PE – 225 Material Technology -2

Course Mini Project

Laser Beam Welding (LBW) of Aluminum Alloys

Under Supervision of
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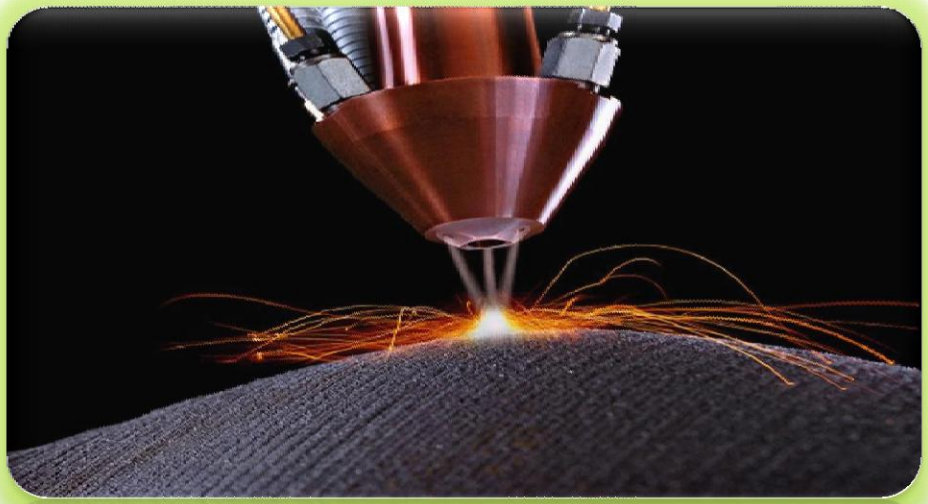
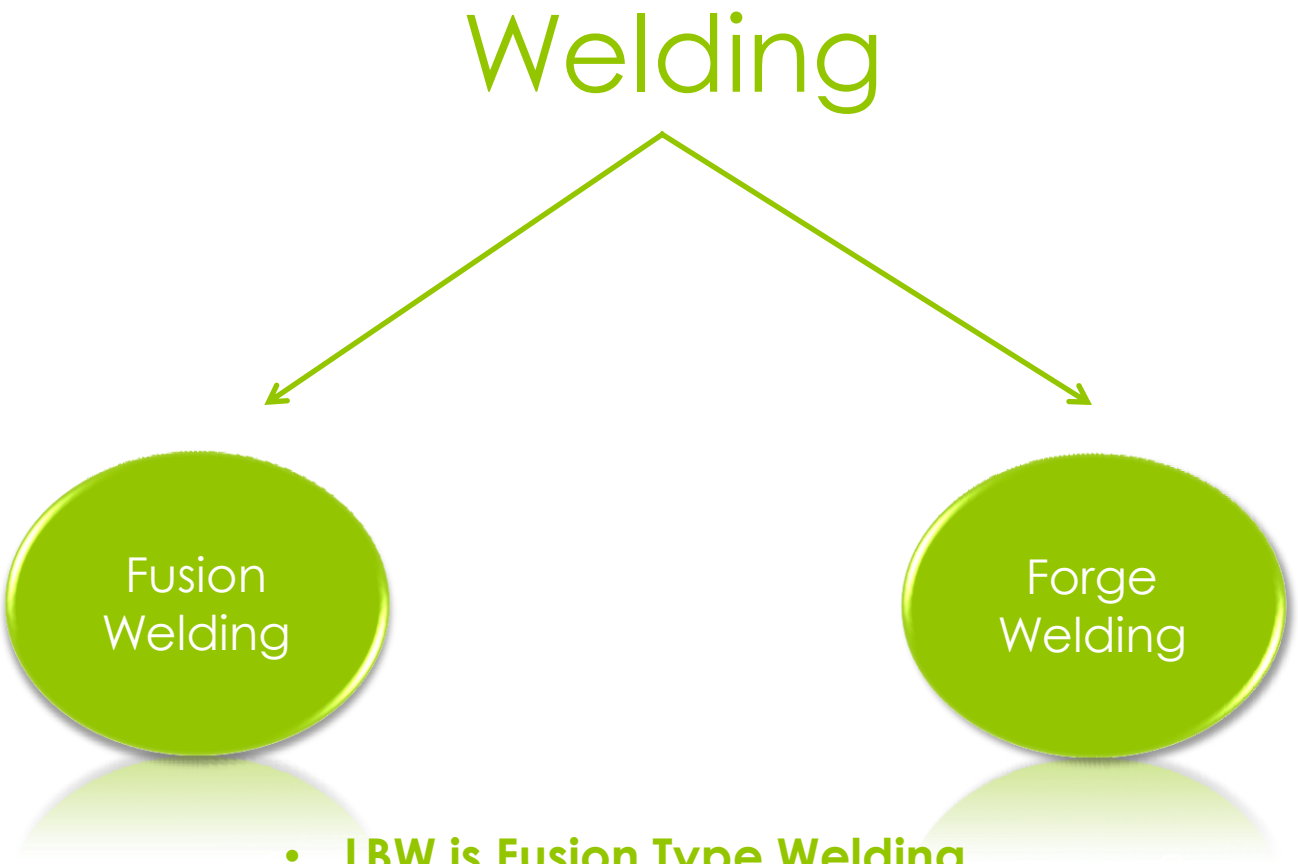


