Dry pre-treatment methods

Cluster Conference 2023

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Pre-treatment methods

- Laser
- Plasma
- Flame treatment
- CO2 cleaning/blasting
- Steam cleaning (”Eco Clean”)

“Traditional” cleaning: Water- or solvent based cleaning methods – not included in today’s presentation

Background

Why pre-treatment?

- To clean a surface
- Prepare it for the next layer
- To secure or obtain good adhesion to next treatment or coating layer
- Increased corrosion inhibition

Note: Pre treatment methods can also work as post process step, i.e. paint removal.

Laser


radiation - remove cover - wear safety
Laserstrahlung - Abdeckung entfernen - Schutzbrille
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Surface treatment with laser - Example of applications

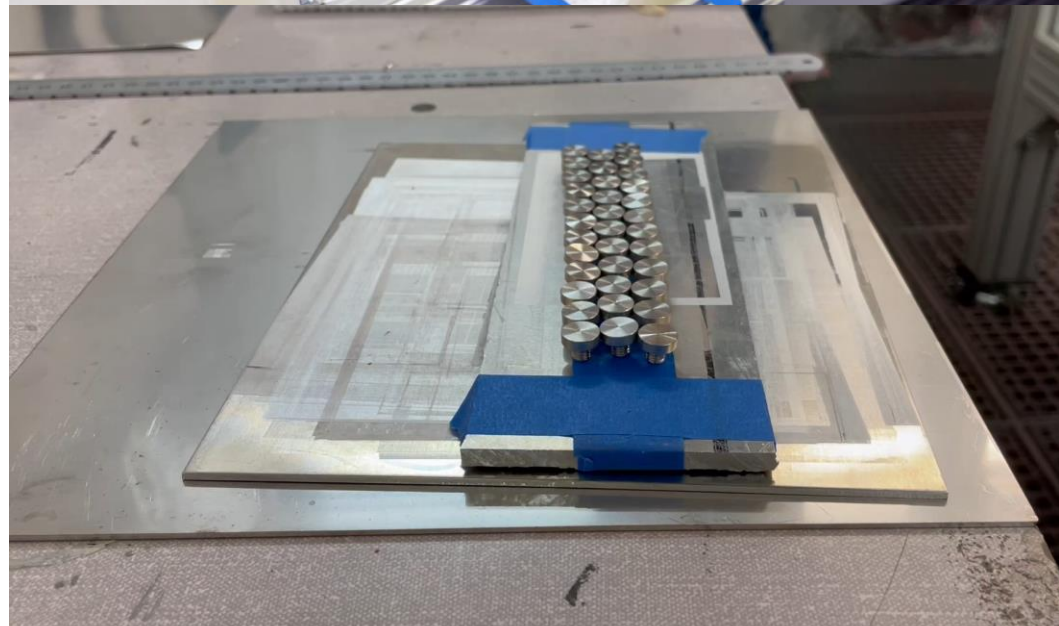
Pretreatment before:

- Adhesive bonding
- Brazing
- Welding
- Varnishing

De-coating

Labeling and marking

Mold cleaning



Lasers

Lasers can be used to

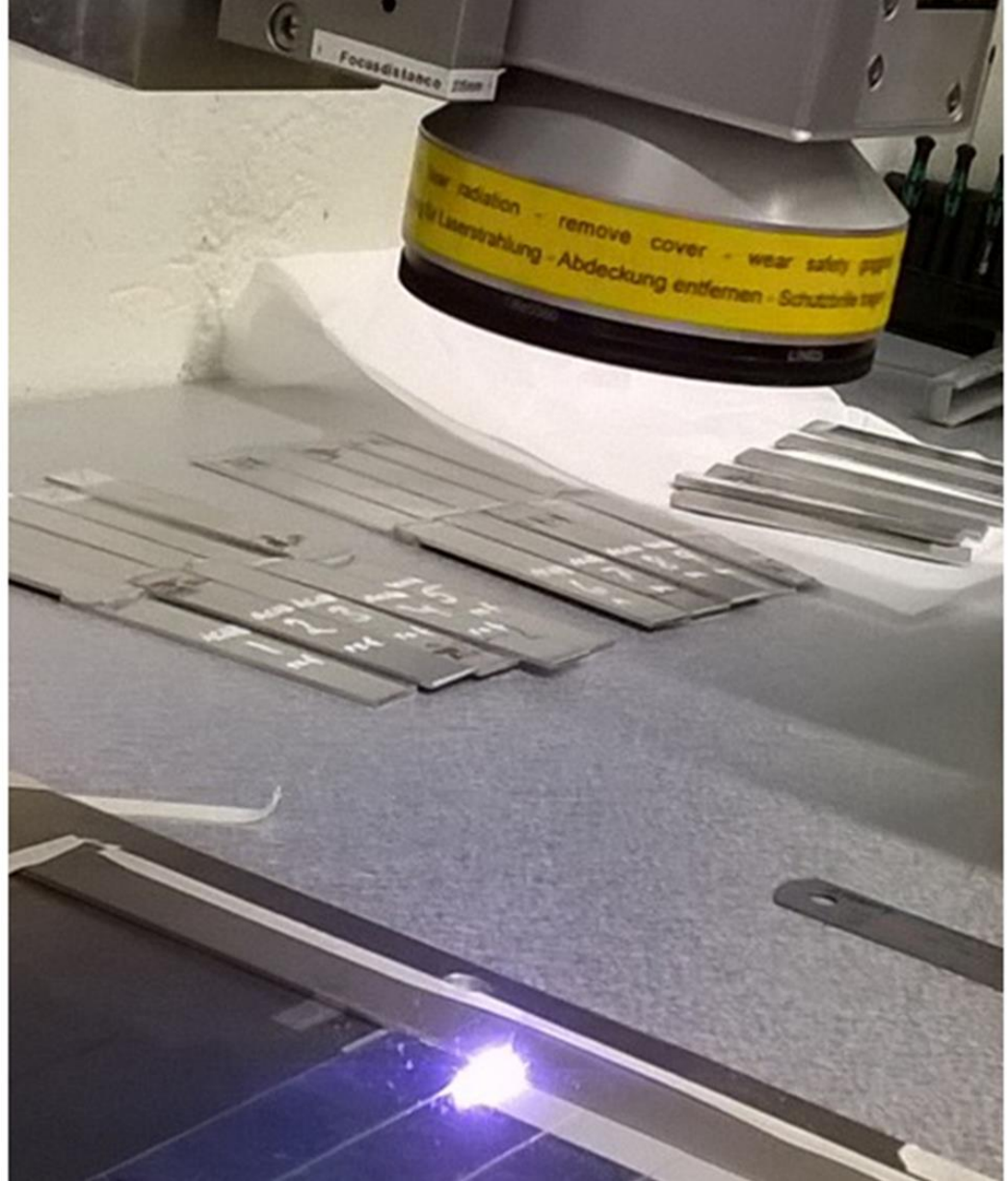
- Clean
- Structure
- Improve the wettability
- Remove or change the oxide layer
- Improved bonding with adhesives

