

Metal-coated optical fiber embedment in Wire Arc Additive Manufacturing aluminum parts for distributed sensing

*J. Popławski¹, K. Wysokiński¹, D. Budnicki¹, J. Domagalski¹, M. Karczewski¹, K. Markiewicz¹, P. Piątek¹,
K. Wilczyński¹, T. Tenderenda¹, A. Iturrioz², I. Rodriguez², X. Angulo², M. Napierała¹, T. Nasilowski¹*

¹ InPhoTech Sp. z o.o., ul. Poznańska 400, 05-850 Oltarzew, Poland

² LORTEK Technological Centre, Basque Research and Technology Alliance (BRTA), Arranomendia kalea 4A, 20240 Ordizia, Spain

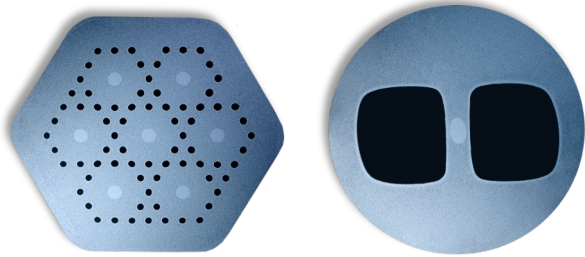
 This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862617 – MULTI-FUN

All information contained in this document is confidential and contains business information and trade secrets and is a property of InPhoTech Sp. z o.o. and LORTEK S COOP. This document as well as any information about the content of said document are subjected to the Intellectual Property rules of InPhoTech group and may not be used, published, or redistributed without prior written consent of InPhoTech Sp. z o.o. and LORTEK S COOP.



InPhoTech – main areas of expertise

Specialty Optical Fiber design & manufacturing



- Multicore Fiber - WR 11,2 Tb/s live, telecom standard transmission tested by Infinera and Orange
- Side-Hole for temp. compensated pressure sensing
- Available mass scale fabrication
- Designated specialty fiber components (Fanouts, Mode filters, Power combiners)



Orange 与Infinera对Seven-core光纤测试达到 11.2 Tb/s

讯石光通讯网 发布时间:2021/08/12 9:28:39 编辑: icczz 加关注 讯石光通讯网 (粉丝3964)

摘要: Orange Polska 与 Infinera 和 InPhoTech 集团一起对创新的多芯光纤和 Infinera ICE6 800G 技术进行了测试。测试期间获得的吞吐量是目前使用标准单芯光纤所能达到的最大值的七倍。

ICC讯(编译: Vicki)Orange Polska 与 Infinera 和 InPhoTech 集团一起对创新的多芯光纤和 Infinera ICE6 800G 技术进行了测试。测试期间获得的吞吐量是目前使用标准单芯光纤所能达到的最大值的七倍。

知道技术创新的重要性, 我们一直而疫情驱动的远程在线工作、学习。这就是为什么我们不断投资未来为客户提供可靠的服务。”

在光子学和光纤集群的支持下, 将由 InPhoTech 集团的 IPT Fiber

该实验与 Orange 合作进行, 使。这相当于 11.2 Tb/s 的总传输

Infinera 合作以实现创纪录的传输, 并在 Orange 的创新实验室

纤的最先进的基础设施一起使用,

IPT Fiber 的首席执行官 Krzysztof Witon 负责多芯光纤部署, 他表示: “通过我们的测试, 我们已经知道 seven-core 波段光纤的传输能力高达 296 Tb/s, 这些是创纪录的数字, 但并不是我们能力的终结。使用整个传输频谱, 即所有可用的光纤将能够实现 Pb/s 或数千太比特的吞吐量。我很高兴我们的 Polish 光纤正在成为解决全球电信障碍的案。”

Orange achieved parallel transmission through the 7-core fiber for single-cable capacity OF UP TO 296.8 TB/S – 7X GREATER THAN TRADITIONAL FIBER

WIFI6 | FIL MÓW Odtwórz (k)

0:23 / 0:57 YouTube

Orange claims 11.2Tbps data rate in lab test

12 Aug 2021

Orange Poland has carried out a test in conjunction with Infinera and InPhoTech, enabling it to reach data transfer rates of up to 11.2Tbps. The tests used single-core fibers with a throughput of 1.6Tbps. Orange says it will use these solutions which will allow it to enhance its backbone network to meet the growing data usage spurred by 5G mobile services.

Orange pushes 11.2Tbps over fibre and looks to 300Tbps

Orange が7コアファイバとInfinera ICE6 800Gによる伝送テストで11.2Tbpsに到達

Orangeは8月11日、Orange PolskaがInfineraおよびInPhoTechグループとともに、革新的なマルチコアファイバとInfinera ICE6 800Gのテストを実施することを発表しました。

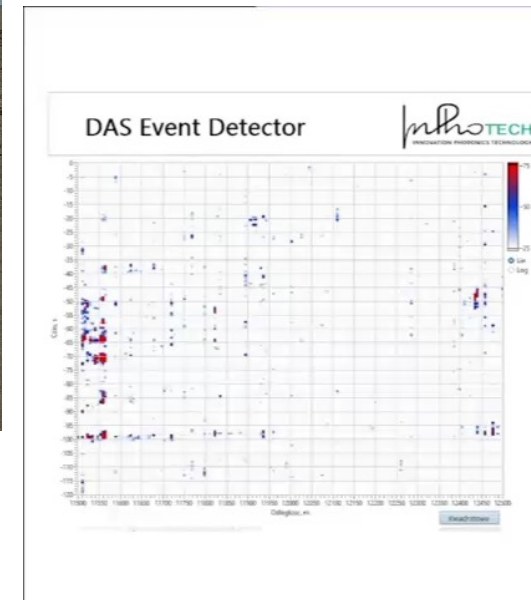
Orangeは「テスト中に得られたスループットは、標準の光ファイバケーブルを使用して現在達成できる最大値の7倍だった」としている。