Laser Beam Welding

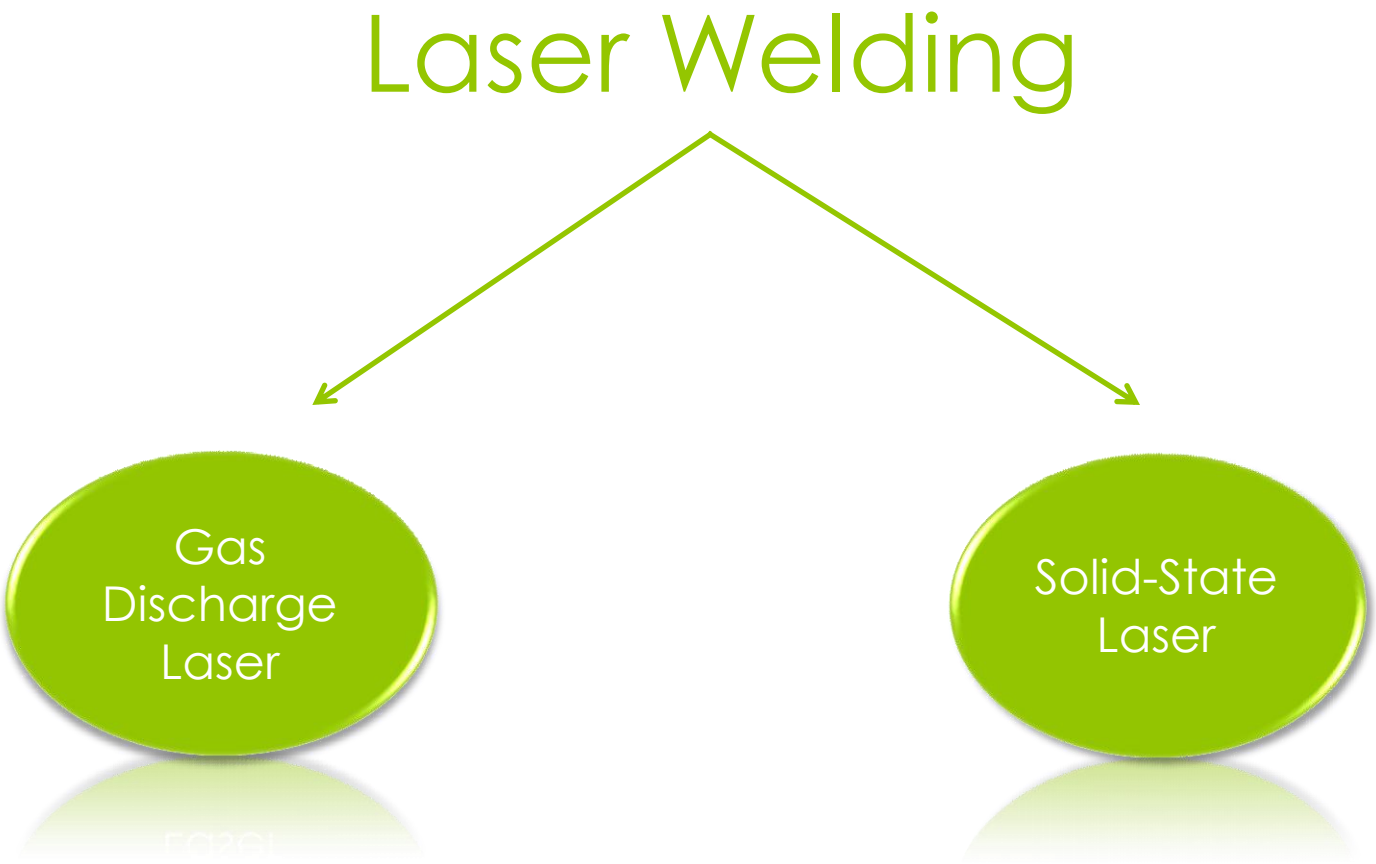


- **LBW is Fusion Type Welding**

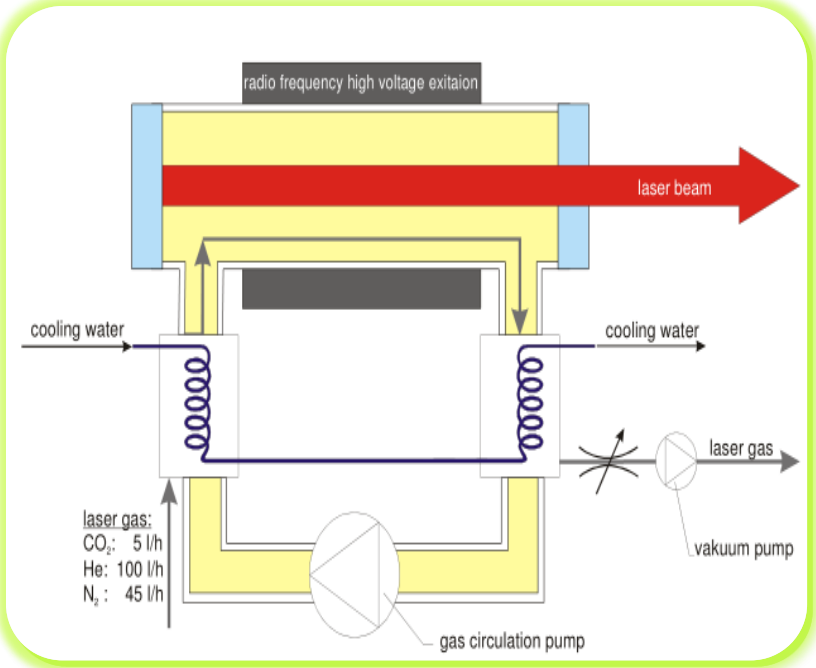
LBW Principle

- Laser is an acronym for light amplification by stimulated emission of radiation.
- Laser Beam Welding (LBW) is a fusion joining