Improving laser based e-drive manufacturing performance:

From processing to testing

IMA AUTOMATION
Flawless Assembly

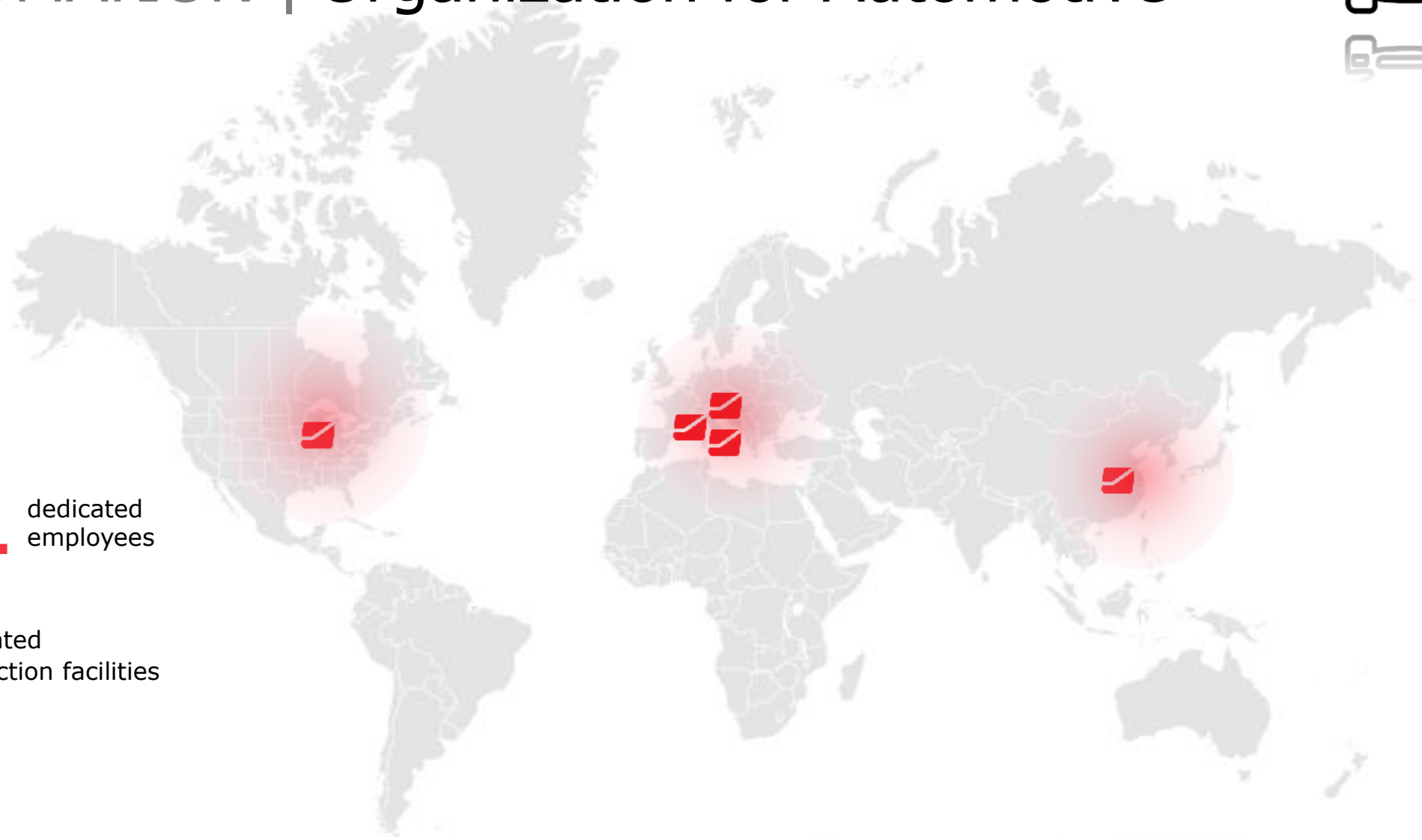
Date – March 10-11, 2022

LaserEMobility| AGENDA OF THE MEETING

- IMA AUTOMATION ATOP
- HAIRPIN SOLUTION – STRIPPING AND WELDING
- HAIRPIN SOLUTION – WELDING OF FLAT AND TIP WIRES
- HAIRPIN SOLUTION – LASER WELDING INSPECTION

IMA AUTOMATION ATOP

IMA AUTOMATION | Organization for Automotive



381 dedicated employees

5 dedicated production facilities

IMA AUTOMATION ATOP | HISTORY AND MILESTONES

1993

INCORPORATION

After **leaving AXIS**, an Italian producer of machines and lines for the manufacturing of electric motors, Mr. Santandrea, Mr. Ponzio and Mr. Cresti **establish ATOP**.

2004

AXIS

Acquisition of the company AXIS, Including trademarks CORAGLIOTTO and PAVESI, costumers' portfolio, highly skilled employees and related know-how and patents.

2009

HAIRPIN TECHNOLOGY START

Start of the manufacturing of lines for the production of electric motors **for traction**, both hybrid and electric, and development of the hairpin technology.

2016

FIRST AUTOMATIC E-TRACTION LINE DELIVERED

First automatic line to manufacture e-traction hairpin stators for mass production is delivered.

2017

IMA AND CHARME CAPITAL PARTNERS

Majority stake acquisition by IMA and Charme Capital Partners.
Appointment of Mr. Felisa as new Executive Chairman.

2019

ACQUISITION BY IMA GROUP

TRACTION BUSINESS DEVELOPMENT

More than **10 Traction production lines installed** and under commissioning worldwide.

2021

INTERNATIONALIZATION

Development of the **international service and sales network** through the establishment of ATOP Shanghai, USA headquarters and Germany service unit.

IMA AUTOMATION ATOP | HEADQUARTERS

16.000 sqm PRODUCTION PREMISES

2.000 sqm OFFICES

600+ COMPLETE AUTOMATIC LINES DELIVERED

2.700+ WINDING MACHINES FOR STATORS AND ROTORS DELIVERED

490+ PATENTS GRANTED (TOP CLASS PROPRIETARY KNOW-HOW)

250+ EMPLOYEES

2010
8.000 m2
PRODUCTION PREMISES

2016
+4.000 sqm
production premises

2019
+4.000 sqm
production premises

REFERENCES

1st E-MOBILITY project: Starting from 2010

	Technology	Area	Year	Capacity (pcs/y)	Flexibility	Customer
1	Hair-pin Stator	EU	2011	5.000	1 product	TR1
2	Hair-pin Stator	EU	2013	5.000	1 product	OEM
3	Hair-pin Stator	EU	2015	210.000	1 product	TR1
4	Wounded rotor	EU	2015	250.000	1 product	OEM
5	Round wire stator	EU	2015	250.000	1 product	OEM
6	Wounded rotor	EU	2016	250.000	1 product	OEM
7	Round wire stator	EU	2016	250.000	1 product	OEM
8	Hair-pin Stator	Korea	2017	25.000	2 products	OEM
9	Hair-pin Stator	EU	by 2017	150.000	3 products	TR1
10	Hair-pin Stator	EU	2018	160.000	2 products	TR1
11	Hair-pin Stator	China	2018	50.000	1 product	TR1
12	Hair-pin Stator	EU	2018	40.000	1 product	TR1
13	Hair-pin Stator	China	by 2018	120.000	3 products	TR1
14	Round wire stator	EU	2018	80.000	1 product	OEM
15	Hair-pin Stator	China	by 2019	180.000	1 product	OEM
16	Hair-pin Stator	Korea	by 2020	250.000	2 products	OEM
17	PM rotor	USA	2020	500.000	1 product	OEM
18	PM rotor	EU	2021	500.000	1 product	OEM
19	Hair-pin Stator	EU	2022	250.000	1 product	TR2
20	Hair-pin Stator	EU	2022	250.000	1 product	TR2

