XLVII CONGRESSO NACIONAL DE SOLDAGEM
CONSOLDA
&
III CBMAdi
CONGRESSO BRASILEIRO DE MANUFATURA ADITIVA

The COAMWELD project is founded by VLAIO, under Grant Number HBC.2020.2994

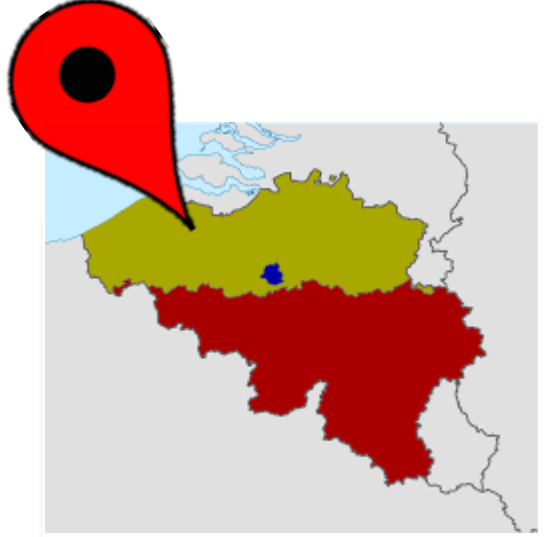
COAMWELD

Belgian Welding Institute
Joining your future.

Overcoming the Challenges in the Welding of Additively Manufactured Aluminium Alloy Parts: Paving the Way for Aerospace & Defence Applications

Sr. Eng. Rafael Nunes
Belgian Welding Institute, UCLouvain, UGent
IIW Future Leader 2025-2026

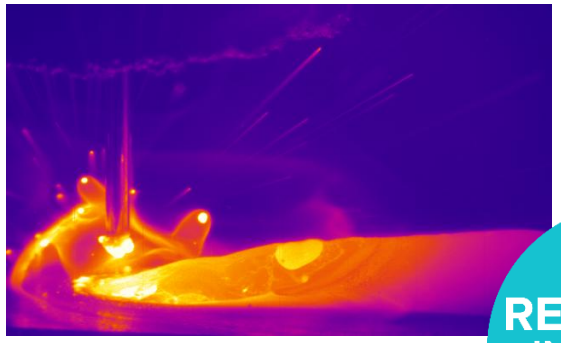
ABS Associação Brasileira de Soldagem
INSTITUTO SENAI DE TECNOLOGIA
INSTITUTO SENAI DE INOVAÇÃO
fapesc Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina
CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico



80 YEARS
1942 – 2022
BELGIAN WELDING INSTITUTE
WELDING EXPERTISE

- Located in Ghent (*NL: Gent – FR: Gand*)
  capital of East Flanders, Belgium
- Founded in 1942 (Founder-member of IIW)
- Official Language: Dutch (*Flemish*)
  Other Languages: English, French, German, Portuguese
- More than 150 international projects performed
- More than 240 associated companies

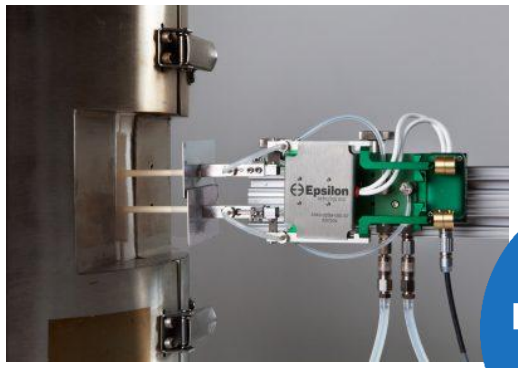
Activities



TRAINING & EVENTS

RESEARCH & INNOVATION

WELDING STANDARDS



Joining your future.
Belgisch Instituut voor Lastechniek vzw

MATERIALS & WELD TESTING

CORROSION & FAILURE ANALYSIS

WELDING CONSULTANCY

Training and Events

Flandres: government authorization for training
(KMO-portefeuille)

Active participation in the harmonized European/international training framework:

European Federation for Welding, Joining, Cutting and Surfacing (EWF)

International Institute of Welding (IIW)

Organizer of European and/or international training:

International Welding Engineer (IWE)

International Welding Technologist (IWT)

International Welding Specialist (IWS)

International Welding Inspection (IWI-C, IWI-S)

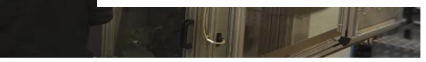
International Robot Welding Personnel (IRWP)

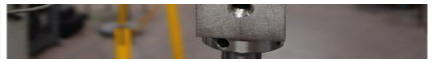
Responsible Welding Coordinator Basic (EWCP-1090 B)

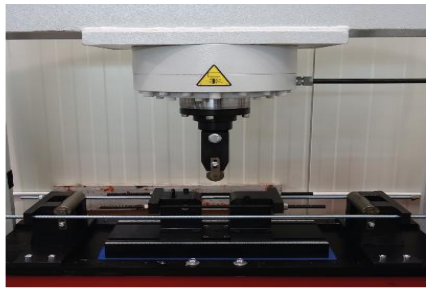
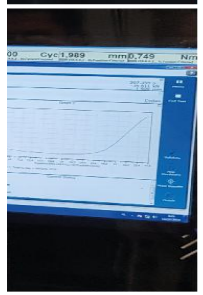
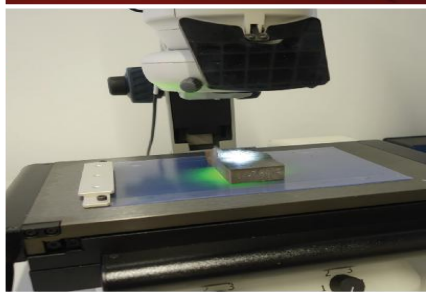
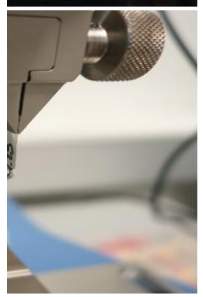
Approval for training via the Association Belge de Soudage (ABS)

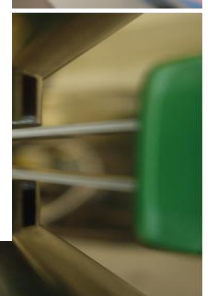
Visual Inspection of Welds (ISO9712)

BWI – Material Test Laboratory







ISO/IEC 17025 accredited destructive testing services for base- and weld materials:

- Tensile testing
- Bend testing
- Impact testing
- Fracture mechanics testing (CTOD)

BELAC Nr. 718-TEST ISO/IEC 17025

ISO9001 CERTIFIED VINÇOTTE

Destructive testing services outside accreditation

- Tensile testing at low- and elevated temperature
- Tensile testing of welded rebars
- Fracture testing
- Fatigue testing
- Custom testing according to client specifications
- Corrosion-fatigue testing
- Crack growth rate testing
- Instrumentation of strain gauges

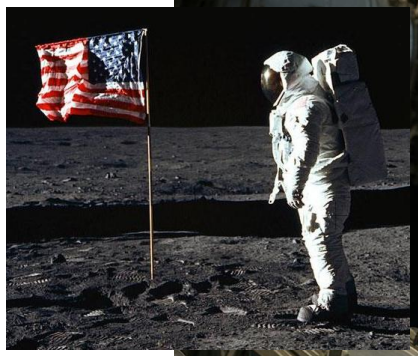
Metallurgical Analysis:

- OM
- SEM
- EDX
- EBSD
- TEM
- Computed Tomography

Europe's Focus on Weldability of AM Aluminium Alloys

- Strategic EU Research Funding
- Focus on Aerospace & Defence Readiness
- Key Role In Circular and Agile Maitenance
- Dedicated Research on Aluminium Alloy Weldability

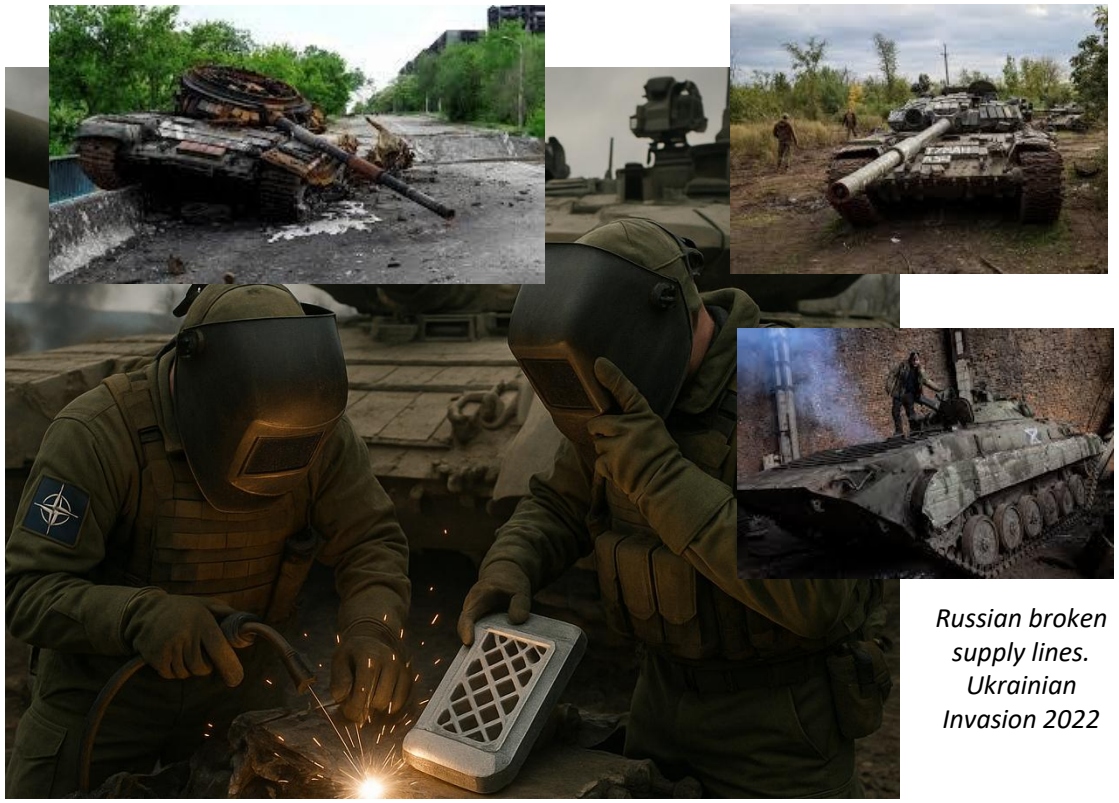
- Collaborative Projects Across Industry and Academia
- Support for Dual-Use Technologies
- Emphasis on Lightweight, High-Performance Materials



USA – Men on the Moon 1969

USSR – Welding in Space 1969

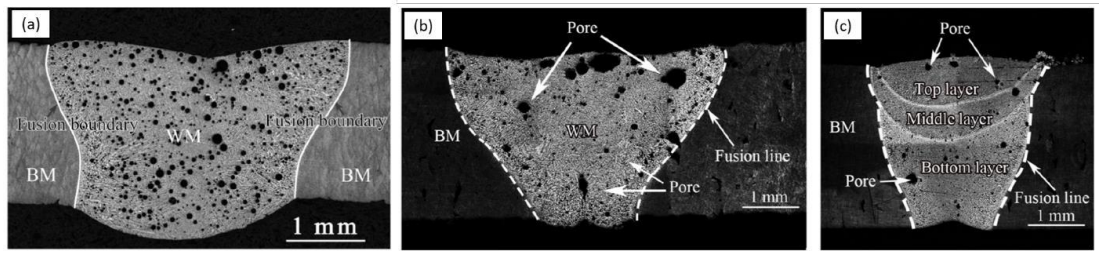
Figures created by AI

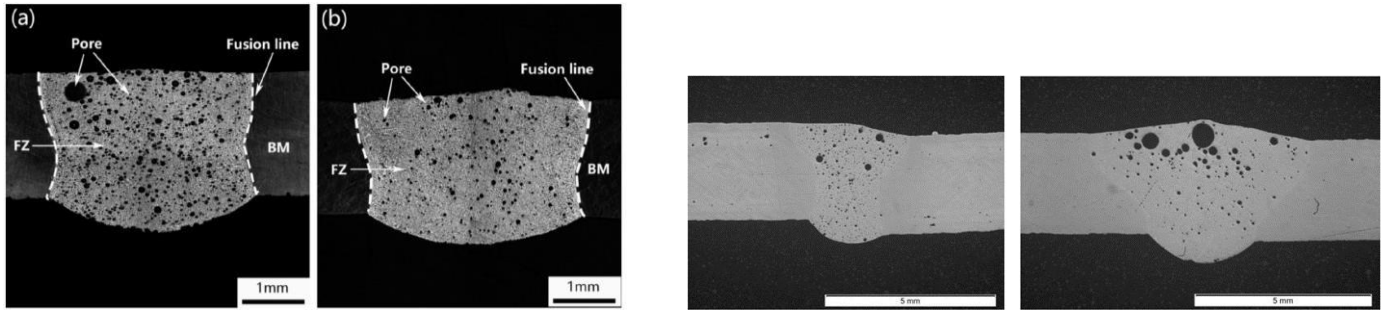


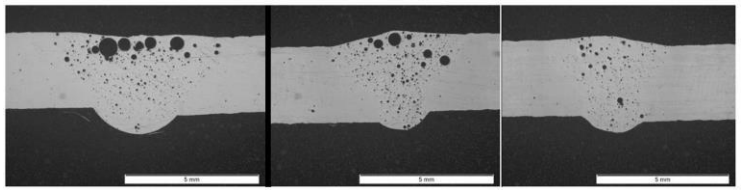
Russian broken supply lines. Ukrainian Invasion 2022

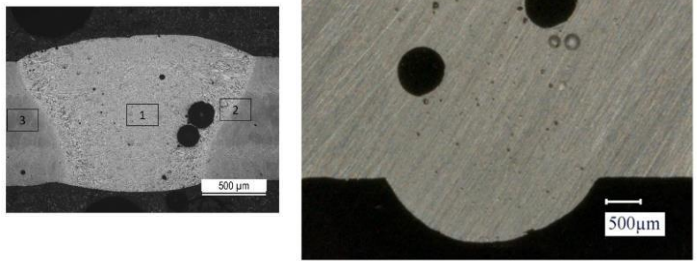
Europe’s Focus on Weldability of AM Aluminium Alloys

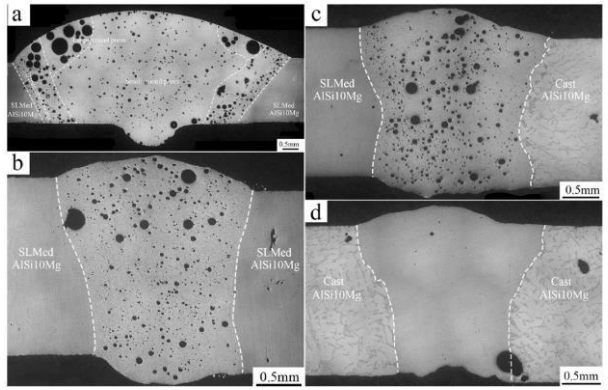
Current Status of the Art | Weldability of AM-ed Al Alloy Parts









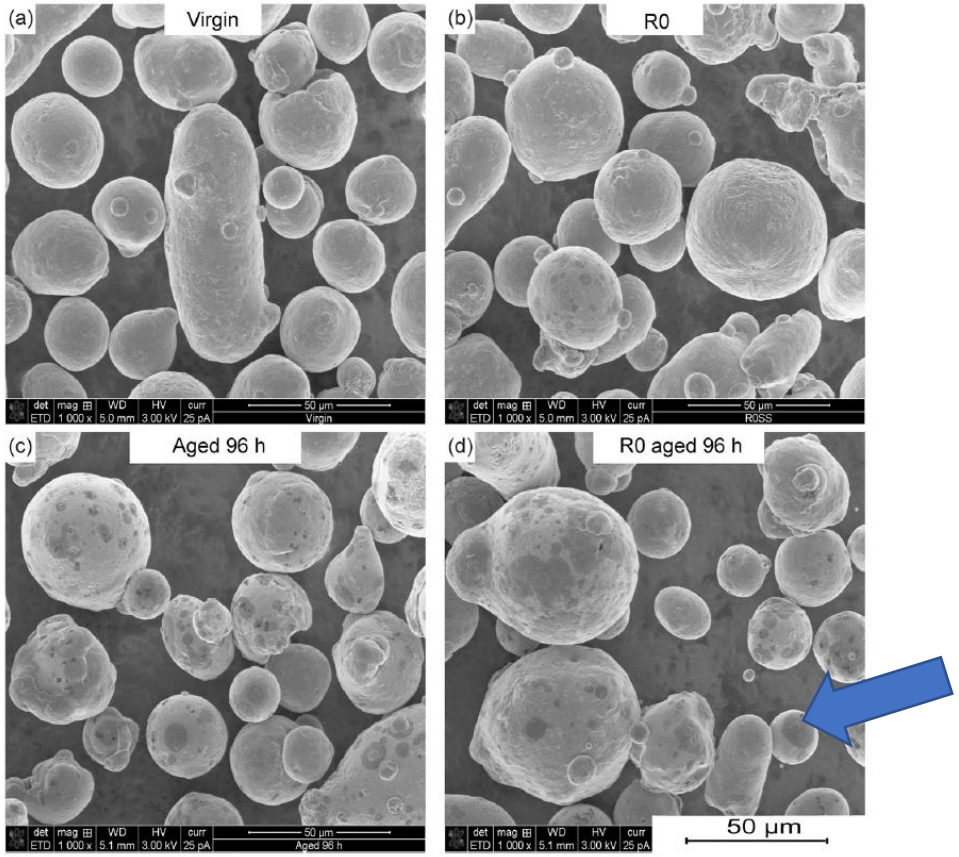


Unlikely the porosity can be entirely avoided by optimization of welding parameters.
Other fusion welding processes are likely to suffer from porosity issues.

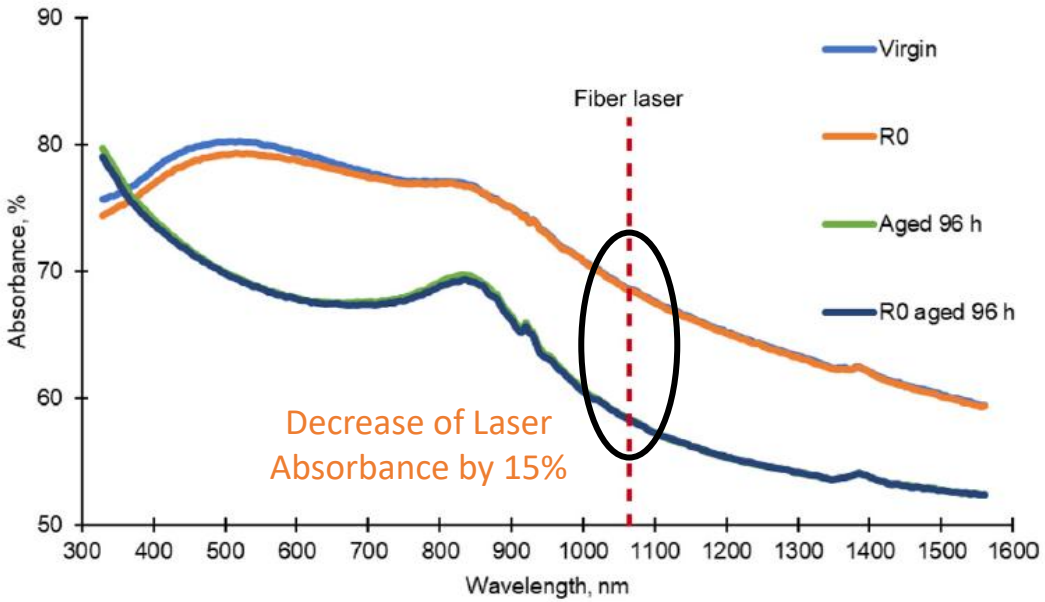
Main Theory:
High porosity levels in PBF-LB joints are formed due to the hydrogen porosity in the PBF-LB base material.

- Higher surface area to volume ratio compared to wire filler material
- Most powder have included porosity
- Most commercial equipment control is based on O_2 content (not by creating a vacuum and then filling it with Ar)
- Common to recycle powder in the PBF-LB process.