この記事は会員限定です。新規登録いただくか、会員の方はログインして続きをお読みください。

InPhoTech – main areas of expertise

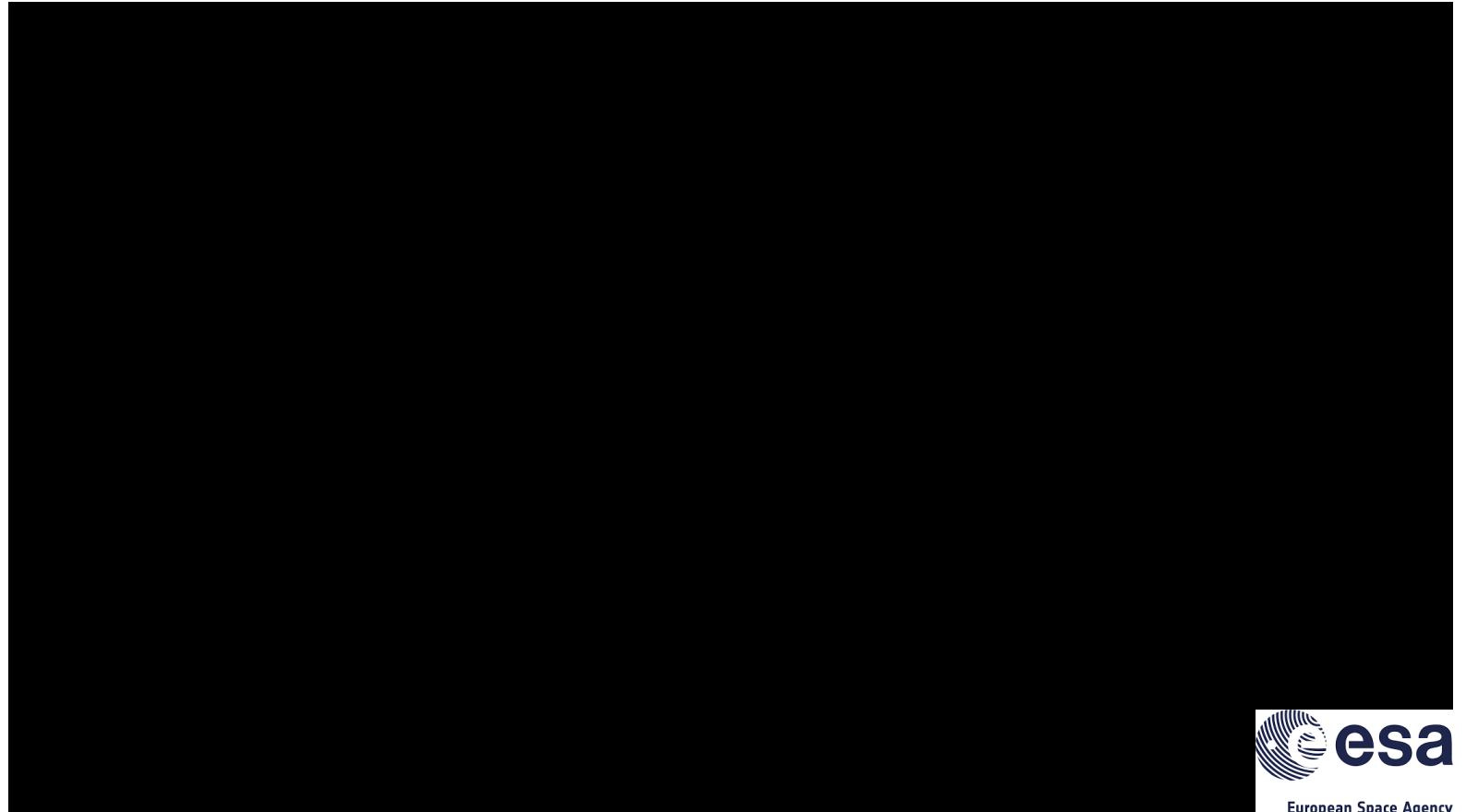
Distributed Fiber Optic Sensors (FOS)

- Installed autonomus distributed sensor for permafrost depth monitoring in Spitzbergen, Svalbard (beyond north polar circle), - climate changes research
- Border/perimetric monitoring with dedicated Distributed Acoustic Sensor using existing telecom fiber network



Distributed Fiber Optic Sensors (FOS)

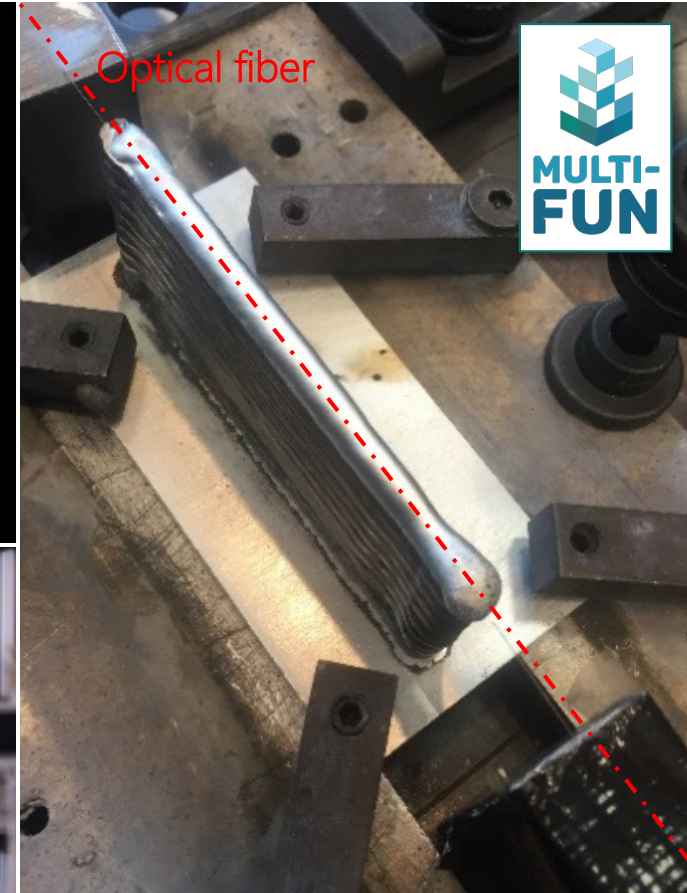
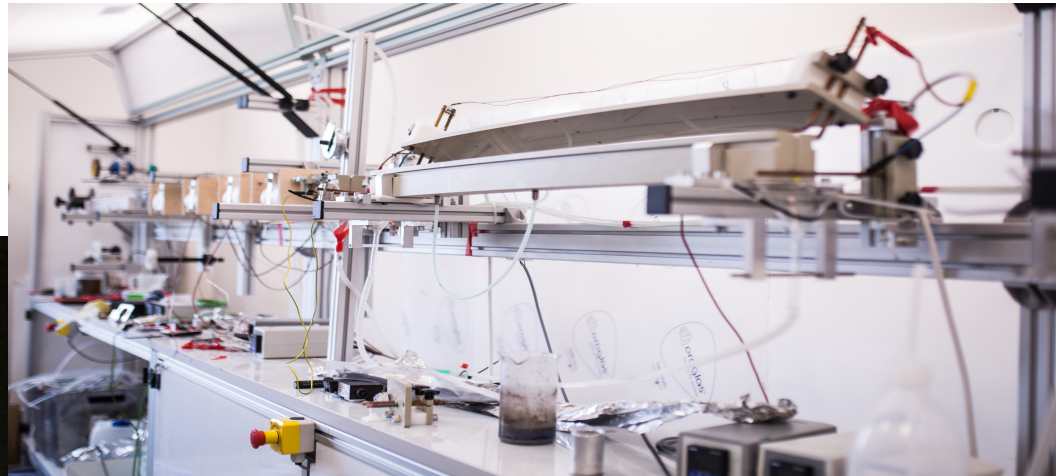
- Installed autonomus distributed sensor for permafrost depth monitoring in Spitzbergen, Svalbard (beyond north polar circle), - climate changes research
- Border/perimetric monitoring with dedicated Distributed Acoustic Sensor using existing telecom fiber network
- Distributed strain map monitoring of composite panels (delivered for European Space Agency)