process that produces coalescence of materials with the heat obtained from a concentrated beam of coherent, monochromatic light impinging on the joint to be welded

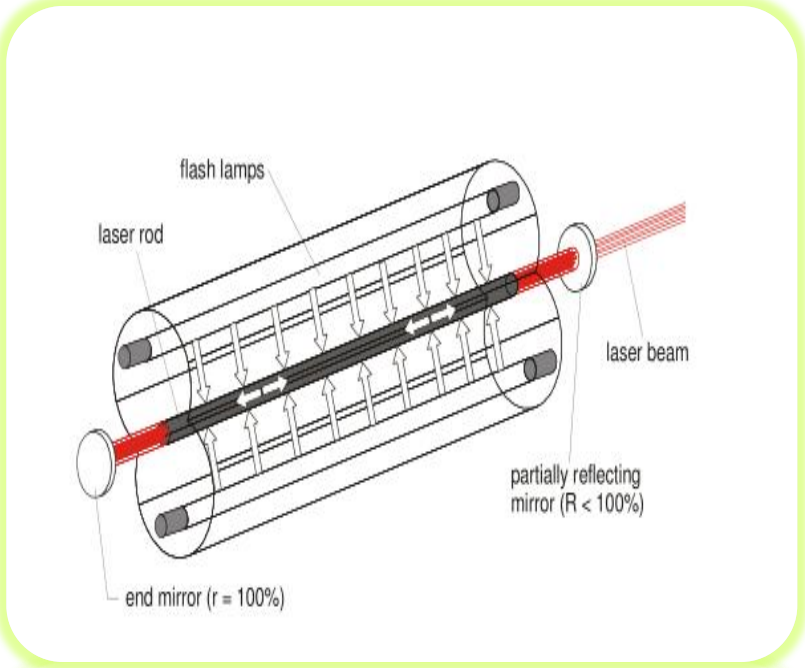
Source : Applications of Lasers in Materials Processing by Metzbower