18 Full automatic lines installed at Customers facilities.

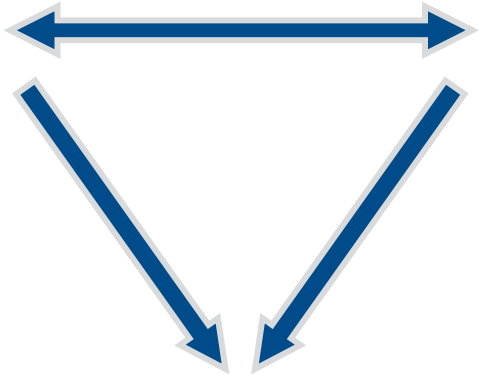
3.300.000 Traction Motors/Year are produced with IMA Automation Equipment's

HAIRPIN SOLUTIONS

Research Project For Laser Applications

(started in 2019)

IMA AUTOMATION ATOP



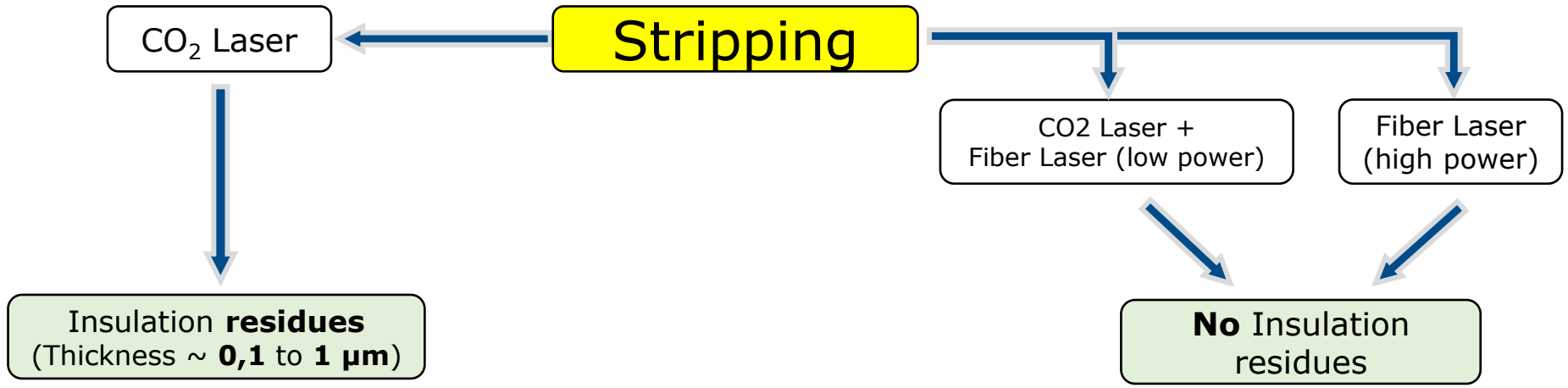
POLITECNICO MILANO 1863

SITEC Laboratorio per le Applicazioni Laser

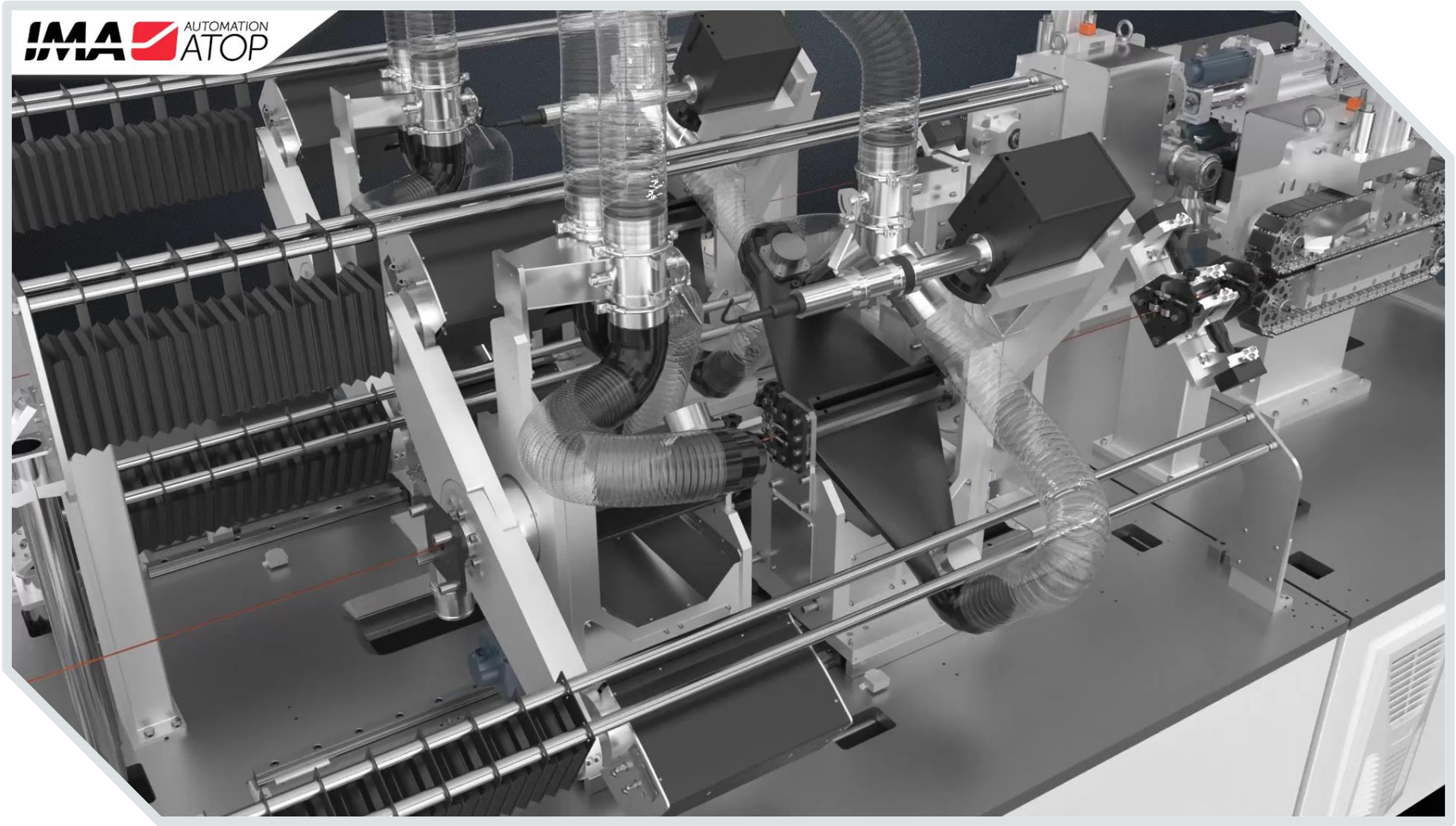
Stripping and Welding Process for Copper Electric Conductors