Particle Morphology, Porosity and Surface Oxidation



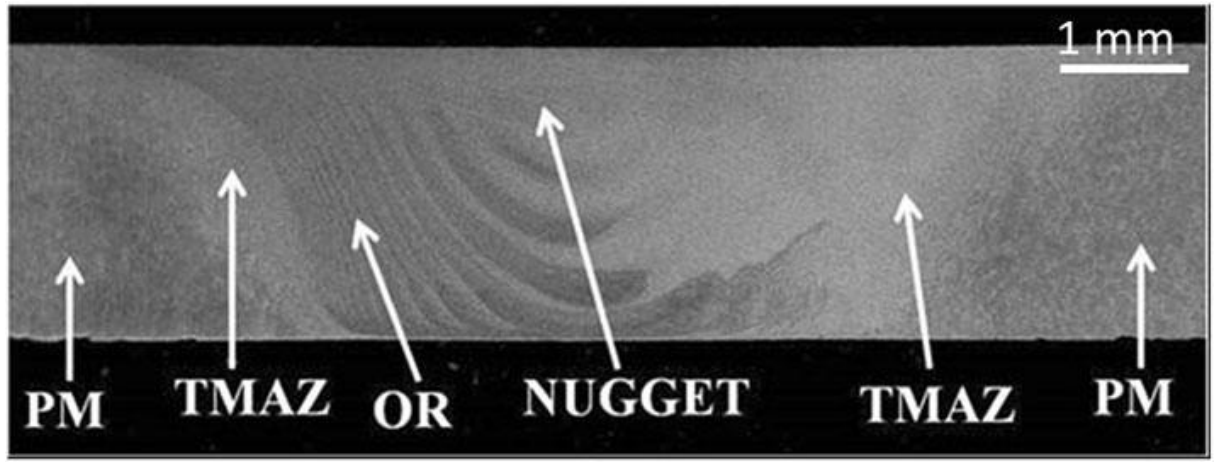
Morphology and surface oxidation condition of new and recycled AlSi10Mg powder

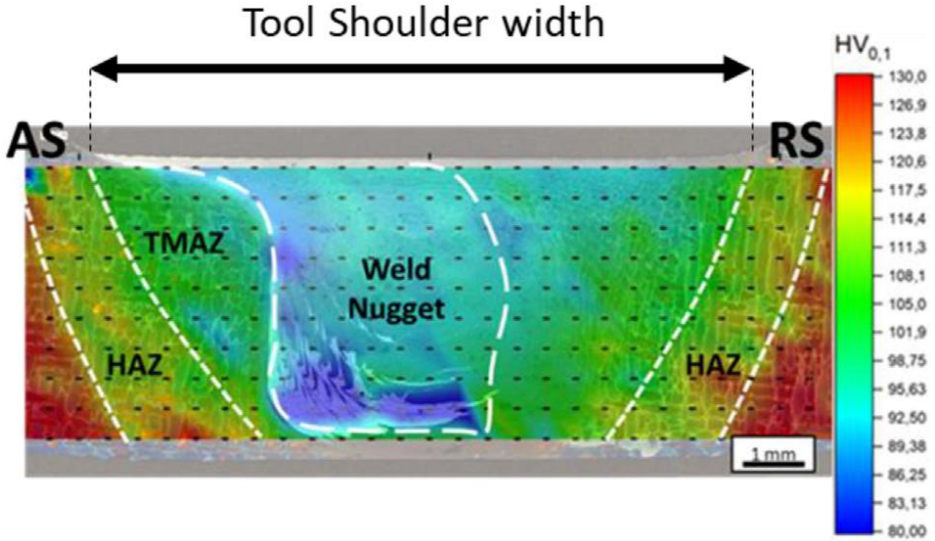


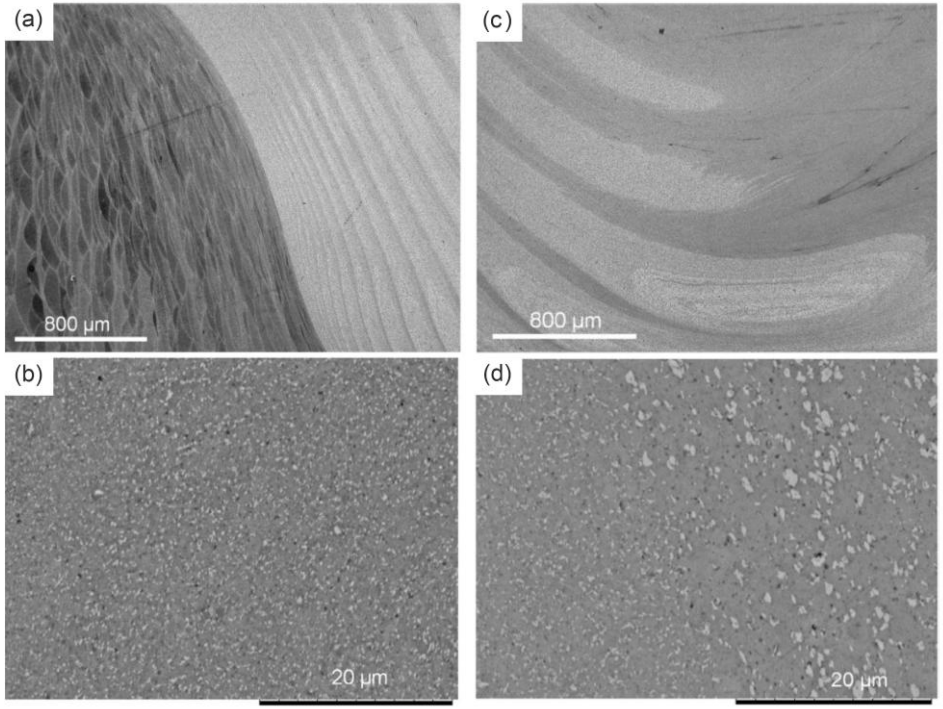
Powder state	Average laser light absorbance [%]
Virgin	68.55 (±0.10)
R0	68.48 (±0.09)
Aged 96 h	58.23 (±0.13)
R0 aged 96 h	58.13 (±0.09)

Fedina, T. *et al.* Influence of AlSi10Mg Powder Aging on the Material Degradation and its Processing in Laser Powder Fusion. Powder Technology 412 (2022) https://doi.org/10.1016/j.powtec.2022.118024

Current Status of the Art | Weldability of AM-ed Al Alloy Parts







Four distinct regions presenting different levels of recrystallization and grain refining:

Base Material (BM)
Thermo-Mechanically Affected Zone (TMAZ)
Onion rings (OR)
Weld Nugget (WG)

Softening in the nugget zone: coarsening of Si-particles (Advancing Size)

→ Welds without any macroscopic defect

Current Status of the Art | Weldability of AM-ed Al Alloy Parts

metals

MDPI

Review

A Review on the Weldability of Additively Manufactured Aluminium Parts by Fusion and Solid-State Welding Processes

Rafael Nunes [1,2,3,*], Koen Faes [1], Wim De Waele [2], Aude Simar [3], Wim Verlinde [1], Matthieu Lezaack [3], Wout Sneyers [2] and Julius Arnhold [4]

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[2] Department of Electromechanical, Systems and Metal Engineering, Ghent University, 9052 Ghent, Belgium; wim.dewaele@ugent.be (W.D.W.); wout.sneyers@ugent.be (W.S.)
[3] Institute of Mechanics, Materials and Civil Engineering, Université Catholique de Louvain, 1348 Louvain-la-Neuve, Belgium; aude.simar@uclouvain.be (A.S.); matthieu.lezaack@uclouvain.be (M.L.)
[4] Chair of Materials Engineering of Additive Manufacturing, TUM School of Engineering and Design, Technical University of Munich, 85748 Garching, Germany; julius.arnhold@tum.de
* Correspondence: rafael.nunes@bil-ibs.be

Abstract: Additive manufacturing (AM) processes are playing a significant role in several industrial sectors such as construction and machine building industries, involving a wide variety of metallic materials. Among these, the AM of aluminium alloys has developed significantly over the last decade, mainly through Powder Bed Fusion (PBF) and Directed Energy Deposition (DED) processes. Despite the many advantages of AM technology, some large or complex products cannot be produced entirely without the use of conventional manufacturing and joining processes, generally for financial or operational reasons. In this way, the ability to join conventionally and additively manufactured components or parts represents a crucial step towards their future use and the consolidation of conventional and additive manufacturing technologies. Despite the growing interest in AM technologies, there is still a significant lack of information on the joining of conventionally and additively manufactured components. The present work proposes a first review of the literature evaluating the weldability of AM aluminium alloys. The focus is on the use of fusion and solid-state welding processes and analysing the achieved microstructural evolution and mechanical properties. A clear relationship is observed between the AM technology used to produce the part, and the physical principles of the joining process. In addition, the gaps in the literature are highlighted to enable focused future work.

Keywords: additive manufacturing; aluminium; powder bed fusion; directed energy deposition; wire arc additive manufacturing; weldability

check for updates

Citation: Nunes, R.; Faes, K.; De Waele, W.; Simar, A.; Verlinde, W.; Lezaack, M.; Sneyers, W.; Arnhold, J. A Review on the Weldability of Additively Manufactured Aluminium Parts by Fusion and Solid-State Welding Processes. *Metals* **2023**, *13*, 1724. https://doi.org/10.3390/met13101724

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1. Introduction

Additive manufacturing (AM) technology has evolved steadily over the last decade to overcome the challenges and operational and financial drawbacks associated with conventional manufacturing processes. AM is a tool-less, near-net-shape production technology, based on three-dimensional (3D) model data [1]. This new type of processing has provided industries with unprecedented opportunities to produce metal components with complex free-form geometries, where such geometries are not achievable using conventional manufacturing techniques [2,3].

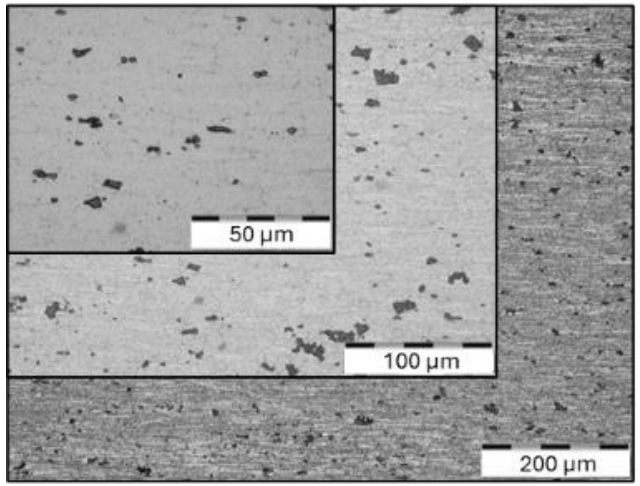
Among the various types of AM processes for manufacturing metallic components, two groups are highlighted as the most promising for industrial applications: Powder Bed Fusion (PBF) and Directed Energy Deposition (DED) processes. Although there may be similarities between the two groups, such as the possibility of using powder as feedstock material, and although some processes of both groups can use the same heat source, such

R. Nunes *et al.* **A Review on the Weldability of Additively Manufactured Aluminium Parts by Fusion And Solid-State Welding Processes**. Metals. Vol 13(10), 2023. https://doi.org/10.3390/met13101724

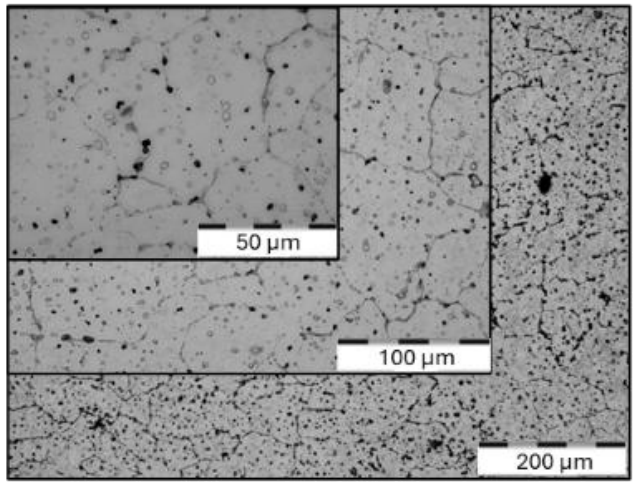
Base Materials

PBD: Parallel to Build Direction (vertical direction) / PDD: Parallel to Deposition Direction (horizontal direction)

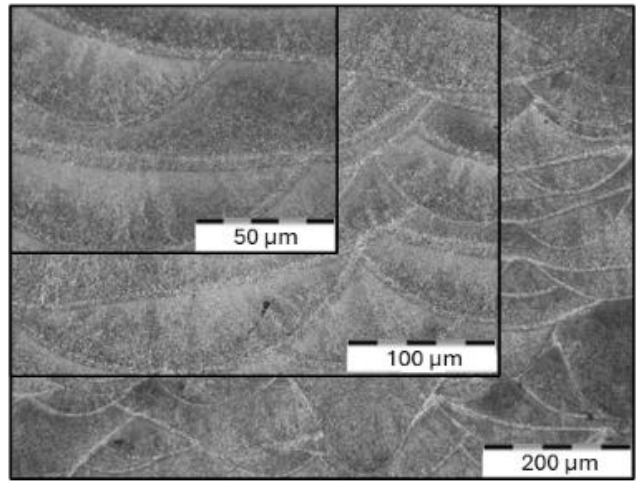
CONV EN AW-5083 Longitudinal



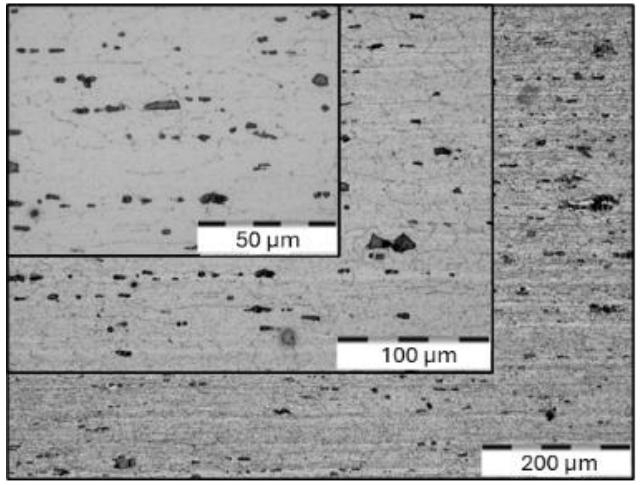
WAAM ER 5183 PBD



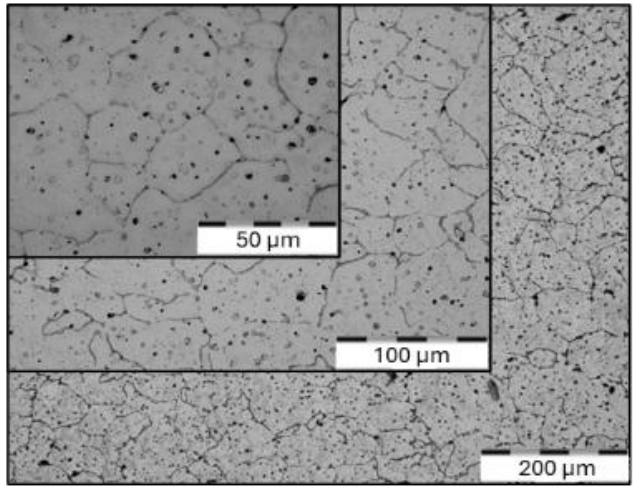
PBF-LB AlSi10Mg PBD



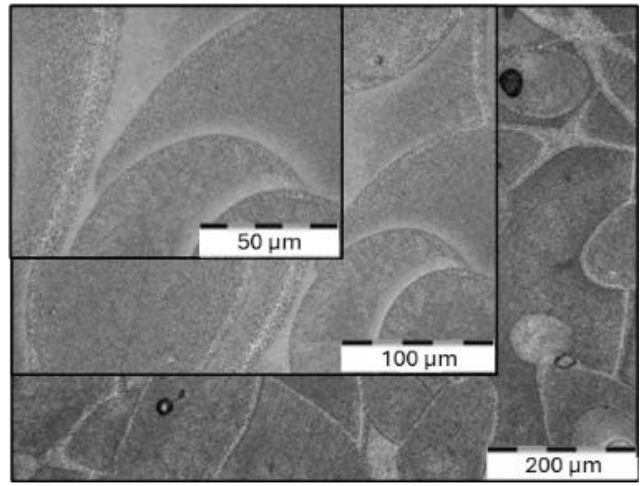
CONV EN AW-5083 Transversal



WAAM ER 5183 PDD



PBF-LB AlSi10Mg PDD

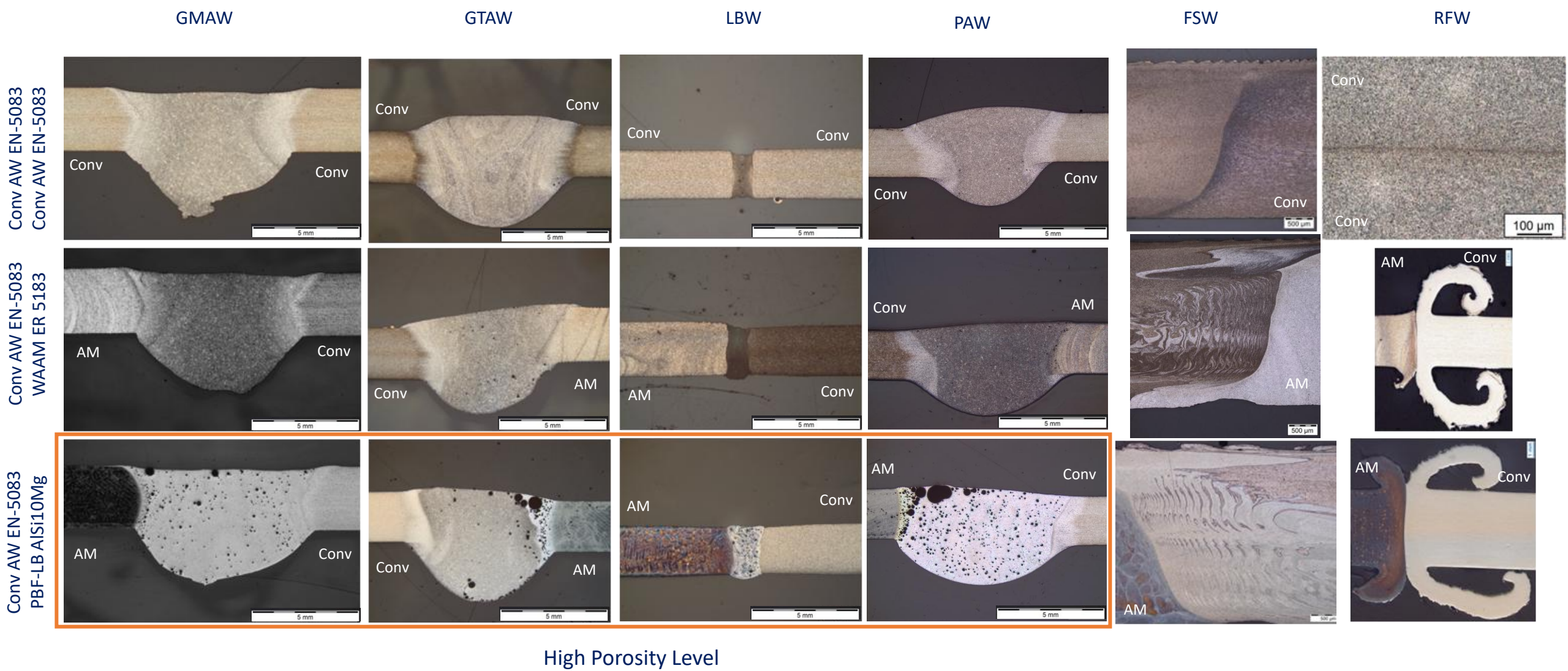


CONV UTS: 310.6 MPa

PBF-LB UTS: 435.6 MPa

WAAM UTS: 288.4 MPa

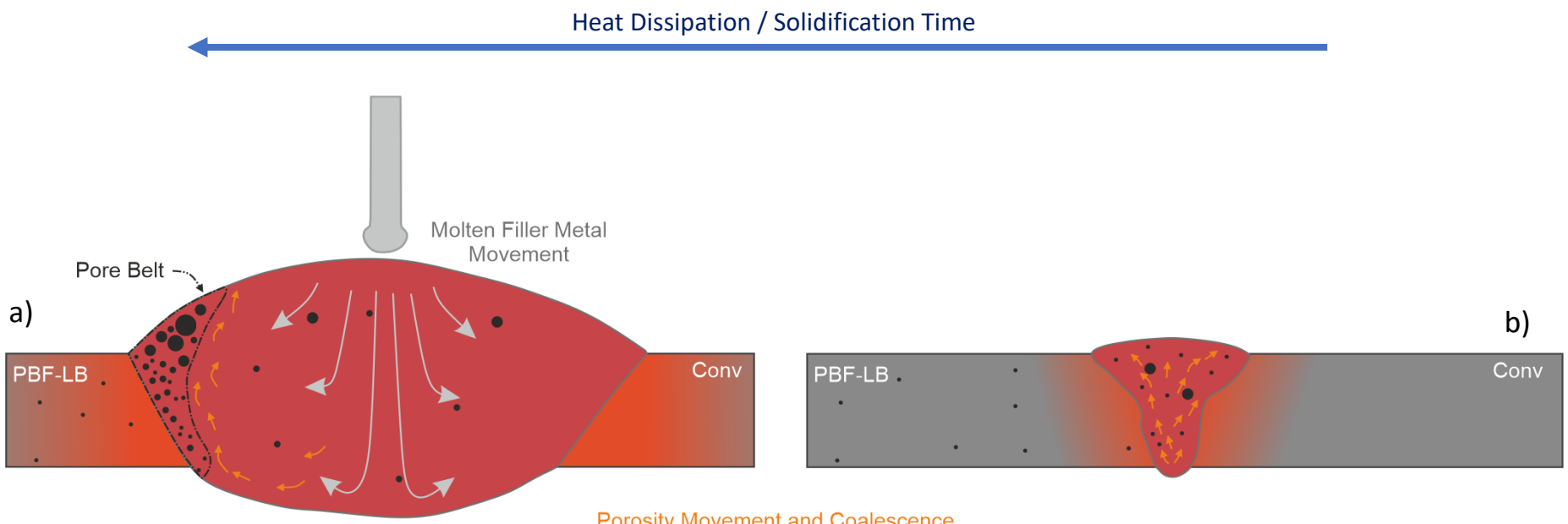
Evaluated Welding Processes | Metallographic Examination