InPhoTech – main areas of expertise

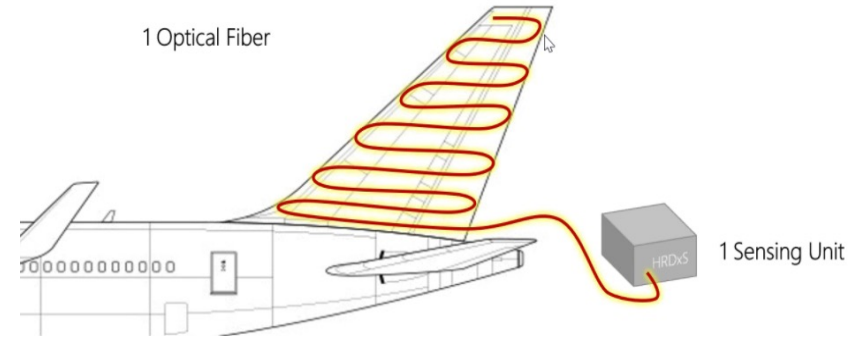
Metallic coatings for any fabricated fiber

- Integrating fibers with metal components for sensing or heatsinking
- Harsh environment applications (e.g. high temp. up to 1000°C)
- More than 200 m continuous length
- Different materials and Multilayers coating (Cu, Au, Ni,)
- Removing acrylate and recoating with metal
- Low induced attenuation



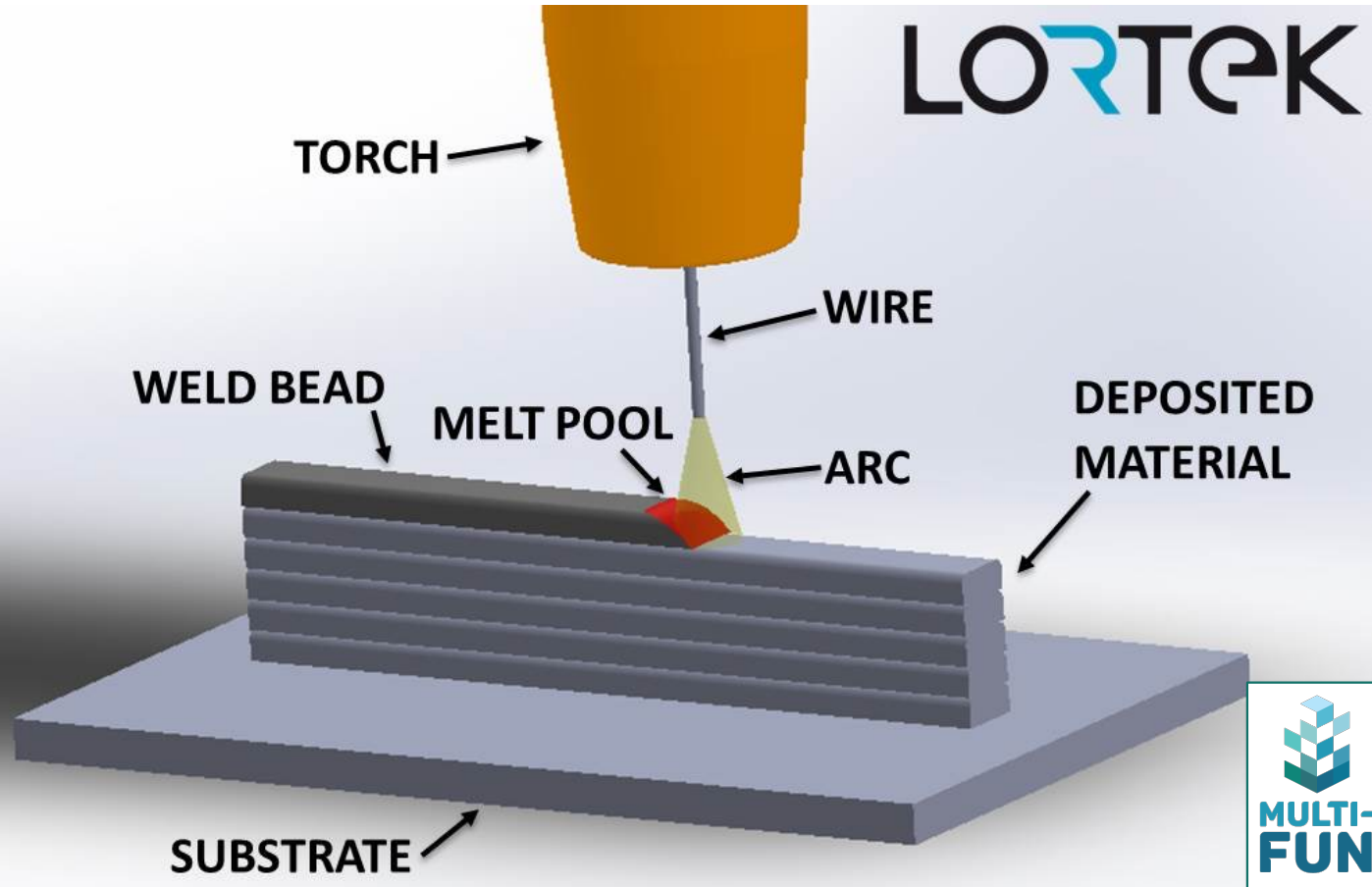
Motivation – Distributed fiber sensing for Structural Health Monitoring (3D print, composites, etc)

Great freedom in designing shape of element using WAAM (Wire Arc Additive Manufacturing) technology



Traditional forms of defect detection through service	Sensing by optical fiber integrated within the structure
Limited number of sensing points	Real-time full mapping of strain / shape / temperature distribution
Hard-to-reach sensing areas	Negligible effect on structural integrity of the structure during measurement
Expensive maintenance: acoustic sensing, visual and manual inspection	Comprehensive monitoring via optical fiber

What is 3D metal printing – WAAM?