Laser Welding
Gas Discharge Laser
Solid-State Laser

LBW Principle



Gas Discharge

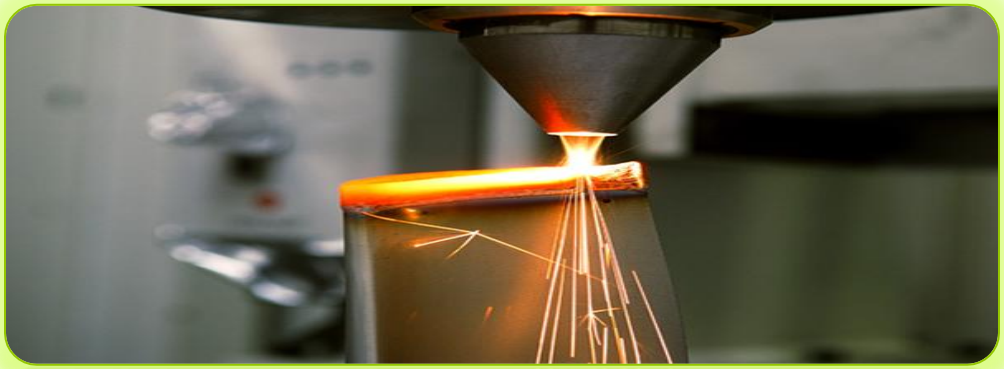


Solid State

Source : ISF aachen

Advantages of LBW

- Low possibility of HAZ in the joint
- No need for filler metal
- Reduce Latency
- No tool wear
- LBW is not influenced by magnetic fields



Source : Applications of Lasers in Materials Processing by METZBOWER

Limitations of LBW

- Joints must be accurately positioned
- Maximum weld penetration is limited (19-21mm)

- High reflectivity and high thermal conductivity of materials like Aluminum effect the weldability of the joint

Case Study

Source : Applications of Lasers in Materials Processing By METZBOWER

Objective

We need to increase the density of the laser beam to overcome the welding problems (reflectivity , heat conductivity) which is achieved by increasing the power as given in the formula –

$$Beam\ Density = \frac{Power}{Area\ X\ C}$$

And as a result of high focus finer grains are produced

Aluminum Alloy 5456

Chemistry Data

Aluminum	Balance
Chromium	0.05 - 0.2
Copper	0.1 max
Iron	0.4 max
Magnesium	4.7 - 5.5
Manganese	0.5 - 1
Silicon	0.25 max
Titanium	0.2 max
Zinc	0.25 max

Applications

- **Pressure Vessels**
- **Marine Applications**

Source : Aluminum.org

Choosing Laser Machine

Specifications	MW 120	MW 160	MW 300	MW 400
Wavelength	1064 nm	1064 nm	1064 nm	1064 nm
Lasertype	Nd.:YAG flash lamp	Nd.:YAG flash lamp	Nd.:YAG flash lamp	Nd.:YAG flash lamp
Mean Power	120 Watt	160 Watt	300 Watt	400 Watt
max. Pulse Energy	80 Joule	120 Joule	120 Joule	120 Joule
max. Peak Power	9 kW	13 kW	13 kW	13 kW
Pulse width	0.5-20 ms	0.5-20 ms	0.5-50 ms	0.5-50 ms
Pulse Frequency	0.5 to 20 Hz	0.5 to 20 Hz	0.5 to 100 Hz	0.5 to 100 Hz
Focus Diameter	0.2 - 2.0 mm motorized	0.2 - 2.0 mm motorized	0.2 - 2.0 mm motorized	0.2 - 2.0 mm motorized
Focal Distance	100 mm	100 mm	100 mm	100 mm
Cooling System	Water/Air integrated	Water/Air integrated	Water/Air external	Water/Air external