The effect varies with:

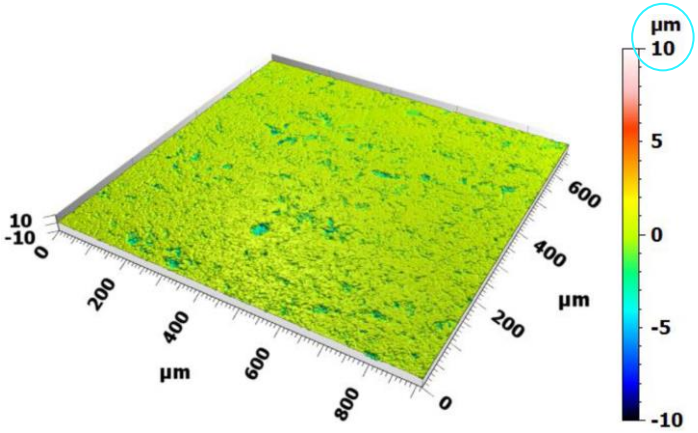
- Laser (type and wavelength)
- Process parameters
- Material

Some advantages:

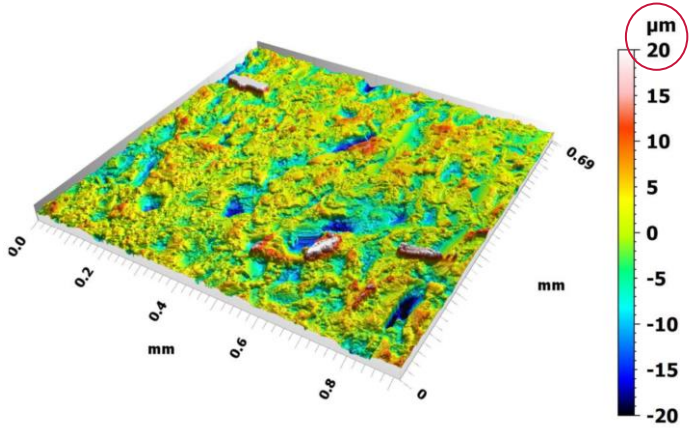
- Rapid, robust, surface near, sustainable, no need of chemicals and an automated process



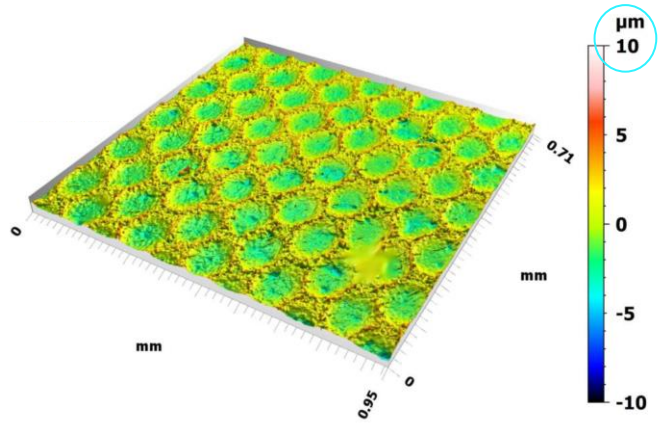
Topography



Reference



Blasted



Laser treated 1 time

Laser equipment @ RISE Mölndal

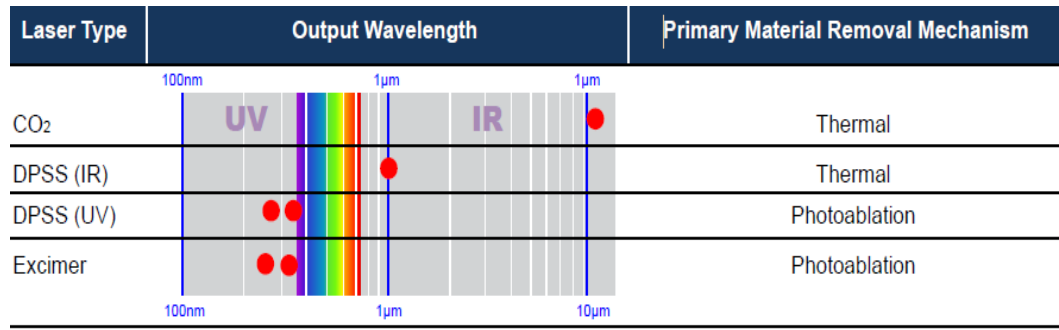
Nd Yag

- Diode pumped solid state laser
- Near IR output wavelength
- Cleaning mainly a thermal effect by heating and gasification of surface contaminants
- Can re-melt the metallic surface
- Risk of thermal degradation in the CFRP and plastics through thermal heating

Specification CL50 (Clean Laser)

Source:	Nd:YAG 1064 nm
Laser system:	CL50
Power:	50W
Optic configuration:	STAMP10
Focal distance:	254 mm
Workfield area:	> ~160x160mm

Longest achievable scan width: ca 240 mm



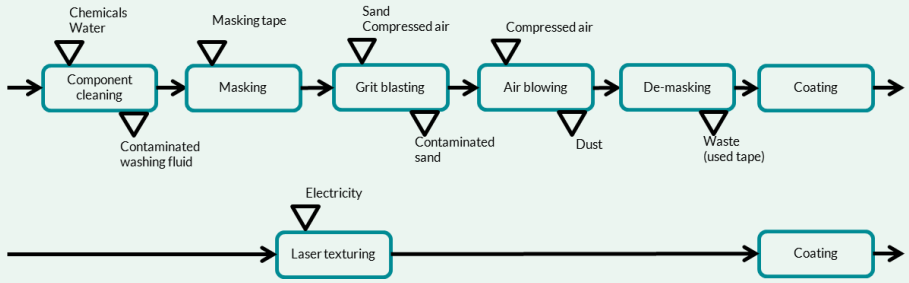
Overview comparison of various laser types for CFRP cleaning.