Wire Arc Additive Manufacturing is a variation of a Direct Energy Deposition technology that uses an arc welding process to 3D print metal parts.

Main issues:

- Frozen stress in 3D metal printed elements
- Probability of material discontinuities and defects

Solution – Integrated Fiber Optic Sensors

LORTEK is a member of Basque research & technology alliance

Optical fiber embedment in WAAM process

Challenges:

- High temperature creates a need for specialty harsh environment coatings
- Inadequate coating materials might burn or melt and weaken the material



Sample before integration process

Comparison of different coating materials

Same process conditions, imply different coating behavior, due to:

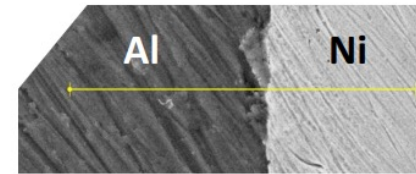
- Melting temperature of each material:

$$\begin{cases} Ni \approx 1455 \text{ }^\circ\text{C} \\ Cu \approx 1085 \text{ }^\circ\text{C} \\ Au \approx 1064 \text{ }^\circ\text{C} \end{cases}$$

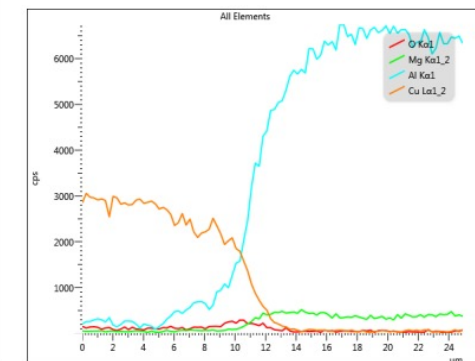
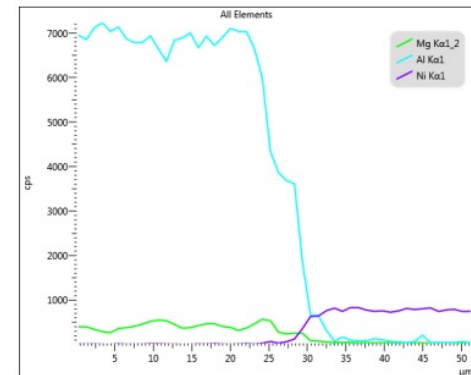
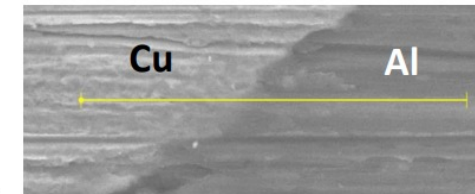
Where WAAM Al melting point is $\sim 1200 \text{ }^\circ\text{C}$

- Alloying behavior among materials; Ni-Al | Cu-Al | Au-Al

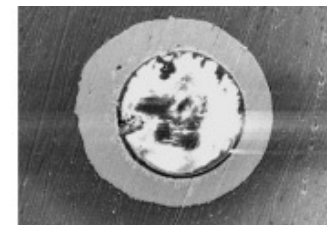
Ni-Al interface:



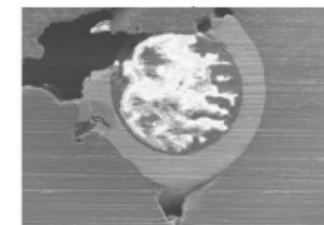
Cu-Al interface:



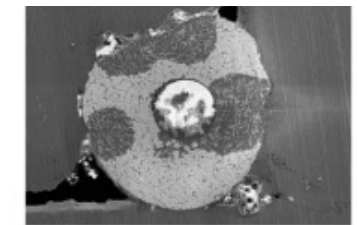
Comparison of cross-sections of samples:



Nickel



Copper



Gold

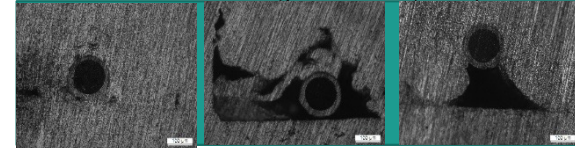
Optimization of welding process parameters

An influence of parameters of subsequent „filling“ WAAM layer were analysed:

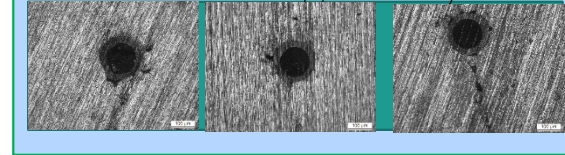
- Position of fiber throughout the process
- Cold Metal Transfer (CMT) mode
- Wire feed speed (WFS)
- Welding Current and Voltage

A suitable range of parameters were found

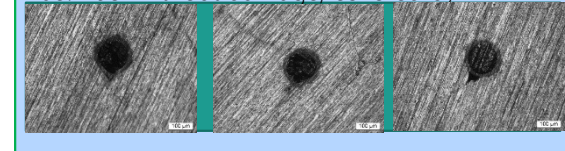
03: fiber without damage, not completely covered by Al



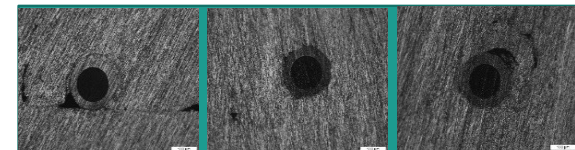
07: fiber without damage, covered by Al



08: fiber without damage, covered by Al



10: fiber without damage, almost covered by Al., but with defects on side crosssections

