OSMOSIS: One Step Modification of Space-Integrated Surfaces

OSMOSIS Project

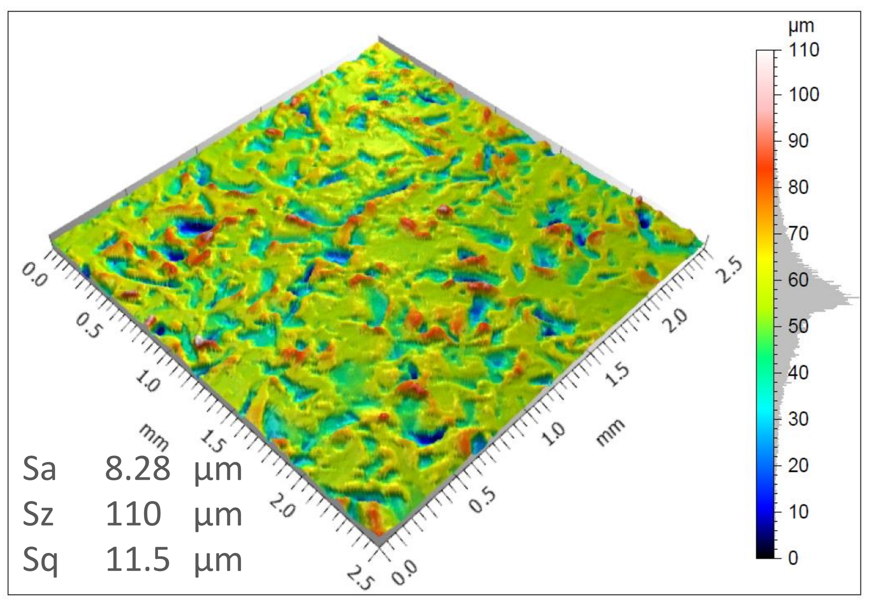
Current state-of-the-art structural adhesive primers rely on chromates for both adhesion promotion and corrosion resistance.

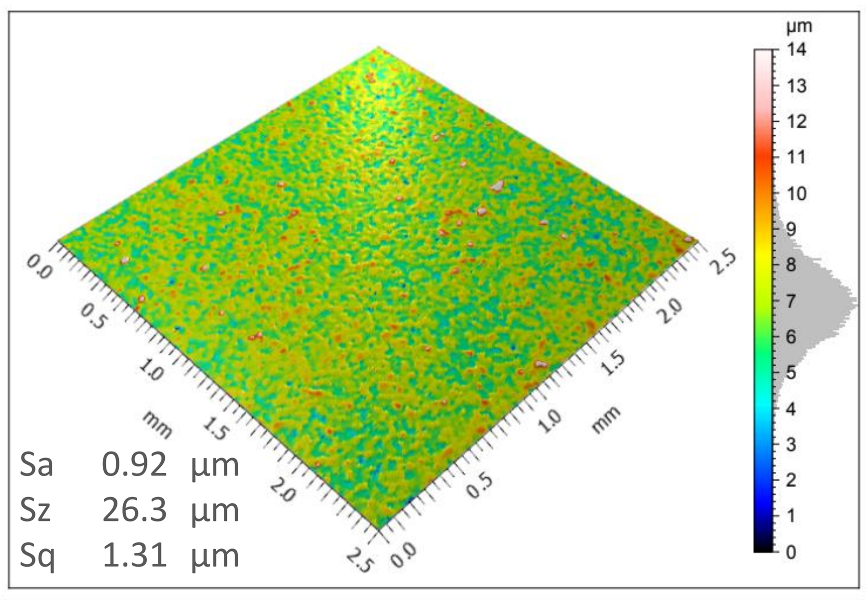
These chrome(VI)-containing compounds have been shown to be carcinogenic, mutagenic and highly toxic. In the EU, REACH regulations aim to eliminate their use.

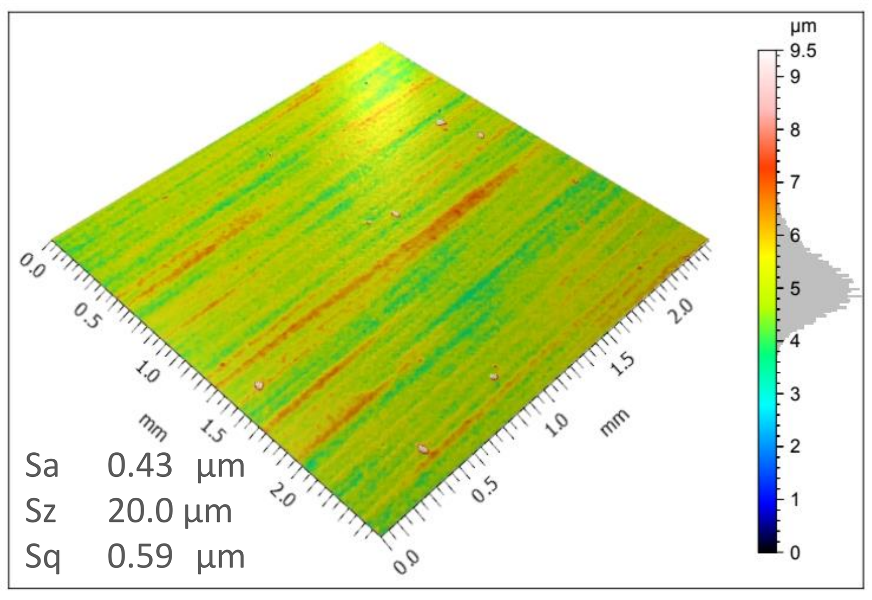
ENBIO's OSMOSIS project aims to use our unique CoBlast surface coating technology to bring a viable alternative to the European Space sector within a period of two years.

A range of materials, both organic and inorganic, were tested and compared against current state of the art options on aluminium substrates. This testing consisted primarily of ASTM D 1002 Lap Shear both before and after humidity ageing and salt fog exposure.

Roughness







By varying the size of abrasive used, different surface roughnesses are achievable, with R_a values between 0.5 and 20 µm being attainable.

Previous work has shown a complex relationship with surface roughness and ultimate adhesive strength, with specific adhesives having preferred roughnesses as a result of varying adhesive wettabilities.

For the majority of this study a Redux 312 1-part epoxy film adhesive was used. A surface roughness $R_a \simeq 0.5$ µm was found to perform well. There is also a practical consideration in that larger abrasive will have an increased impact energy and may deform thin lightweight panels.

Surface Energy

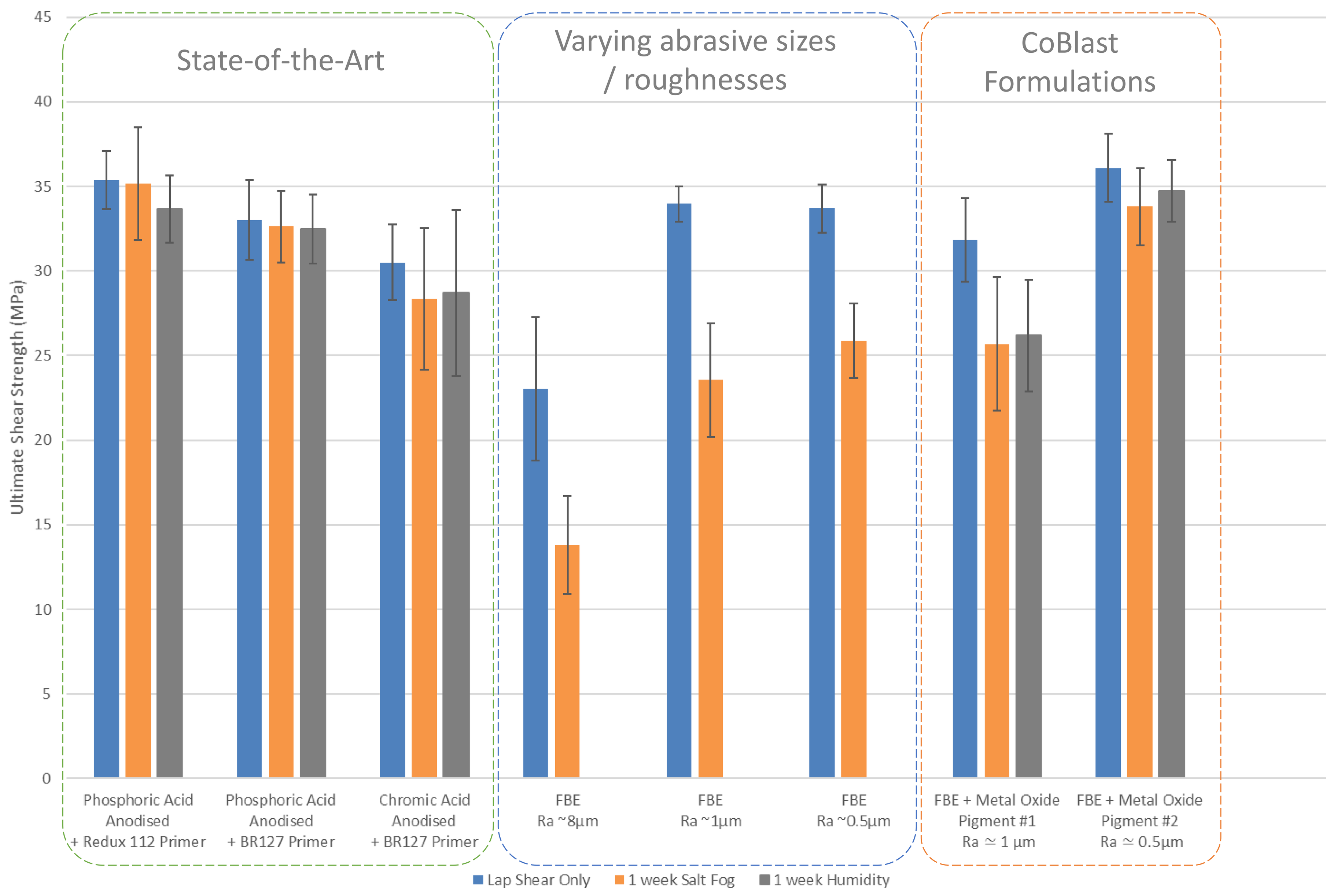
Surface energy is an important factor for an adhesive primer system – a highly compatible surface energy improves wetting and ultimately the bond strength.

Material	Dispersive mN/m	Polar mN/m	Total Surface mN/m
Grit Blast only	37.70	21.90	15.80
FBE	46.71	0.41	47.12
FBE + Metal Oxide #1	44.89	0.05	44.94
FBE + Metal Oxide #2	47.26	0.73	47.99
Redux 312 adhesive	27.60	1.25	28.85

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 757088

Results

Multiple rounds of testing have been completed with a range of metal oxide, metal phosphate and organic materials.



Of these, FBE- fusion bonded epoxy (thermoset polymer powder) has shown significant promise. Partially cured epoxy is deposited and co-cured with the adhesive. This promotes strong cross-linking and high strength, matching current state-of-the-art. Latest work has focused on the inclusion of corrosion-inhibiting pigments to improve strength retention after humidity and salt fog exposure.

Conclusions & Future Work

Work to date on FBE has proven extremely promising. Next steps will include optimisation of blend ratios and deposition parameters. Verification of repeatability and effectiveness on other aluminium and titanium alloys will also be investigated. Finally, qualification of space worthiness, including thermal cycling and outgassing testing will be undertaken.

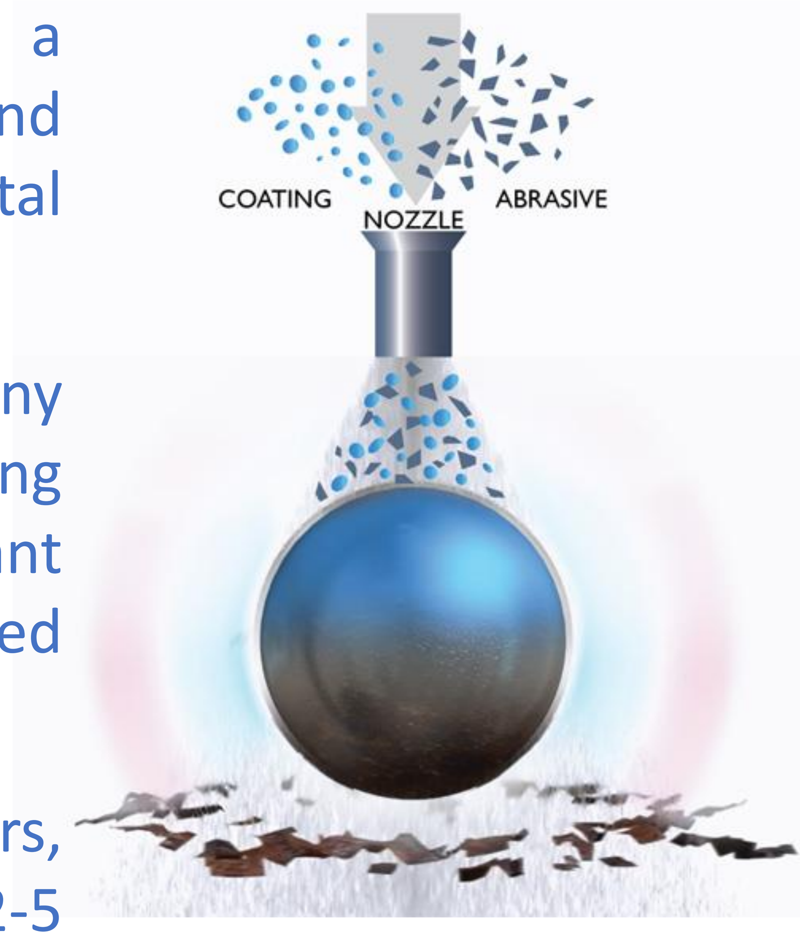
CoBlast

The CoBlast processes consists of a concurrent stream of dopant and abrasive material striking a metal surface.

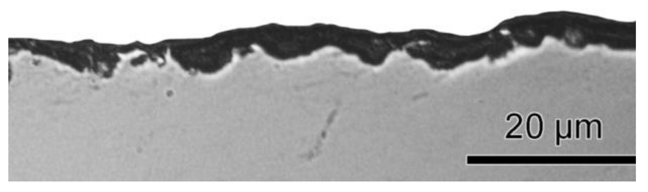
This simultaneously removes any metal oxide layer present, exposing bare reactive metal, and drives dopant material onto this newly exposed surface.

By adjusting various parameters, coating thicknesses of between 2-5 µm can be achieved.

This process has various applications, from depositing ultrathin layers of PTFE for mould release purposes to thermal control coatings for spacecraft.



Schematic of CoBlast process



Cross-section of CoBlast treated metal surface indicating coated layer and texture

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