High Porosity Level

Evaluated Welding Processes | Pore Belt Region

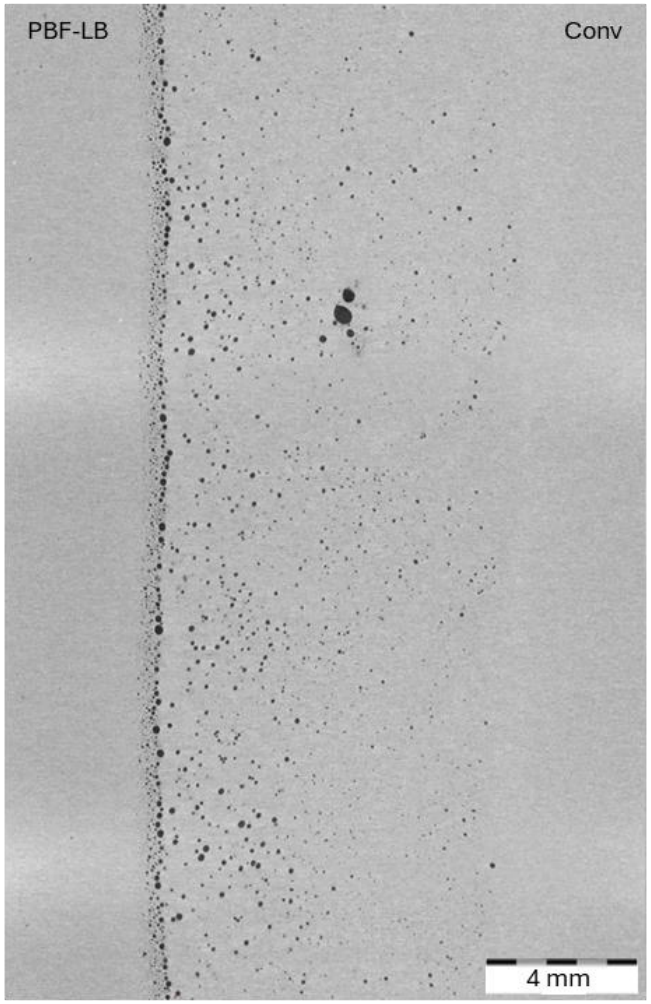
(a) Arc Welding Processes with Filler Metal Feeding



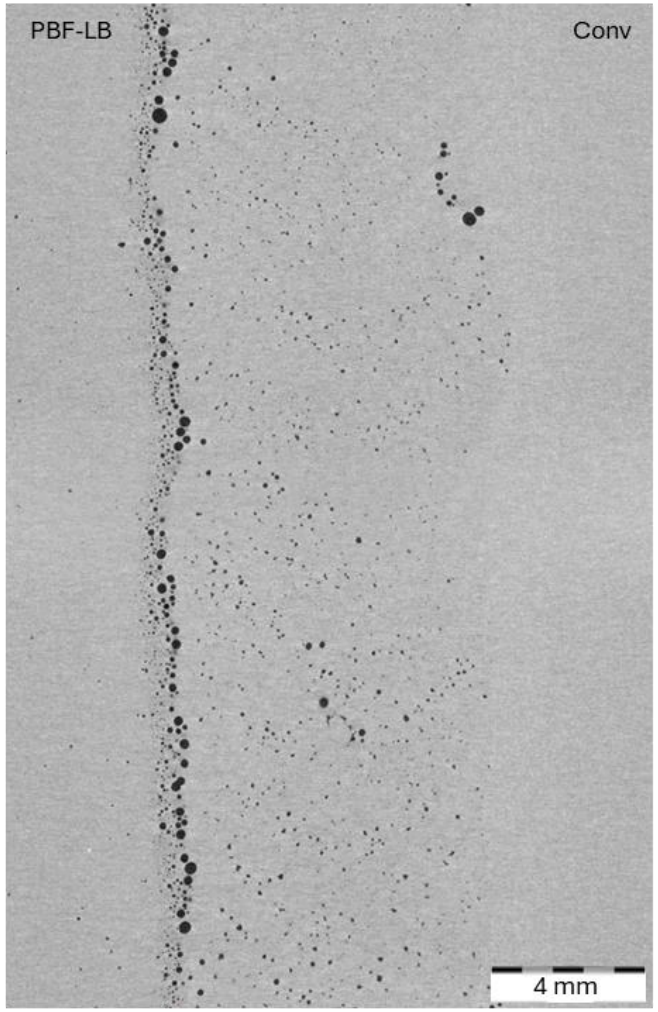
(b) Laser and Electron Beam Welding Processes without Filler Metal Feeding

Evaluated Welding Processes | CT of Pore Belt Region

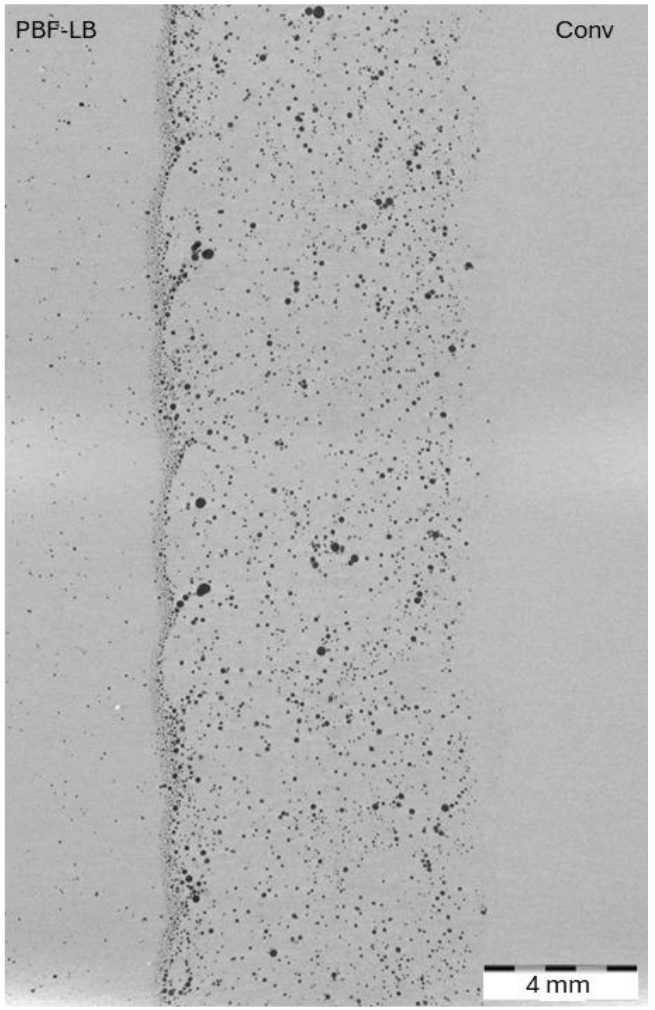
a) GMAW with Laser Cleaning



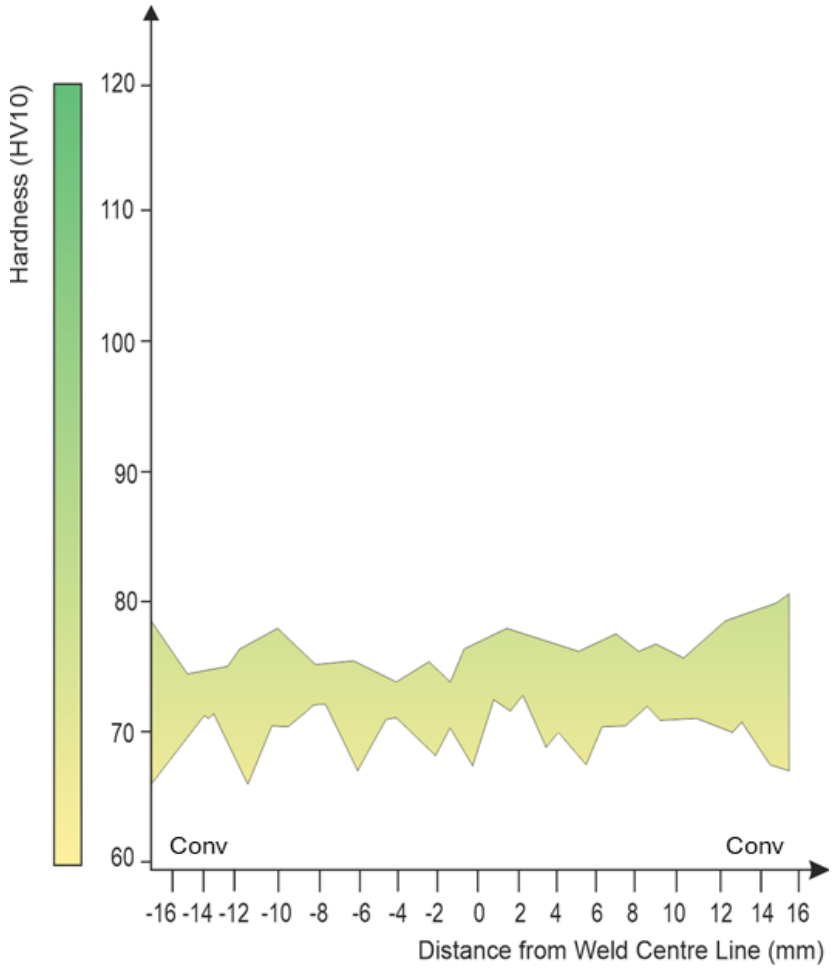
b) GTAW

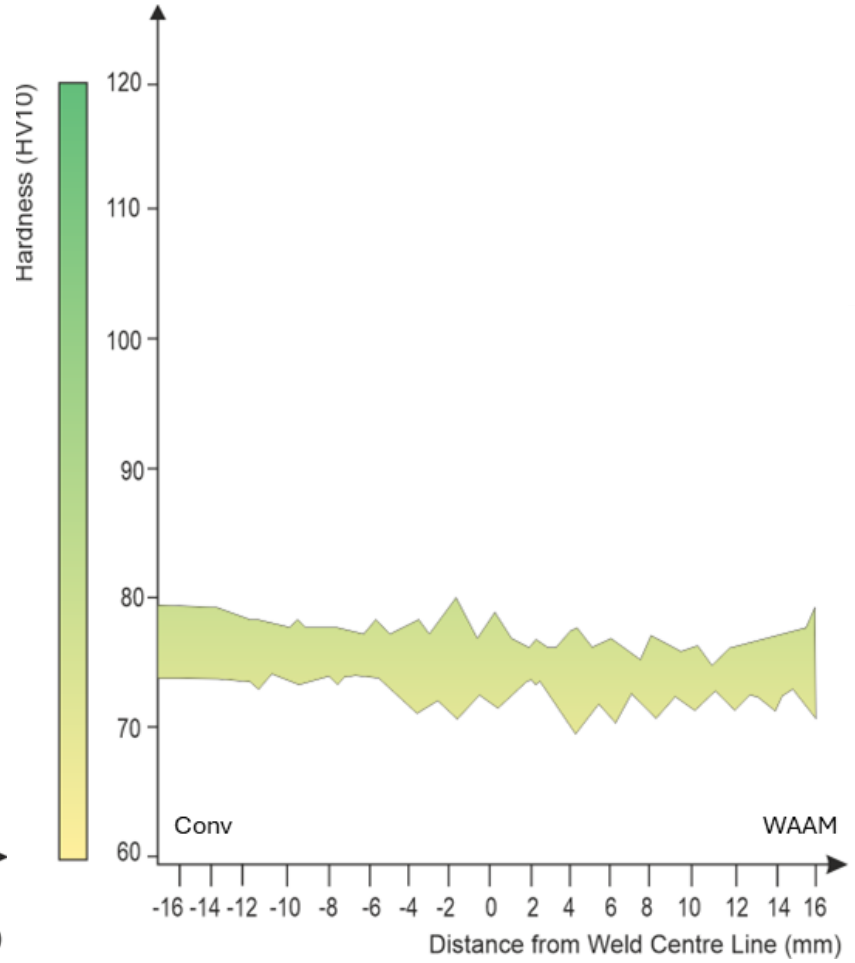


c) PAW



Evaluated Welding Processes | Hardness Evolution
Welds Between Conv - Conv and Conv - WAAM Materials





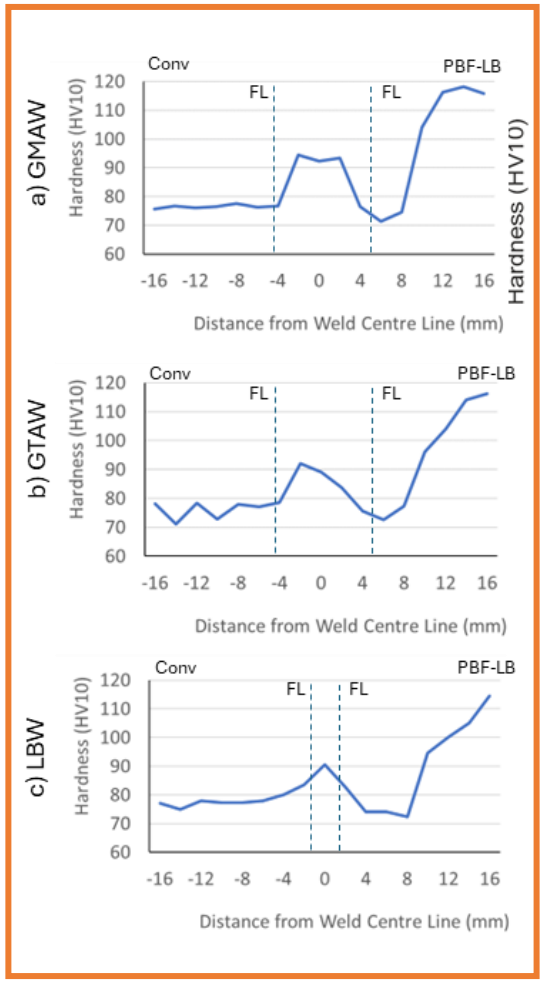
Hardness Profile of Welds Performed by GTAW, GMAW, PAW, LBW, FSW, and RFW

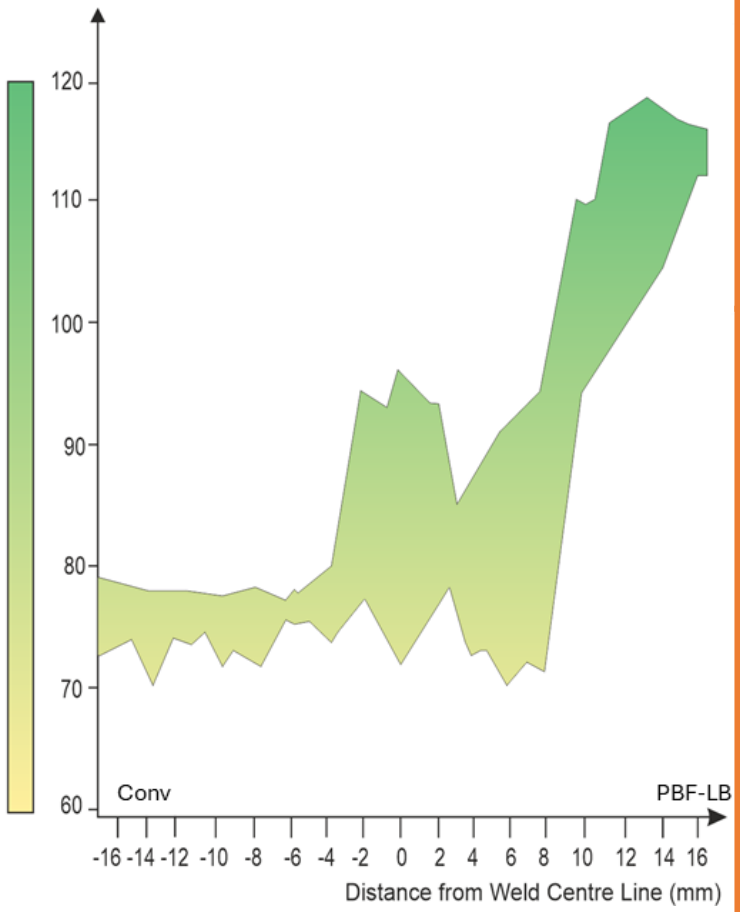
Hardness measurements (HV10) taken in the centre of the plate thickness. Distance between indentations = 2 mm

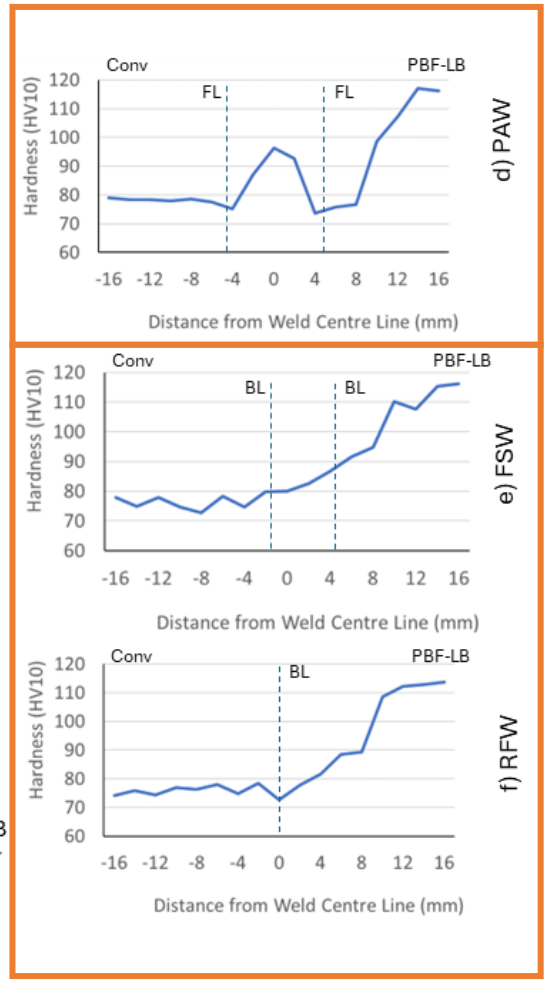
Welds between Conv – Conv and Conv-WAAM materials:

- No signifcant variations in the hardness profiles

Evaluated Welding Processes | Hardness Evolution
Welds Between Conv – PBF-LB Materials







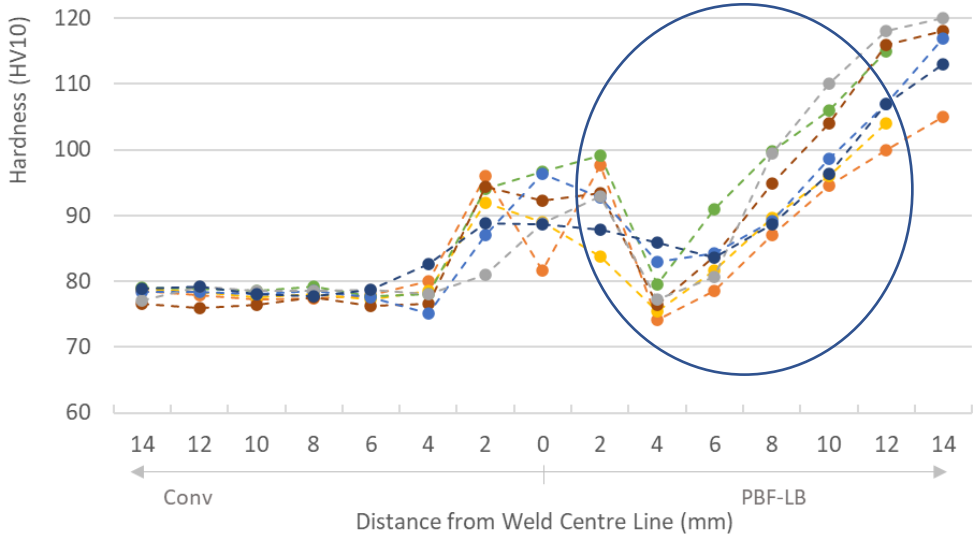
Hardness Profile of Welds Performed by GTAW, GMAW, PAW, LBW, FSW, and RFW

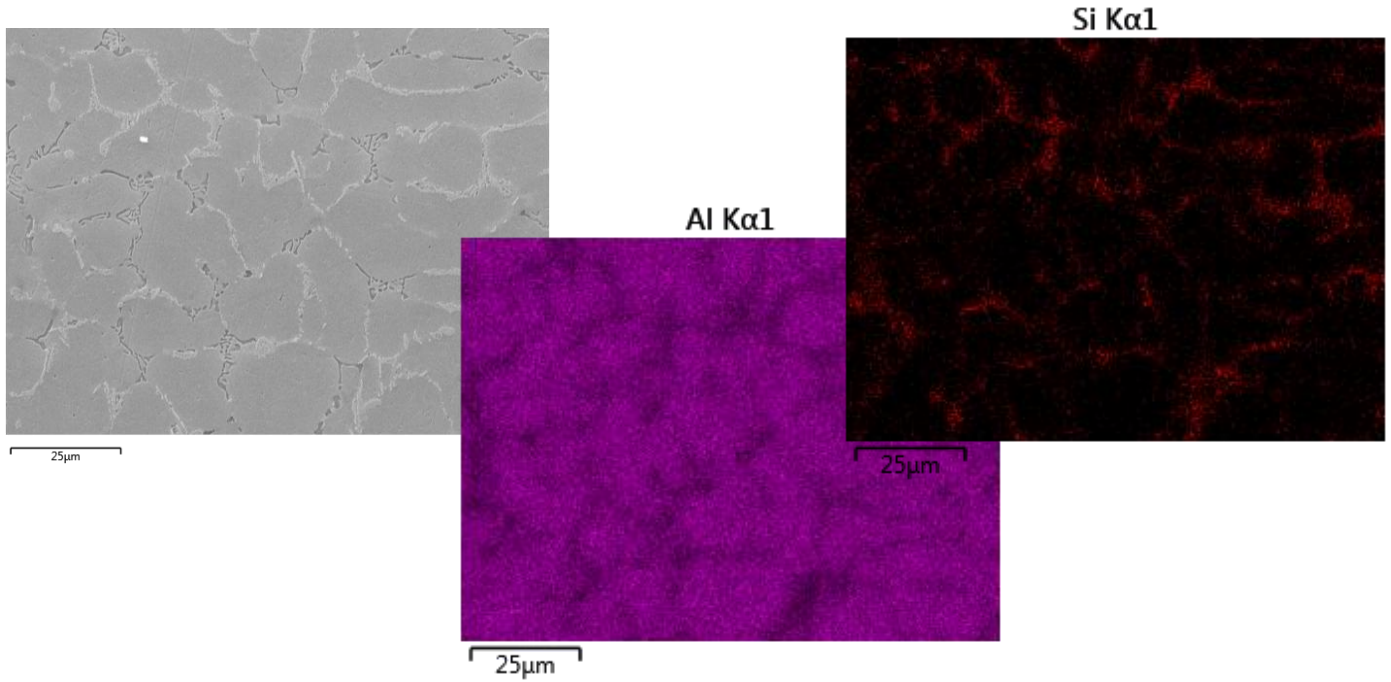
Hardness measurements (HV10) taken in the centre of the plate thickness. Distance between indentations = 2 mm

Welds between Conv – PBF-LB materials:

- Fusion Welding Processes:
  - Hardening in the WM zone
  - Softening in the HAZ of the PBF-LB material
- Solid-State Welding Processes:
  - Smooth increasing of the hardness from the Conv to the PBF-LB material

Evaluated Welding Processes | Metallographic Examination - Fusion



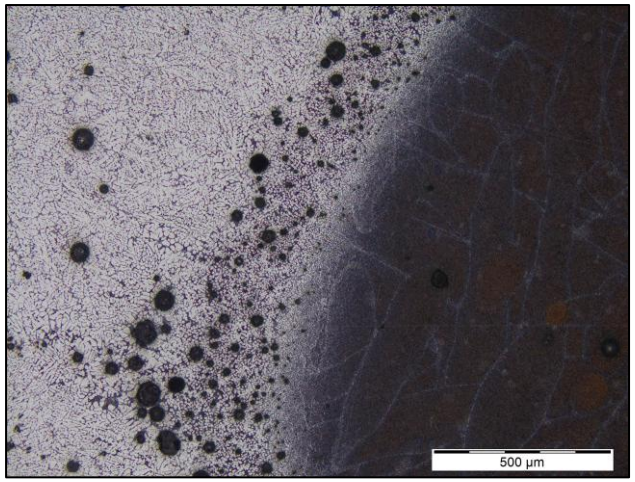


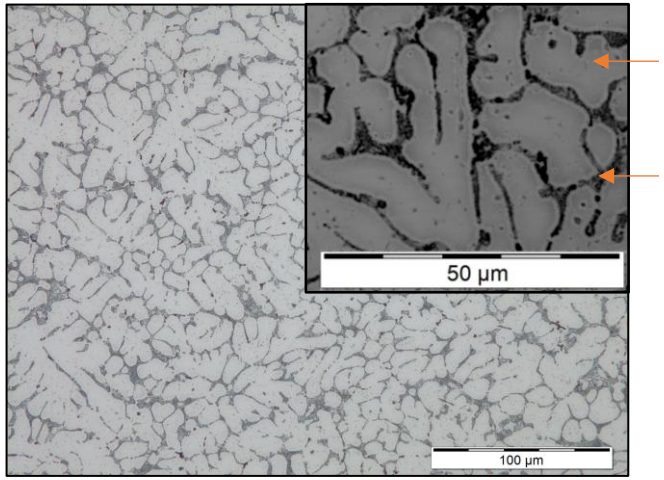
<u>Hardening</u> in WZ in the Conv - PBF-LB welds :

- α-Al cells surrounded by Si-rich eutectic phases

<u>Softening</u> in HAZ of Conv - PBF-LB welds :

- Pore belt region formation decreasing the hardness and strength
- Spheroidization of the silicon in the base material

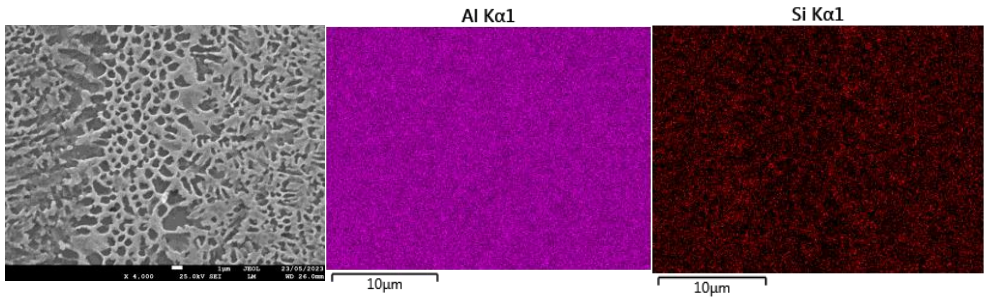


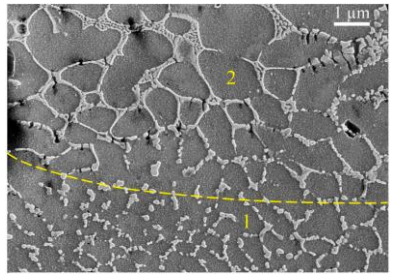


α-Al cells

Si-rich eutectic phases

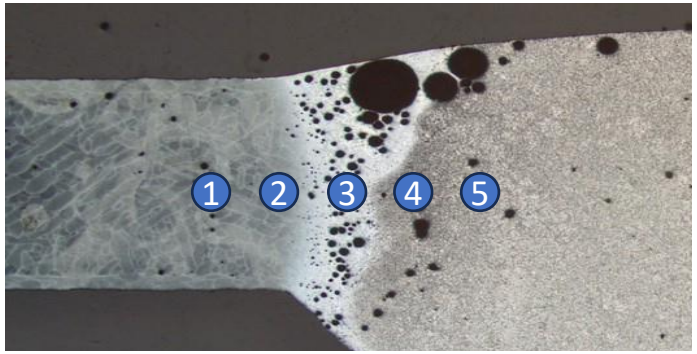
Evaluated Welding Processes | Metallographic Examination – Fusion Eutectic Si Particles

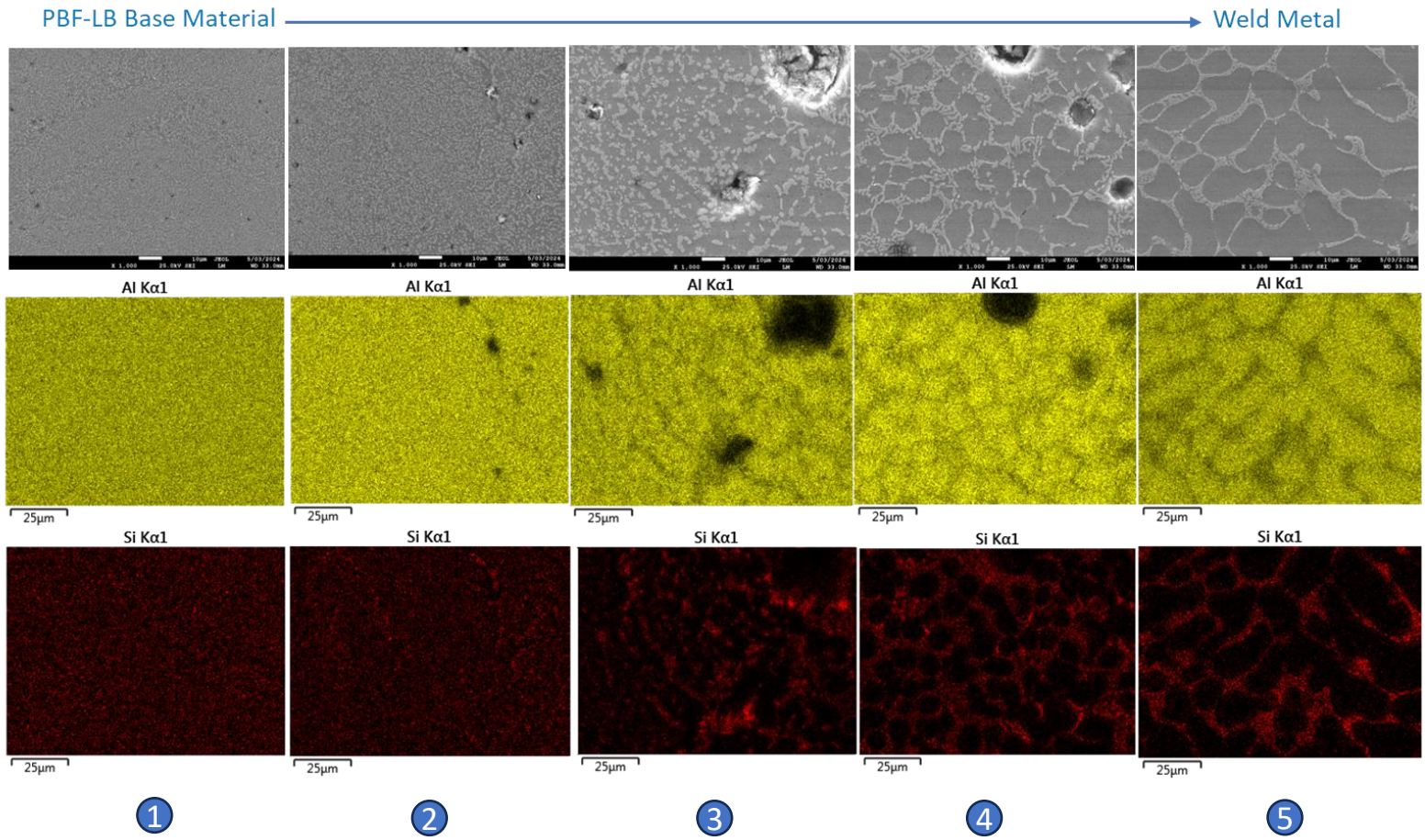




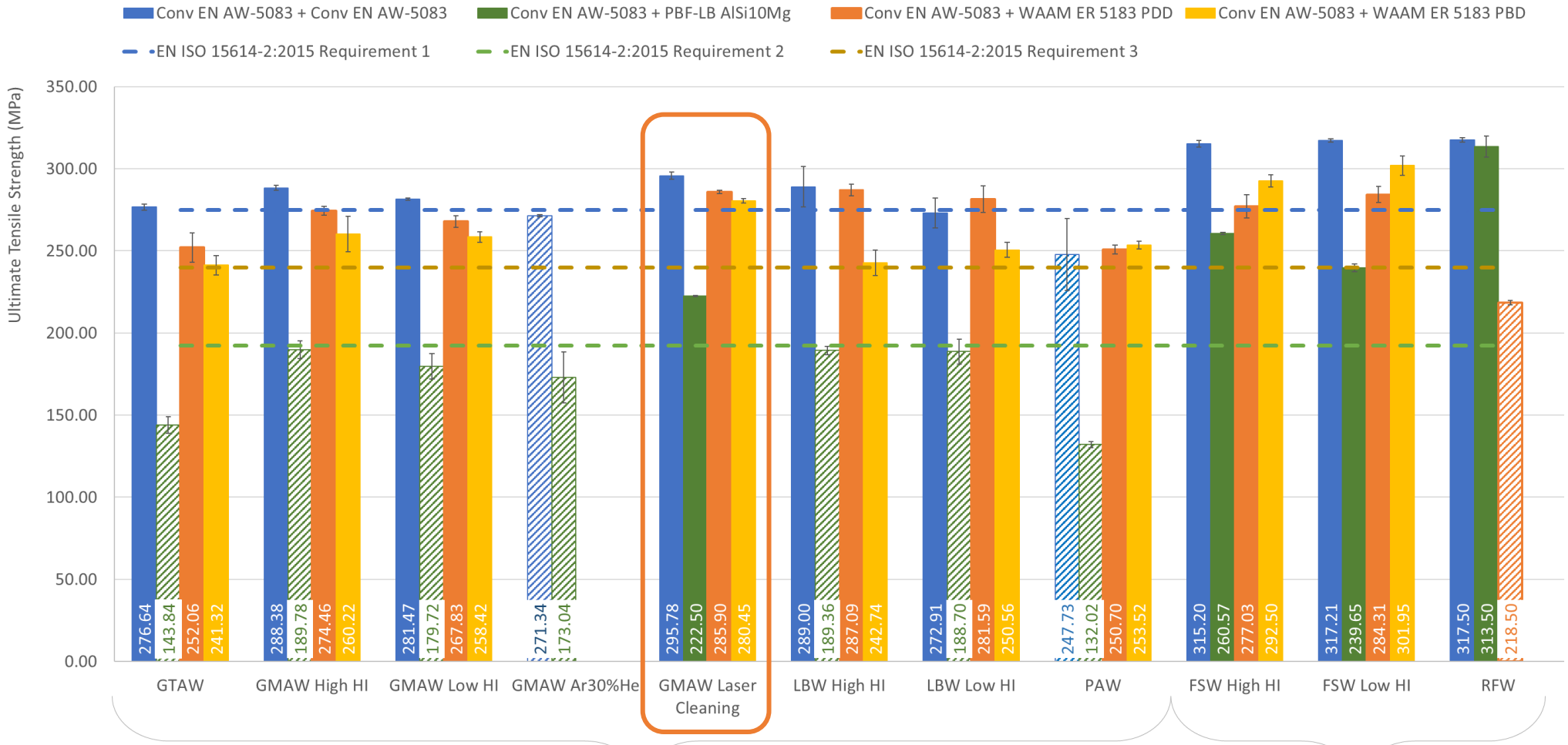
HAZ of Conv – PBF-LB weld (PBF-LB side)

Zhao *et al.* (2019)