LaTex - Laser texturing before thermal spraying

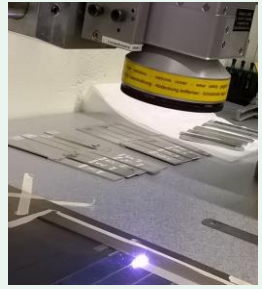
PURPOSE AND GOALS:

- LaTex proposes the substitution of the traditional multi-step grit-blasting process by a one-step automated laser texturing as the surface preparation process before thermal spraying
- The overall goal of the project is to demonstrate the effectiveness and benefits of laser texturing before thermal spraying in industrial environments

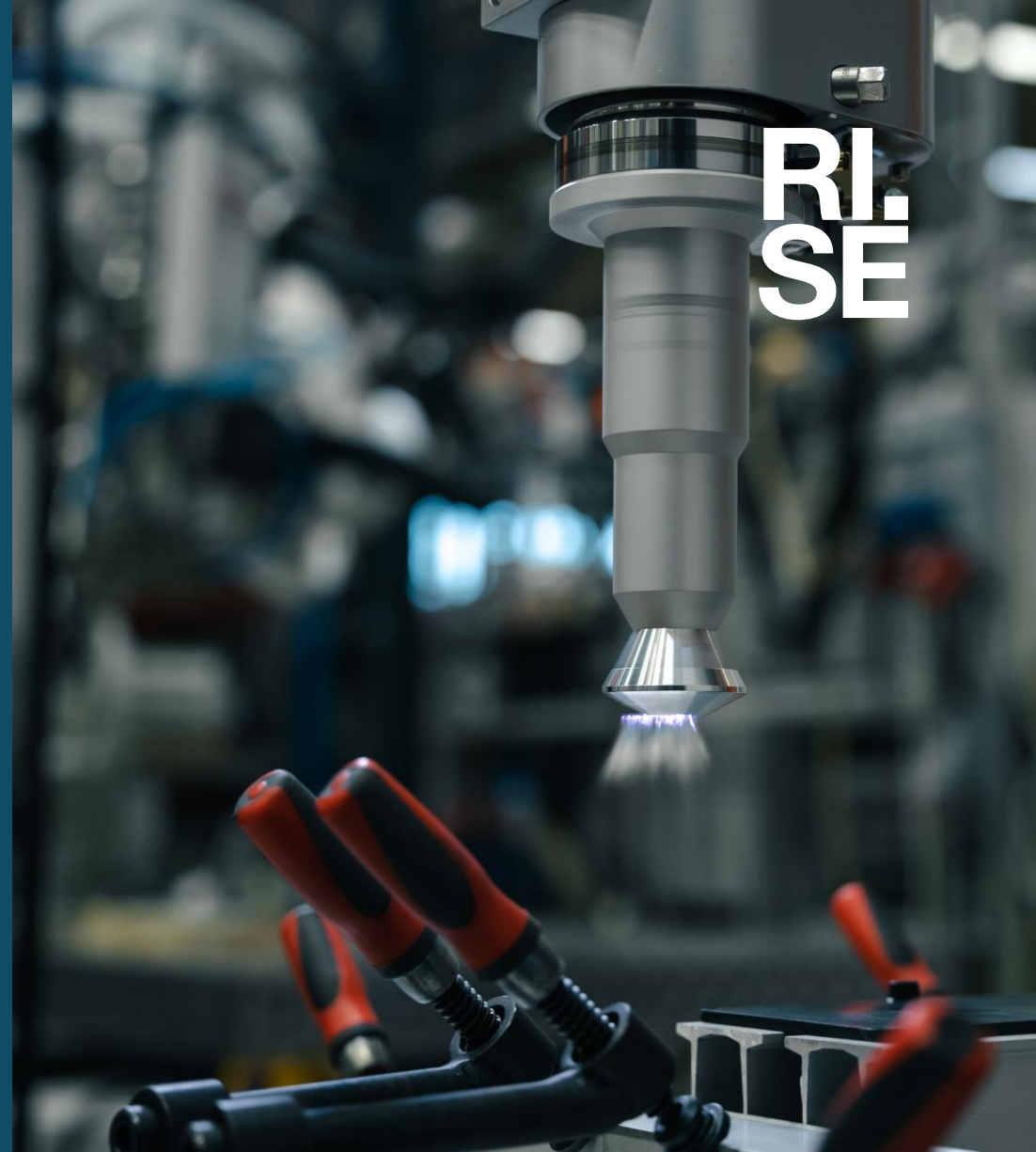
- **PROJECT PARTNERS**: RISE (Coordinator), Högskolan Väst, Azelio, Tenneco, LEAX Skaraborg, IKEA of Sweden, Agaria, Skandinavisk Ytförädling
- **Project time**: 2021-11-15 – 2024-11-15
- **Budget**: 3 660 000 SEK
  - Produktion2030 grant: 1 830 000 SEK



Illustrations:
- Right – NdYAG Laser CL-50 @RISE
- Left – Comparison of surface preparation process flow between grit-blasting (above) and laser texturing (below)



Plasma

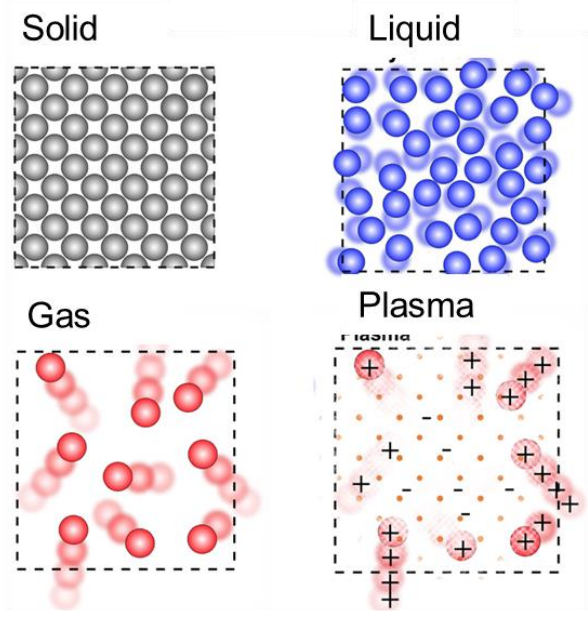


What is plasma?

The fourth state of matter:

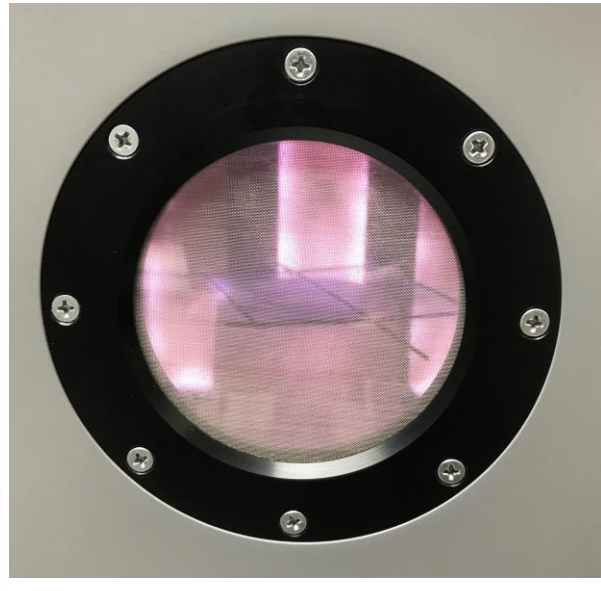
- Ionized gas

Our sun and stars are examples of illuminated matter in the plasma state



Source - http://husbynv.weebly.com/vaumlrme.html

Low pressure plasma chamber



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Atmospheric plasma

- No need of vacuum chamber
- High voltage electrodes ionizes a gas
- Strong enough to break C-C bonds in the surface
- Surface can be changed chemically and structurally
- Common chemical groups on organic substrates COOH, C=O and C-C-OH
- Potential to activate or deposit functional layers
- Parameters:
  - Speed
  - Distance (typical. 10-30 mm)
  - Power (not always flexible)