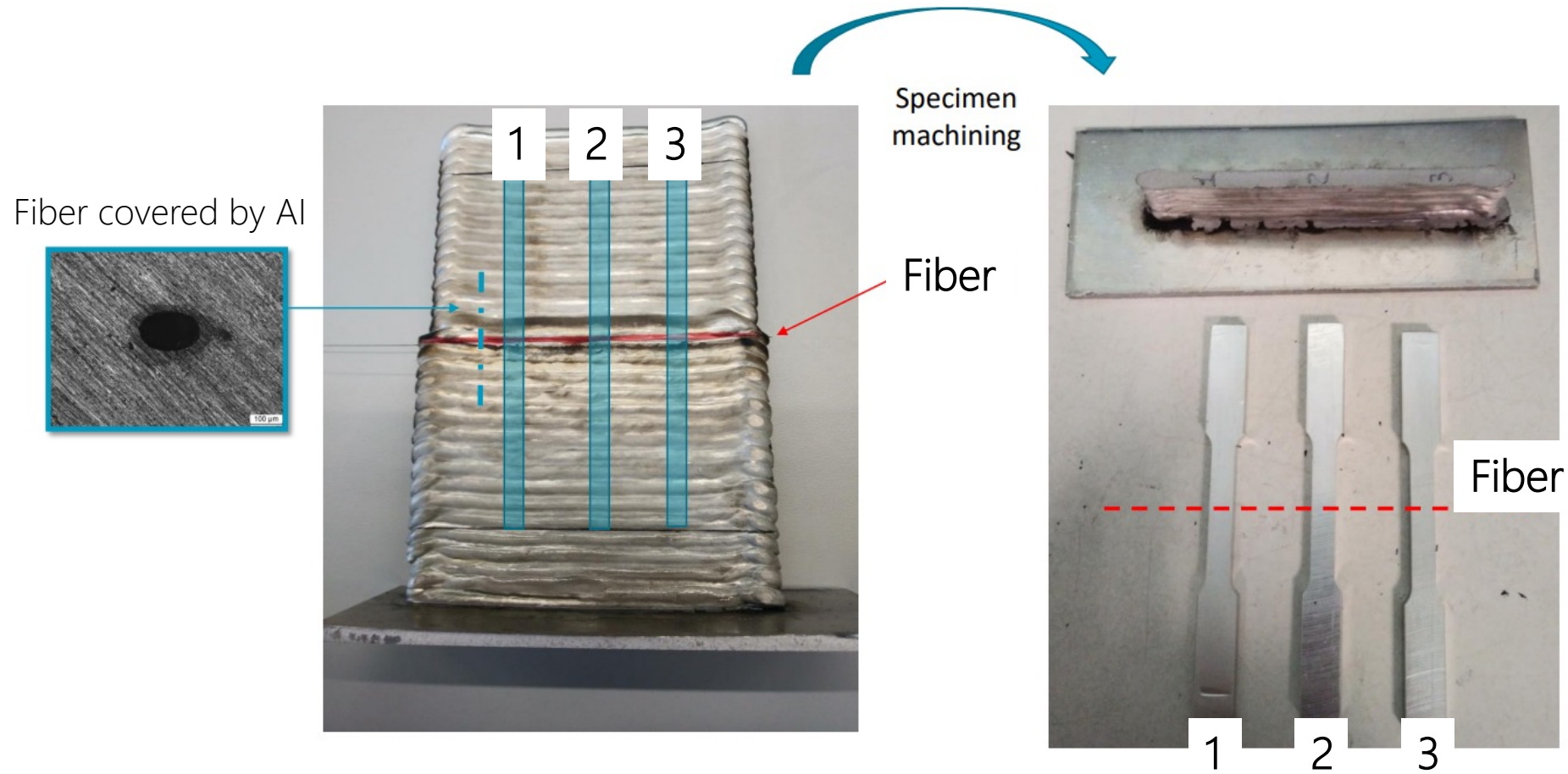


Demonstration of embedding process



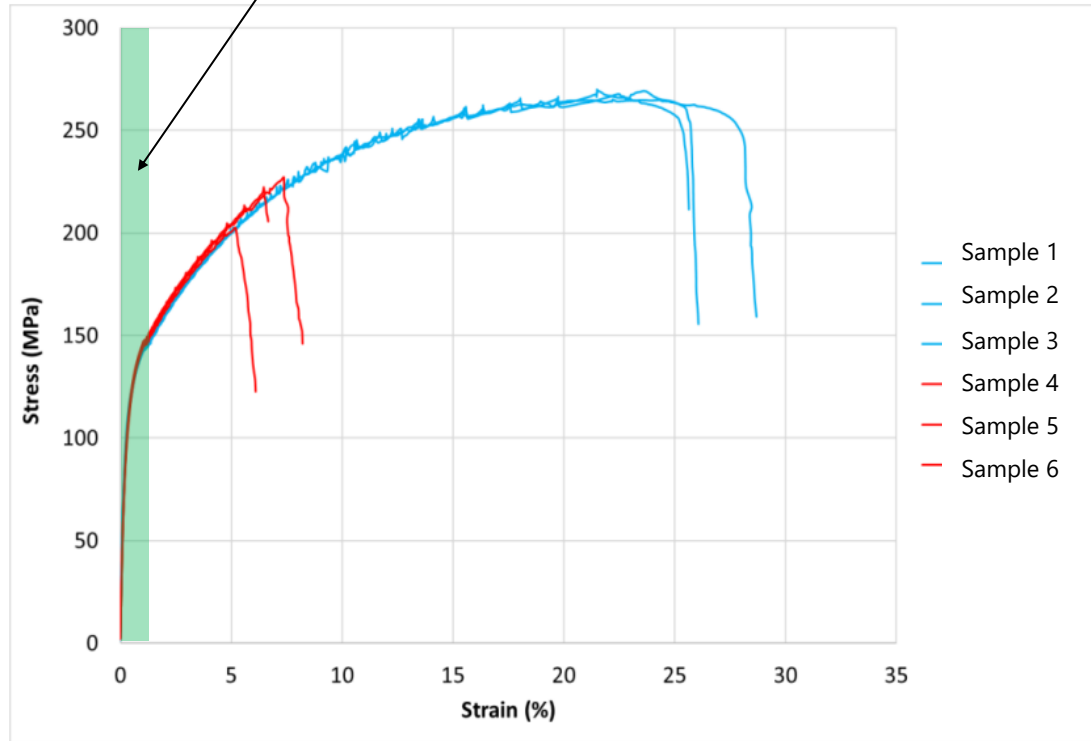
Sample after integration process

Mechanical strength analysis - tensile test specimen machining



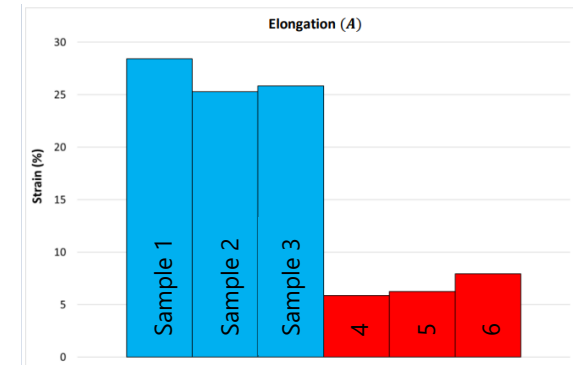
Mechanical strength analysis - tensile test results