Evaluated Welding Processes and Conditions | Tensile Testing

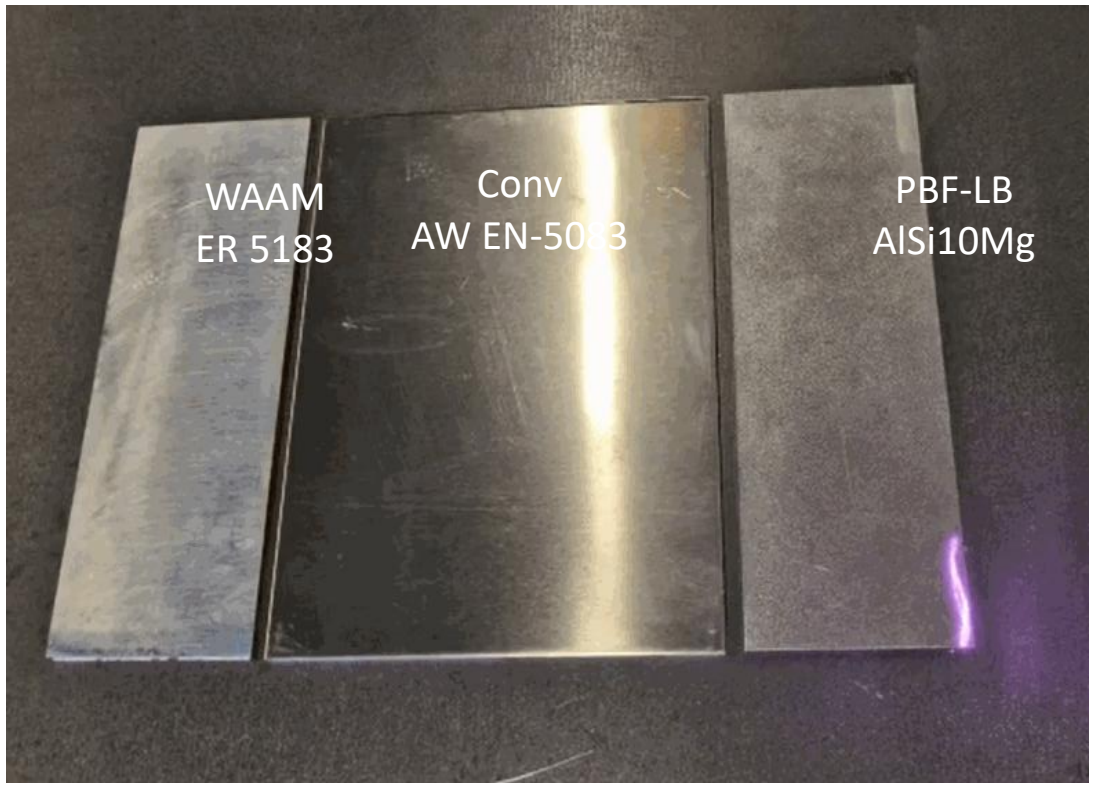


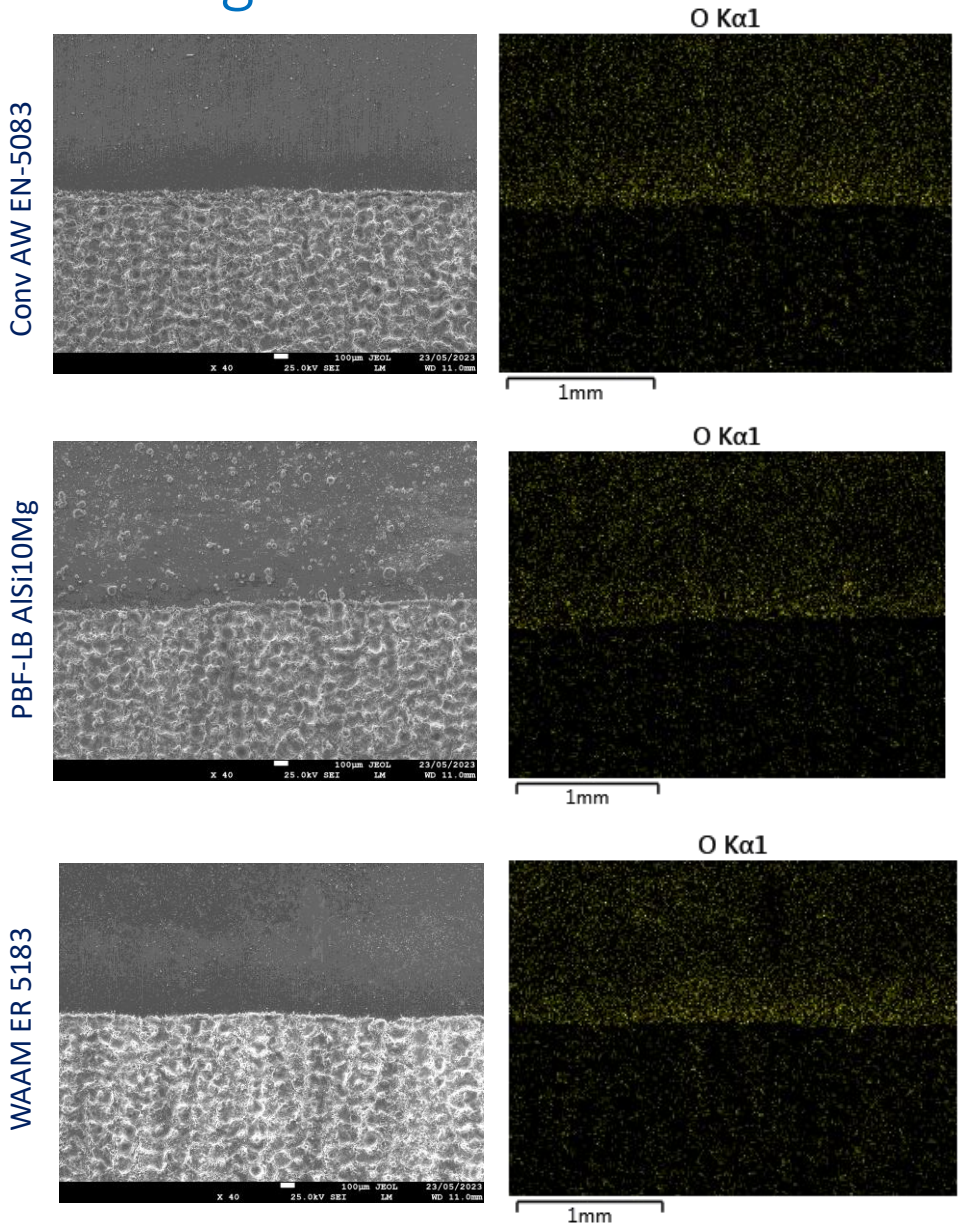
Solid Columns = Approved EN ISO 15614-2:2005
Non-solid Columns = Not Approved EN ISO 15614-2:2005

Conv EN AW-5083 + Conv EN AW-5083 = EN ISO 15614-2:2005 Requirement 1
Conv EN AW-5083 + PBF-LB AlSi10Mg = EN ISO 15614-2:2005 Requirement 2
Conv EN AW-5083 + WAAM ER 5183 = EN ISO 15614-2:2005 Requirement 3

Weldability of AM Al Alloys | Laser Cleaning Prior to Welding

→ Siginificant reduction in the Oxygen Content (Al_2O_3 Oxyde Layer) in the 3 base materials:

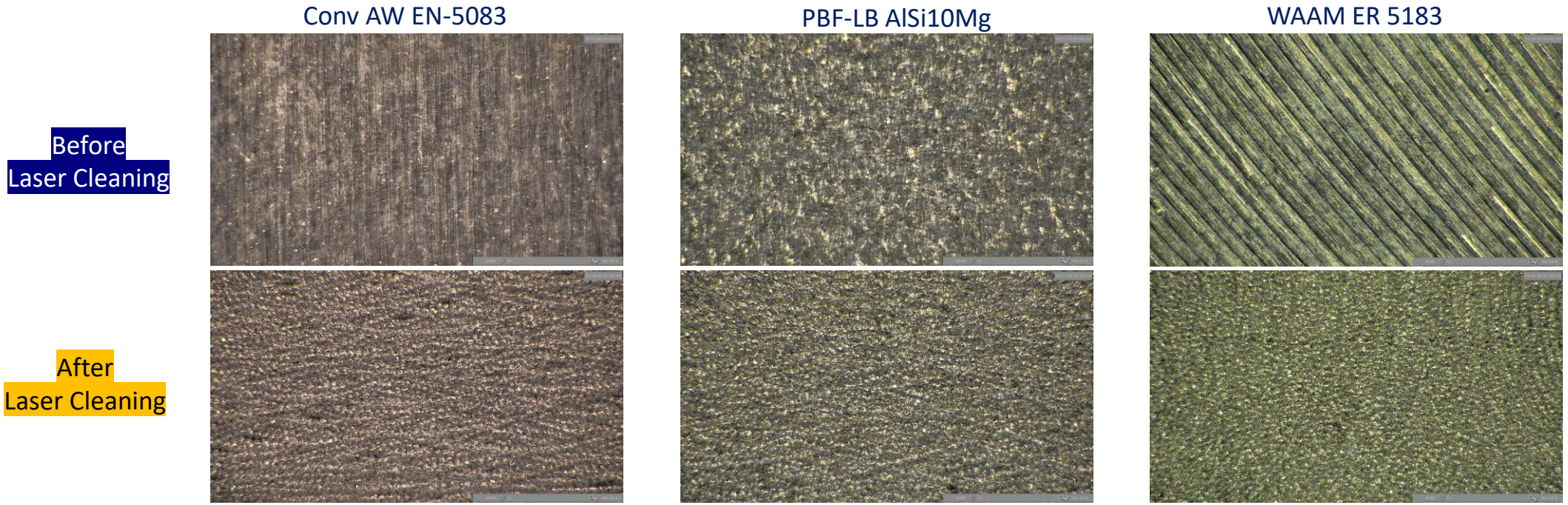




*No literature available showing the use of laser cleaning prior to the welding of AM-ed Al parts

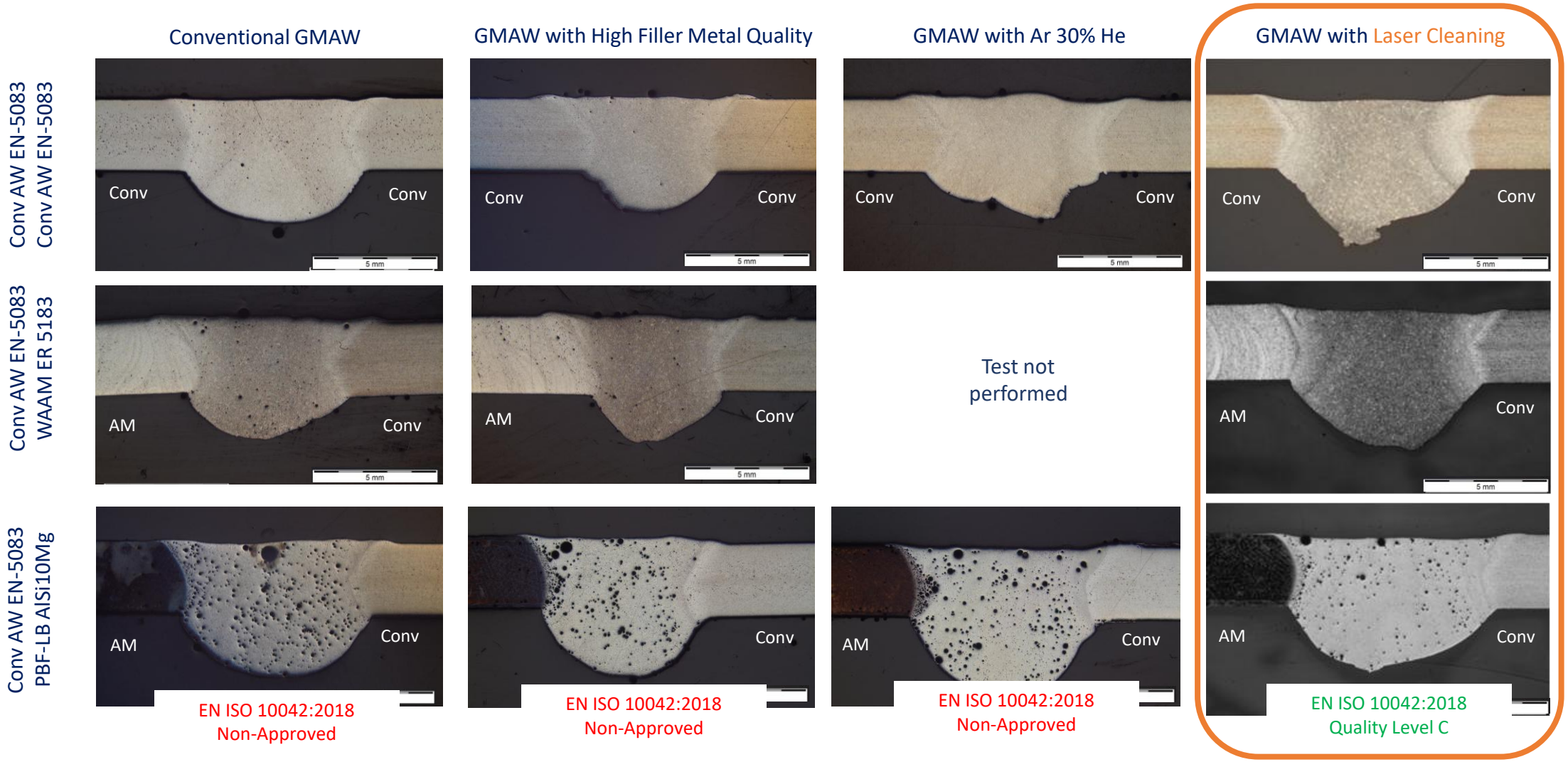
*SEM analysis performed 1 day after the Laser cleaning

Weldability of AM Al Alloys | Laser Cleaning Prior to Welding



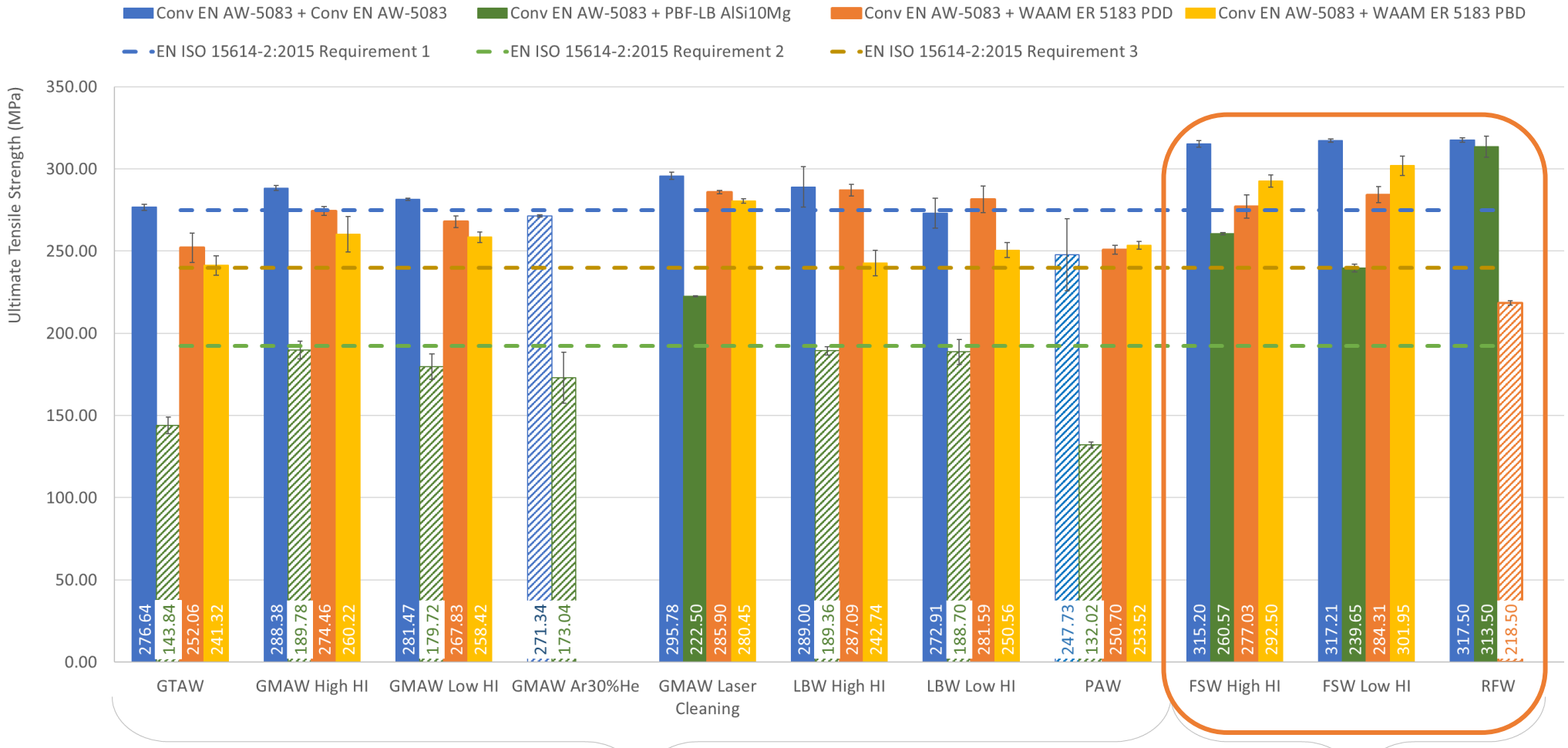
Material	Before Laser Cleaning				After Laser Cleaning			
	Ra (µm)		Rz (µm)		Ra (µm)		Rz (µm)	
Conventional AW EN-5083	0.269	**0.271**	1.980	**1.997**	3.902	**4.129**	29.300	**31.100**
	0.261		1.930		4.137		31.600	
	0.284		2.080		4.348		32.400	
PBF-LB AlSi10Mg	7.011	**6.576**	49.300	**46.167**	7.561	**7.495**	49.800	**51.167**
	6.074		41.700		7.888		55.500	
	6.643		47.500		7.037		48.200	
WAAM ER 5183	2.118	**2.109**	13.200	**12.600**	5.362	**6.337**	32.800	**40.000**
	2.111		12.500		6.670		41.900	
	2.099		12.100		6.979		45.300	

Evaluated Welding Processes | Metallographic Examination



Weldability (porosity level & tensile strength) improvement of all material combinations by laser cleaning prior to the GMAW welding

Evaluated Welding Processes and Conditions | Tensile Testing



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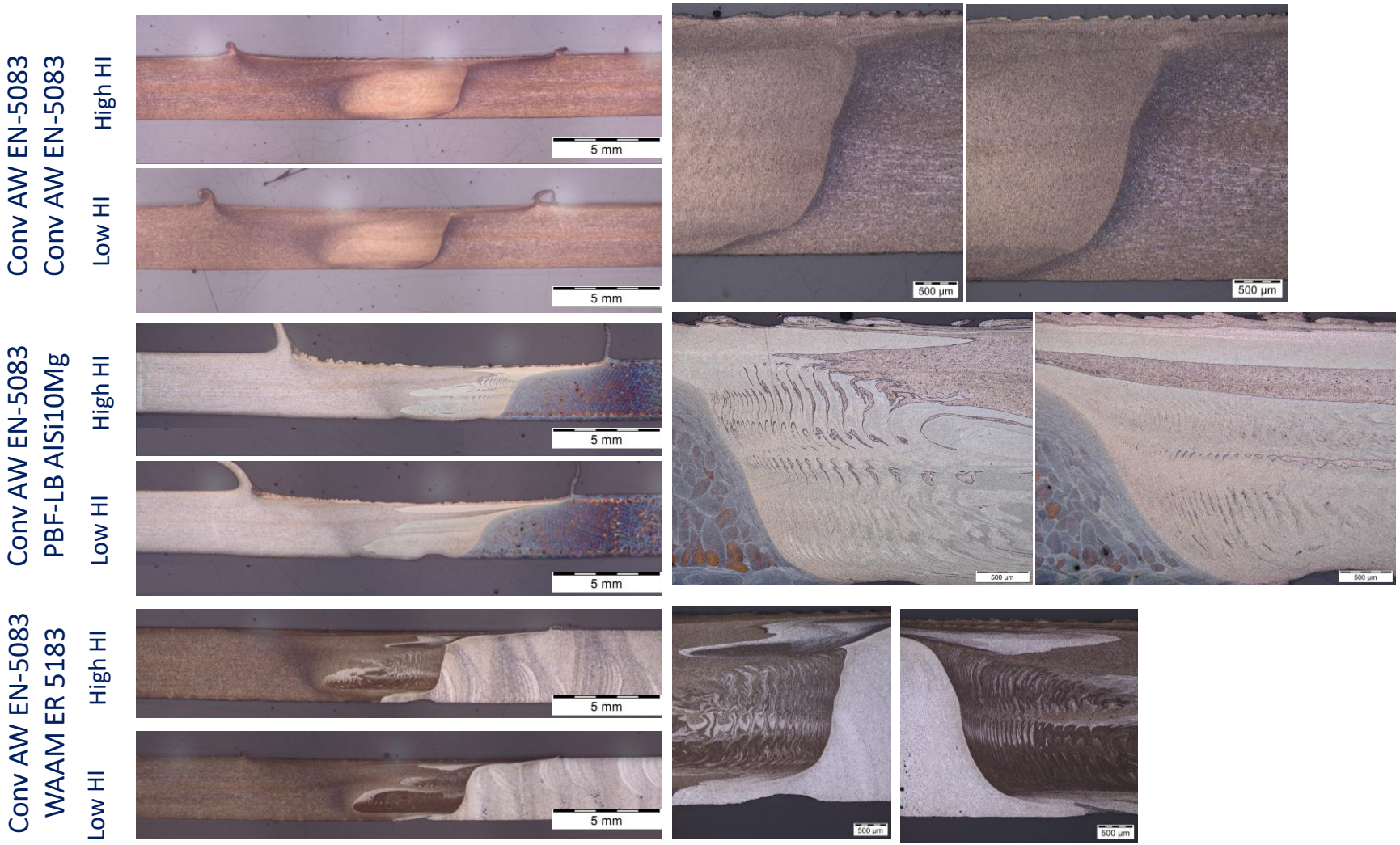
Conv EN AW-5083 + WAAM ER 5183 = EN ISO 15614-2:2005 Requirement 3

