High Speed laser cladding in Geothermal environments

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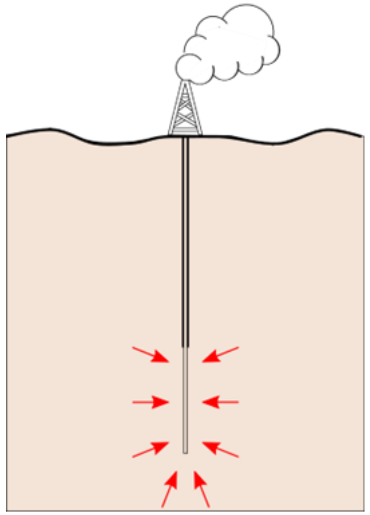
TWI's role in COMPASS

- When geothermal fluid condenses, it becomes highly corrosive, as almost all the chloride in the steam goes into the droplets forming HCl
- The use of highly corrosion resistant alloys (CRAs), such as high alloy stainless steels, nickel alloys necessary to mitigate corrosion damages to the casing.
- Within the project TWI will develop a cost effective and high-performance cladding solution to the corrosion issue via EHLA (Extreme High-speed Laser Application).



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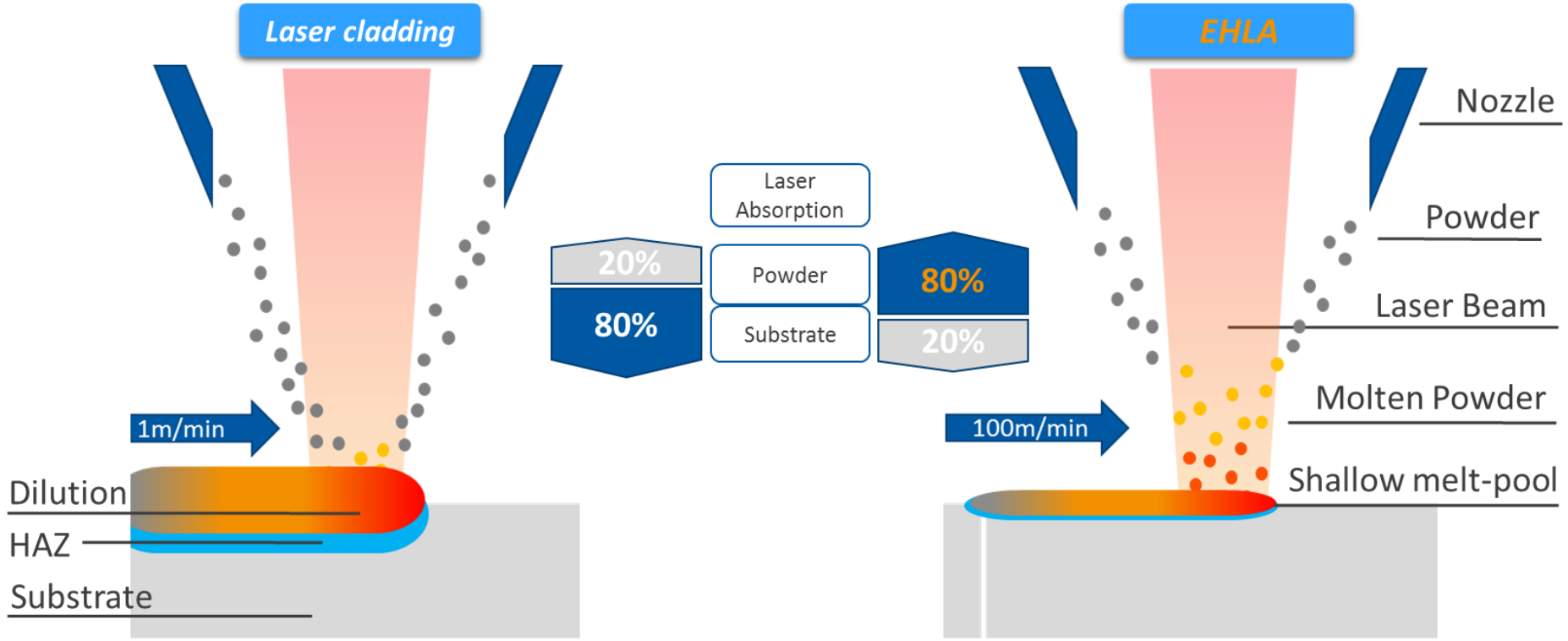
Understand EHLA

- EHLA (Extreme High Speed Laser Application)
- Thin accurate layer
- Low dilution zone
- Very High Speed: 25-500m/min

Technology Overview: EHLA



- **High Precision cladding:** Layer thickness 20-300µm
- **Very Low Heat input:** small HAZ / Dilution >5-10µm **(10-100x less than laser cladding)**
- **Low Surface Roughness:** Rz = 10-20µm
- **High Deposition Rate:** ~2Kg/h
- **Very High Speed:** 25-500m/min @ > 1.5m^2/hr **(10-100x faster than laser cladding)**