HAIRPIN SOLUTIONS | 1. STRIPPING

Research Project Road-Map



HAIRPIN SOLUTIONS | 1. STRIPPING



HAIRPIN SOLUTIONS | 2. STRIPPING AND WELDING

Concerning the **laser stripping** processes, the following can be stated <u>today</u> about the **mechanical resistance of welded joints** and **the Effectiveness to Cost ratio**:

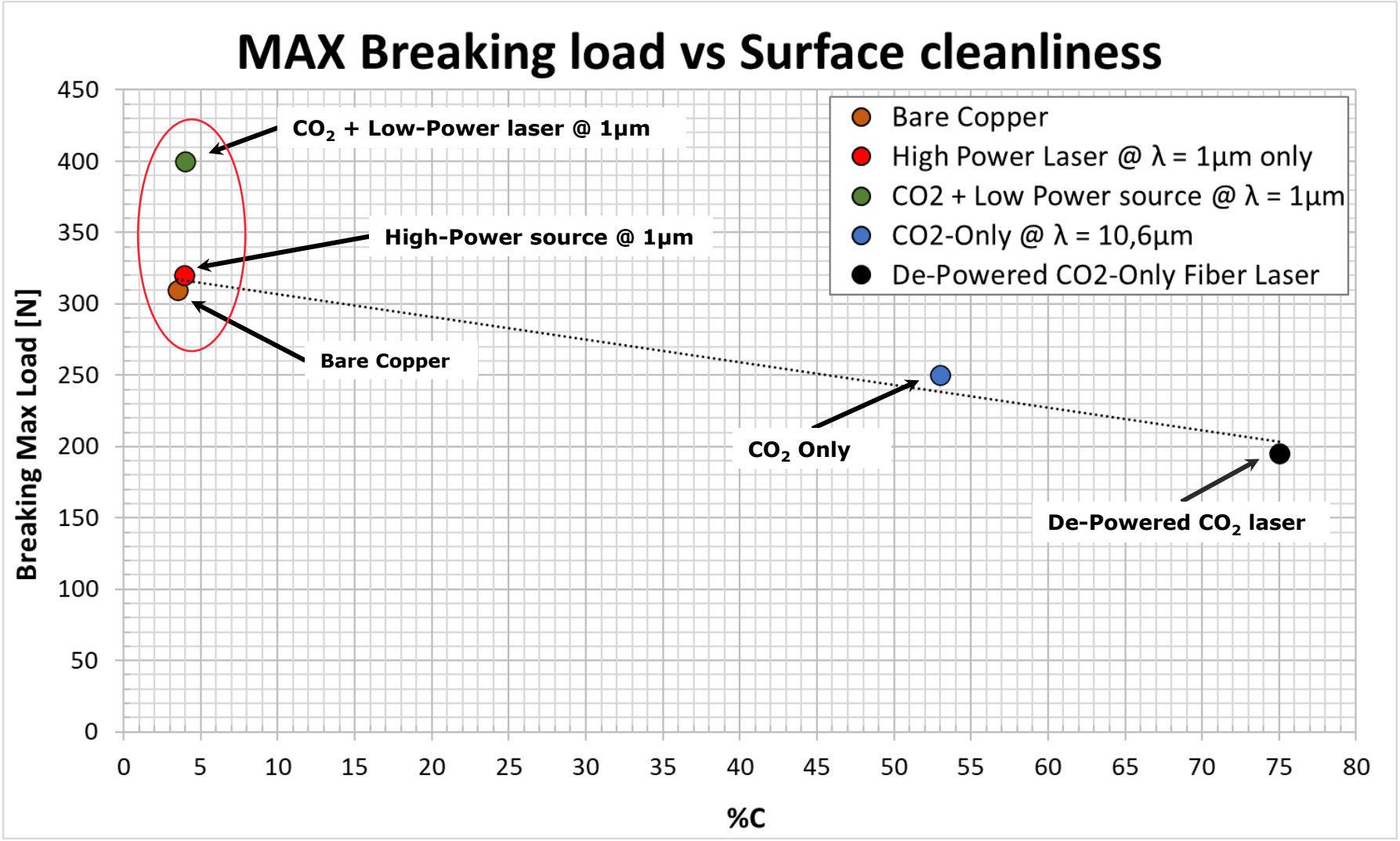
- Only CO_2

- Only High-Power "1µm sources"

- CO_2+ Low Power "1µm source"
  (<u>ATOP solution,</u> <u>PATENT PENDING</u>)

	Relative pulling force	Porosity	Economic investment
Only CO_2	*ref*	*ref*	*ref*
Only Fiber high power	+ 30%	*Not available*	+ 170%
CO_2 + Fiber low power *(ATOP solution)*	+ 70%	- 10%	+ 100%

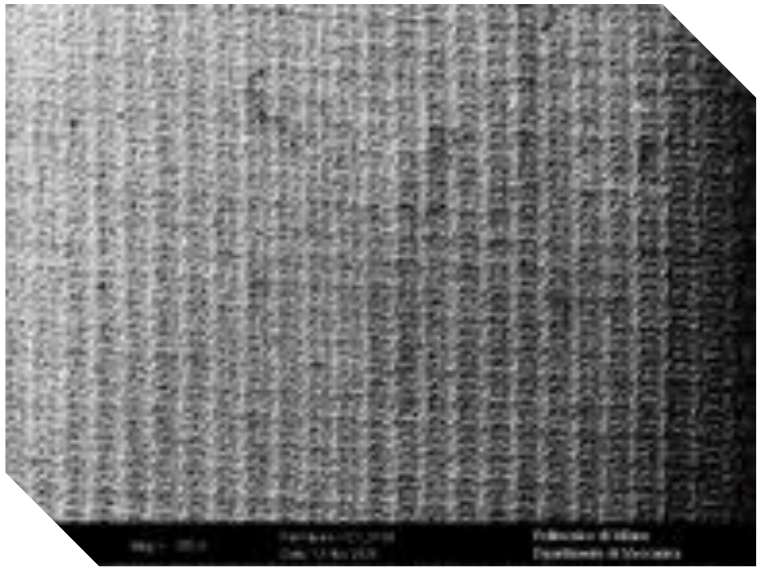
TECHNOLOGICAL CURVE for a specific Hairpin Cross-Section sample:

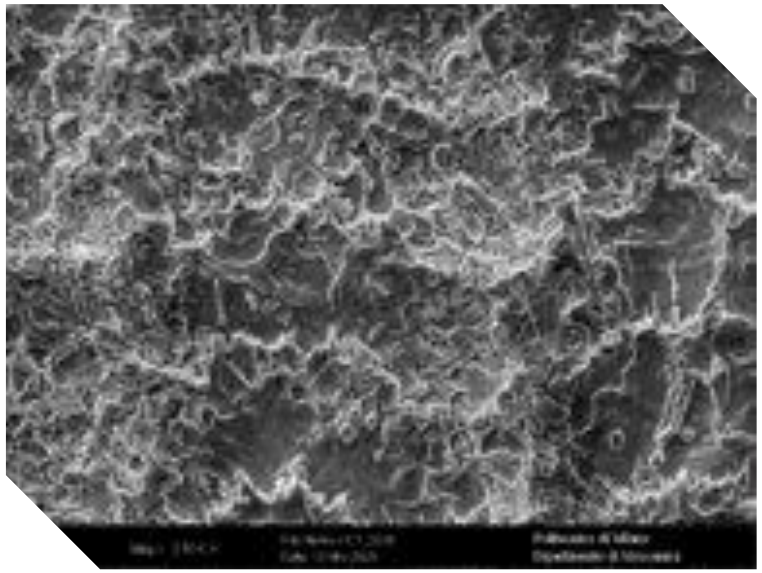


IMPACT OF STRIPPING QUALITY ON WELDS – TECHNOLOGICAL CURVE

- The fiber laser works the copper and leaves grooves on its surface (micro-removal of material), see left figure.
- Depending on how these grooves are made, the mechanical strength of the weld joint changes **(ATOP Patent Application)**.
- In the joint research between ATOP and the POLITECNICO di Milano, a particular pattern was identified that increases the pull force of the welding joint **(ATOP Patent Application)**.