Evaluated Welding Processes | Metallographic Examination - FSW

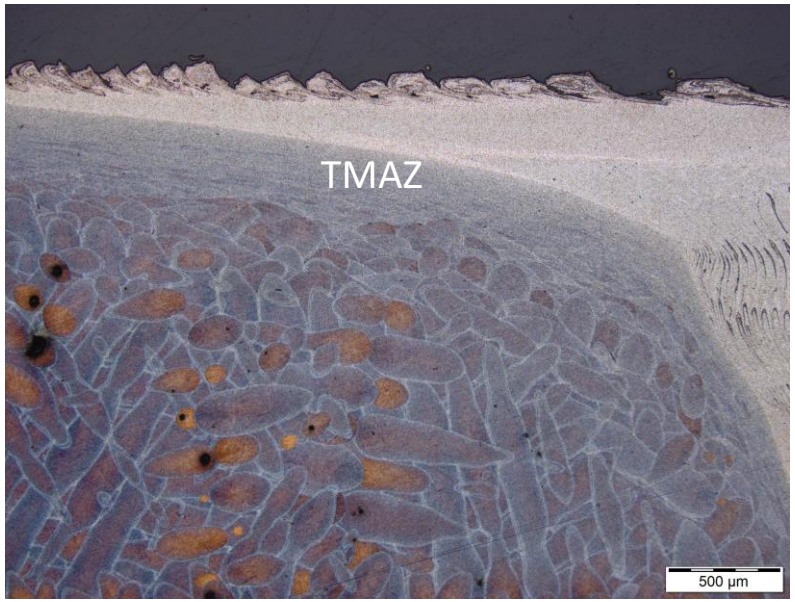


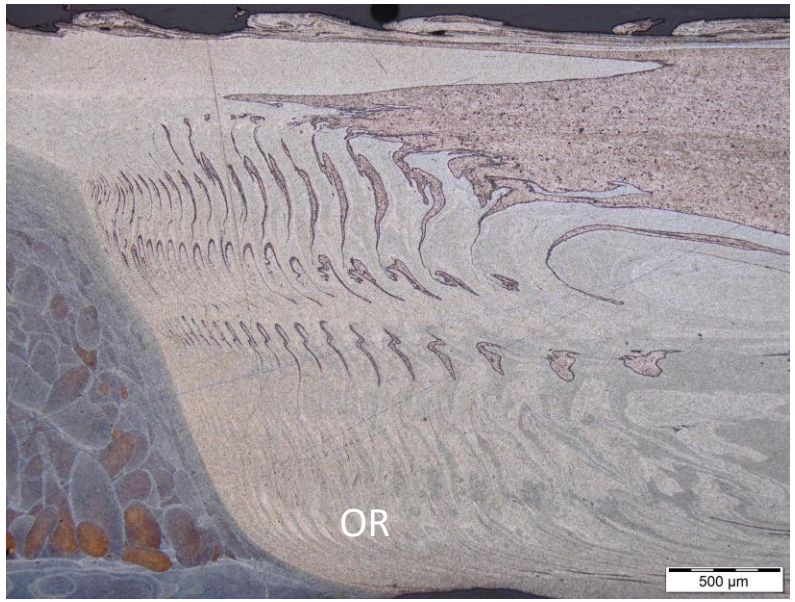
Four distinct regions:

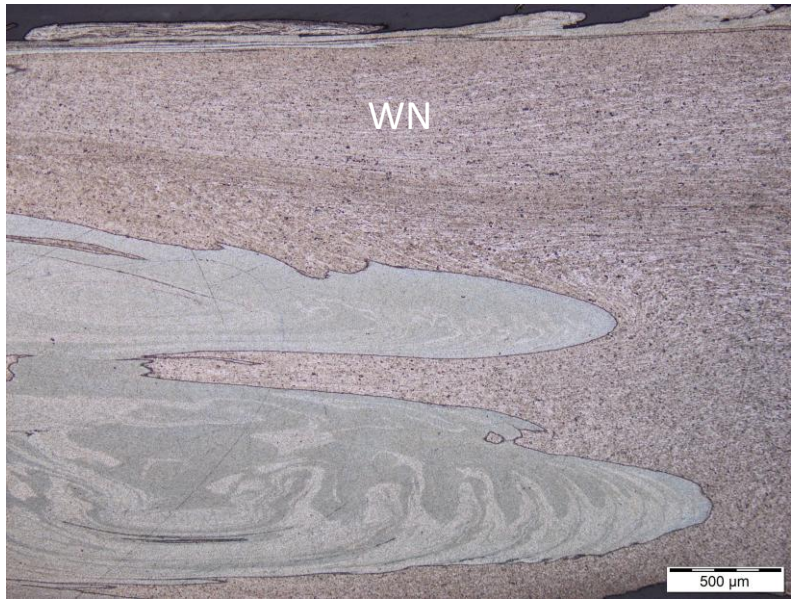
Base Material (BM)
Thermo-Mechanically Affected Zone (TMAZ)
Onion rings (OR)
Weld Nugget (WG)

Although there are still opportunities for parameters optimization, the FSW process achieved defect-free welds for every materials combination

Evaluated Welding Processes | Metallographic Examination - FSW







PBF-LB BM: High Porosity Level.

TMAZ: Highly deformed microstructure, subjected to elevated temperatures and deformation, with grains elongated in an upward-flowing pattern, compressed around the nugget due to the tool's forging action. In this region, recrystallization and grain coarsening are absent, likely because of insufficient deformation strain.

OR: More pronounced presence on the advancing side, due to the expectedly greater plastic deformation on the advancing size during the welding process.

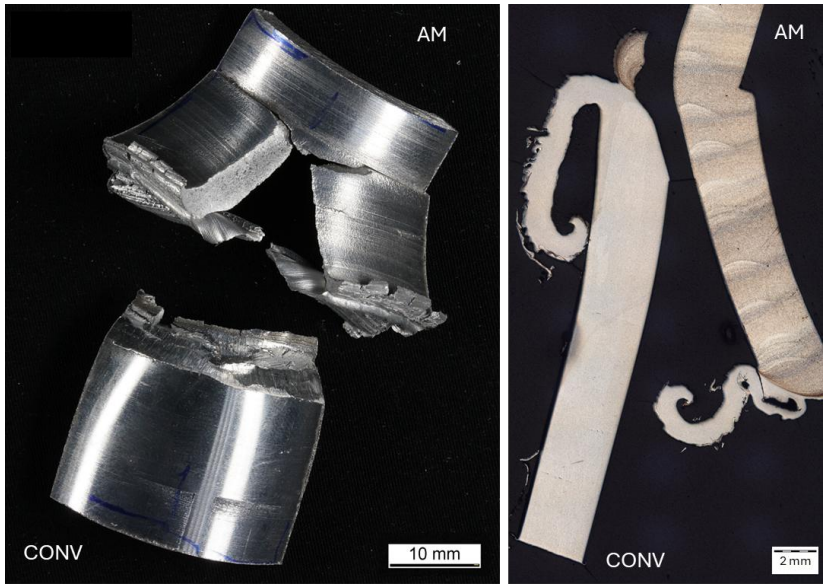
WN: Fine grains resulting from the significant plastic deformation, friction heating, and subsequent dynamic recrystallization.

Significant difference of properties between the materials

Ductility WAAM >> Conv

- The WAAM part tends to deform excessively under the frictional heat and pressure

- Using a low friction pressure and/or a short friction time can minimise the deformation of the highly ductile WAAM part. However, this approach increases the risk of a poor bond formation in the weld zone, because there is not enough heat to create a strong connection

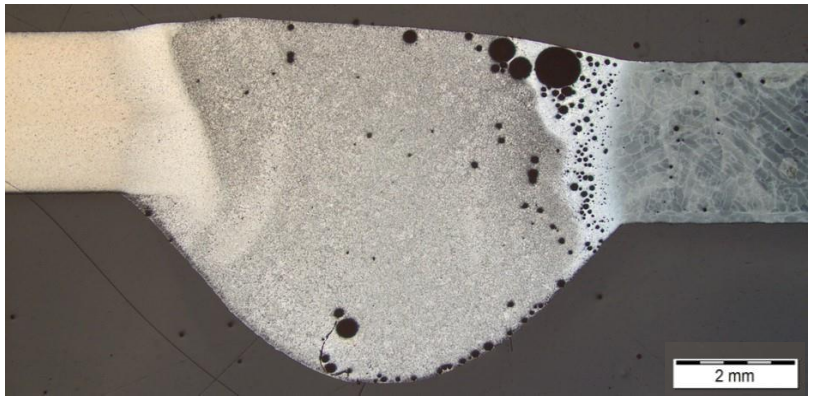


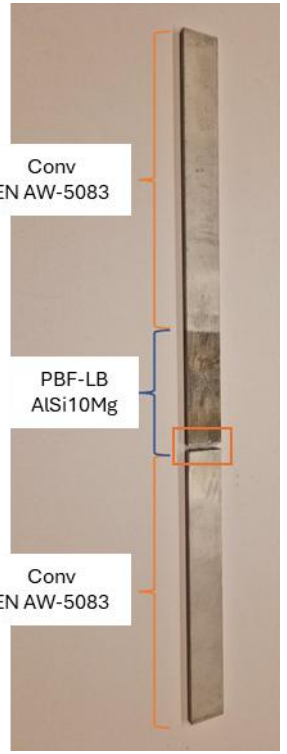
Process Heat and Pressure

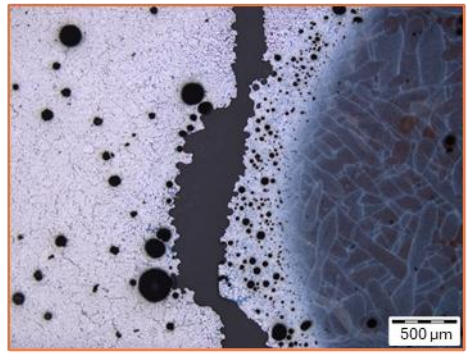
Evaluated Welding Processes and Conditions | Bend Testing

	Welding Process	Material A	Material B	Bend Testing Result*
Fusion Welding Processes	GMAW	Conv EN AW-5083	Conv EN AW-5083	Approved
		Conv EN AW-5083	PBF-LB ALSi10Mg	Not Approved
		Conv EN AW-5083	WAAM ER 5183	Approved
	GTAW	Conv EN AW-5083	Conv EN AW-5083	Approved
		Conv EN AW-5083	PBF-LB ALSi10Mg	Not Approved
		Conv EN AW-5083	WAAM ER 5183	Approved
	LBW	Conv EN AW-5083	Conv EN AW-5083	Approved
		Conv EN AW-5083	PBF-LB ALSi10Mg	Not Approved
		Conv EN AW-5083	WAAM ER 5183	Approved
	PAW	Conv EN AW-5083	Conv EN AW-5083	Approved
		Conv EN AW-5083	PBF-LB ALSi10Mg	Not Approved
		Conv EN AW-5083	WAAM ER 5183	Approved
Solid-State Welding Processes	FSW	Conv EN AW-5083	Conv EN AW-5083	Approved
		Conv EN AW-5083	PBF-LB ALSi10Mg	Approved
		Conv EN AW-5083	WAAM ER 5183	Approved
	RFW	Conv EN AW-5083	Conv EN AW-5083	Approved
		Conv EN AW-5083	PBF-LB ALSi10Mg	Approved
		Conv EN AW-5083	WAAM ER 5183	Not Approved

* EN ISO 15614-2:2005







Main factor for strength and ductility reduction:

High porosity level in HAZ near the PBF-LB part (Pore Belt Region)

Conclusion and Final Remarks

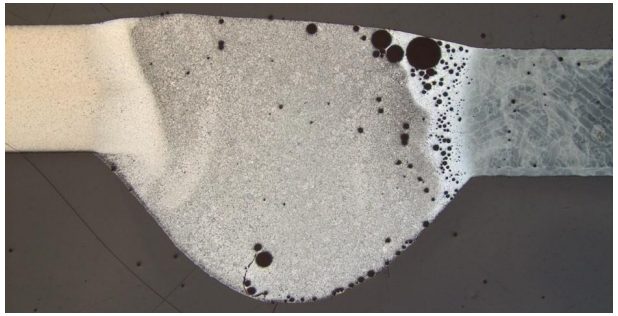
- Different thermal cycles
- Different filler material form (wire/powder)
- Different microstructure
- Different mechanical (material) properties

Fusion Welding Processes

Solid-State Welding Processes

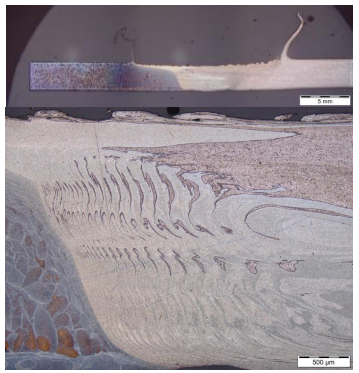
Weldability

Welding of PBF-LB Al Alloy Parts



Arc Welding / LBW

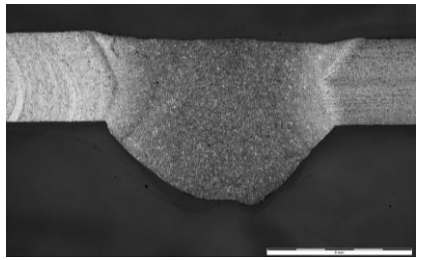
RFW



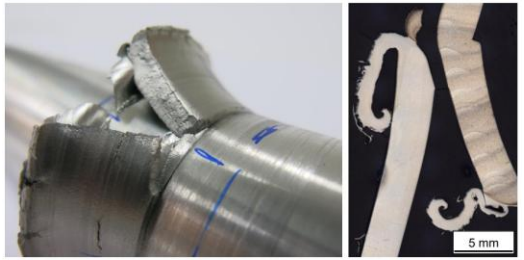
FSW

Welding of WAAM Al Alloy Parts

FSW



Arc Welding / LBW



RFW

*Low weldability observed only during FRW
High mechanical properties achieved by FSW

- Highest Weldability/Welding Quality for all Materials Combinations: FSW

Publications on Peer-Reviewed Journals

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Review

A Review on the Weldability of Additively Manufactured Aluminium Parts by Fusion and Solid-State Welding Processes

Rafael Nunes [1,2,3,*], Koen Faes [1], Wim De Waele [2], Aude Simar [3], Wim Verlinde [1], Matthieu Lezaack [3], Wout Sneyers [2] and Julius Arnhold [4]

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Abstract: Additive manufacturing (AM) processes are playing a significant role in several industrial sectors such as construction and machine building industries, involving a wide variety of metallic materials. Among these, the AM of aluminium alloys has developed significantly over the last decade, mainly through Powder Bed Fusion (PBF) and Directed Energy Deposition (DED) processes. Despite the many advantages of AM technology, some large or complex products cannot be produced entirely without the use of conventional manufacturing and joining processes, generally for financial or operational reasons. In this way, the ability to join conventionally and additively manufactured components or parts represents a crucial step towards their future use and the consolidation of conventional and additive manufacturing technologies. Despite the growing interest in AM technologies, there is still a significant lack of information on the joining of conventionally and additively manufactured components. The present work proposes a first review of the literature evaluating the weldability of AM aluminium alloys. The focus is on the use of fusion and solid-state welding processes and analysing the achieved microstructural evolution and mechanical properties. A clear relationship is observed between the AM technology used to produce the part, and the physical principles of the joining process. In addition, the gaps in the literature are highlighted to enable focused future work.

Keywords: additive manufacturing; aluminium; powder bed fusion; directed energy deposition; wire arc additive manufacturing; weldability

1. Introduction

Additive manufacturing (AM) technology has evolved steadily over the last decade to overcome the challenges and operational and financial drawbacks associated with conventional manufacturing processes. AM is a tool-less, near-net-shape production technology, based on three-dimensional (3D) model data [1]. This new type of processing has provided industries with unprecedented opportunities to produce metal components with complex free-form geometries, where such geometries are not achievable using conventional manufacturing techniques [2,3].

Among the various types of AM processes for manufacturing metallic components, two groups are highlighted as the most promising for industrial applications: Powder Bed Fusion (PBF) and Directed Energy Deposition (DED) processes. Although there may be similarities between the two groups, such as the possibility of using powder as feedstock material, and although some processes of both groups can use the same heat source, such

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https://doi.org/10.3390/met13101724

Meeting: 202407 Annual Assembly Tags: Scientific document

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XY-ZWTQ-2024

Welding of Additively Manufactured Aluminium Alloy Components: Challenges and Mitigation Strategies

R. Nunes[1,4,5,#], K. Faes[1,3], W. Verlinde[1,#], F. Probst[3,#], J. De Freese[2,#], J. Arnhold[4,#], W. De Waele[4,#], M. Lezaack[3,#], A. Simar[3,#]

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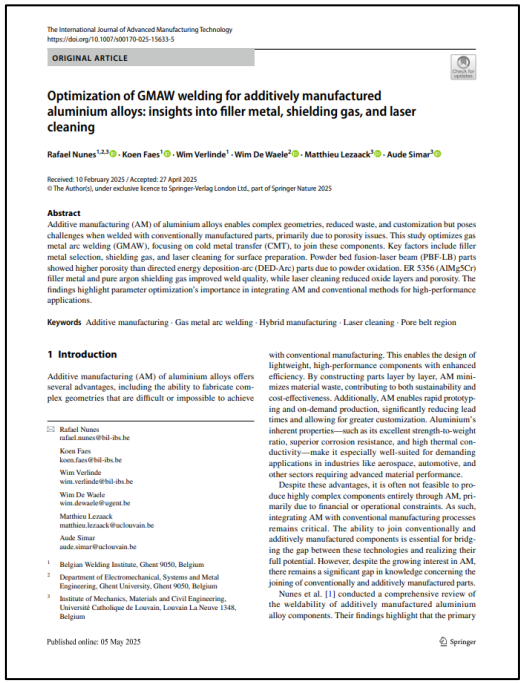
Competing Interests: Authors are required to disclose financial or non-financial interests that are directly or indirectly related to the work submitted for publication. Please refer to "Competing Interests and Funding" below for more information on how to complete this section

Abstract

Additive manufacturing (AM) has contributed to significant advances in the production of aluminium alloys, particularly through powder bed fusion (PBF) and directed energy deposition (DED) processes. However, joining of conventionally and additively manufactured components remains essential. This work focuses on the weldability of AM aluminium alloys using fusion and solid-state welding processes. The study analyses the microstructural evolution and mechanical properties, revealing a relationship between AM technology and joining process. In particular, fusion welding of PBF-LB produced aluminium alloys presented a significant limitation due to the high porosity level, especially in the weld zone near the PBF-LB base material. This region of high porosity, known as the pore belt region, has an enormous detrimental effect on the mechanical properties of the weld. This phenomenon is not observed when the welds are carried out by solid-state welding processes, which makes this group of welding processes very suitable for this type of material. On the other hand, fusion welding of aluminium alloys produced by Wire Arc Additive Manufacturing (DED-Arc or WAAM) exhibits a good stability and repeatability, analogous to conventional aluminium alloy welding practices. Rotational friction welding of DED-Arc-produced components presented an unexpected challenge. Due to the difference in ductility compared to conventionally

R. Nunes *et al.* **Welding of Additively Manufactured Aluminium Alloy Components: Challenges and Mitigation Strategies**. Welding in the World. Vol 69. 2025.
https://doi.org/10.1007/s40194-025-01923-9



The International Journal of Advanced Manufacturing Technology
https://doi.org/10.1007/s00170-025-15633-5

ORIGINAL ARTICLE

Optimization of GMAW welding for additively manufactured aluminium alloys: insights into filler metal, shielding gas, and laser cleaning

Rafael Nunes[1,2,3] · Koen Faes[1] · Wim Verlinde[1] · Wim De Waele[2] · Matthieu Lezaack[3] · Aude Simar[3]

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Abstract
Additive manufacturing (AM) of aluminium alloys enables complex geometries, reduced waste, and customization but poses challenges when welded with conventionally manufactured parts, primarily due to porosity issues. This study optimizes gas metal arc welding (GMAW), focusing on cold metal transfer (CMT), to join these components. Key factors include filler metal selection, shielding gas, and laser cleaning for surface preparation. Powder bed fusion-laser beam (PBF-LB) parts showed higher porosity than directed energy deposition-arc (DED-Arc) parts due to powder oxidation. ER 5356 (AlMg5Cr) filler metal and pure argon shielding gas improved weld quality, while laser cleaning reduced oxide layers and porosity. The findings highlight parameter optimization's importance in integrating AM and conventional methods for high-performance applications.