Useful range for components design (commercial applications)



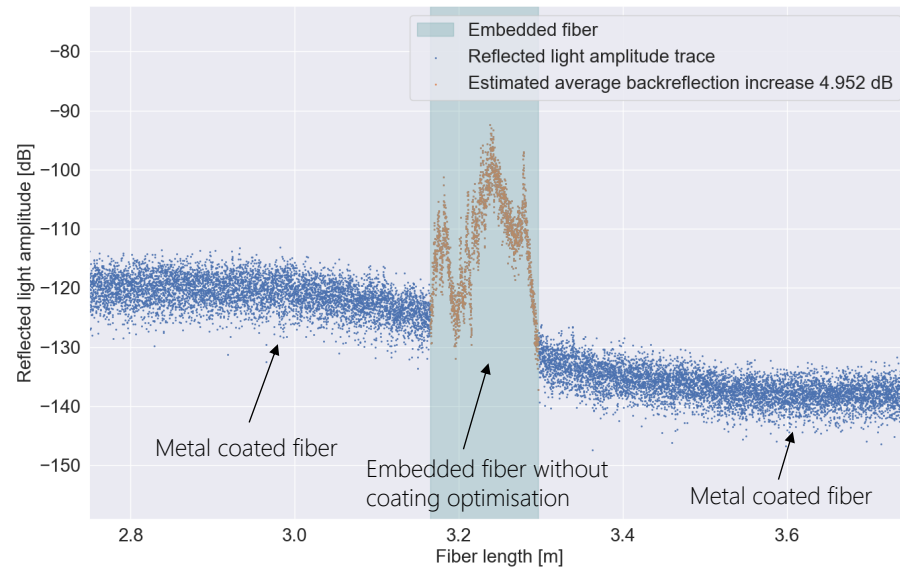
No fiber embedded

Fiber embedded

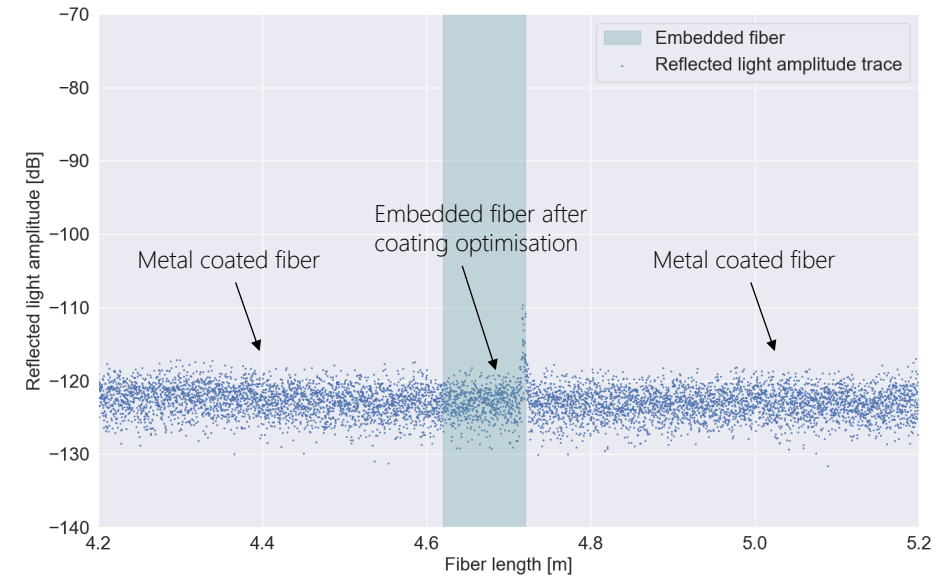


Presence of an optical fiber does not affect yield stress. Samples maintain their properties within an elongation range useful for components design.

Optical analysis – backscatter discontinuity phenomenon

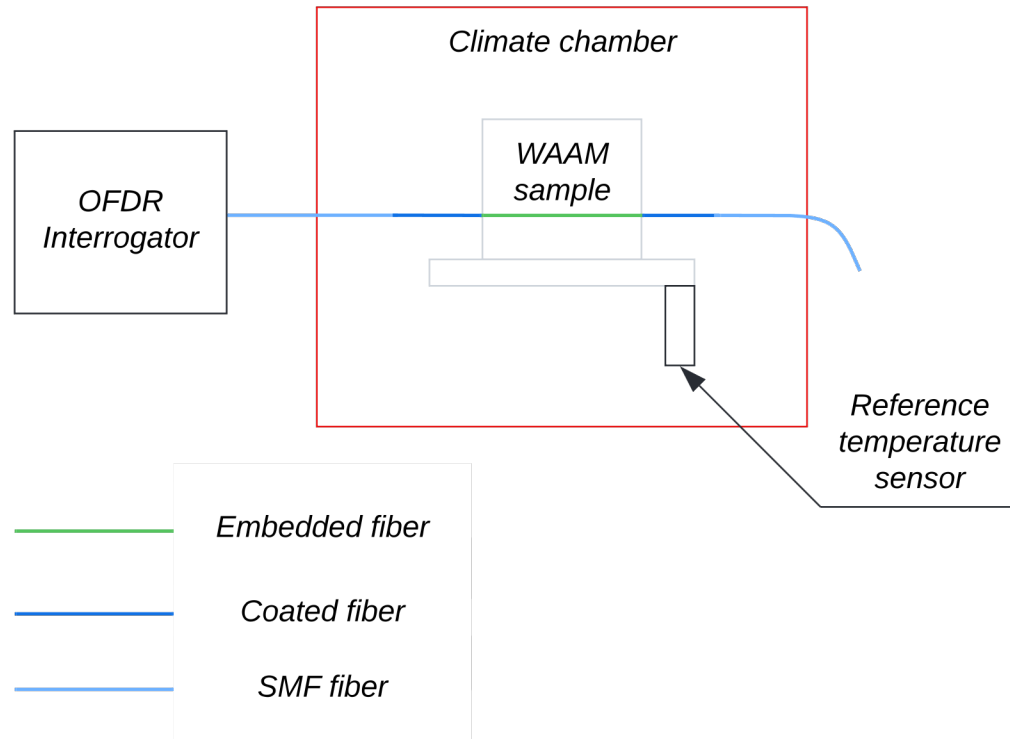


Optimization of
coating layers



The induced changes in backscatter were minimised by proper composition of coating and thickness selection