Laser Machine

Sigma Laser Welding Machine MW 400 Series

Special features:

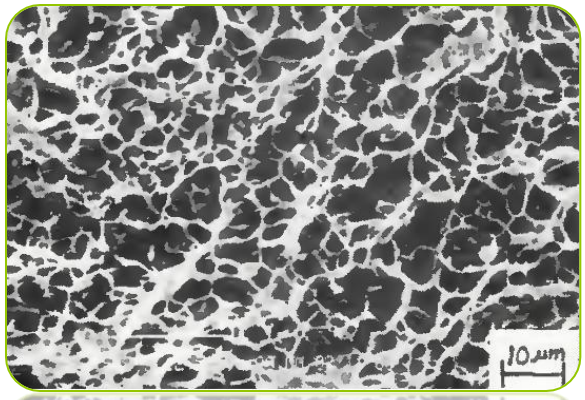
- Pulse shaping for welding special alloys to make near perfect welds on highly reflective materials .
- Variable density of Laser Beam according to high peak pulse power

Source : Sigma Laser GmbH

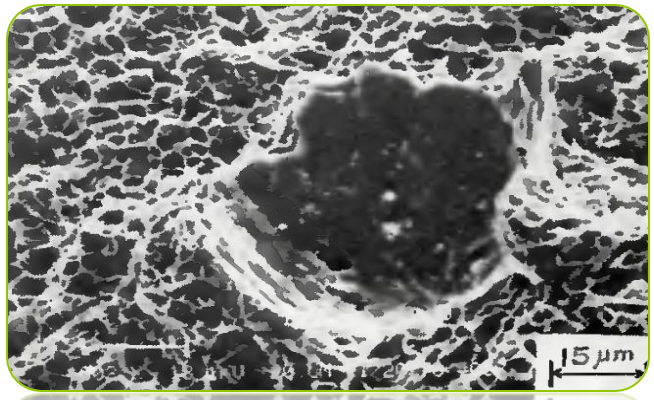
Metallographic Examination

- Transverse cross sections were cut from the weldments for metallographic examination.
- Specimens were polished with diamond powder less than 1 μm

Electron Beam Microprobe Analysis



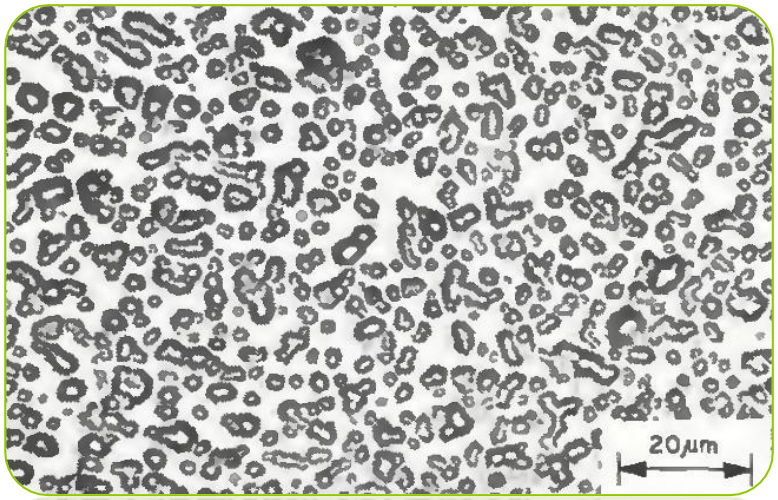
Fracture surface of DT specimen



Typical pore of the fracture surface of a DT specimen of a laser weld

Metallographic Examination

Representative microstructures of the fusion zone and the base metal .



Fine grained Al solid solution in fusion zone of Al 5456 laser weldment.

The microstructure of fusion zone is considerably finer than that for the base metal.
This is attributed to the fact that laser beam is a very high density power source.

Conclusion

- More than 90% of the precipitates are vaporized during laser beam welding
- Both the tensile strength and ductility of the laser beam weldments are lower than the base metal properties.
- The toughness values (DT energy) of the laser beam weldments are superior to the base plate values due to the fusion zone purification mechanism and refined structures.

Source : D. W. MOON AWS Publications 1983

Thank You

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Beshoy Raafat	2	53
Takla Nabil	3	55
Mohamed Mostafa	6	156