Example: Improved paint adhesion

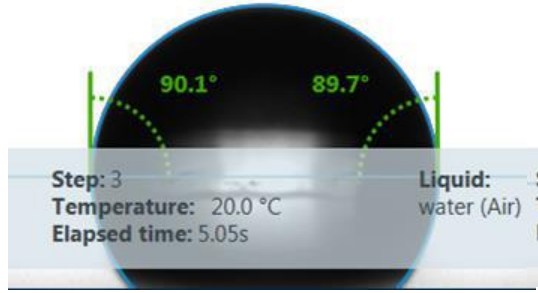
Substrate: Polypropylene (PP)

Paint: Acrylic cured at increased temperature

Effect on wettability:

- Strongly improved wetting with water
- Improved surface energy and polar contribution

PP, as is



PP, cleaned with IPA

PP, after plasma

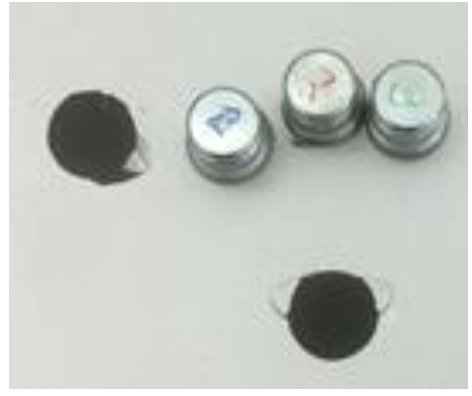
Sample	Surface energy (mN/m)	Polar contribution (mN/m)
Reference	34	3
Isopropanol cleaned	38	3
Plasma treated	67	28

Improved adhesion from plasma with paint

Effect on adhesion:

- Poor adhesion on reference or isopropanol cleaned reference
- Good adhesion on plasma treated substrate
  - Substrate failure, in the plastic panel

PP, as is



PP, after plasma

Sample	Cross cut Rating 1-5	PAT failure mode
Reference	5 paint removal)	100% AF
Isopropanol cleaned	4,5	100% AF
Plasma treated	0	100% SF

AF = Adhesive Failure
SF = Substrate Failure

Ongoing project within plasma:

APPLY

Industrial atmospheric plasma treatment of plastics before painting

The project main contributions

- Industrially relevant and **evaluated technical concepts for plasma treatment of plastic prior to painting**
  - A new concept for repainting (production defects)
  - Deeper knowledge of variations in technical results between type of materials, paints and equipment
- A virtual twin and a completely unique **simulation tool** to support design and efficient implementation of robotic plasma processing.

Project partners: Agaria, AMB, Bröderna Bourghardt, FCC, Plasman, RobNor, Scania, Volvo LV, SPF and RISE

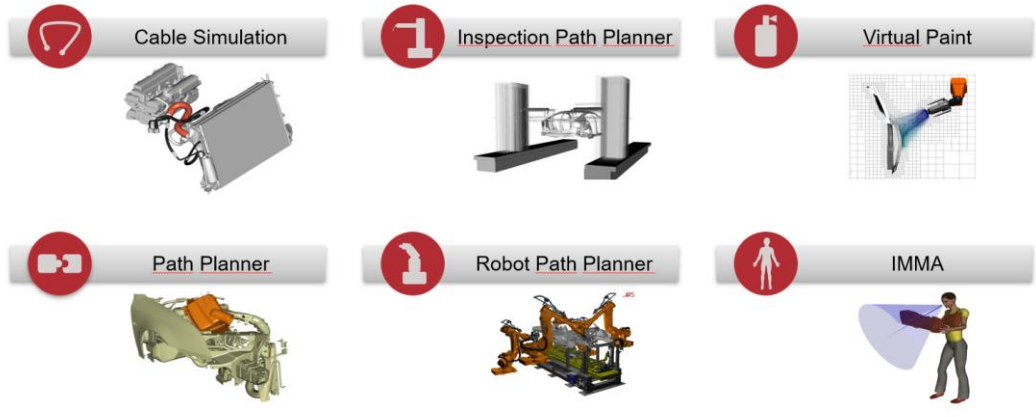
APPLY

Industrial atmospheric plasma treatment of plastics before painting

Industrial Path Solutions (IPS) Software Platform

- Different modules spanning many aspects of production planning, e.g.
  - Cable simulation
  - Manual assembly and ergonomics
  - Robotics path planning and optimization
  - Laydown simulation of paint, adhesive, and additive manufacturing

- Over 100 customers worldwide, mainly within the automotive and aerospace industry



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IPS Plasma module

Plasma equipments:

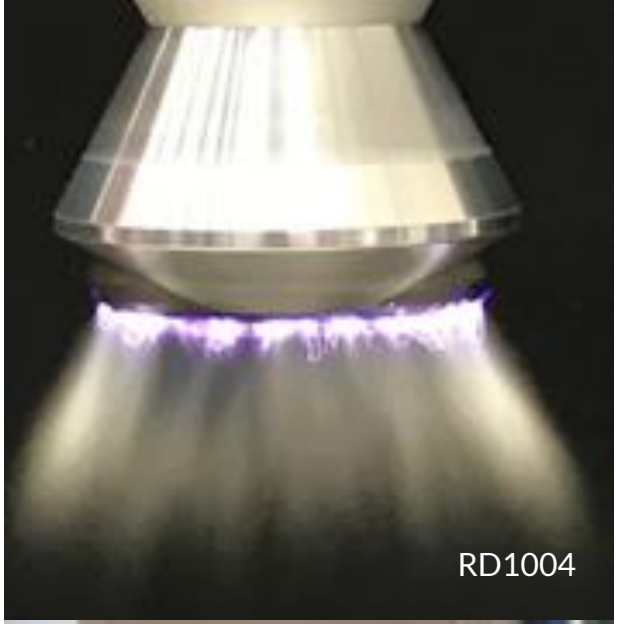
- Plasmatreat RD1004 (43mm)
- Tigres MEF 56

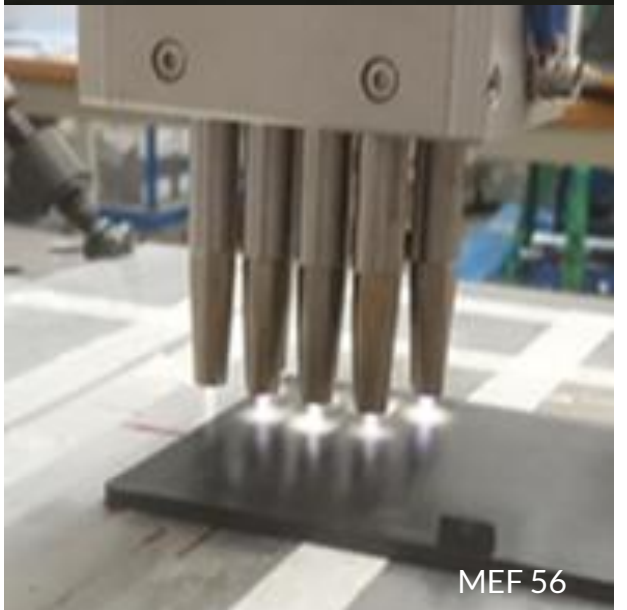
Effect studied on:

- Distance, Speed, Tilted nozzle, Repeated treatment, Variations from center of nozzle and outside treatment , Variations between left and right side of nozzle sides from combination of movement together with rotation direction etc.