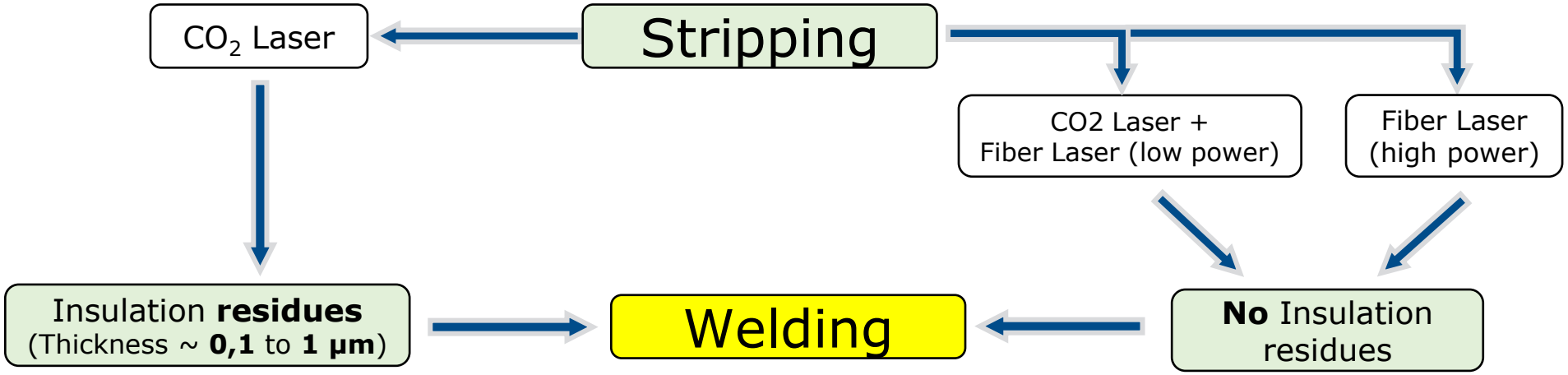
SEM 150X

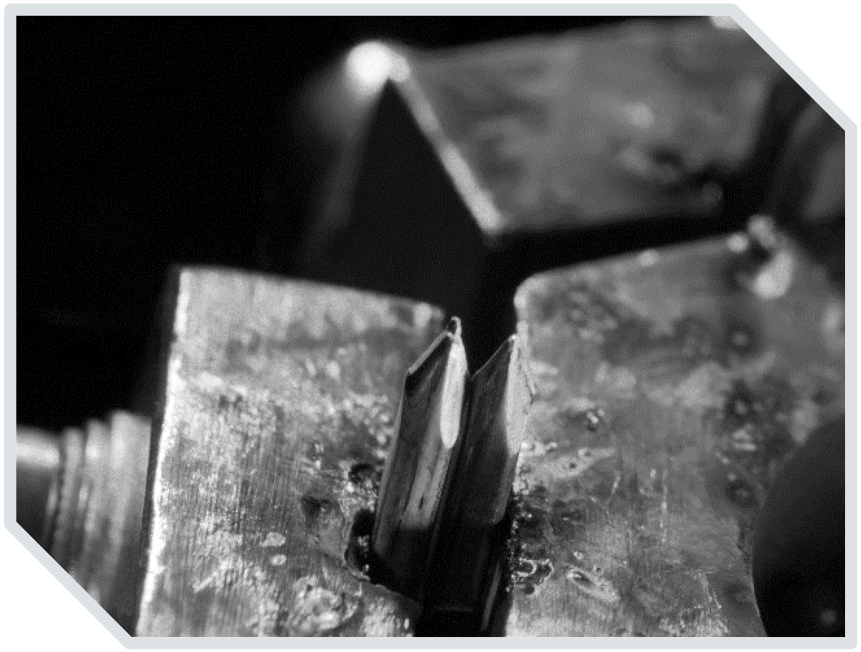




SEM 2000X

Research Project Road-Map



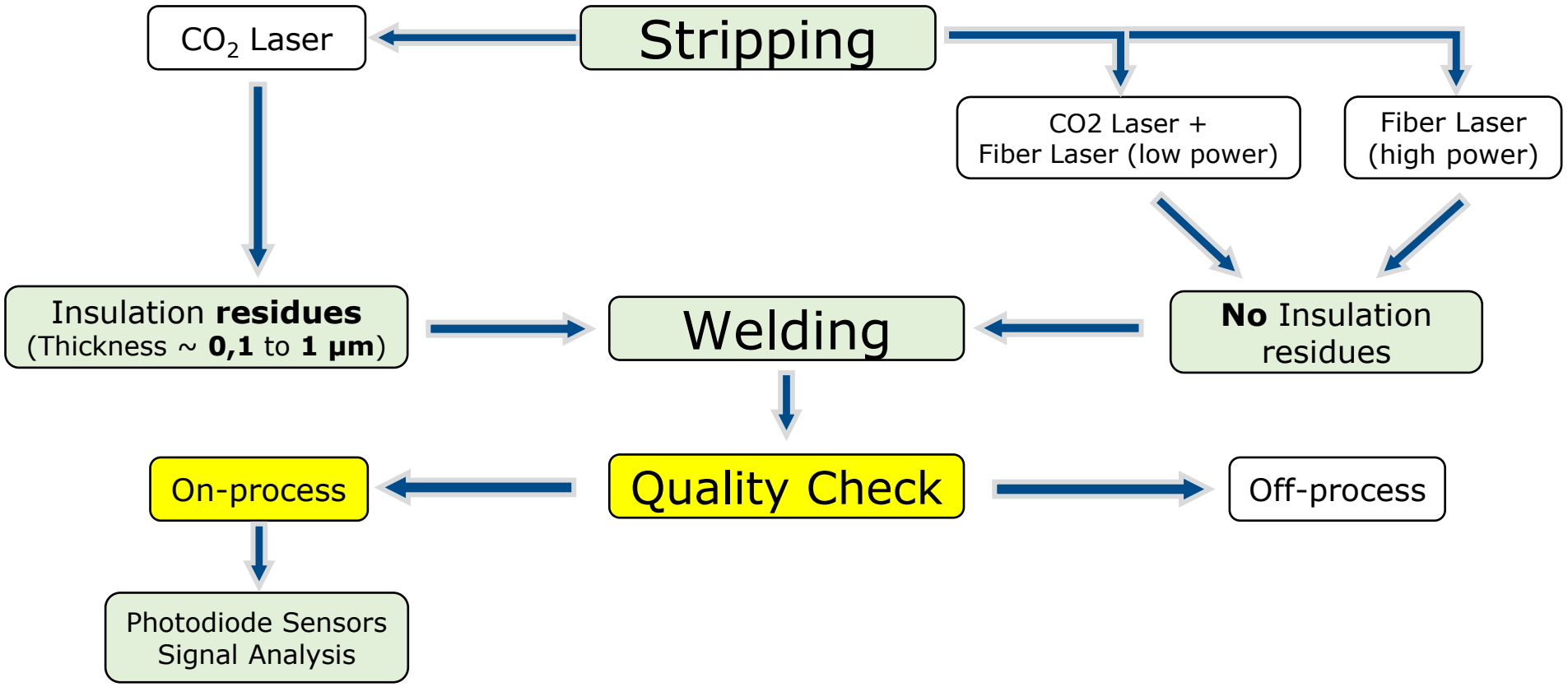


Fine-tuning of the welding parameters using a high-speed camera.

Resolution	Maximum Frame Rate (FPS)
1280 x 800	3,200
640 x 480	10,100
512 x 512	11,500
512 x 256	23,000
256 x 256	39,800
64 x 8	650,000