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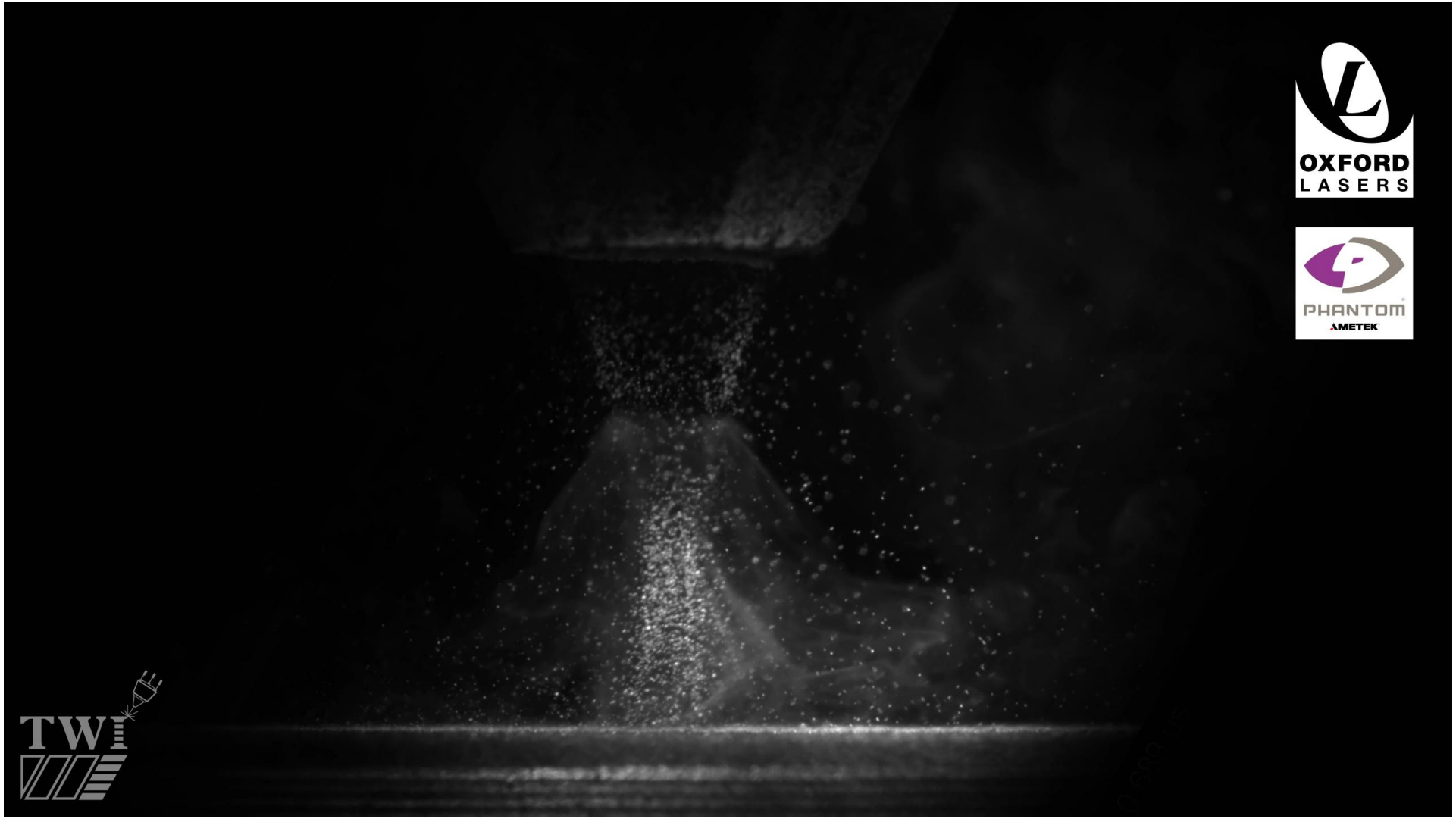
EHLA In-flight Laser Powder Gas Interaction



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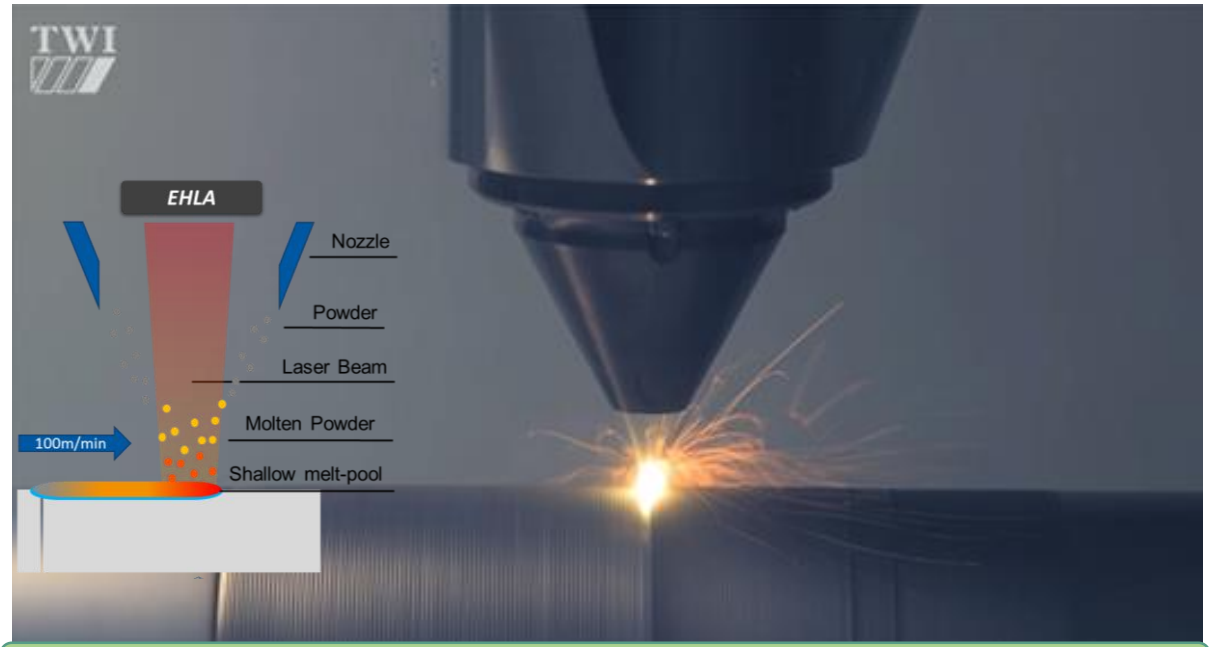
EHLA – Extreme High-Speed Laser Application

A novel coating solution to protect industrial components



- High process speeds; up to 500m/min and 5m²/h
- High material efficiency; up to 90% powder captured
- Integral metallurgical bond & excellent coating properties
- Minimal impact to component; dilution low as 5µm and HAZ 10µm

- Chrome plating replacement
- Thermal spray alternative
- Weld overlay replacement
- Application of corrosion and wear resistant alloys
- Green Technology – New environmental restrictions

Potential Applications

Brake Discs

Hydraulic Cylinders

CRA Pipelines

Valves and Seats

COMPASS WP4 Achievements so far

- Machine specifications in collaboration with Hornet Laser Cladding
- Laboratory specifications
- Initial cladding DoE on small scale machine
- Recruitment of corrosion engineer to consult on testing