Verified with:

- Surface free energy, adhesion test with cross cut test and IR camera


RD1004


MEF 56

Wet processes, CO_2 eq

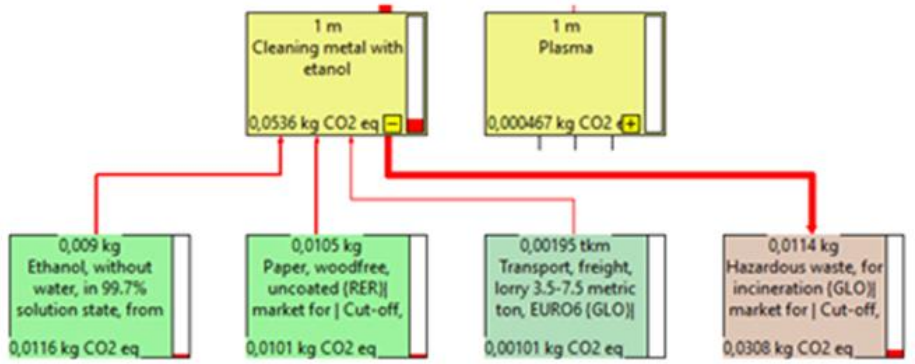
Case 1: Wiping with ethanol before bonding of metal

- Strongest impact from hazardous waste, followed by ethanol and paper
- **114 times** higher CO_2 eq release compared with plasma

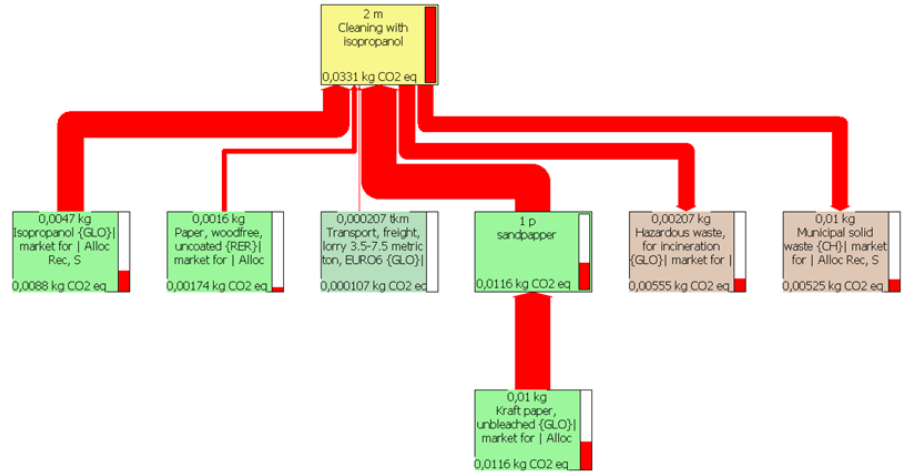
Case 2: Wiping with isopropanol and grinding with sandpaper

- Strongest impact from isopropanol, paper and sandpaper
- **34 times** higher CO2 eq release compared with plasma