high-speed video to optimize the welding process

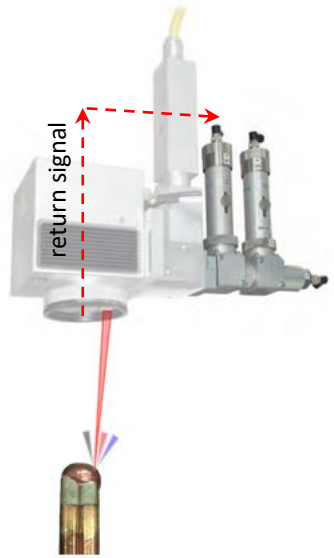
Research Project Road-Map

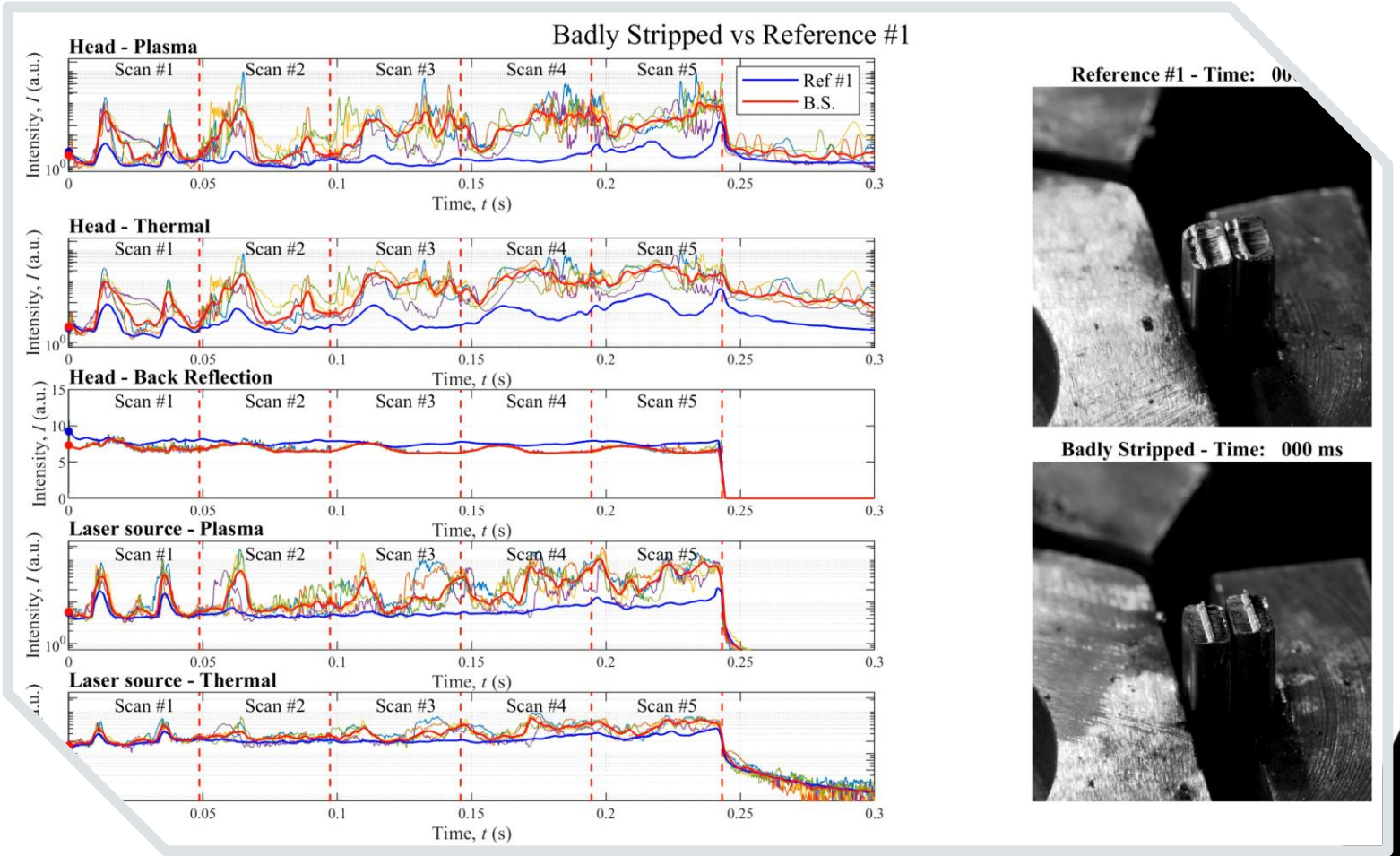


On-process inspection – Degradation of the stripping wire quality

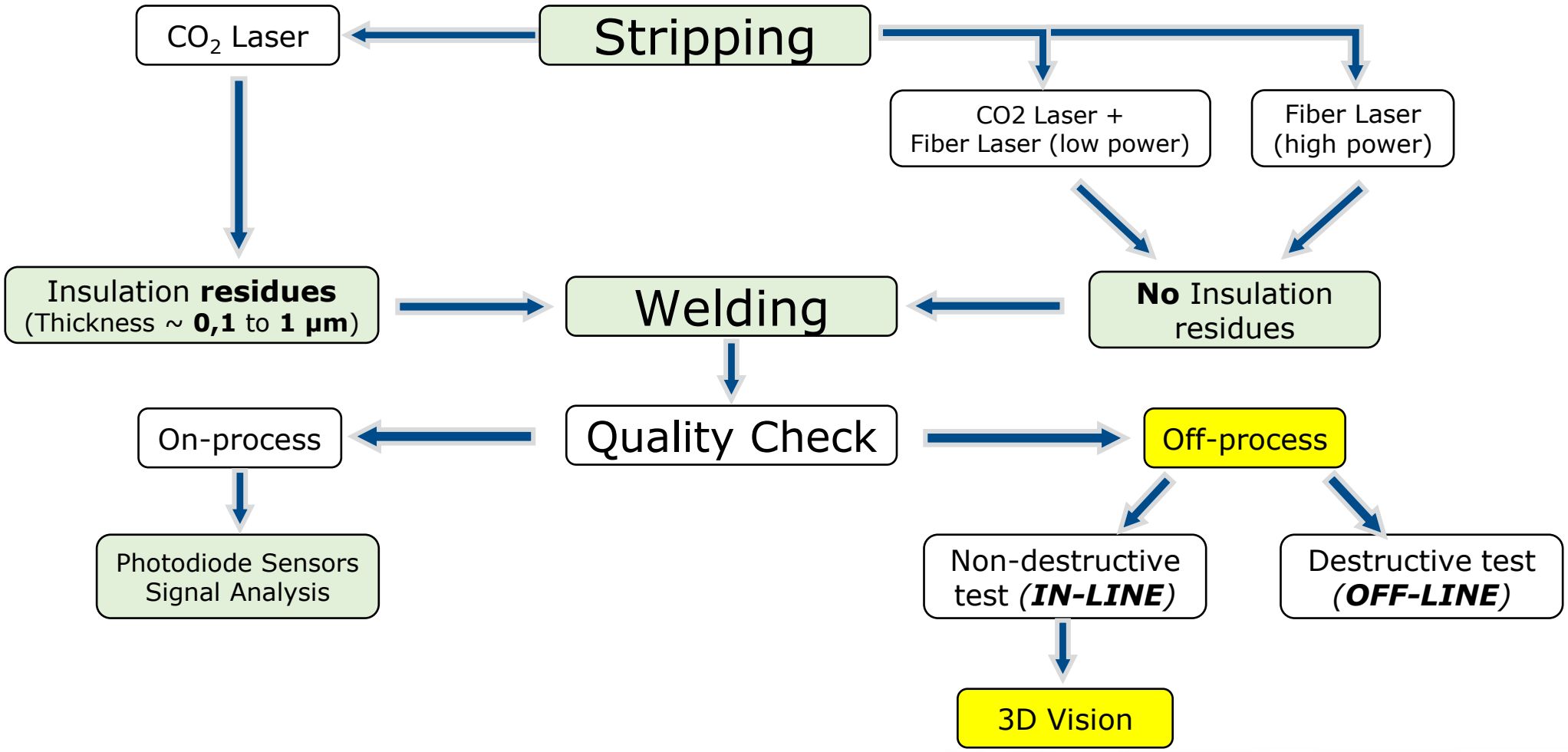
The video shows two welding processes with different de-coating quality levels compared.

E.g.: The badly stripped pins give a signal which differs clearly from the reference signal (blue line).



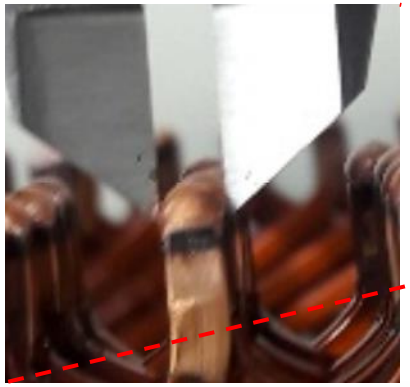


Research Project Road-Map

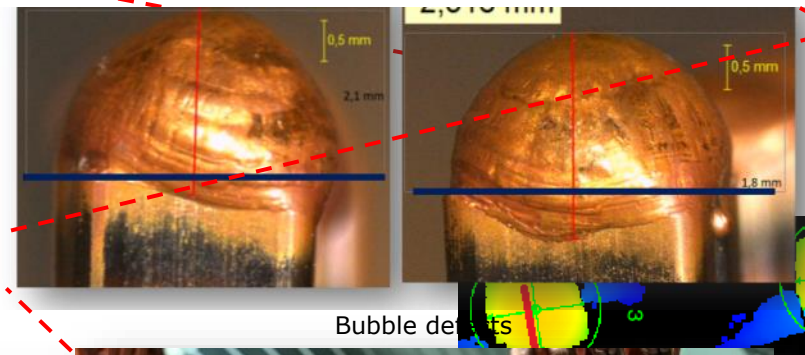


Examples of detectable defects

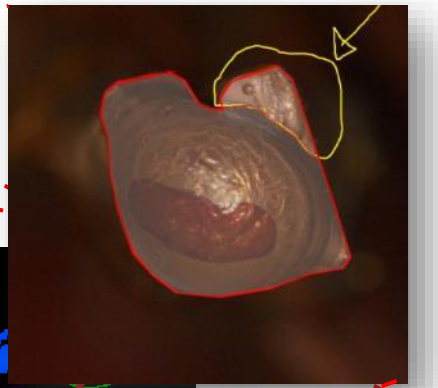
External dimensions (top view) of the welding bubble