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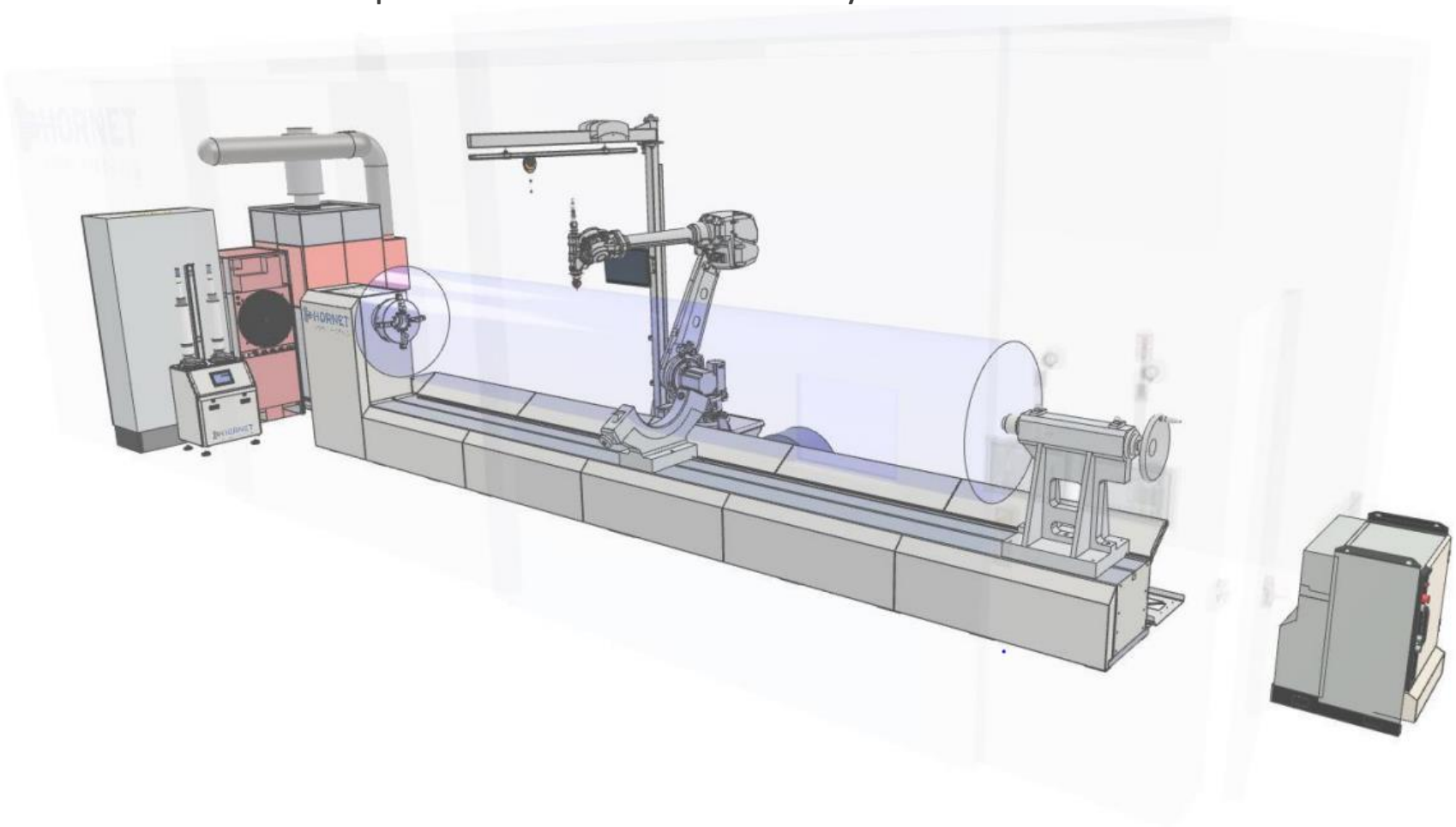
Machine Concept design

- 6 axes ABB – IRB 2600-20/1.65 robot arm mounted on a linear guides
- 3 additional integrated axes for spindle, linear guide for Stinger and linear guide for robot
- Potential 20KW laser power to maximise efficiency



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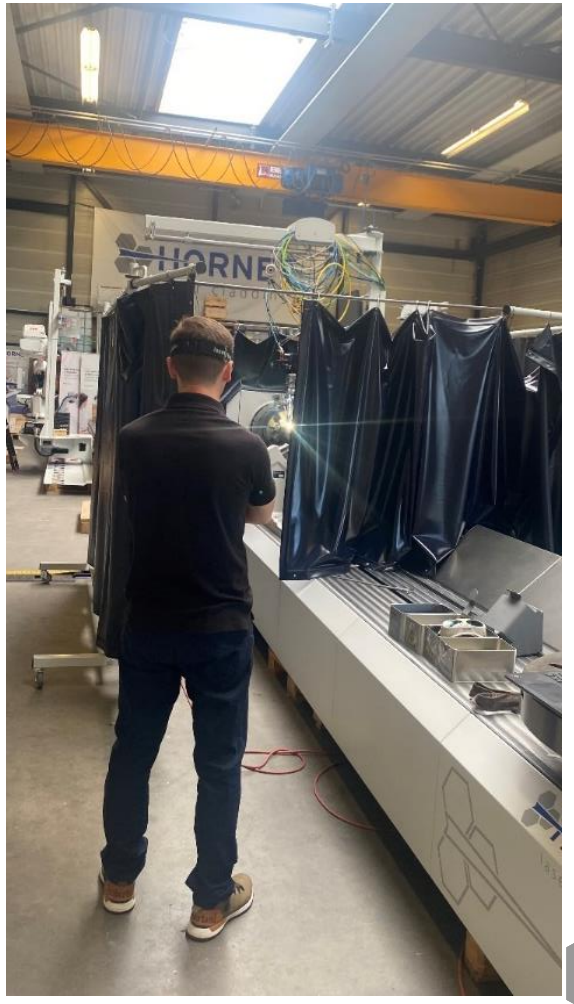
HORNET
laser cladding
ABB

FATs Alblasserdam, NL

- Robot axis tested
- ID stinger tested
- Manipulator tested
- Both check and manipulator tested to max speed (600 RPM & 300 RPM)



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COMPASS machine install

12Kw laser

6-axis robot, ABB IRPB 2600

Fully interpolated turn table (10th axis)

Load capacity of machine (work pieces up to 1.000 kg)

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Results so far

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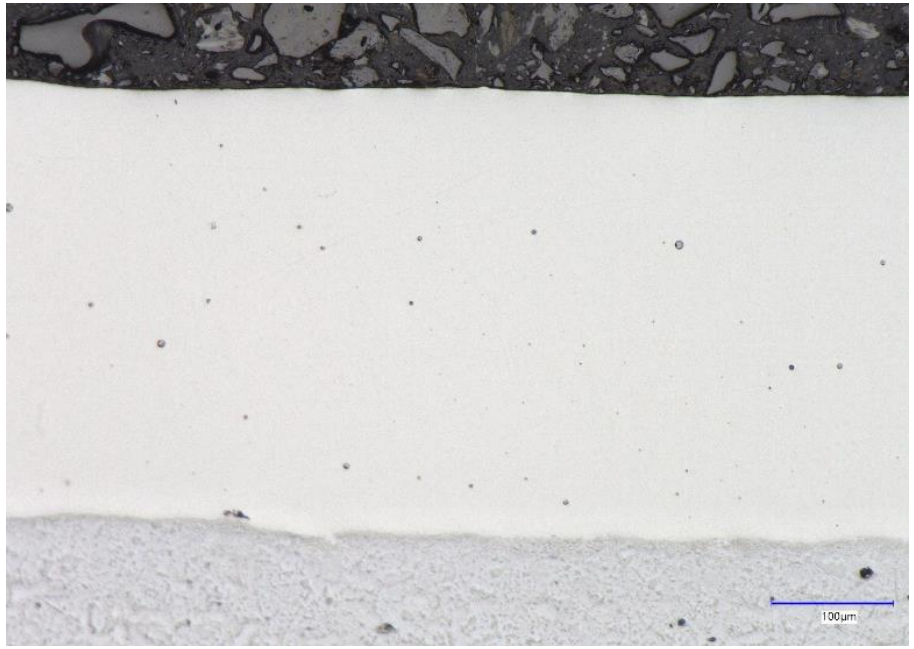
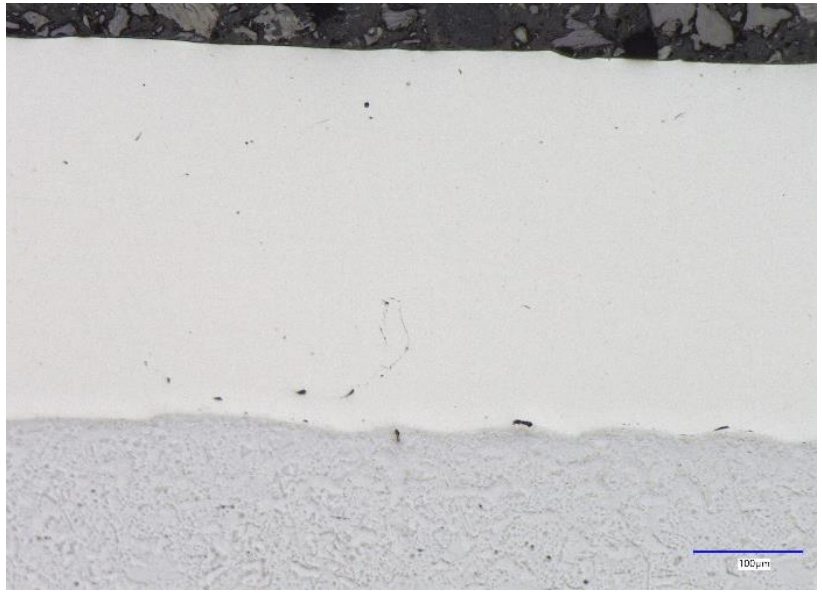
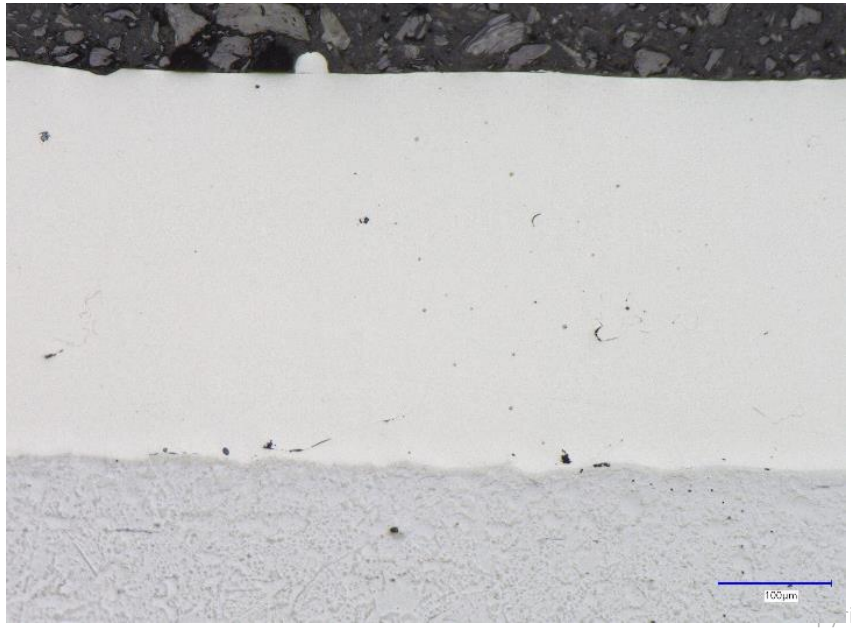
Clad 04 Thickness: approx. 370 µm







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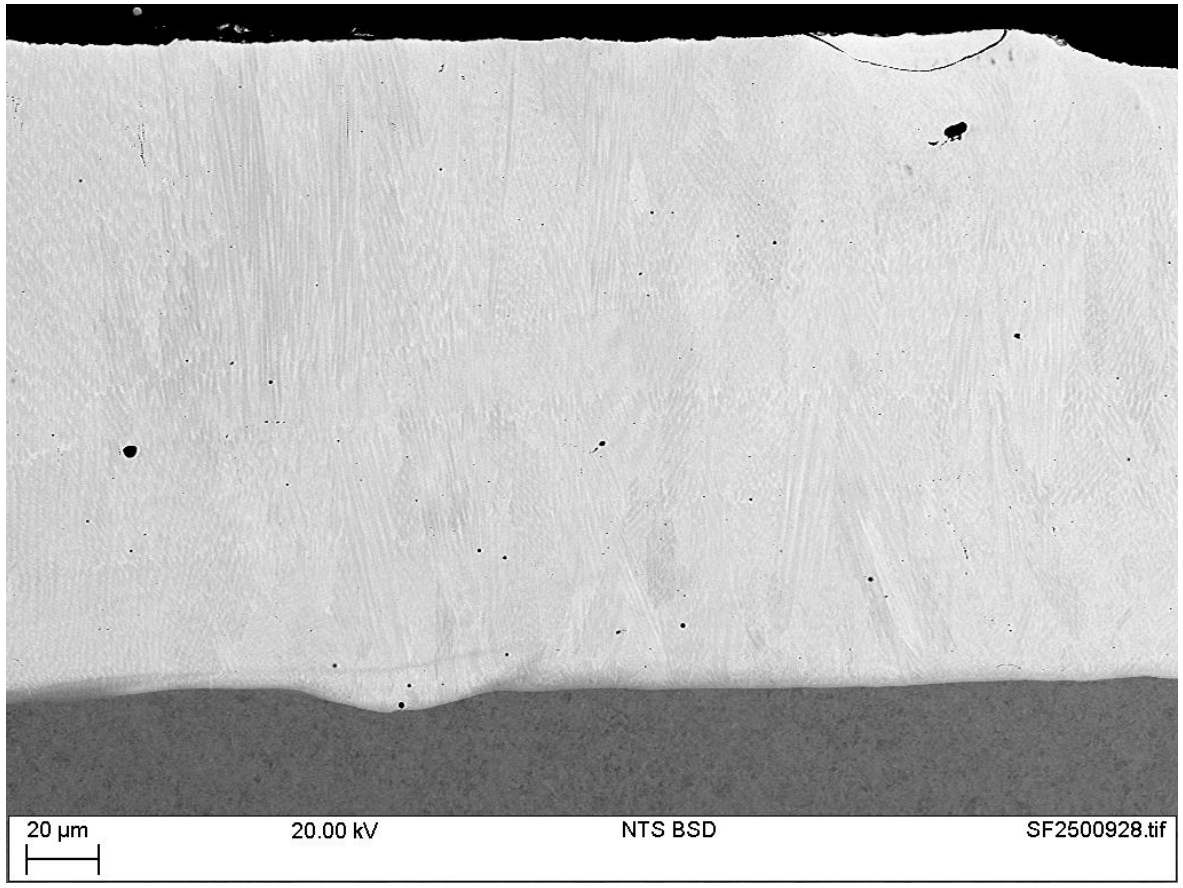
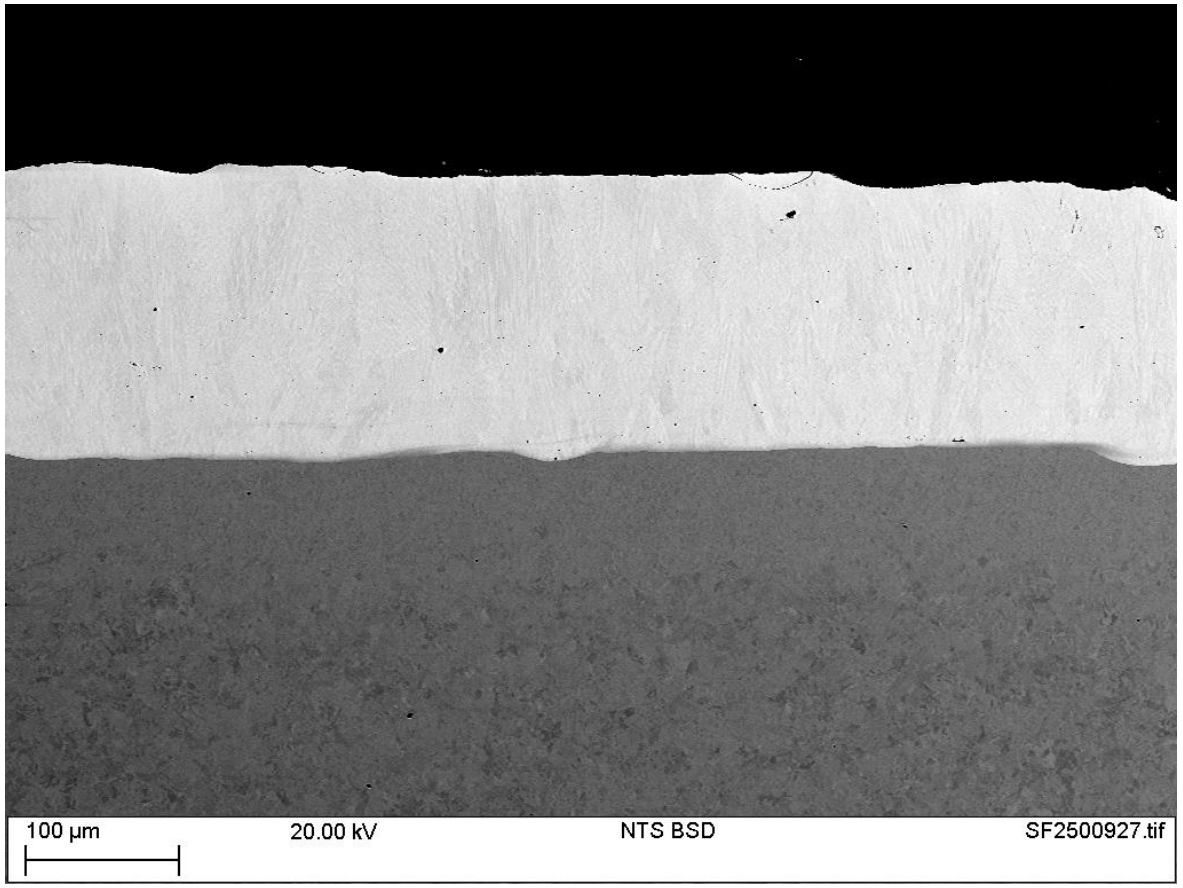
Clad 03 Thickness: approx. 250 µm





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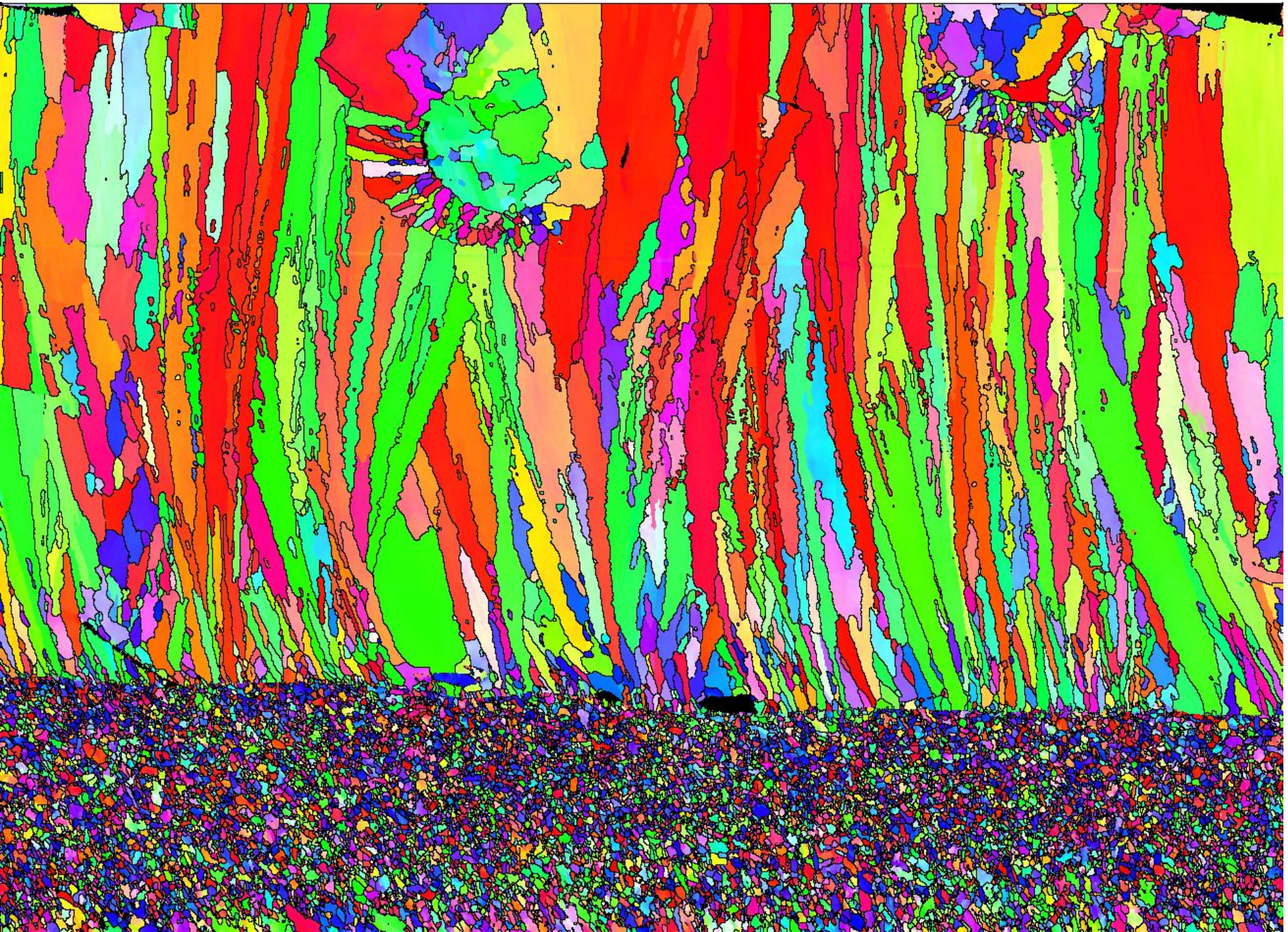
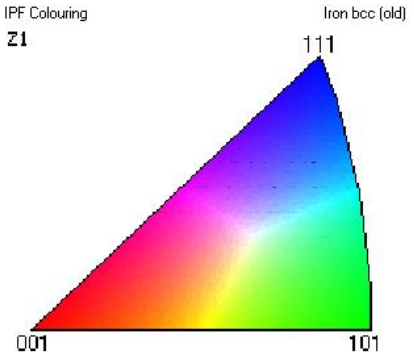
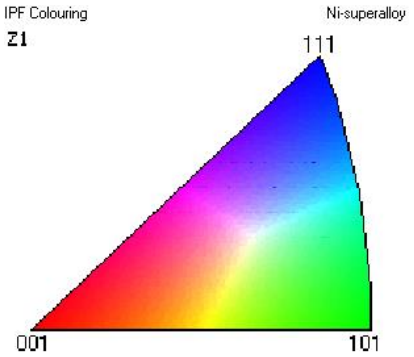
IPF Orientation map

In 625







50 µm

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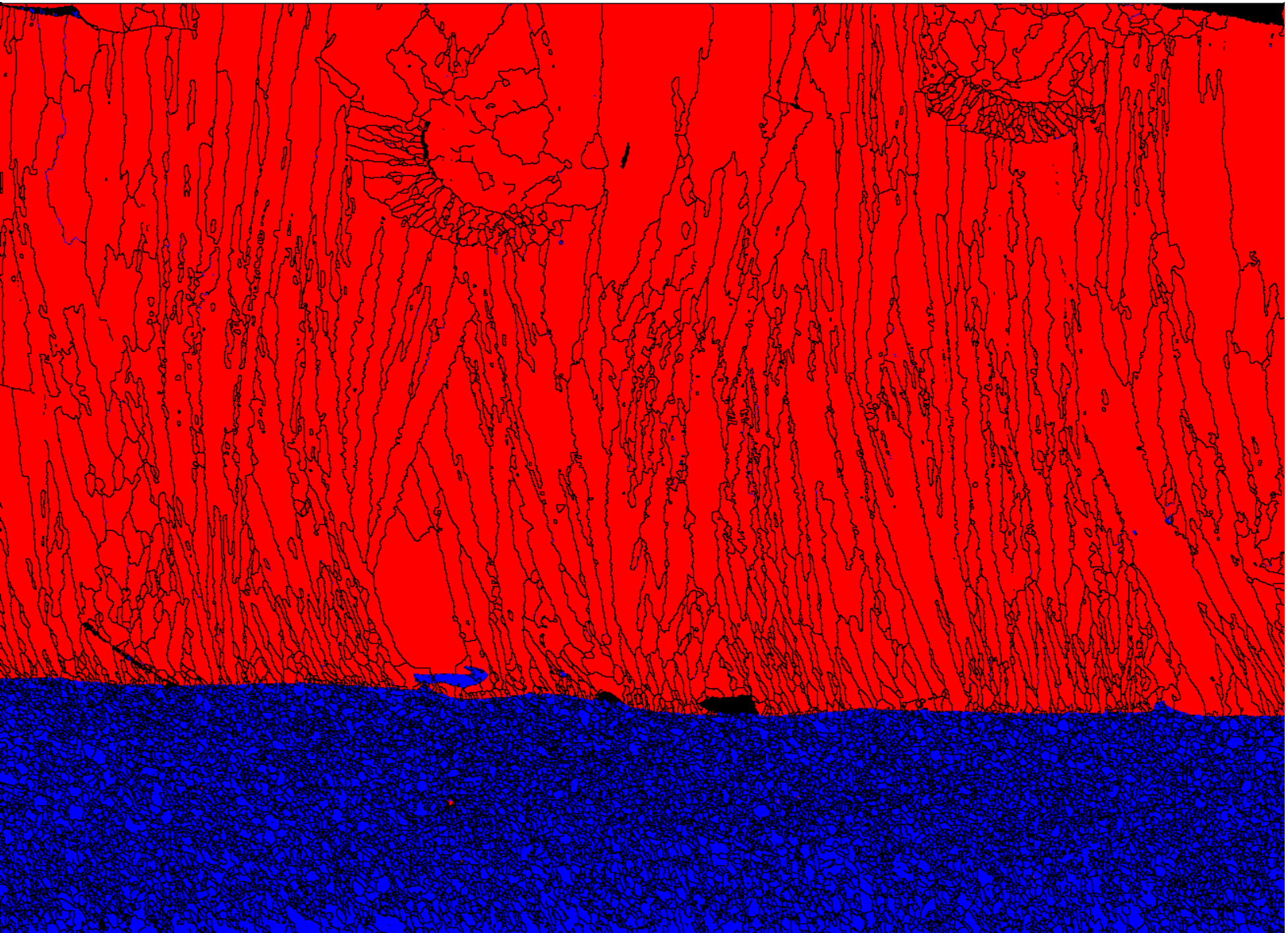

Phase
Distribution map

In 625

Ni superalloy

Iron (bcc)

50 µm

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Corrosion testing

The corrosion risk at a geothermal site is very unpredictable depending both on the materials selected, the chemical composition of the geothermal brine, gas phase as well as the conditions of the well (pressure, temperature).

At least 172 metals and alloys have been tested for corrosion in different types of geothermal fluids.

Materials should have both heat- and corrosion-resistant properties, and their integrity must be maintained during the development and production periods.

Aim

Determine whether cladding CRA material on K55 steel show improvement in corrosion performance of the material for geothermal applications

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KPIs

ID.	Coating material	KPI	Test	Unit	Requirements	Comment
LCM-01-C	C-276 gas atomised powder of PSD 25-45 micron onto K55 substrate	Density	Quantitative image analysis	%	99.8%	Density in excess of 99.8%. This will be measured by cross sectional analysis of a coating and subsequent pixel count using Leica 2.0 software.
LCM-02-C		Hardness	Vickers hardness	Hv	>350 Hv	Improvement of hardness and microstructure (porosity) as compared with current applied materials.
LCM-03-C		Corrosion Resistance	4-point bend test ASTM G39, NACE TM0177	pass/fail	TBD	Improved or no reduction in corrosion resistance comparative with traditional techniques.
LCM-04-C		Crevice test	ASTM G78	N/A	TBD	Improved or no reduction in corrosion resistance comparative with traditional techniques.
LCM-05-C		Coating thickness	Quantitative image analysis	um	1mm	A consistent coating thickness of ~1mm (minimum) within a tolerance of 20%

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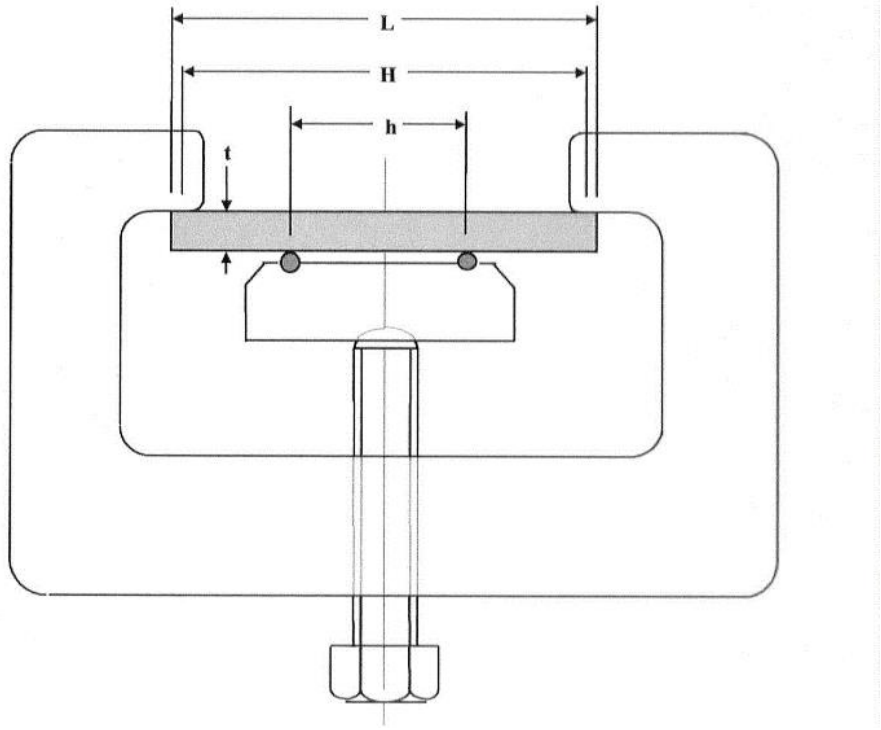
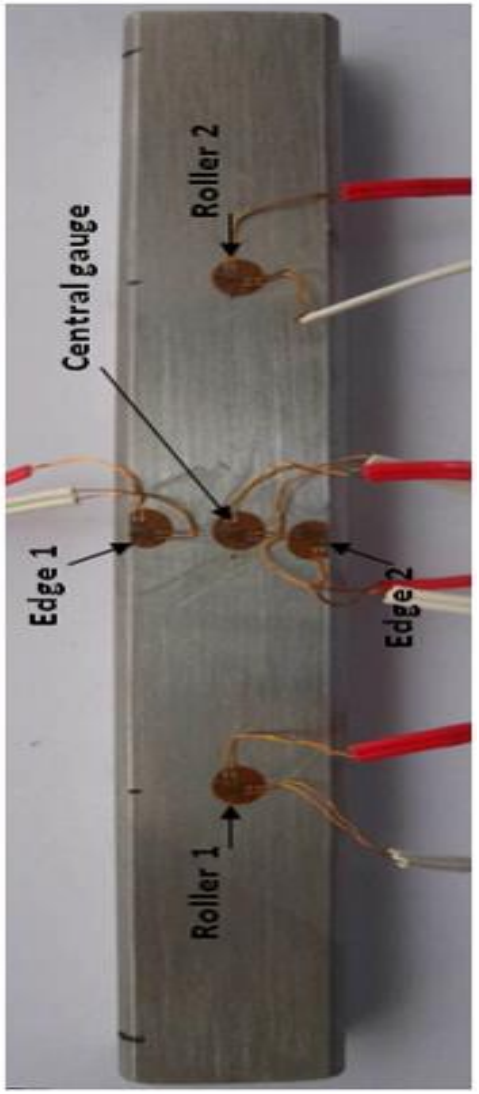
4PB Corrosion Testing

EFC 16 / EFC 17 / NACE TM0177/ ASTM G39 / NACE MR0175/ISO 15156

Applied stress 80% AYS, 90%AYS or 100% AYS





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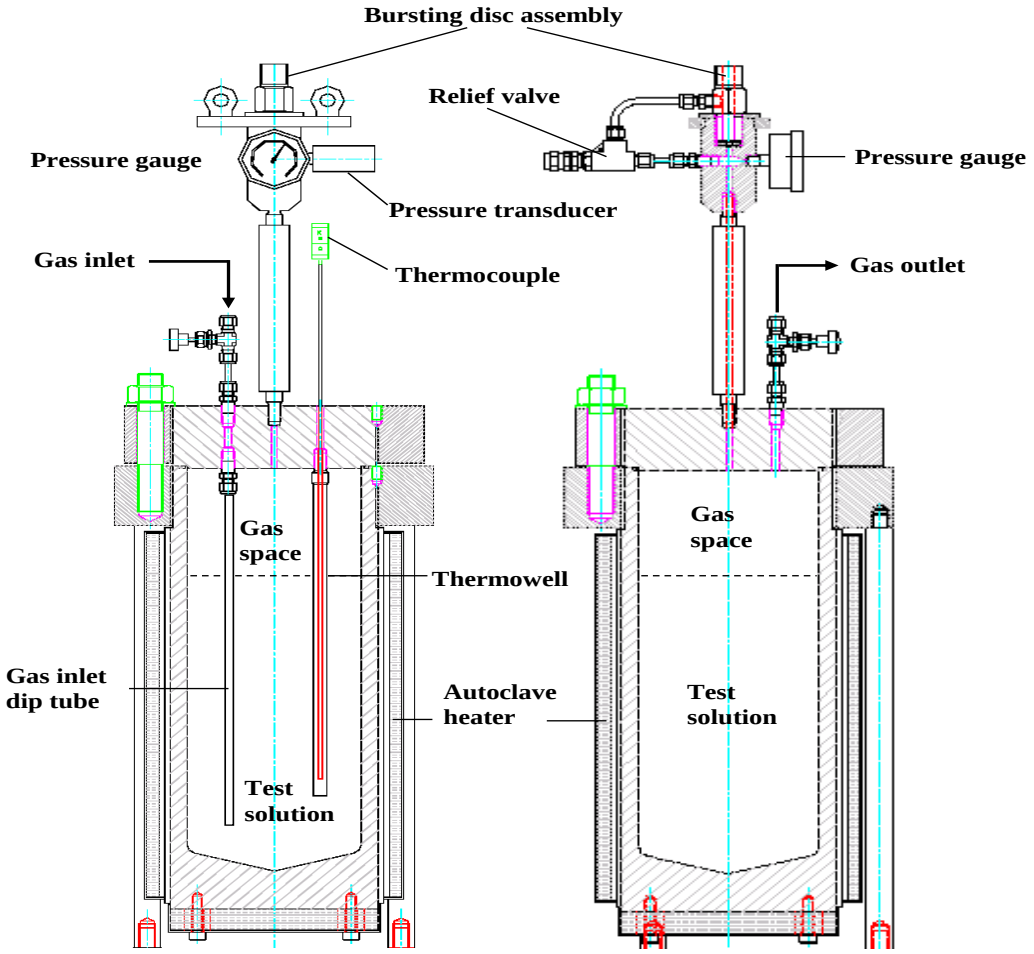
Autoclave Schematic



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Thank you.

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