Keywords Additive manufacturing · Gas metal arc welding · Hybrid manufacturing · Laser cleaning · Pore belt region

1 Introduction

Additive manufacturing (AM) of aluminium alloys offers several advantages, including the ability to fabricate complex geometries that are difficult or impossible to achieve with conventional manufacturing. This enables the design of lightweight, high-performance components with enhanced efficiency. By constructing parts layer by layer, AM minimizes material waste, contributing to both sustainability and cost-effectiveness. Additionally, AM enables rapid prototyping and on-demand production, significantly reducing lead times and allowing for greater customization. Aluminium's inherent properties—such as its excellent strength-to-weight ratio, superior corrosion resistance, and high thermal conductivity—make it especially well-suited for demanding applications in industries like aerospace, automotive, and other sectors requiring advanced material performance.

Despite these advantages, it is often not feasible to produce highly complex components entirely through AM, primarily due to financial or operational constraints. As such, integrating AM with conventional manufacturing processes remains critical. The ability to join conventionally and additively manufactured components is essential for bridging the gap between these technologies and realizing their full potential. However, despite the growing interest in AM, there remains a significant gap in knowledge concerning the joining of conventionally and additively manufactured parts.

Nunes et al. [1] conducted a comprehensive review of the weldability of additively manufactured aluminium alloy components. Their findings highlight that the primary

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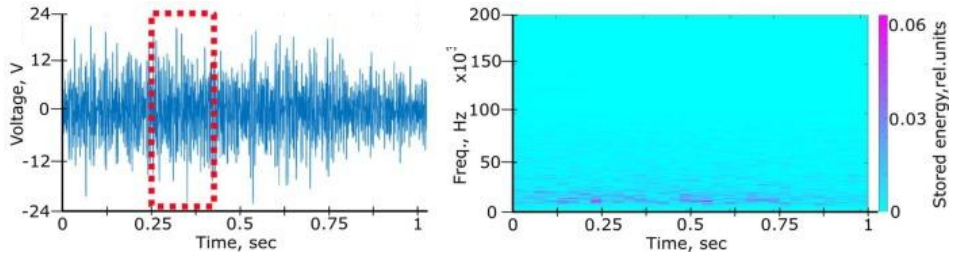
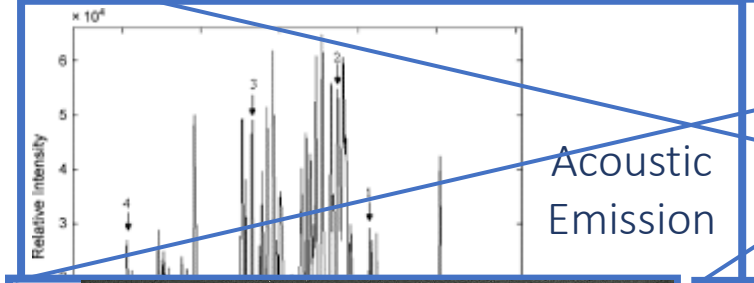
https://link.springer.com/article/10.1007/s00170-025-15633-5

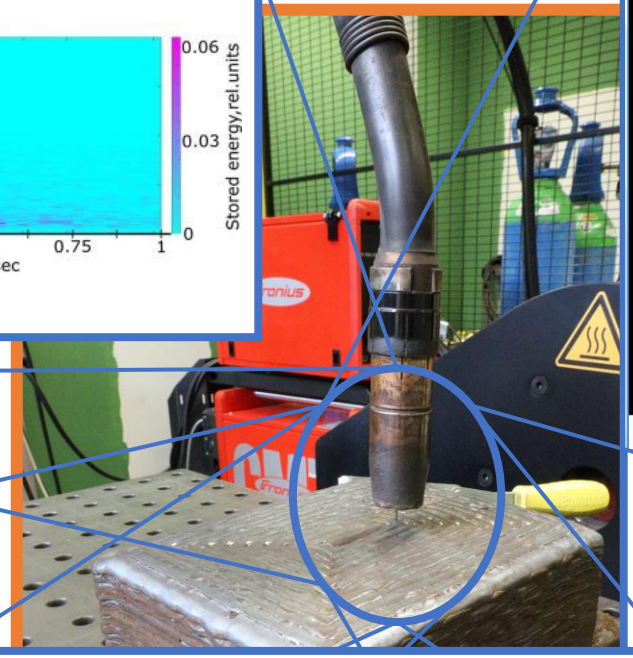
In-Process Quality Monitoring in Welding & WAAM

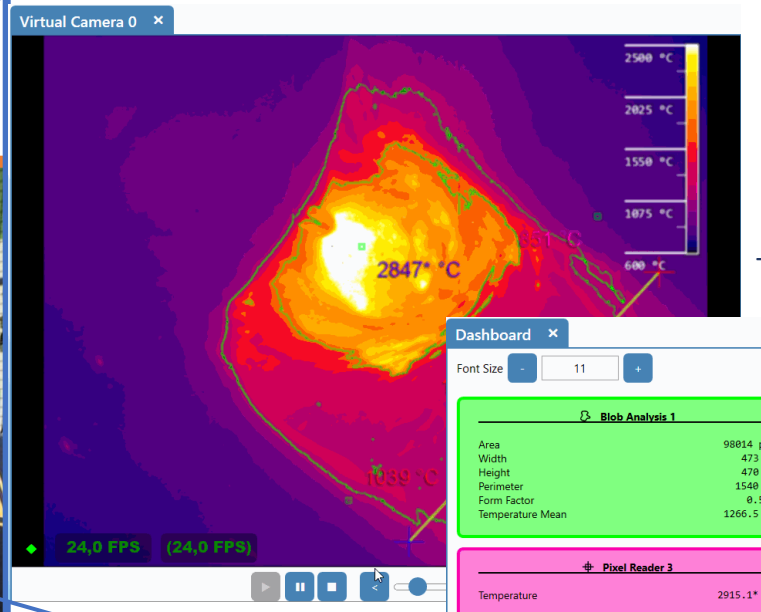


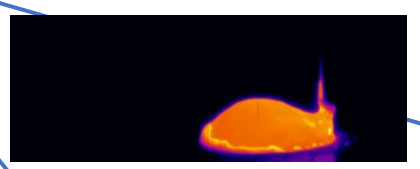
Spectroscopy

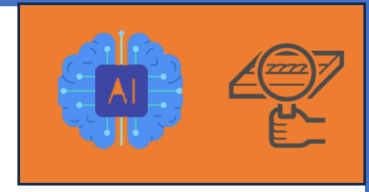


Acoustic Emission

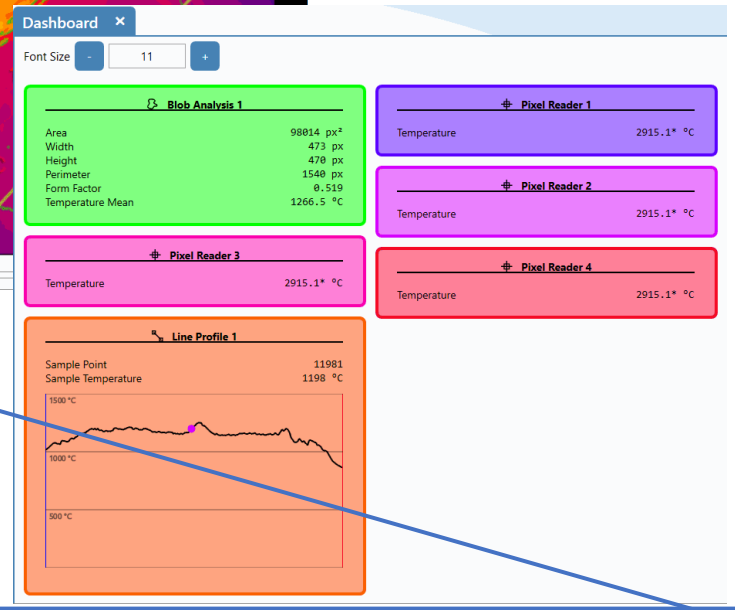




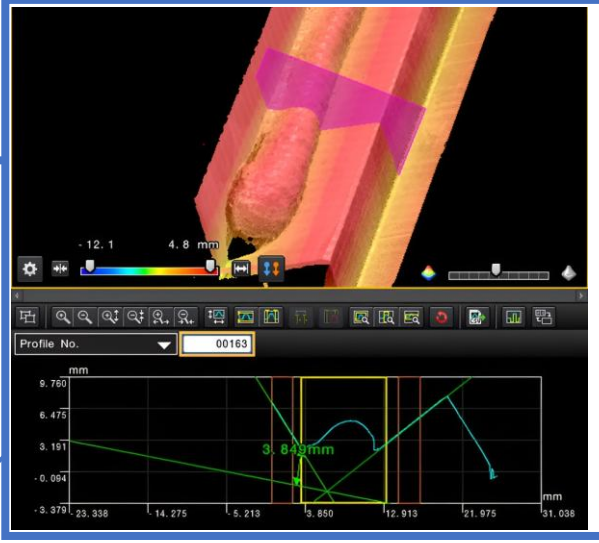




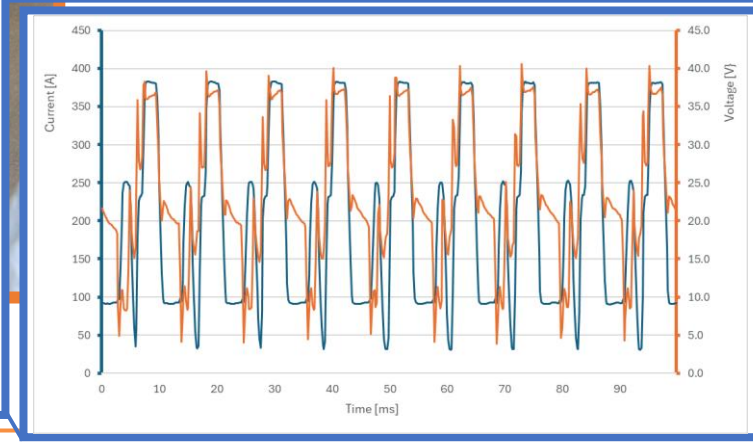
Thermal Filming



Filming

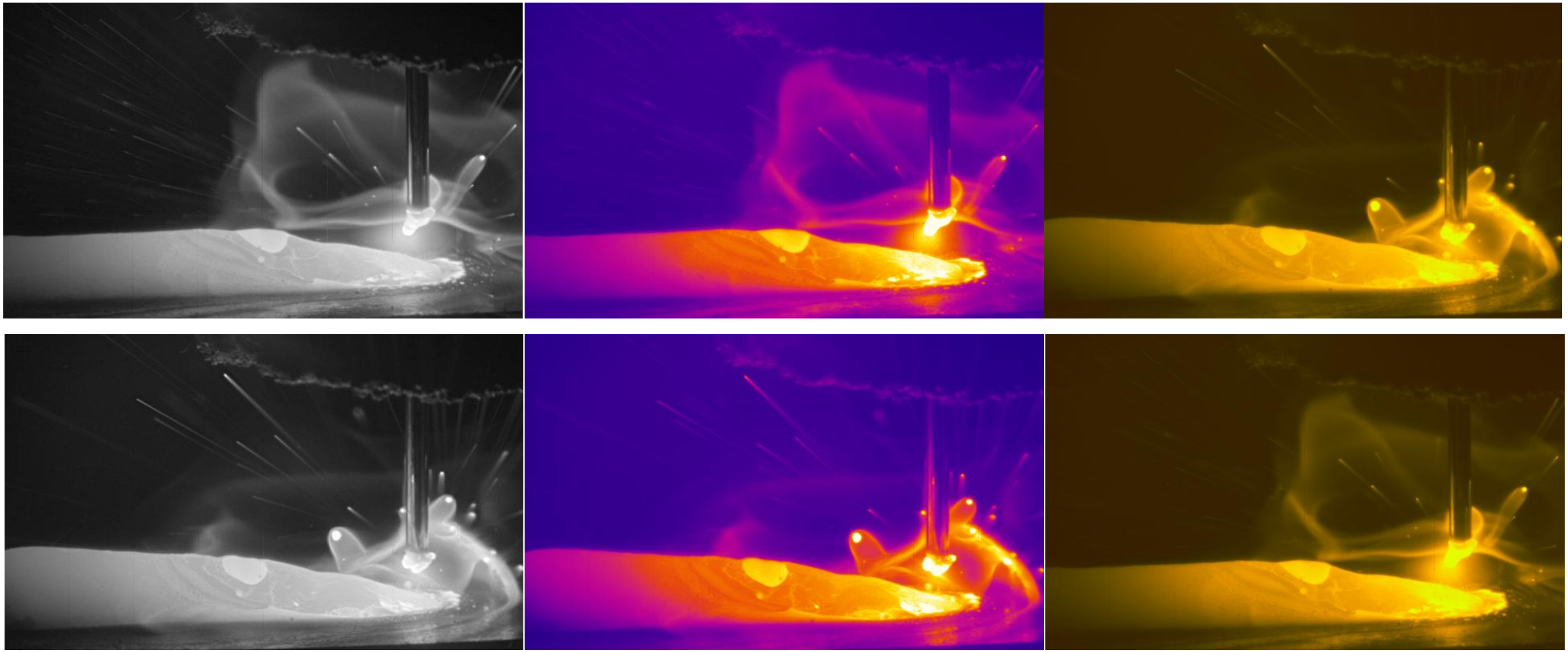


Laser Scanning



Arc Parameters

CMT (Cold Metal Transfer) – Selected Frames



Call for Participation in International Projects

Increased Product Integrity Through Intelligent Real-Time Weld Quality Monitoring of Arc Welding

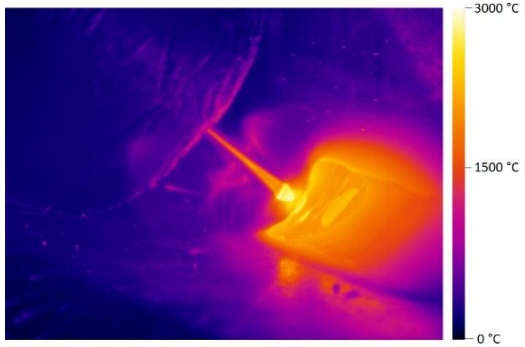
- Validation of fast multi-sensor measurement systems for real-time quality monitoring for arc welding, with the flexibility to perform local (weld pool) and global (full weld/product) monitoring,
- Explore detection capabilities: which welding defects can be detected (e.g. lack of fusion, incomplete penetration, undercut, …), and what is the accuracy,
- Development of predictive models to correlate the measurements with physical defects,
- Control strategies that will guarantee the quality of the joint and product,
- Evaluation of the performance of the new quality control strategies,
- Demonstration of the applicability of real-time quality control using pilot test test-ups for the industrial project partners.

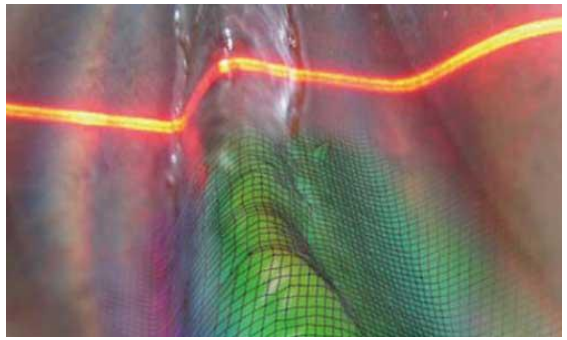
Belgium
Belgian Welding Institute

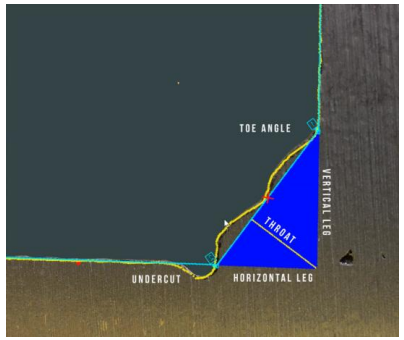
Germany
RWHT

Brazil
LABSOLDA

https://cornet.online/EN/Home/Home_node.html



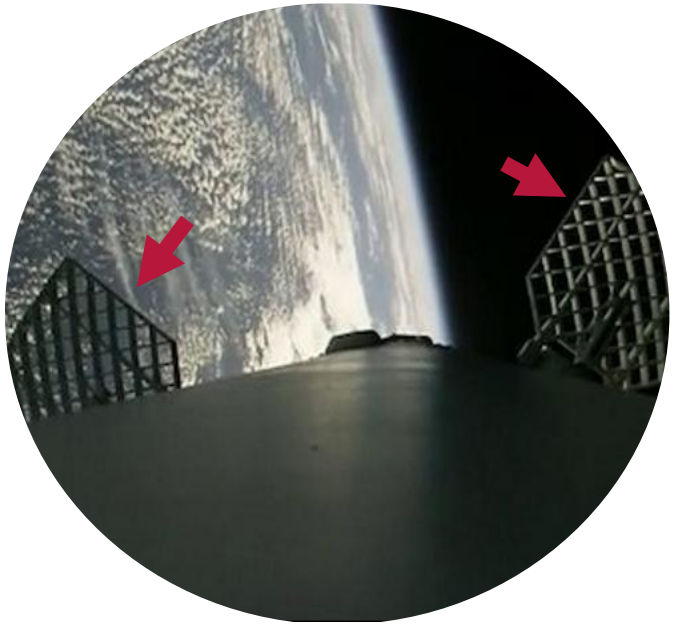




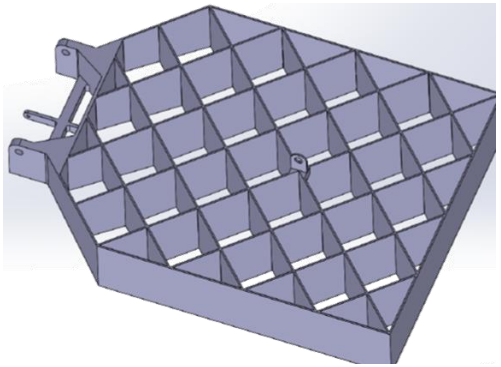
ESA Project DE-RISK

Hybrid Manufacturing for Large Space Structures

Can we add features by directed energy deposition (DED) on a conventional aerospace structure?