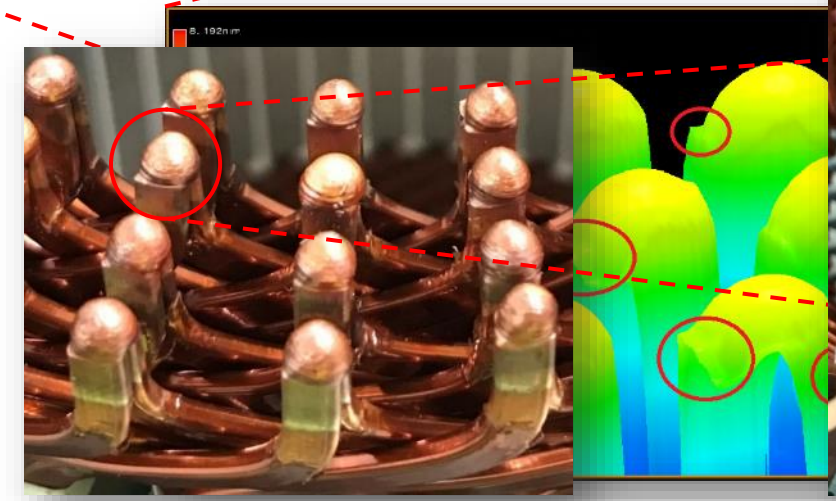
Height (depth) of the weld bubble

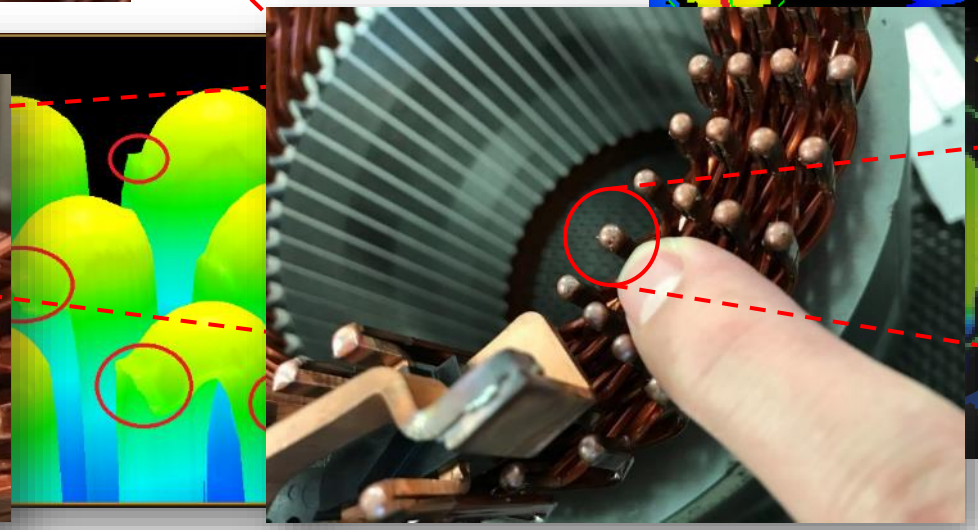


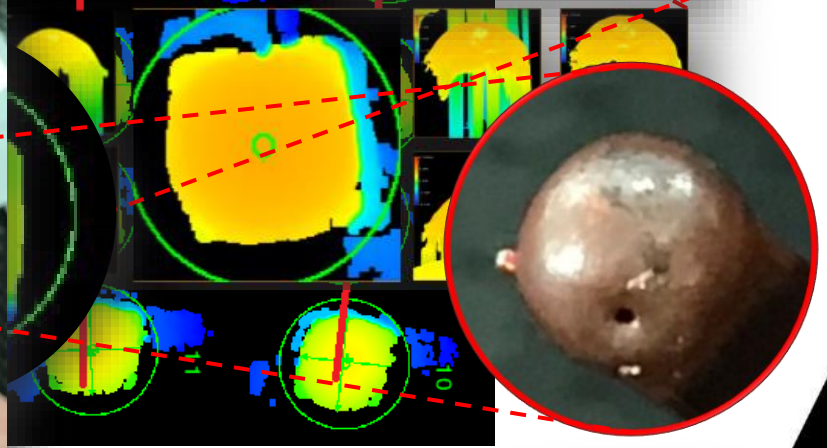
Areas not welded correctly



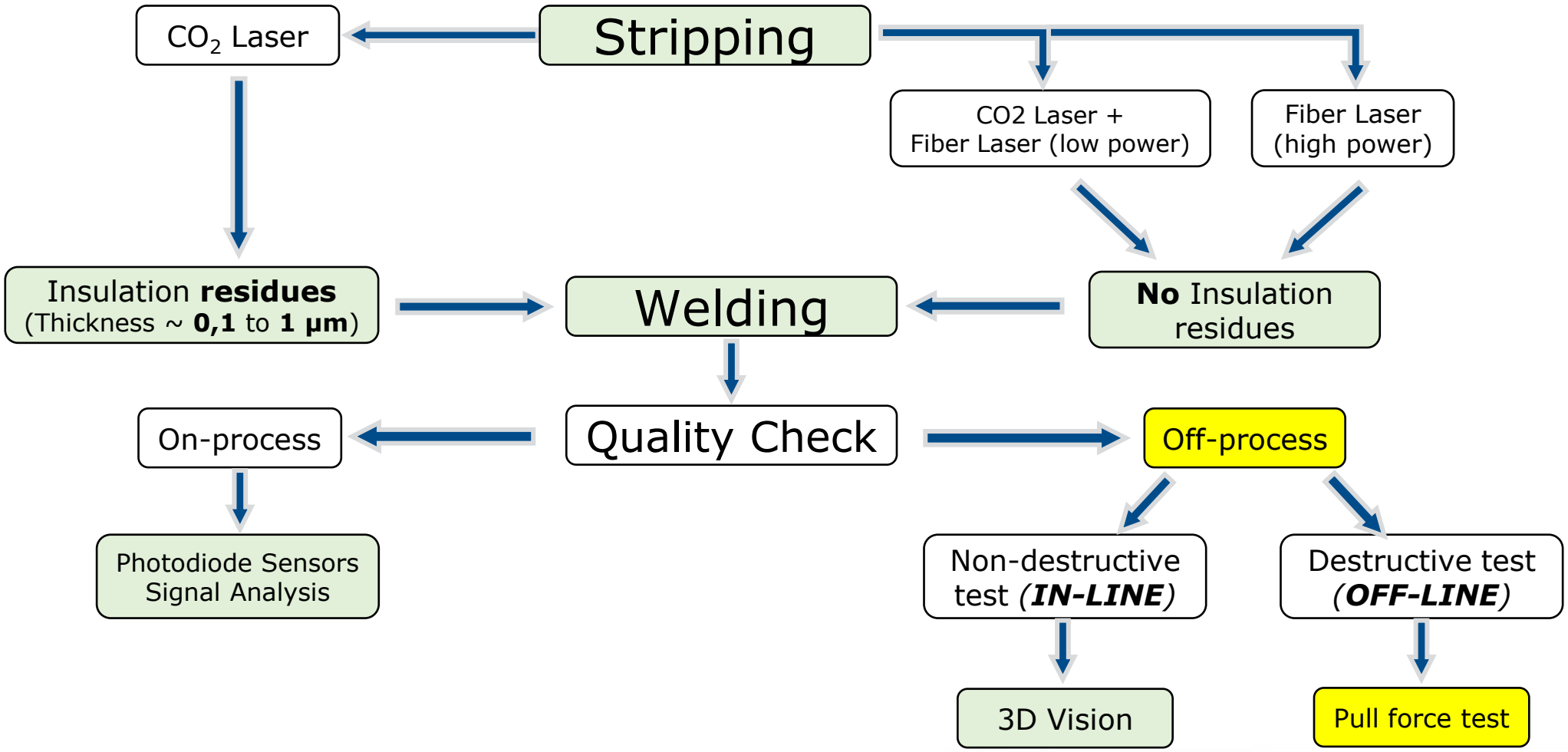
Bubble defects



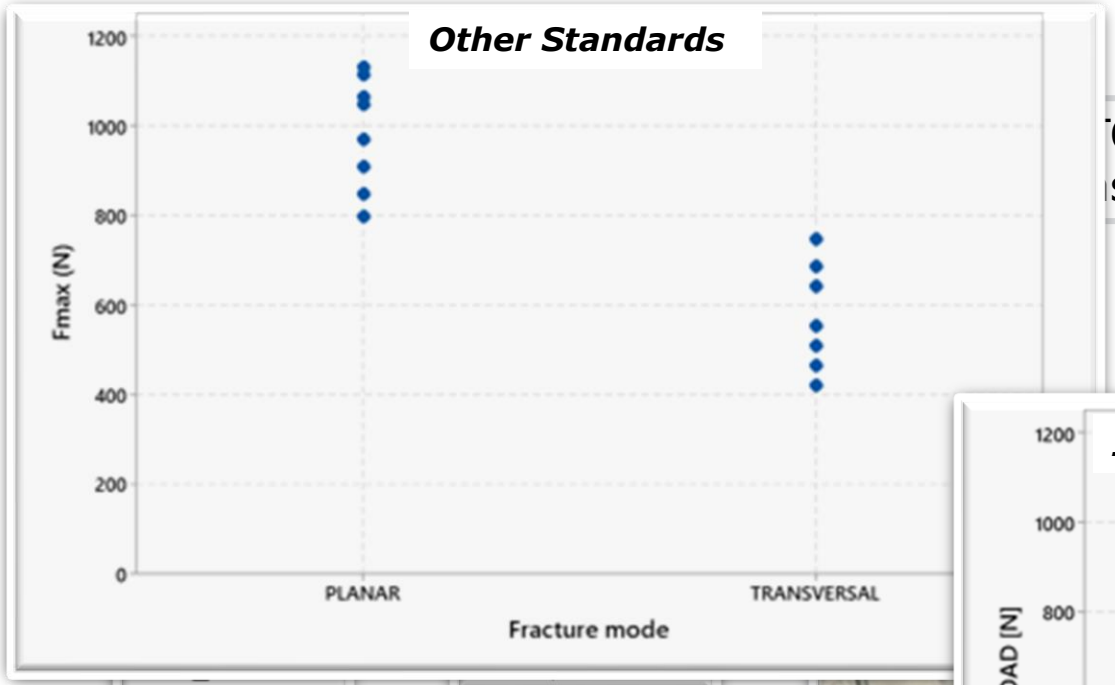




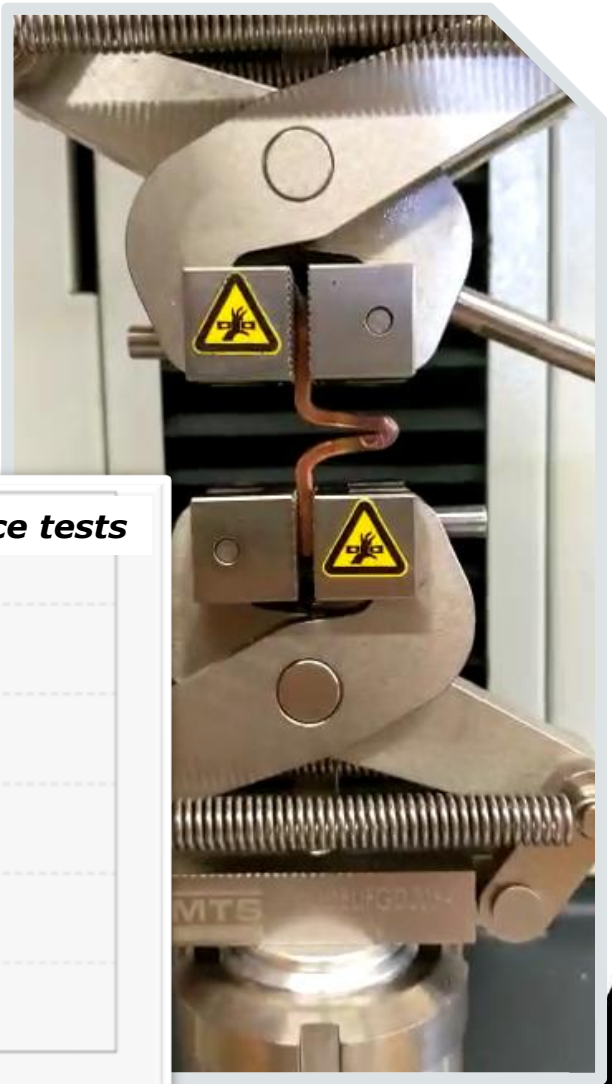