Case 1

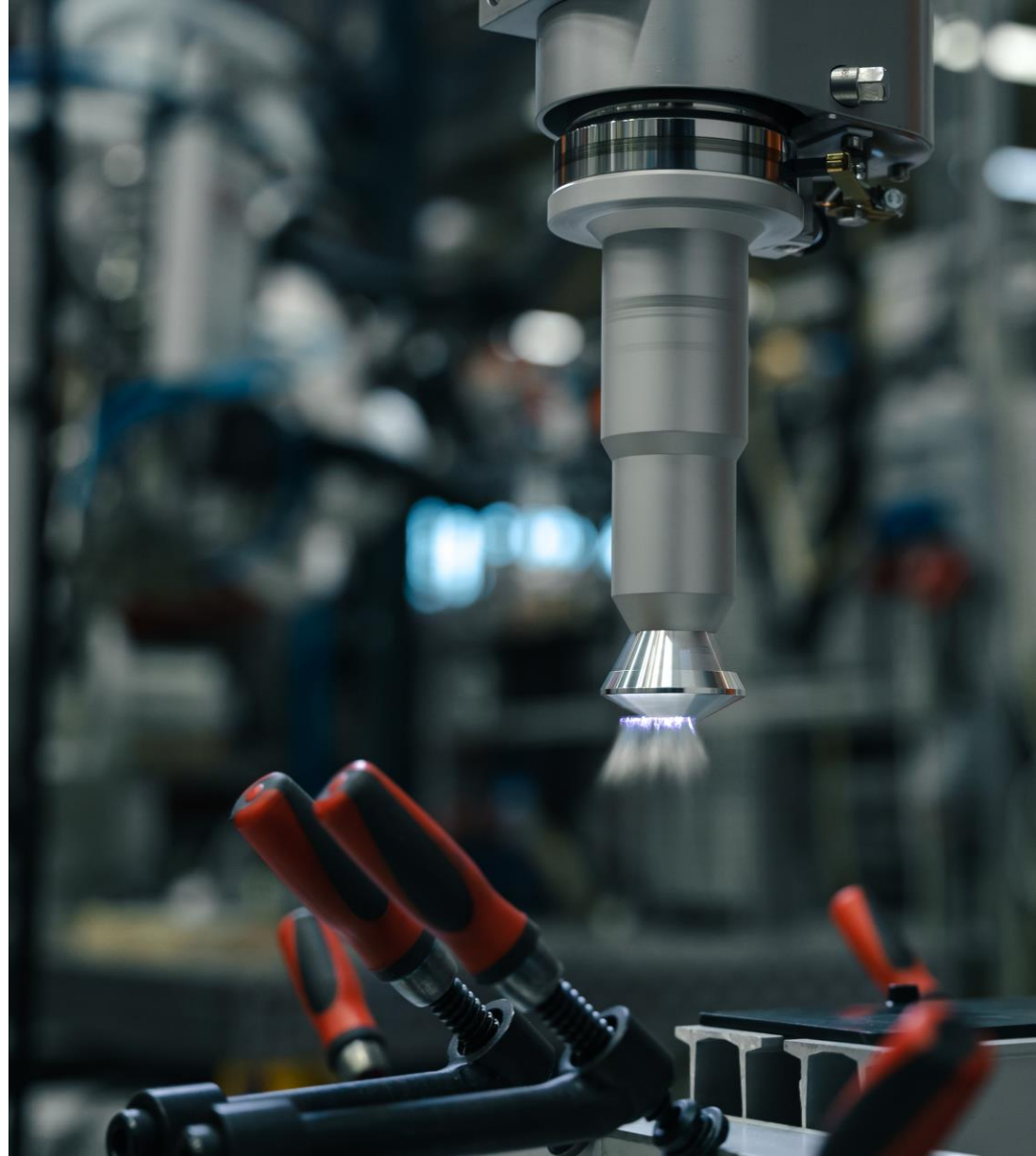


Case 2



Plasma treatment

- **Plasma can be used for a variety of materials and application.**
  - It can improve the wettability and bonding strength.
  - It gives a cleaning, and for some materials an etching effect.
- **The plasma parameters can vary with the materials**,
  - both substrate and the post process material (adhesive, paint or resin)
  - Process parameters needs to be adjusted for each concept.
- **The activation effect drops with time and storage conditions**
  - Time, temperature, humidity and how it is stored have an influence.
- **Plasma can be implemented in a work environmentally friendly way**
  - No chemical risks as with solvents and primers but ventilation is recommended.



Flame treatment

Hot flame pre-treatment

- During treatment of polymers an **oxidation reaction occurs**, **where contamination may be evaporated** followed by a partial oxidation.
- The oxidation will give an **increase in polar groups** that can lead to an increase in surface free energy
- Used as a pretreatment before painting or bonding of plastic materials
  - Plastic film and flexible packaging
  - Consumer goods
  - Automotive
  - Textiles
  - Medical device

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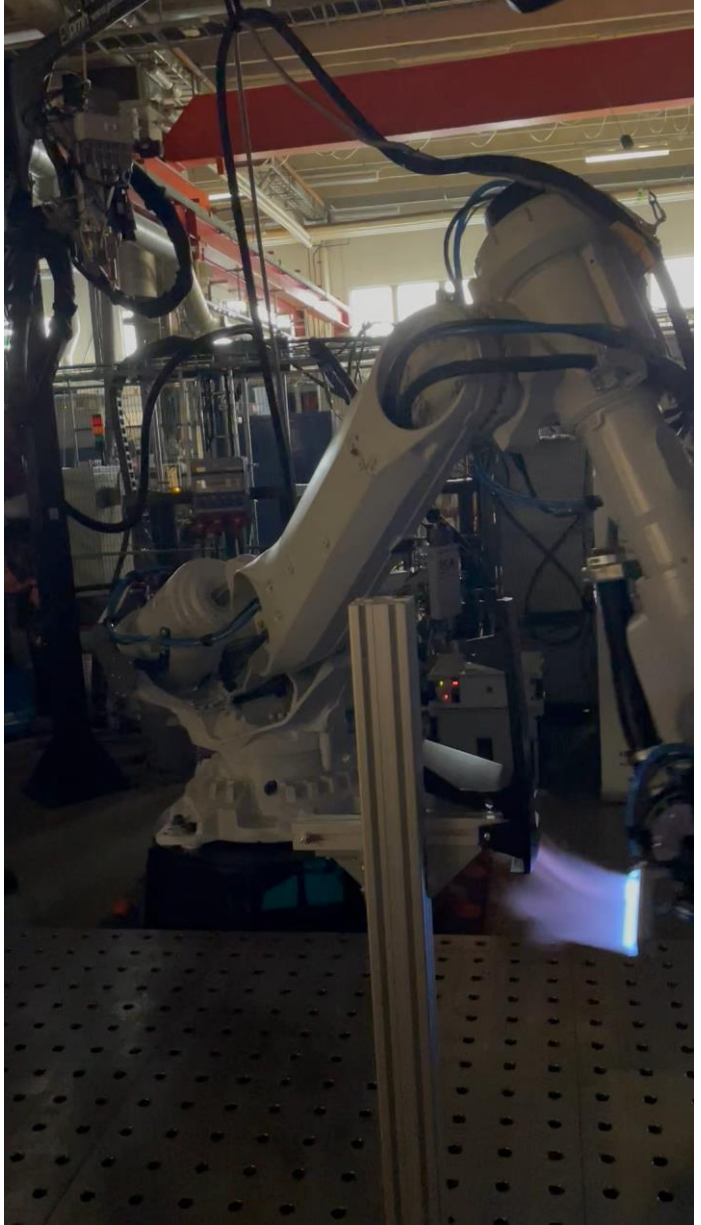
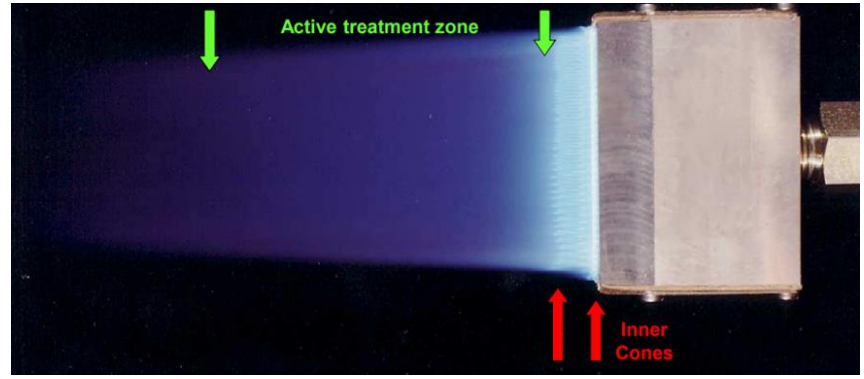
Flame treatment



Flame treatment



Common key parameters for flame treatment are:

- Flame energy – flame size (mm)
- Flame consistency – measured by either excess oxygen or air/fuel ratio
- Burner to substrate distance – gap between burner and substrate (mm)
- Process speed (m/min) (300 mm/s (18 m/min)
- Burner shape and configuration

The flame treatment is used with a blend of air and natural gas or propane gas.

The burner to substrate distance is also discussed as the active treatment zone, where the flame treatment will provide a good and efficient surface treatment

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CO2 blasting

CO2 blasting

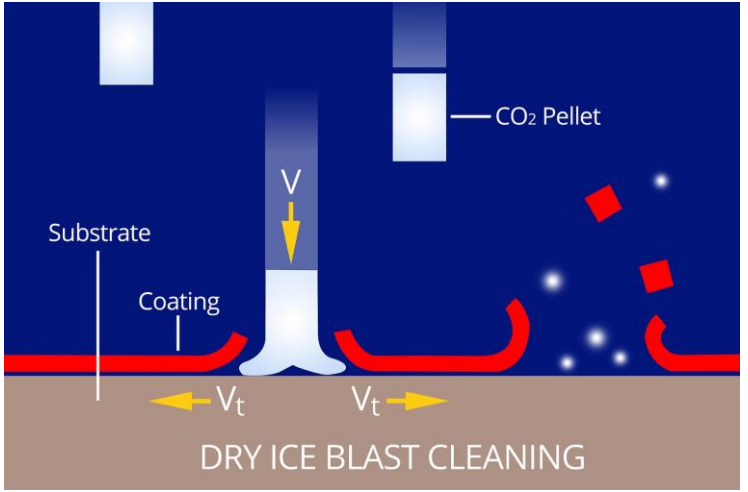
CO2 pellets can be formed by:

- compressing dry ice snow
- using liquid CO2 to form solid pellets in the equipment/nozzle

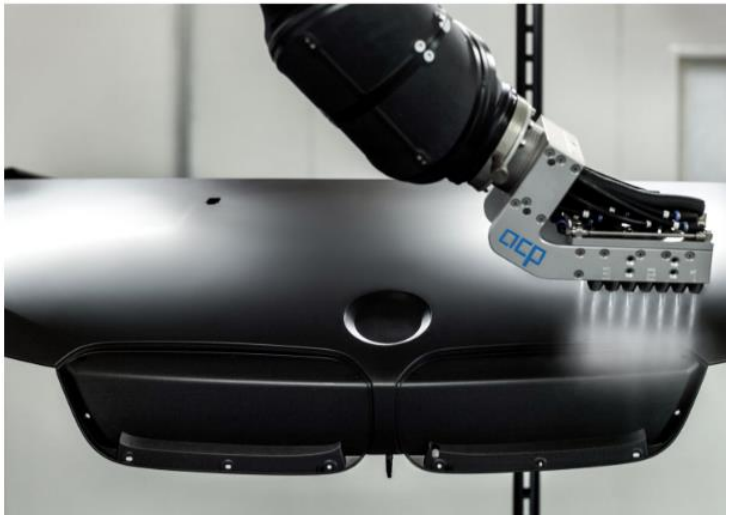
- Dry ice from compressed snow breaks apart more easily and is not as aggressive for cleaning.

Application areas:

- Food processing equipment
- Sensitive substrates and products, i.e. conservation of art objects
- Semiconductors, aerospace, medical device



Source: Wikipedia



Source: acp

CO2 blasting – risks

- Carbon dioxide is increasingly toxic starting at concentrations above 1% and can also displace oxygen resulting in asphyxia if equipment is not used in a ventilated area.
- Carbon dioxide is heavier than air, exhaust vents are required
- Eye and ear protection are required to safely use dry-ice cleaning equipment.

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Steam cleaning

Steam cleaning

Application areas: Various industries: Food, machinery, automotive…

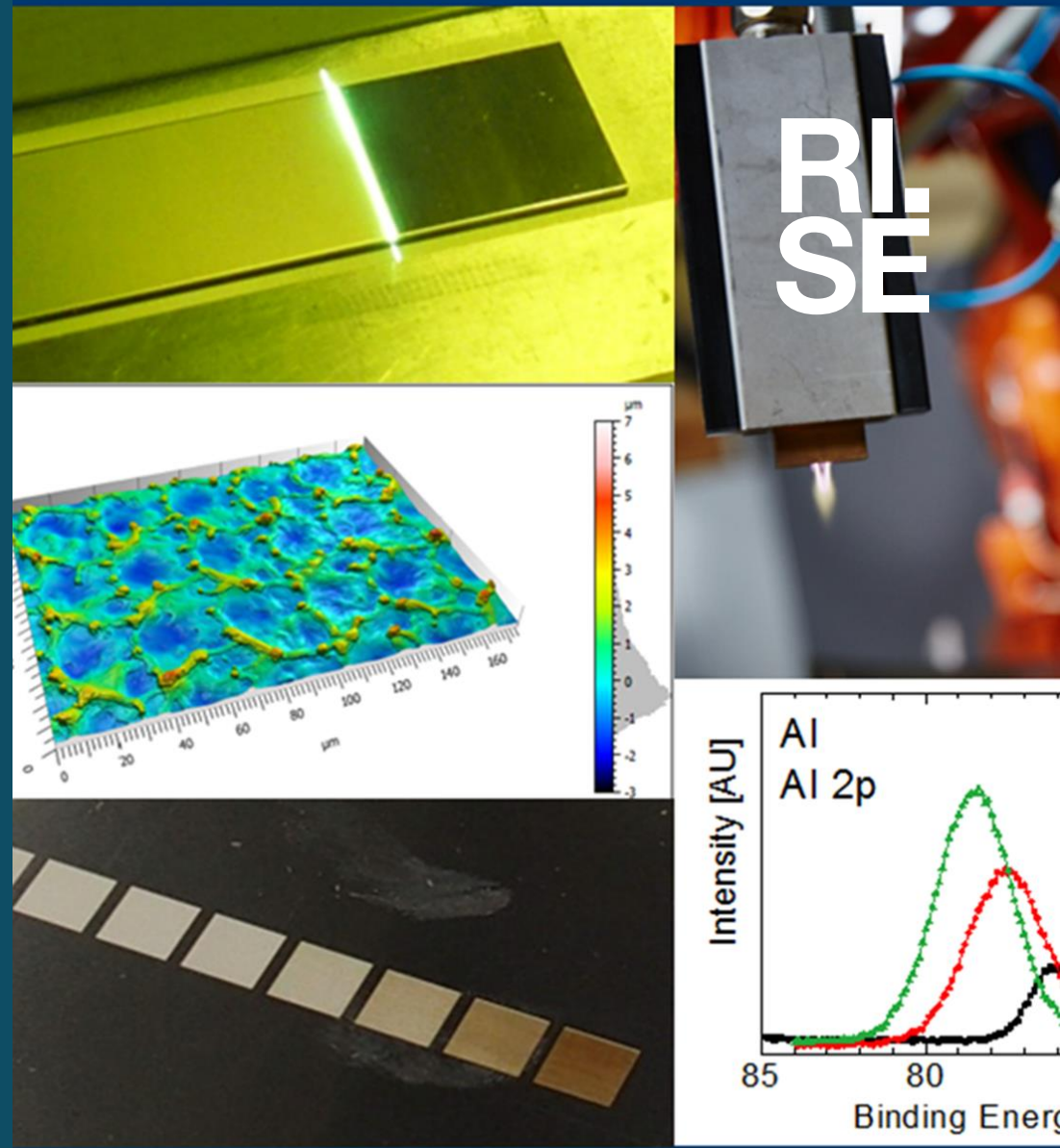
Gentle cleaning

Process time?

