AVT-339 Research Workshop on Robotics and laser/plasma – paint interaction in paint removal

Nd:YAG laser de-painting and its effects on military aircraft surfaces

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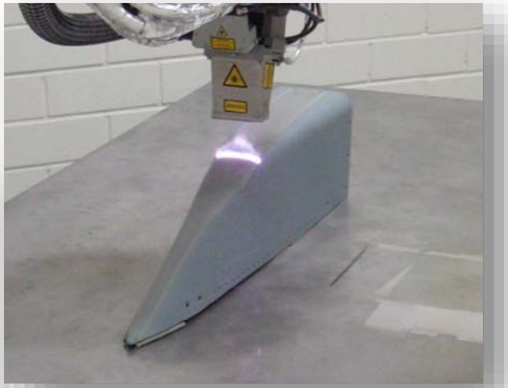
Introduction: YAG:Nd laser de-painting process

Airbus has qualified two pulsed YAG:Nd laser de-painting processes:

- Handheld laser de-painting of electrical bonding points as per 80-M-35-0230
- Robot-guided laser de-painting of aircraft components as per 80-M-35-9140



Laser equipment parameters	
Manufacturer	Clean-Lasersysteme GmbH, Herzogenaurach, Germany
Main unit	CL500
Scan frequency (applied)	100 Hz
Scan width	≤ 70 mm
Pulse frequency (applied)	27 kHz
Brennweite	160 mm
Focus diameter	700 µm (focal length of 150 mm)
Laser class	4
Feed rate	0.028 $^{m}/_{s}$

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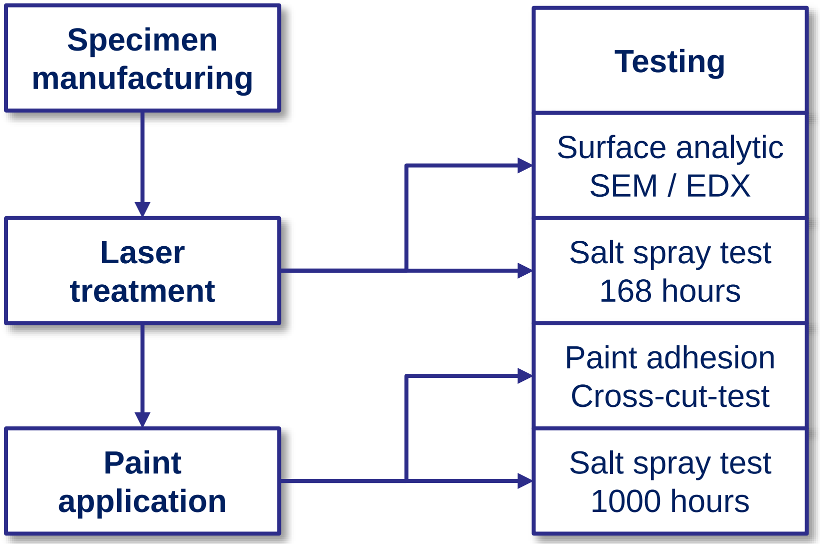
Nd:YAG laser de-painting trial campaigns

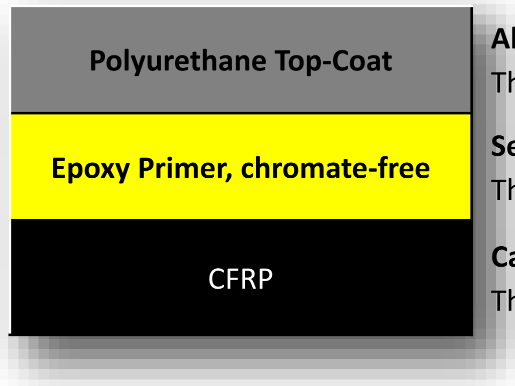
- In order to gather hands-on experience and finally qualify the laser de-painting process, two de-painting trial campaigns were conducted by Airbus Manching.
- The first campaign focussed on the verification of process parameters and establishment of de-painting programs.
- The second campaign focussed on the potential of laser de-painting as a pre-treatment and adhesion promotion before re-painting.