Research Project Road-Map

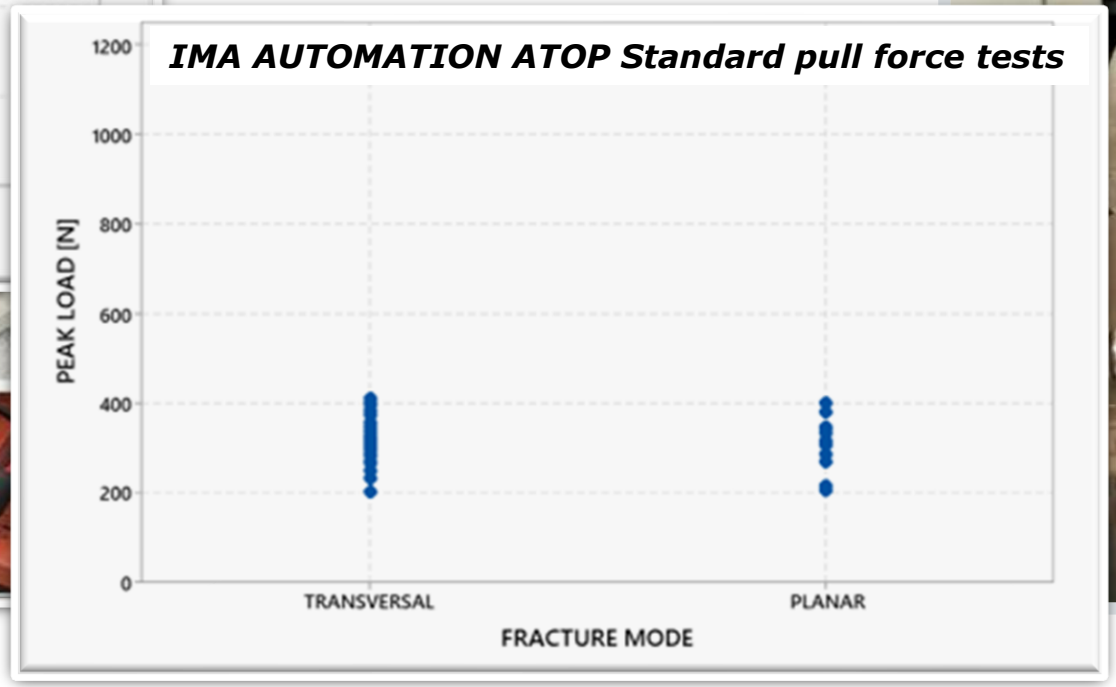


HAIRPIN SOLUTIONS | 4. WELD QUALITY CHECKS: PULL FORCE TEST

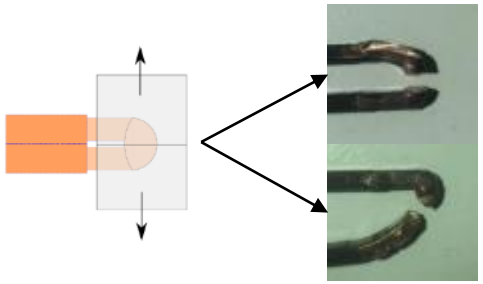


TOP standard pull force test based on BS EN ISO 14270: 2016.





Fracture mode:



Planar

Transversal

Thank you
for your attention

IMA AUTOMATION