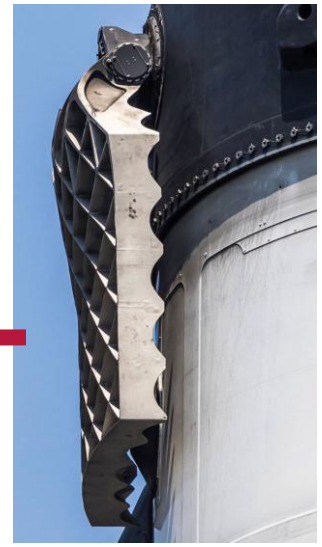


Grid fins on re-usable launcher vehicles
(PT: Grade de aletas)



Material Selection: 17-4 PH

(martensitic stainless steel)



Weldability of Aluminium 7075 (Al-Zn-Mg-Cu) Alloy

Primary Phases: α-Al (aluminium-rich matrix)

Secondary Phases:

- **η-phase (MgZn2):** Precipitated during ageing, provides high strength
- **Al7Cu2Fe**: Large and brittle precipitates

Grain Structure: Typical equiaxed after solution heat treatment (conventional material)

Precipitation Strengthening: Achieved via T6 or T73 tempers, where fine MgZn2 precipitates enhance strength

Ultimate Tensile Strength: 510-580 MPa

Yield Strength: 430-500 MPa

Elongation: 5-11%

Hardness: ~ 150 HB

Density: 2.81 g/cm3

Thermal Conductivity: ~ 130W/m*K

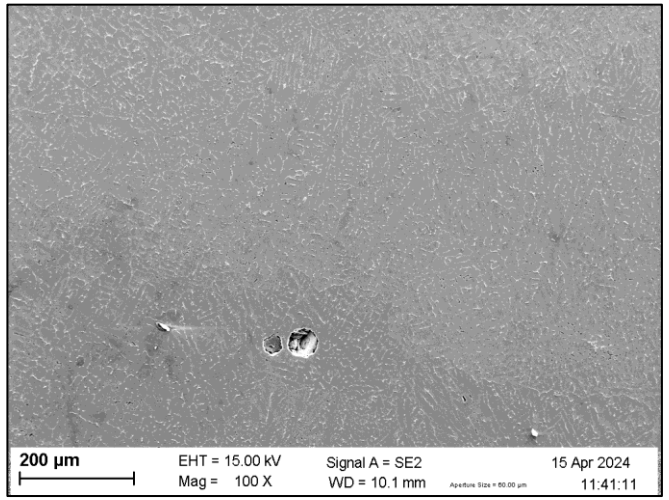
Fatigue Strength: ~160 MPa

Corrosion Resistance: Fair, improved in T73 temper

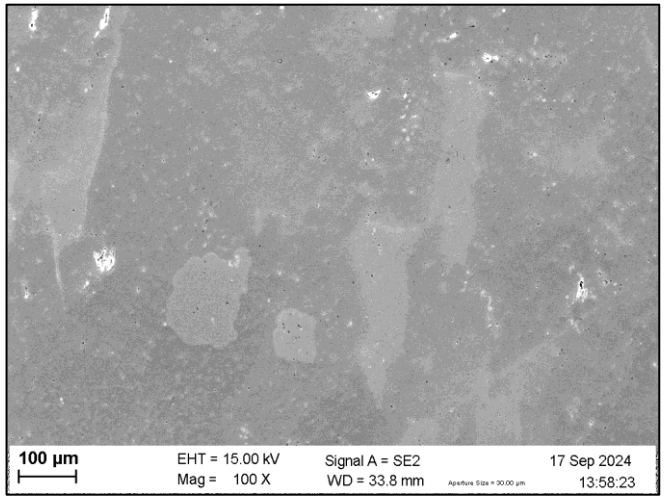
Poor Weldability

UNWELDABLE

High Zn and Mg Content	→	Hot Cracking
Precipate-rich Grain Boundaries	→	Liquation Cracking
Precipitation Hardening	→	HAZ Softening
Hydrogen Solubility	→	Porosity

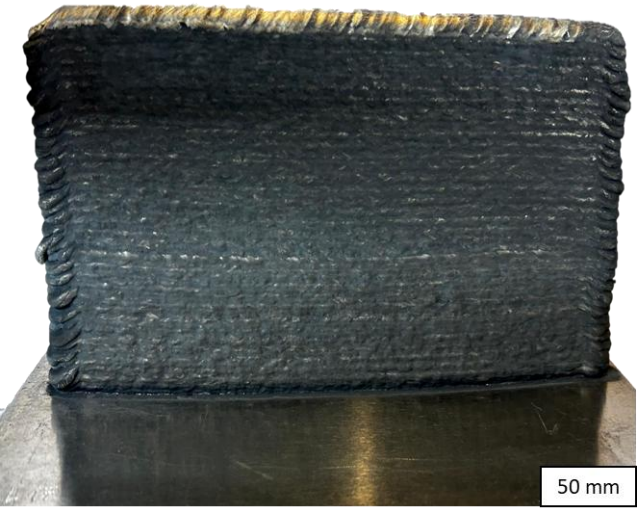


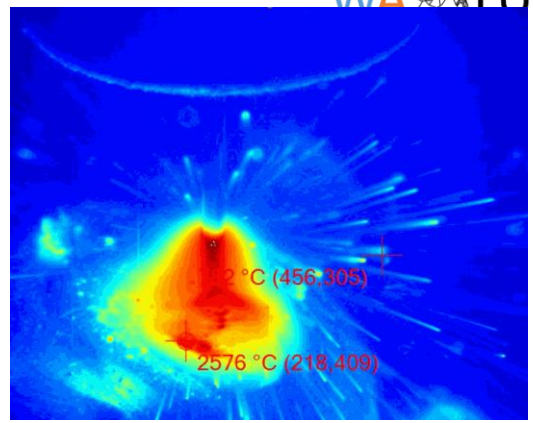
WAAM-ed ER7075
As Built

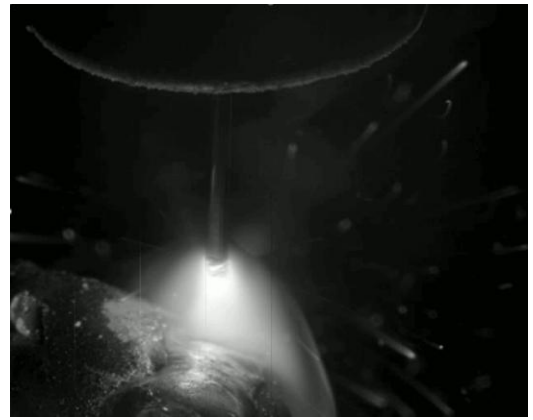


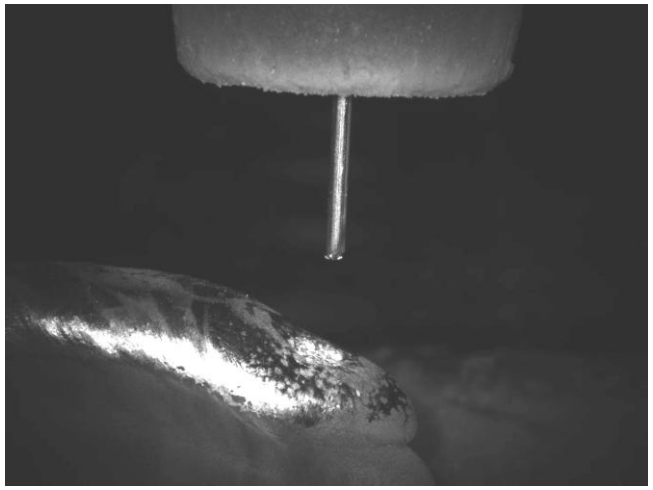
WAAM-ed ER7075
After PWHT

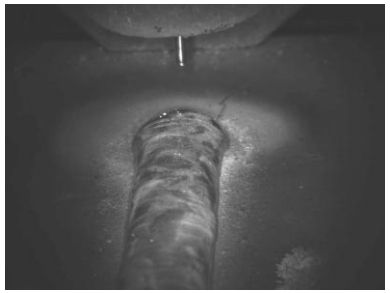
WAAM of ER7075 | Process Monitoring & Optimization

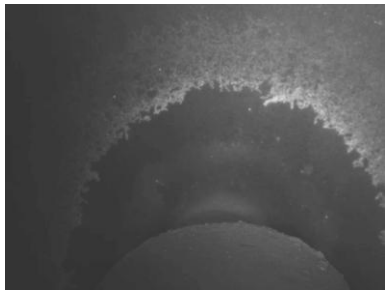


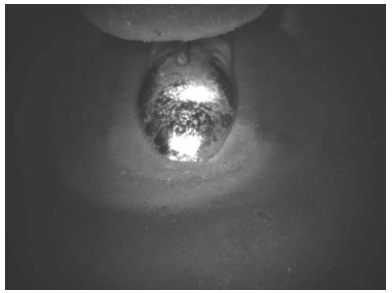


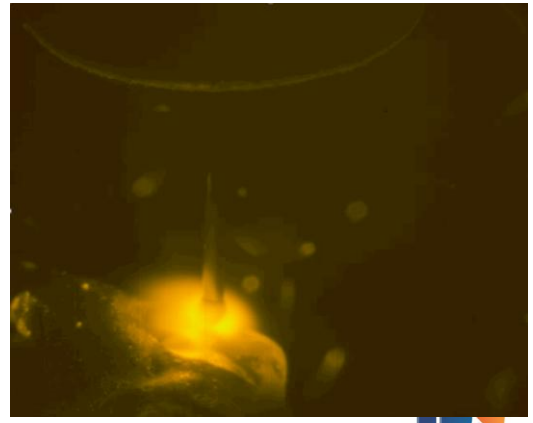










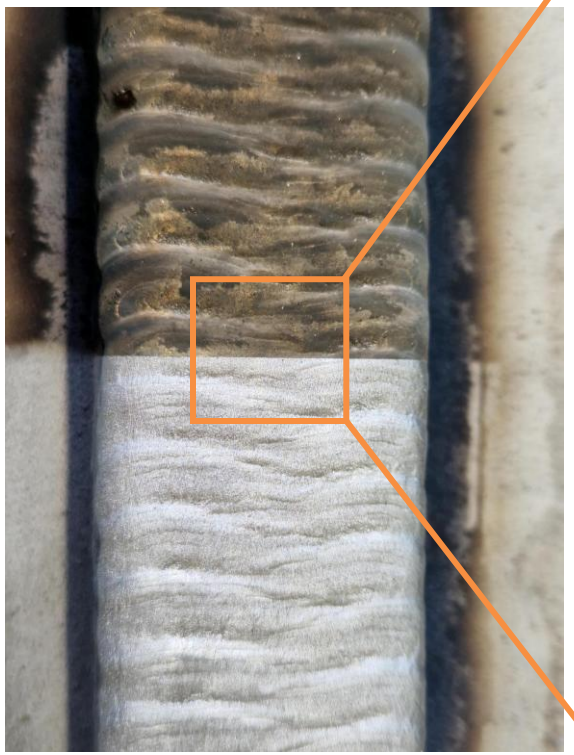


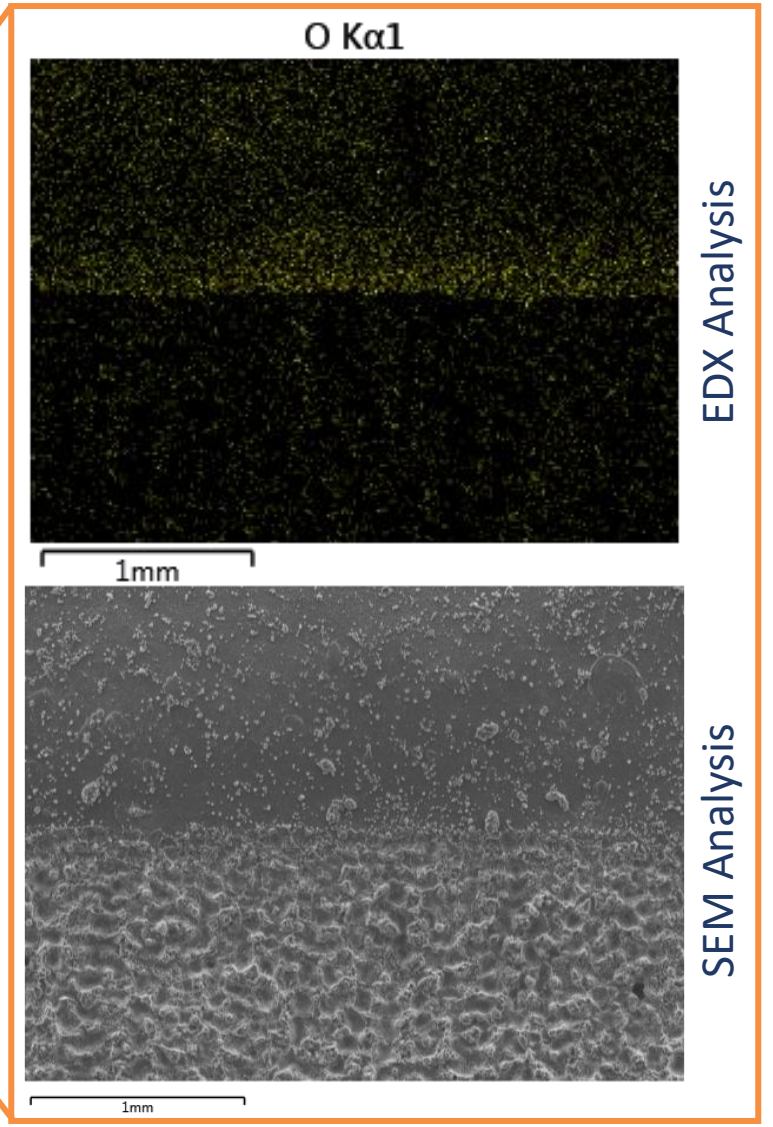
Optimization of parameters based on visual monitoring, highlighting the arc stability, defects formation (e.g. solidification cracking), and wire detachment mode.

WAAM of ER7075 | Process Monitoring & Optimization

*SEM analysis performed 1 day after the Laser cleaning

Applicability of Cleaning Methods during printing

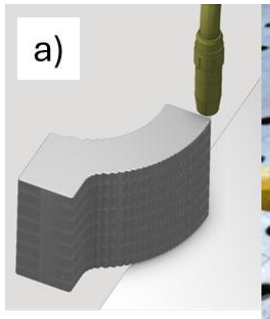


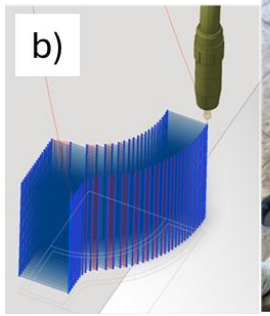


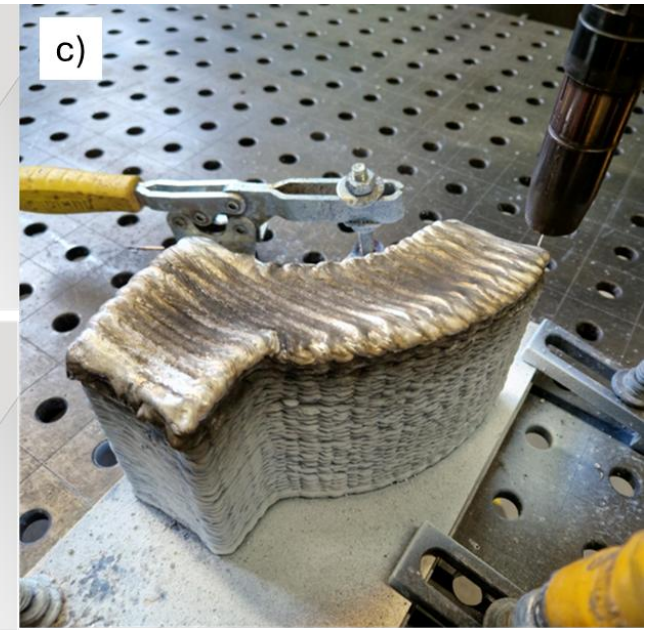
Performing of Laser cleaning between every layer:

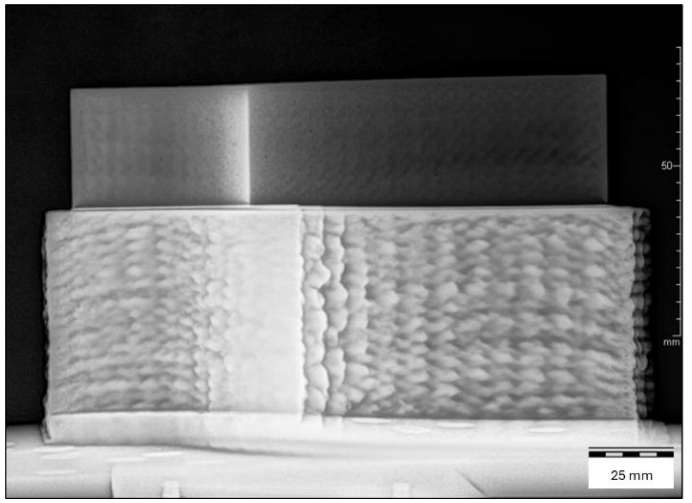
- Approximately cleaning time: 3 min 30 s
- Dwell Time: 4 min

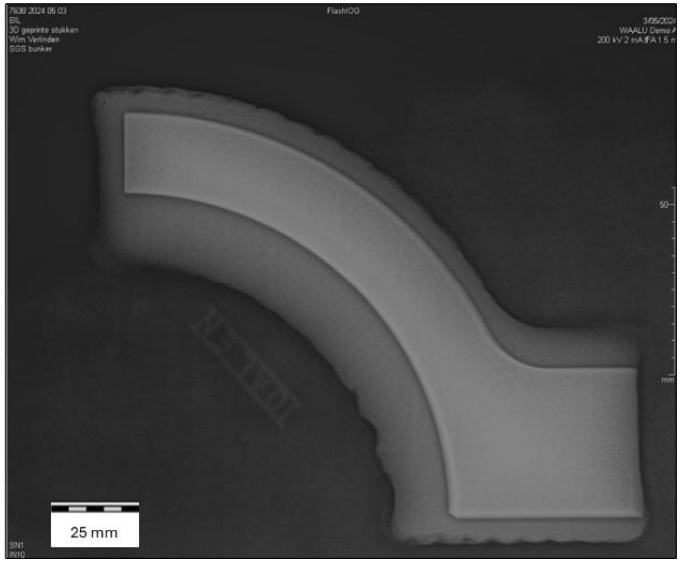
WAAM of High Strength Al Alloys – ER7075 | Demonstrators

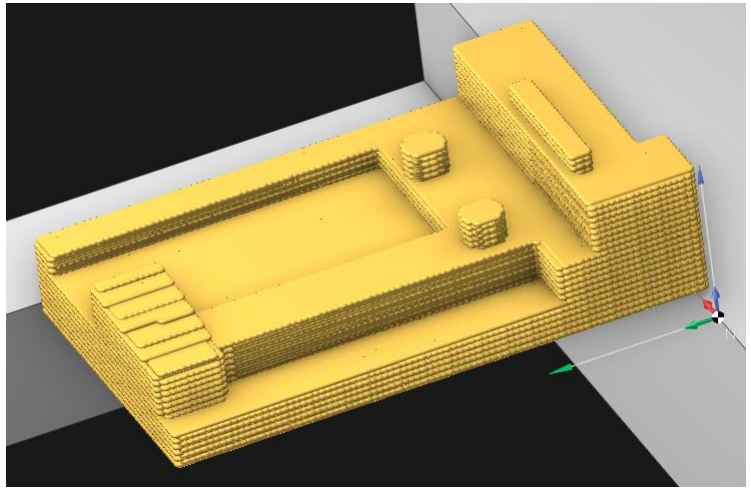












Real Demonstrators Manufacturing → Machining → Evaluation

WAALU Workshop

SAVE THE DATE!

05/11/2025

Belgian Welding Institute
Ghent, Belgium

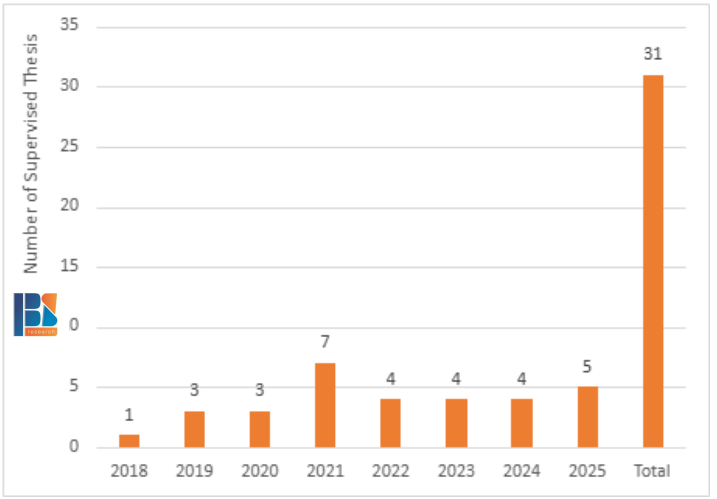
Presentation of final results

Practical demonstration on WAAM manufacturing of high strength Al alloy using a robot and a collaborative robot (cobot)

Internship / Traineeship Opportunities at BWI

Igor Felice
Alumni UFU (LAPROSOLDA)
https://www.linkedin.com/in/igor-oliveira-felice/

MX3D



Research and Development in:

- Robotic Welding (Robot and Cobot)
- Solid-State Welding Processes
- Real Time Quality Monitoring of Welding and WAAM
- WAAM Manufacturing of Advanced Materials

Duration:

- 6-12 months | Flexible start dates

Location:

- On-site at Ghent, Belgium

Who Can Apply:

- Master's Degree and PhD Students

Partners and Clients Around the World

XLVII CONGRESSO NACIONAL DE SOLDAGEM
CONSOLDA
&
III CBMAdi
CONGRESSO BRASILEIRO DE MANUFATURA ADITIVA

The COAMWELD project is founded by VLAIO, under Grant Number HBC.2020.2994

COAMWELD

Thank you for your attention!

Sr. Eng. Rafael Nunes
Welding and WAAM R&D

IIW Future Leader 2025-2026

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rafael.nunes@bil-ibs.be

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info@bil-ibs.be | www.bil-ibs.be

UCLouvain

GHENT UNIVERSITY

ABS Associação Brasileira de Soldagem

INSTITUTO SENAI DE TECNOLOGIA

INSTITUTO SENAI DE INOVAÇÃO

fapesc Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina

CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico