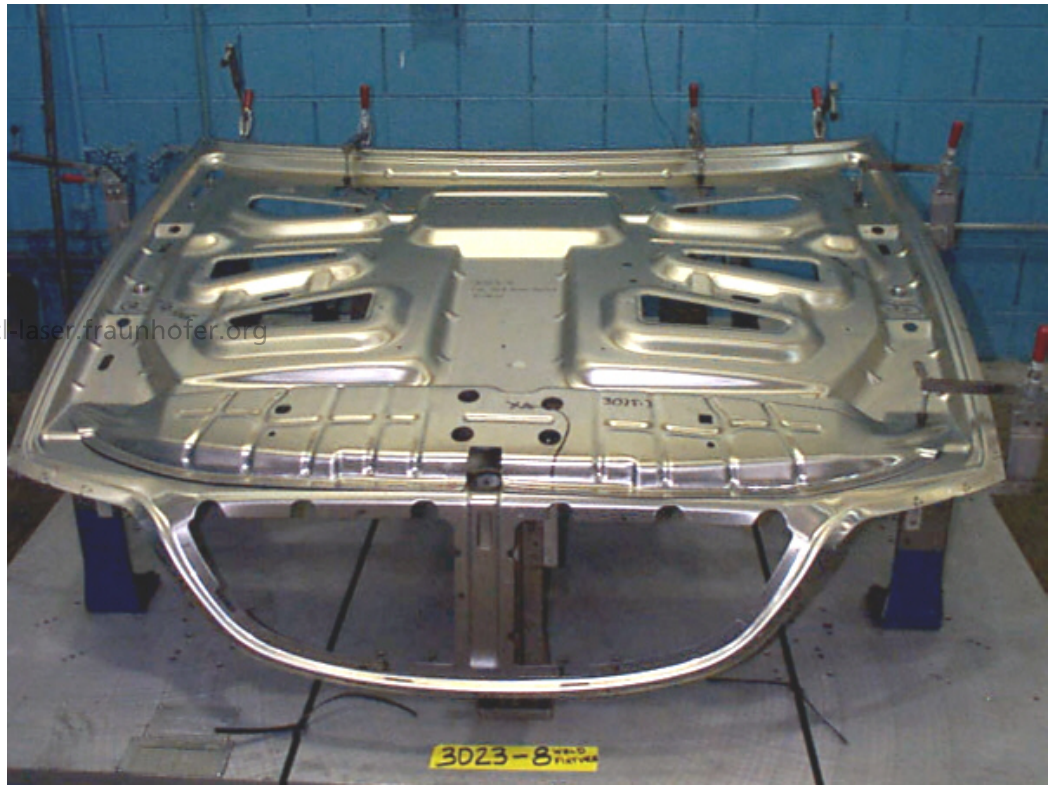
Fraunhofer USA Long Term Development Experience

- Aluminum Hood Welding in 2002 (Ford)
  - Overlap joints
  - Al6111 to Al6111 and Al6111 to Al5754 material combinations
  - Stitch welds