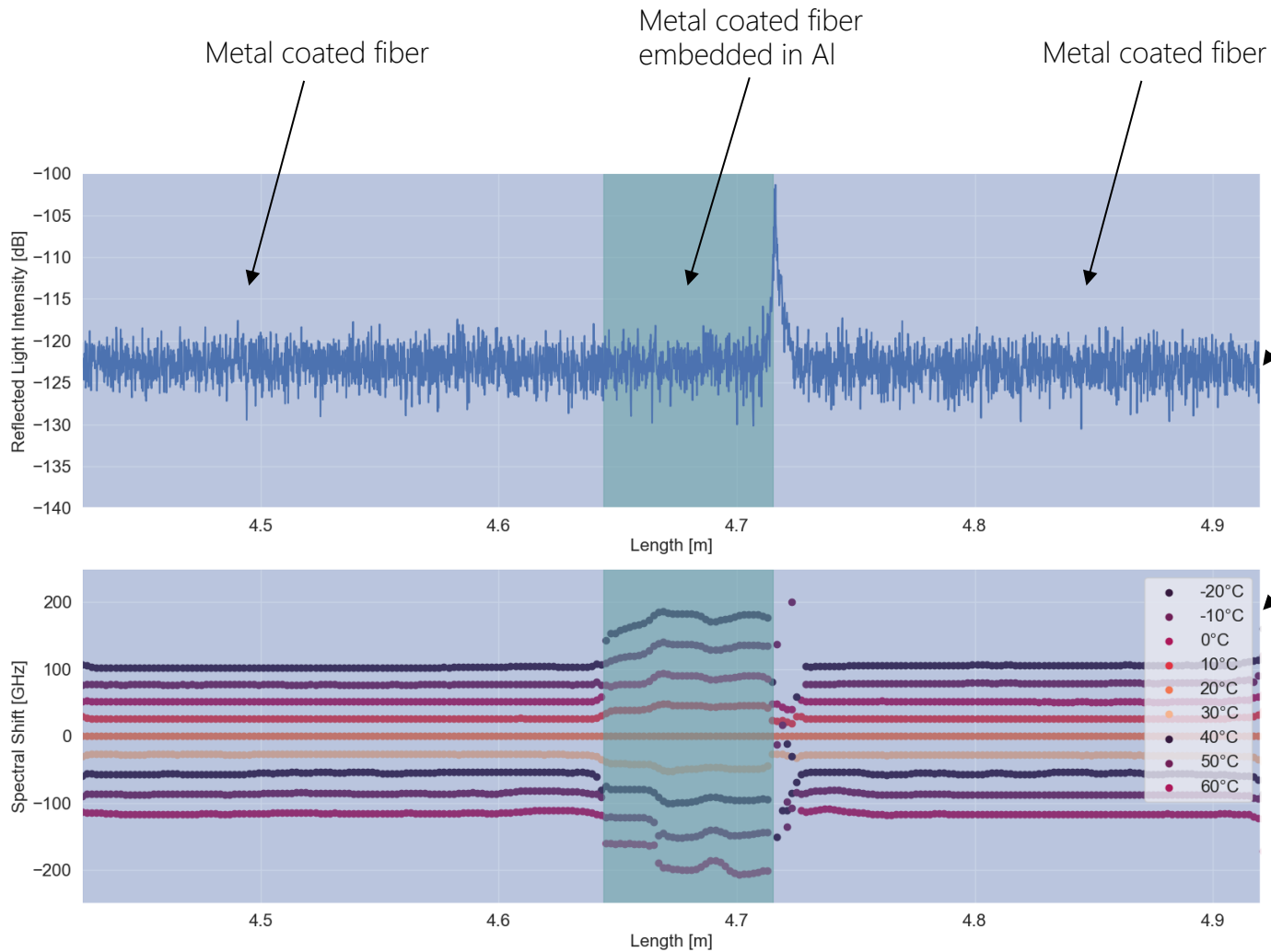
Optical distributed sensing - temperature measurement testing setup



During the optical tests the temperature was set from -20 to 60°C with steps of 10°C

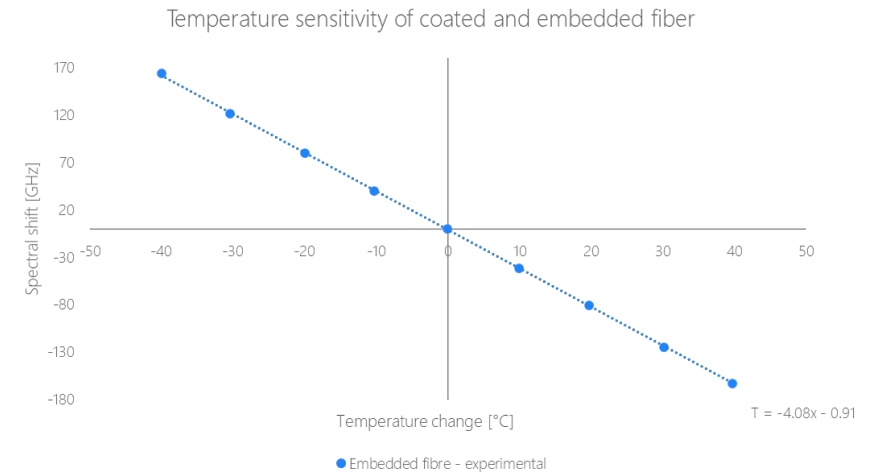
Temperature near a sample was measured with a reference sensor with 0.01°C resolution