Nd:YAG laser effects test programme

Carbon fibre composite specimens “Eurofighter”

- The first group of specimens represents approx. 80 % of the EF exterior surface.
- Specimen built-up:



Alexit 472-22, matt
Thickness: 48 ± 5 µm

Seevenax 113-24
Thickness: 22 ± 12 µm

Carbon Fibre prepreg
Thickness: 2 mm

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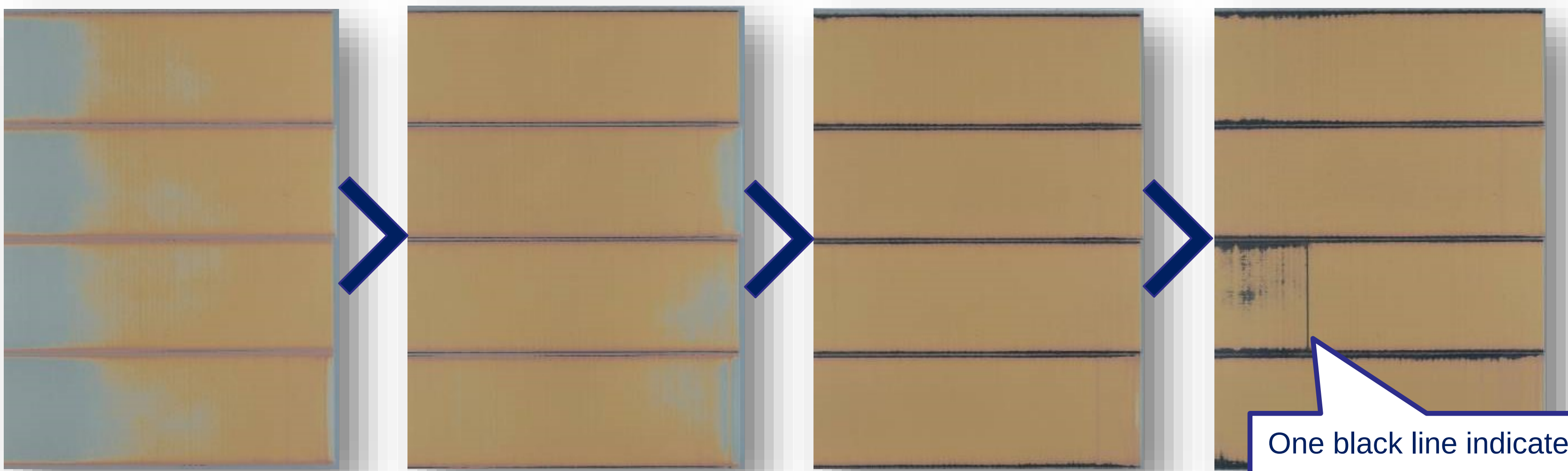
Nd:YAG laser effects test programme

Carbon fibre composite specimens “Eurofighter”

2 overruns: 3 overruns: 4 overruns: 5 overruns:



PUR top-coat with areas of EP primer coming through

EP primer with residues of PUR top-coat

EP-primer, edges show fully de-painted substrate

One black line indicates full de-painting, which caused aborting of de-painting procedure.

- 50 µm of PUR top-coat is mostly removed after 3 de-painting overruns.
- 25 µm of epoxy primer are still intact after the same energy intake.

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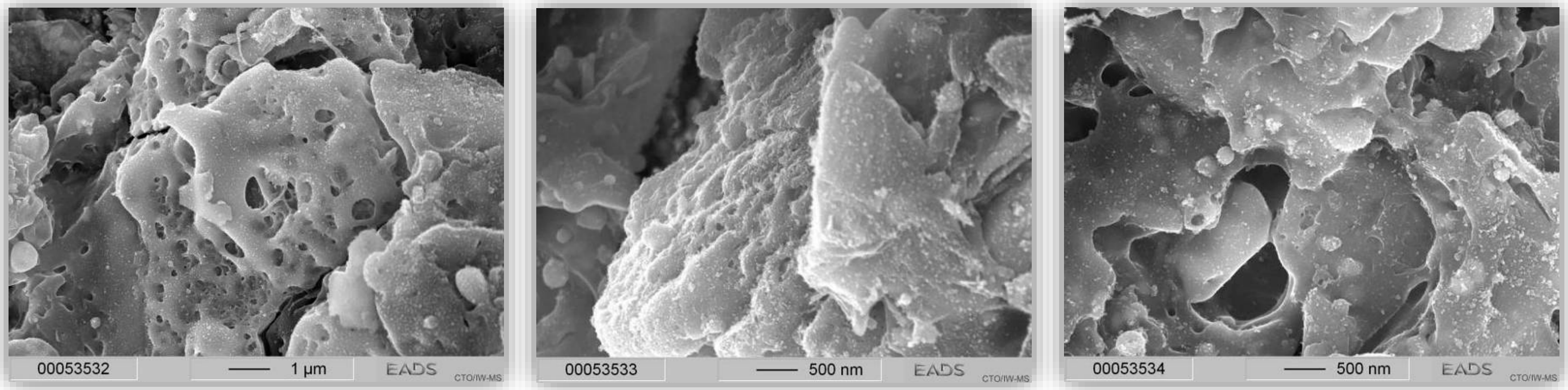
Nd:YAG laser effects test programme

Carbon fibre composite specimens "Eurofighter"

De-painted surfaces were examined by means of Scanning Electron Microscopy (SEM).



- The examined CFRP specimen shows a very rough surface, some parts of which apparently being molten.

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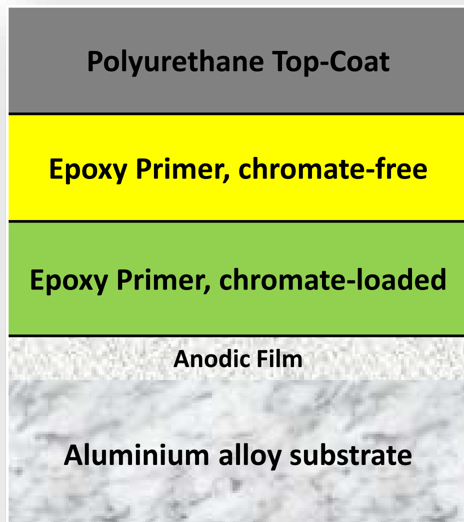
Nd:YAG laser effects test programme

Aluminium alloy specimens "Eurofighter"

- The second group of specimens represents < 15 % of the EF exterior surface.
- Specimen built-up:



Alexit 472-22, matt
Thickness: 40 ± 10 µm

Seevenax 113-24
Thickness: 25 ± 5 µm

Seevenax 113-22
Thickness: 25 ± 5 µm

Thickness: 2 µm

AA2024T3, unclad

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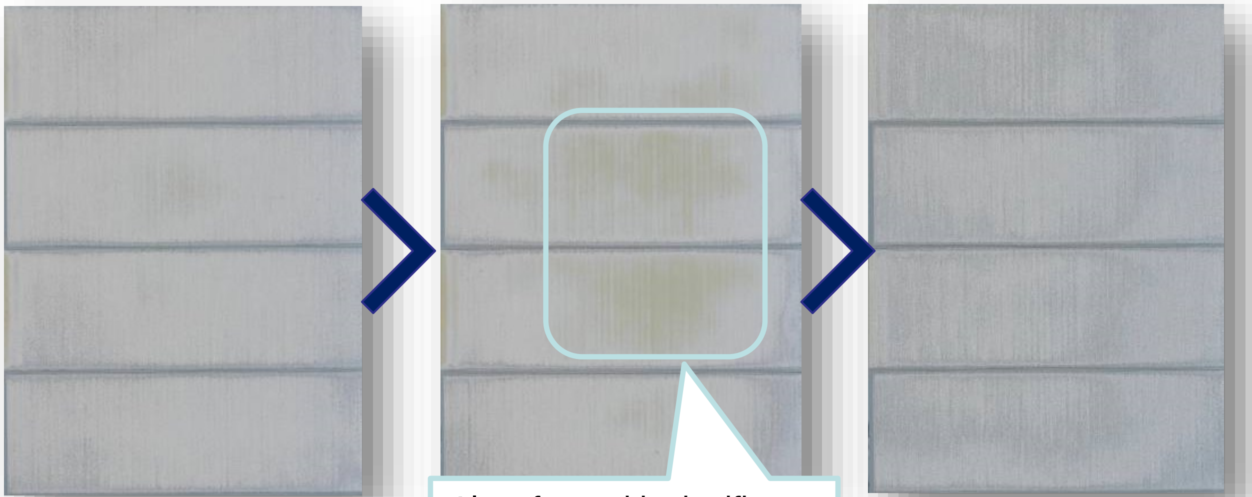
Nd:YAG laser effects test programme

Aluminium alloy specimens “Eurofighter”

3 overruns | 4 overruns | 5 overruns



Al surface with slight residues of EP-Primer

Al surface with significant EP-primer residues (Thickness: 8 µm)

Clean Al surface

Amount of paint residues is clearly depending on the paint layer thickness: While there were only little residues on the 3 de-painting overrun specimen, on the 4-overrun-specimen up to 8 µm of primer remain.

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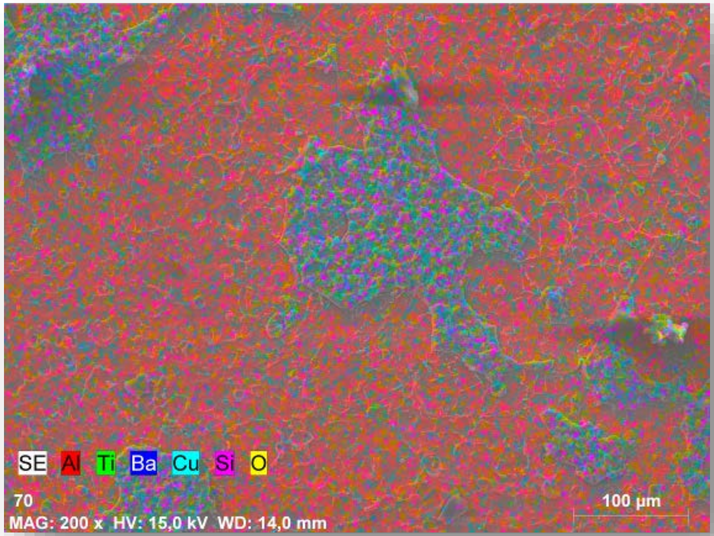
Nd:YAG laser effects test programme

Aluminium alloy specimens "Eurofighter"

The „clean" specimen was examined in Energy-dispersive X-ray spectroscopy (EDX) for element analysis:



5 overruns

Clean Al surface

- The shows traces of Barium (blue colour area), which originates from paint residues
- The coating material has not been entirely removed without residues.
- EDX shows an even distribution of oxygen compounds, which indicates the formation of an even oxide layer.

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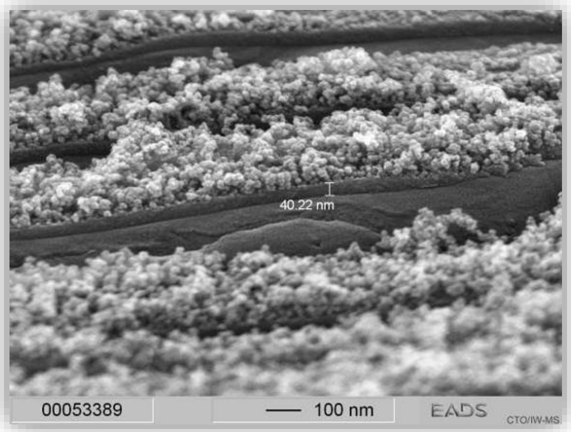
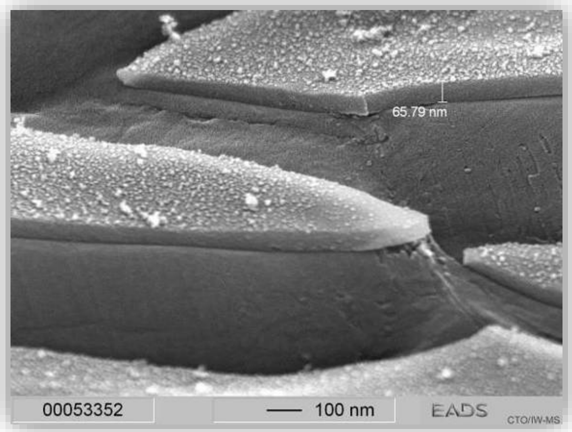
Nd:YAG laser effects test programme

Aluminium alloy specimens “Eurofighter”

The „clean“ specimen was examined in Scanning Electron Microscopy (SEM).





5 overruns

Clean Al surface

- Both CAA substrates (pictures b and c) show the removal of the anodizing layer. Instead there is found an apparently compact oxide layer of 40 to 60 nm in thickness that shows molten areas.
- In addition the oxide layer of both specimens is covered with small agglomerated particles.
- On the left SEM picture paint residues are clearly visible.

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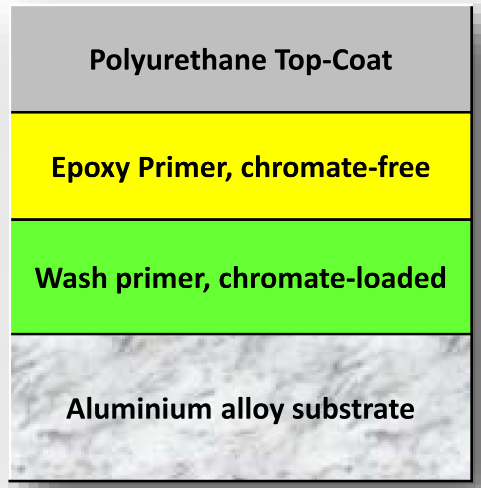
Nd:YAG laser effects test programme

Aluminium alloy specimens “Tornado”

- The third group of specimens represents > 80 % of the TOR exterior surface.
- Specimen built-up:



Aerodur HF A 133D
Thickness: 40 ± 10 µm

Seevenax 113-24
Thickness: 25 ± 5 µm

Celerol 913-21
Thickness: 10 ± 2 µm

AA2024T3, unclad

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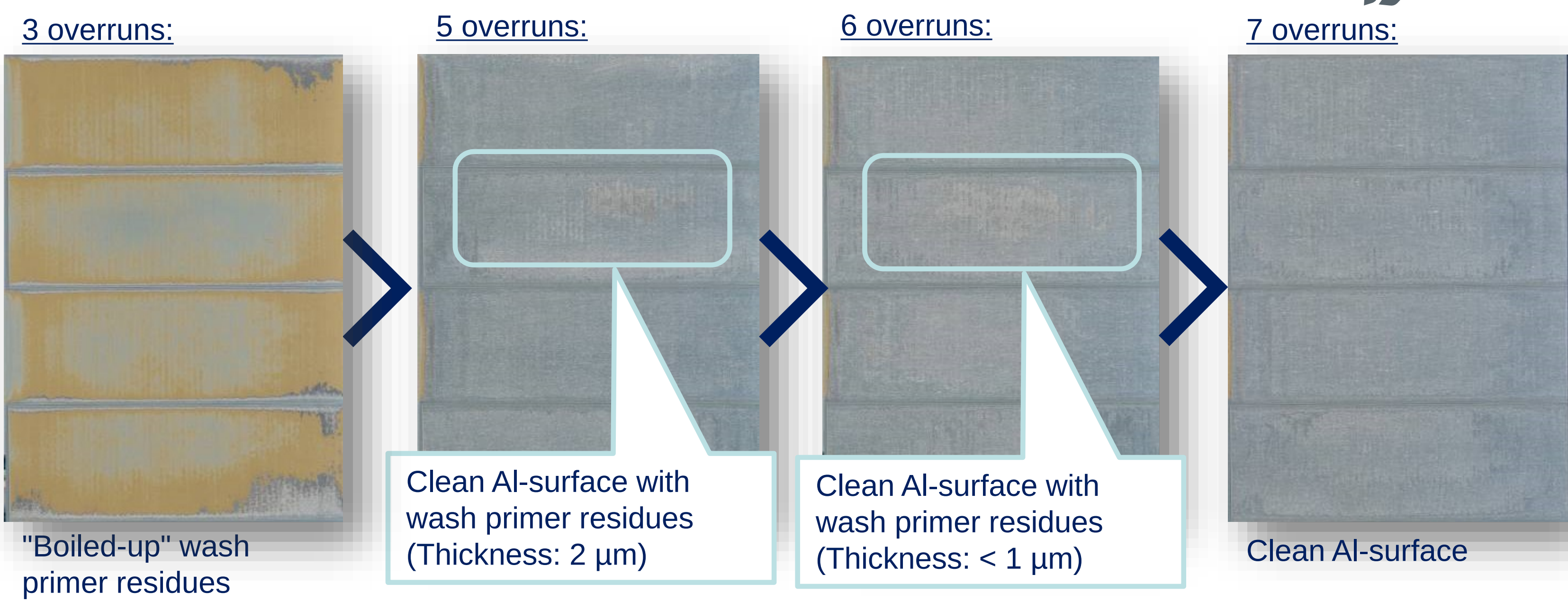
Nd:YAG laser effects test programme

Aluminium alloy specimens “Tornado”



- Laser treatment damages the adhesion of the EP primer on the wash primer.
- PUR top-coat and EP primer are removed easily after the 3rd overrun.
- Selective de-painting of top-coat is not possible.
- Wash primer residues remain on the surface for a very long time.

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Nd:YAG laser effects test programme

Aluminium alloy specimens “Tornado”

The „clean“ specimen was examined in Energy-dispersive X-ray spectroscopy (EDX) for element analysis:

7 overruns:

Clean Al-surface

- The EDX picture shows an even oxide layer.
- In addition, the picture still shows remnants of carbon, indicating an incomplete removal of the coating material.

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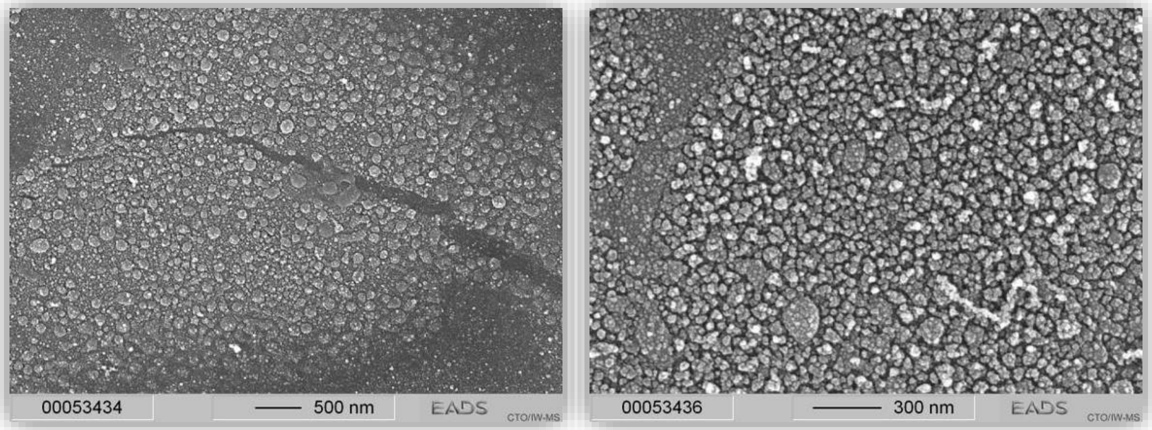
Nd:YAG laser effects test programme

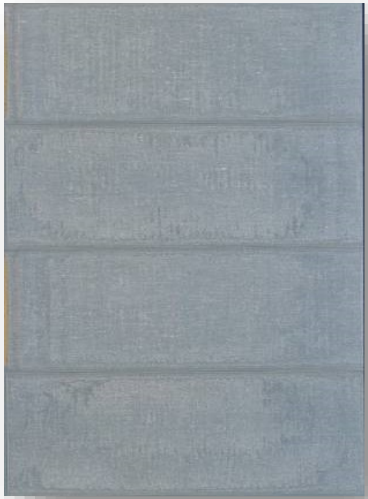
Aluminium alloy specimens “Tornado”

The „clean“ specimen was examined in Scanning Electron Microscopy (SEM).



- The SEM pictures show a compact oxide layer with thicknesses between 50 to 100 nm.
- The surface shows a grainy structure. The paint apparently has been completely removed.
- Smooth areas as well as molten areas are visible.

7 overruns:



Clean Al-surface

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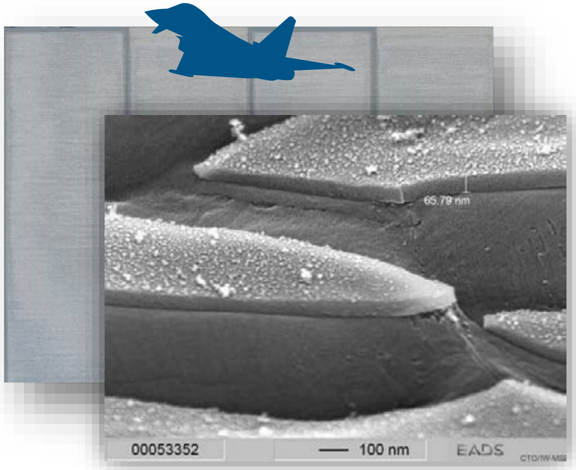
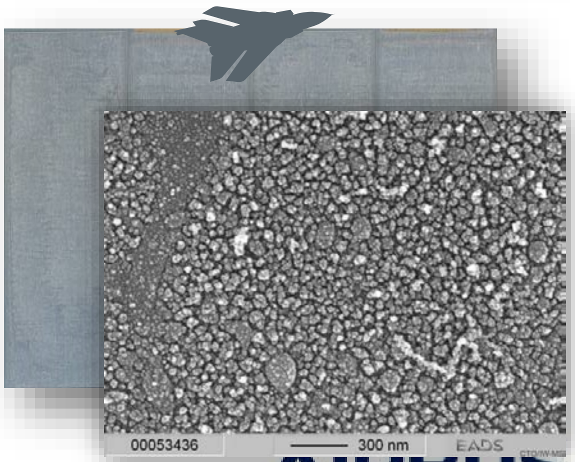
Examination of newly generated oxide layer

- Both aluminium alloy specimen types showed the generation of a compact oxide layer on the Al surface.
- SEM analysis of these layers revealed thicknesses between 10 and 100 nm.
- In order to characterize the oxide layers as a potential pre-treatment for re-painting, Airbus performed further examinations, i.e.:
    - Adhesion of subsequent paint coatings,
    - Corrosion protection of bare Al surface,
    - Corrosion protection of painted Al surface.
- For this purpose clean unpainted Al specimens were treated with the same laser parameters.





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Examination of newly generated oxide layer

Paint adhesion on laser-de-painted surfaces

	TSA Reference	Laser-treated bare Al-sheets	Laser -treated anodized Al-sheets	Laser de-painted Al-sheets
Aerowave 2002 + Aerowave 5001				
Aerowave 2001 + Aerowave 5001				
Aerodur 2100 MgRP + Aerodur 5000				
Seevenax 313-02 + Alexit 341-77				

Good paint adhesion, but water blisters after water immersion!

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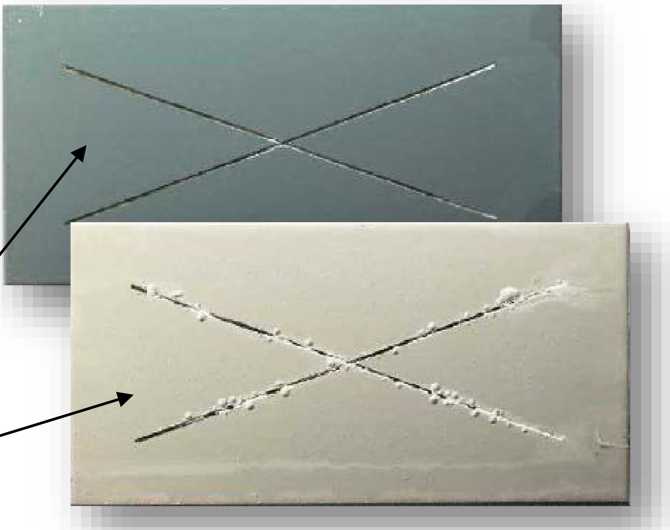
Examination of newly generated oxide layer

Corrosion protection

24 hours of salt spray exposure acc. to ISO9227:

TSA Reference, untreated	Laser-treated CAA	Laser-treated AA2024, bare	Laser de-painted

Salt spray exposure 1000 hours acc. to ISO9227 Painted and scribed	**TSA Reference**	**Laser-treated bare Al-sheets**	**Laser -treated anodized Al-sheets**	**Laser de-painted Al-sheets**
Aerowave 2001 + Aerowave 5001				
Aerodur 2100 MgRP + Aerodur 5000		Paint Creepage		Paint Creepage & Blisters



Summary

- Laser de-painting of all examined paint materials proved to be feasible. However, different types of paint require different amounts of energy.
- For full removal of all paint residues from Al surfaces high enrgies (≤ 7 overruns) are required.
- Laser-treatment generates a very rough CFRP surface with partly molten areas.
- Laser-treatment destroys anodic films and generates a dense oxide layer of 10 to 100 nm in thickness on Al surfaces.
- Examinations of these oxide layers showed detrimental behavior with regard to adhesion of subsequent paint layers and corrosion protection.

➔ Therefore Airbus Defence and Space took the decision that the laser de-painting process may not be applied for the removal of an entire coating system from an aluminium surface. Instead, the top-coat on an Al component shall be selectively de-painted until the primer surface is reached.

➔ In case of full de-painting the oxide layer has to be removed, e.g. by abrading.

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Open questions

- **Does CO_2 lasers have a similar influence on Al surfaces?**

- **Which effects does laser de-painting have on surface corrosion?**
  - Are these “oxide layers” also removed?
  - Is corrosion removal (e.g. by means of shot peening) still required?

- **How does the generated oxide layer effect fatigue life of treated parts?**

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Nd:YAG laser de-painting and its effects on military aircraft surfaces

Thank you

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