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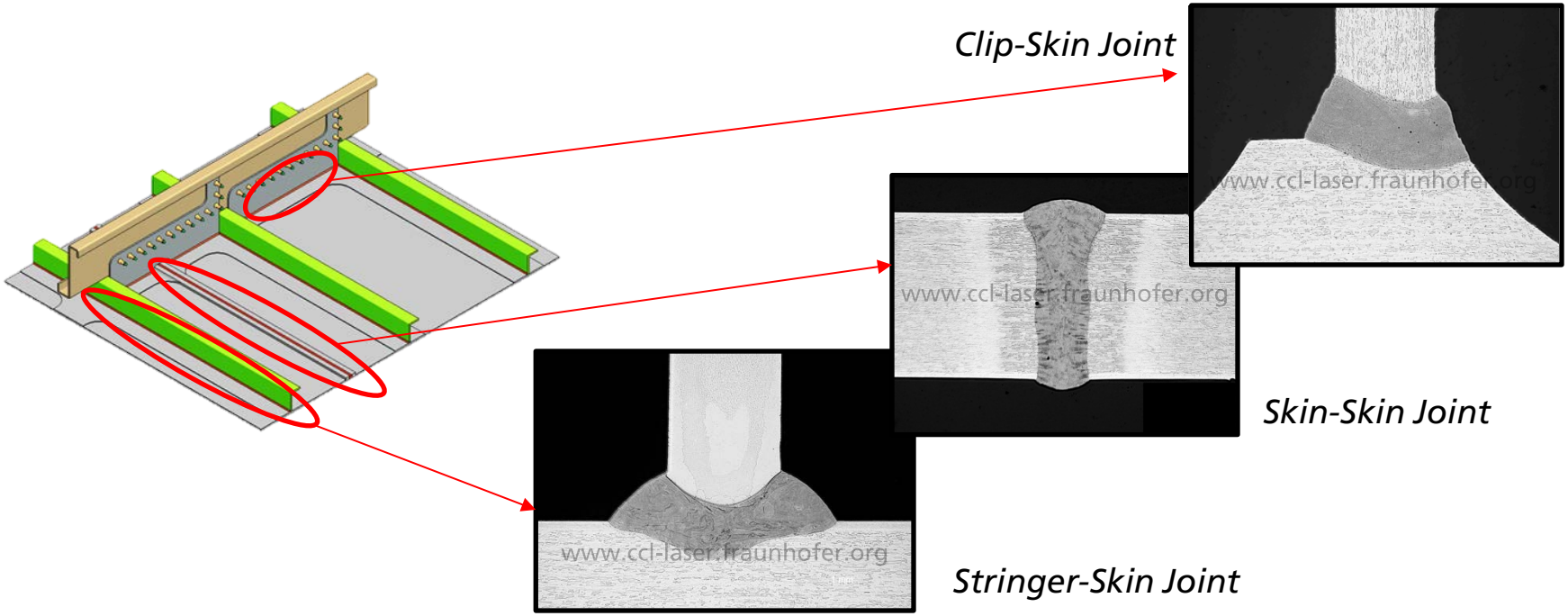
Fraunhofer Long Term Development Experience

- Aluminum Airframe Components
  - Fully welded metallic integral structure
    - Loading tolerant stringer-skin- joints
    - Load adapted clip-skin-joints
    - Damage tolerant skin-skin joints



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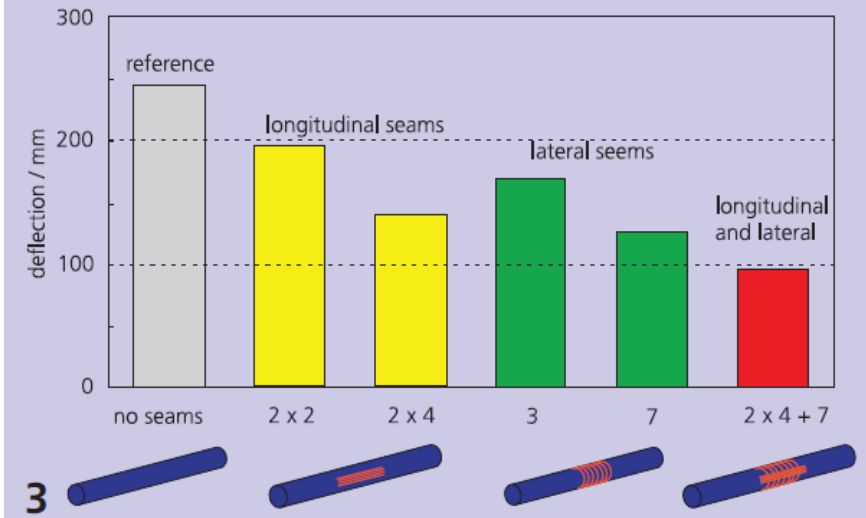
Laser Welding for Enhanced Crash Performance

Improvement of the crash behavior of laser strengthened pipes in dropping experiments



Crash performance of steel parts can be modified using the following processes:

- Laser Beam Hardening
- Laser Beam Welding (bead on plate)
- Laser build up welding (with filler wire)

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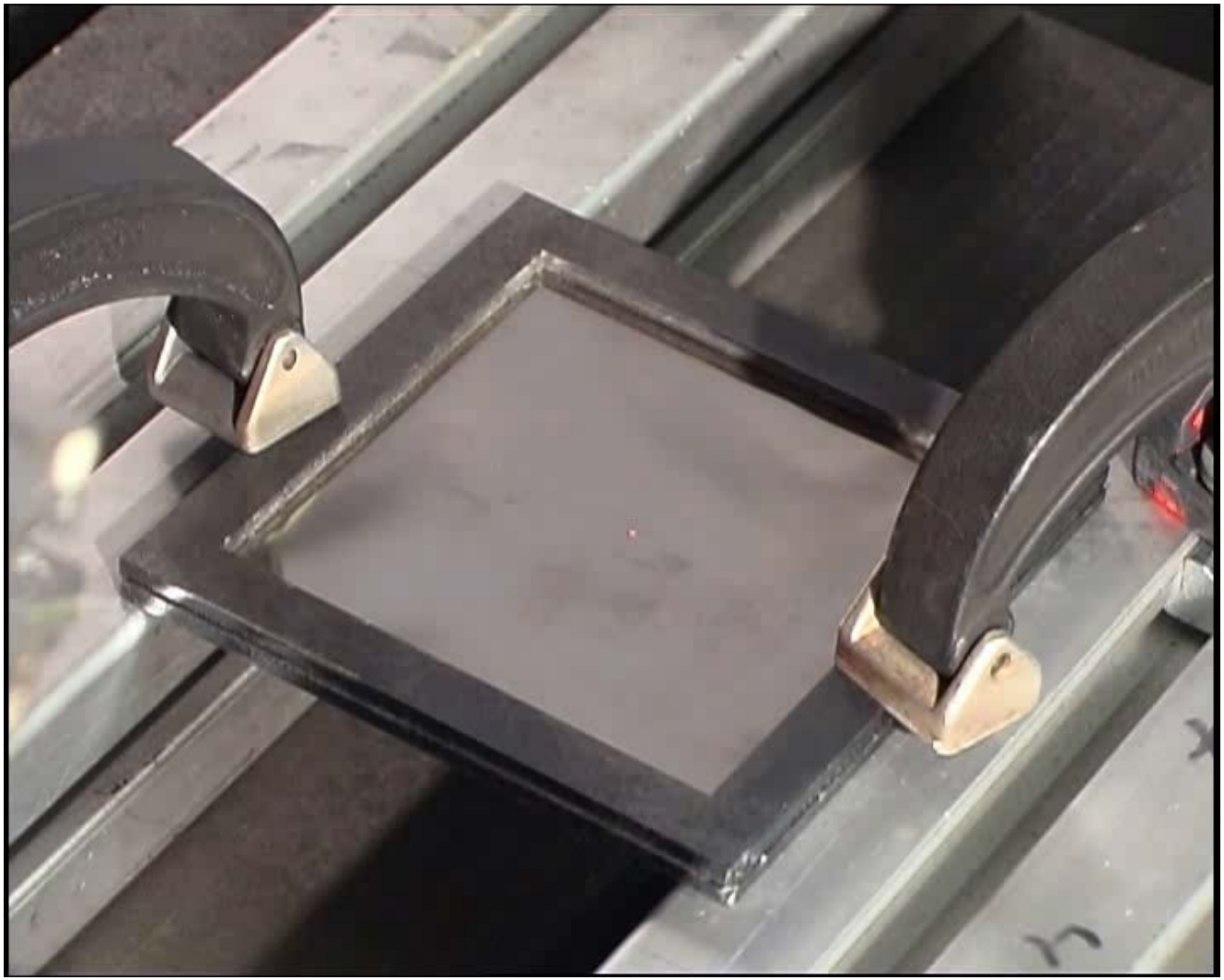
Video: High Speed Remote Cutting for steels and composite materials



Conclusions

- Increased use of Aluminum continuing for both automotive and aerospace applications. In addition to advanced high strength steels, Aluminum will enable future vehicle mass reduction and enable fuel efficiency improvements.
- Laser Welding is fast, flexible and automated and provides minimal heat input and distortion compared to conventional welding technology.
- Laser Welding with filler material can reduce crack susceptibility and loss of alloying elements, and can generate welds with strength properties close to the parent material
- Laser welding process applications development for Aluminum and other lightweight materials is ongoing at Fraunhofer as the Automotive and Aerospace industries continue to move towards lighter more fuel efficient vehicles.

Thank you!

You are invited!

Fraunhofer Annual Open House Event Next Week!

Contact: Craig Bratt
Director – Laser Applications
Email: cbratt@fraunhofer.org
Tel. 734 738 0550

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