Optical distributed sensing - temperature measurement results

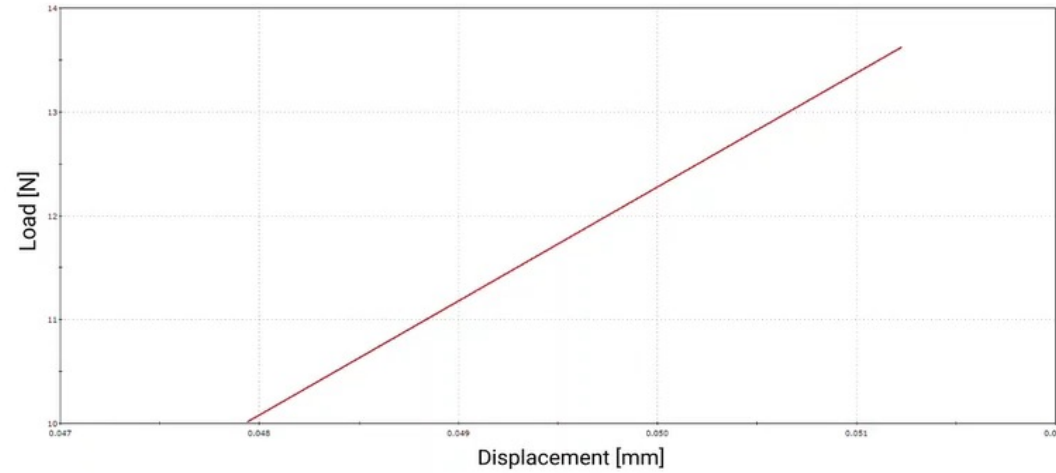
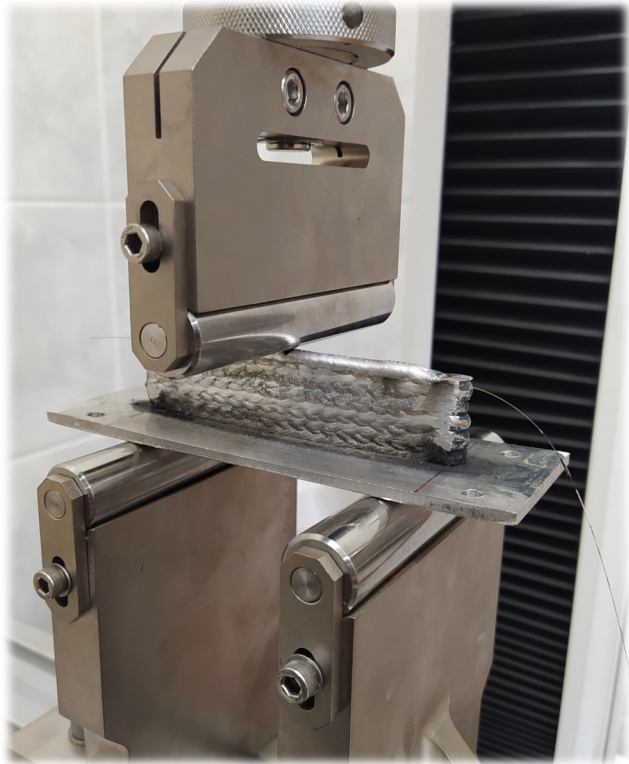


Backscattered light amplitude vs distance

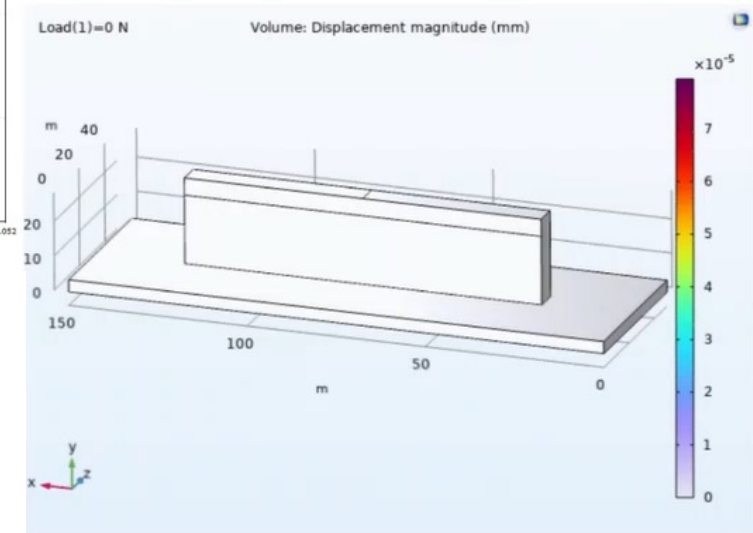
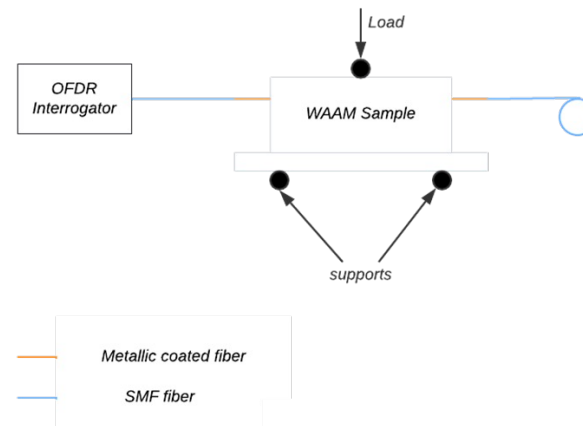
Spectral shift (optical response) for each temperature vs distance



Optical distributed sensing - strain measurements



3-point bending



An effective method of embedding optical fiber into WAAM printed parts was successfully developed:

- Optical Fibers were not destroyed during the integration process and retained their optical properties
- Embedment does not cause local defects in 3D printed structure
- Mechanical properties (yield stress) of the constructed part are suitable

It was proven that we can monitor the stress and temperature of WAAM elements

Further development of technology is planned as follows:

- Manufacturing of a full-scale demonstrator of an aeroplane bulkhead panel



THANK YOU FOR YOUR ATTENTION

Krzysztof Wilczyński
kwilczynski@inphotech.pl

 This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862617 – MULTI-FUN

All information contained in this document is confidential and contains business information and trade secrets and is a property of InPhoTech Sp. z o.o. and LORTEK S COOP. This document as well as any information about the content of said document are subjected to the Intellectual Property rules of InPhoTech group and may not be used, published, or redistributed without prior written consent of InPhoTech Sp. z o.o. and LORTEK S COOP.