- Mainly manual applications
- Steam < 180 ˚C
- Steam pressure < 10 bar
- Low water consumption (~0,4
- Noise 72 dB(A)

Source: Mercedes

Summary



Overview

	Facility demands (power, water, chemicals, compressed air…)	*Waste**	*Work environment*	*Plus/Minus*	*Cost*
Plasma	Power Compressed air	-	Safety distance (Automated process)	- Distance to object close and critical + air as process gas	Relatively high investment cost Low running cost
Laser	Power	-	Highly regulated – encapsulation of the process, safety education for operators etc.)	- Distance to object need to be precise + rapid, robust, precise and automated process - Safety regulations	High investment cost Low running cost
Flame treatment	Power Gas (Propane or natural gas)	-	Safety distance Heat Noise	+ Mature technology - Thermal impact	
CO2 blasting	Power Compressed air Liquid CO2	-	Noise	+ Suitable for sensitive substrates i. e electronics	
CO2 pellet blasting	Power Compressed air Liquid CO2	-	Noise	- Pellet handling	
Steam cleaning	Power Water	-		- High temperature - Manual process	

* *Contamination residuals*

To be continued:

Continue with a more detailed evaluation and comparative study of pre-treatment methods:

- Sustainability evaluation (LCA or similar, energy and resource efficiency etc.)
- Limitations such as substrate materials and type of components (geometry, size…)
- Process time, capacity and through put
- Automation level
- Investment and running cost
- Quality control (Both for the process and for the treated surface)
- …

Increased knowledge for industrial partners to select the best available pre-treatment methods for the right application from a sustainability perspective

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Questions?

Thank you for listening!

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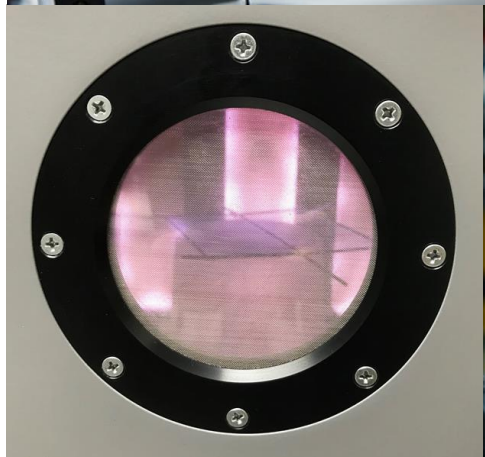
Dry pretreatment at RISE in Mölndal

Equipment

- Robotized atmospheric plasma jet
  - 2 for activation and
  - 2 for coating
- 1 DBD plasma for 2D materials
- 1 low pressure plasma
- 1 Nd:Yag laser
- With potential to borrow or rent complementary equipment when needed

Evaluation

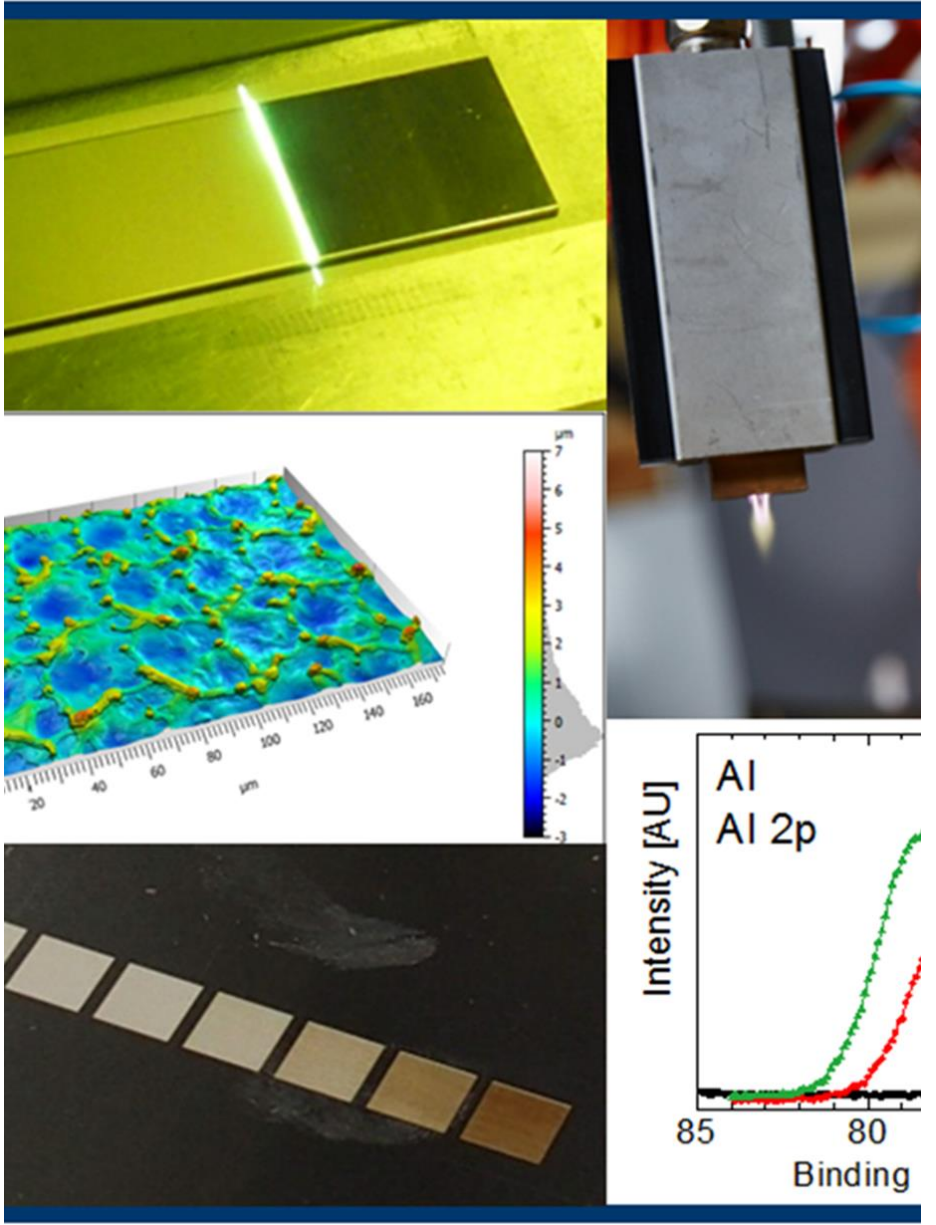
- Robotized hybrid joining cell and paint box. Adhesive, paint and composite lab and extensive laboratory facilities for technical evaluation



Dry pretreatment at RISE in Mölndal

This for:

- Improved bonding with adhesive, paint, printing and resin
- Treatment of plastic, composites, fabric, fiber, metal and glass
- With activation or plasma deposition process



Plasma - conclusions

- **Plasma can be used for a variety of materials and application.**
  - It can improve the wettability and bonding strength.
  - It gives a cleaning, and for some materials an etching effect.
- **The plasma parameters can vary with the materials**, both substrate and the post process like adhesive, paint, or resin to be bonded. Heating and chemistry needs to be adjusted for the concept.
  - We do not want to remelt or degrade the surface or to prevent other chemical reactions to occur.
  - Process variations can be needed also for thermoplastic materials with similar melting temperatures and between different paints or adhesives
- **The activation effect drops with time and storage conditions**
  - Time, temperature, humidity and how it is stored have an influence.
- **Plasma can be implemented in a work environmentally friendly way**
  - No chemical risks as with solvents and primers but ventilation is recommended.
- **Sustainability is besides improved adhesion/bonding strength one of the motives** for RISE to work with plasma