MIDTERM-WORKSHOP

PDC coating developments with improved high temperature corrosion and erosion resistance

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The project has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement N° 958374.

Objectives and applications

Development of a "easily applicable and inexpensive" anti-corrosive coating based on PDC and fillers for industrial user case

Objectives
O3.1. To assess the thermodynamically characteristics for optimum selection the nature of charges and pre-ceramic polymer for improved high-temperature corrosion and wear resistance. O3.2. To select the appropriate formulation and determine processing parameters for coatings development. O3.3. To Identify the processing-composition-properties relationship that control high-temperature characteristics against aluminium attack.

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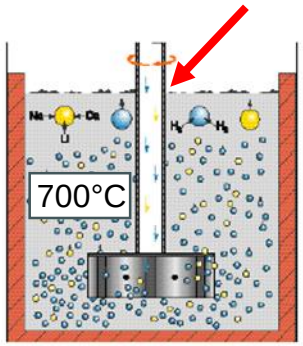
User cases

Constellium

→ Components of Aluminum foundry casting

- ❑ Bricks (refractory)
- ❑ Rotors (graphite)



→ Difficulties

- Adhesion, wearing and diffusion of Aluminum into refractory
- Oxidation in air of graphite

Objectives :

- ❖ Reduce defects for the rotor
- ❖ Reduce of 25% the replacing frequency
- ❖ Increase durability at least 20%

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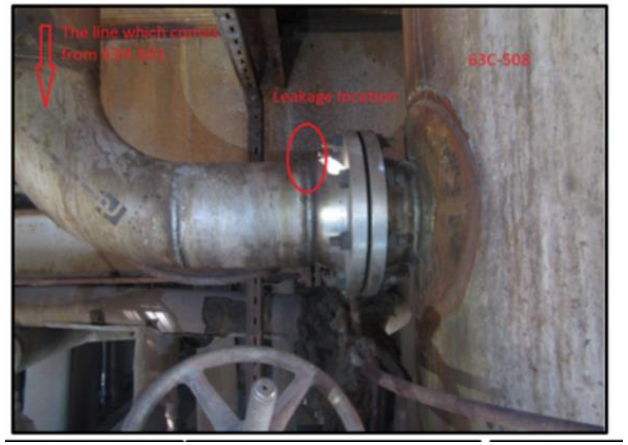
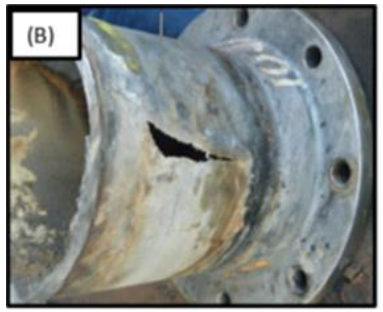
User cases

Tüpraş
Turkish Petroleum Refineries Corp.

→ Continous Catalyc Cracking unit venting pipeline (*converts naphta into high octane reformate*)

- Corrosion and leakage damage on SS321 pipes in HCl environment





Objectives :

- Decrease corrosion by 40% (6 → 3.6 mm/year)
- Decrease replacing frequency of the pipelines
- Increase the maintenance interval (>12 month).

→ Saves: cost production, energy consumption
→ Decrease the risk on the process safety

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Approach

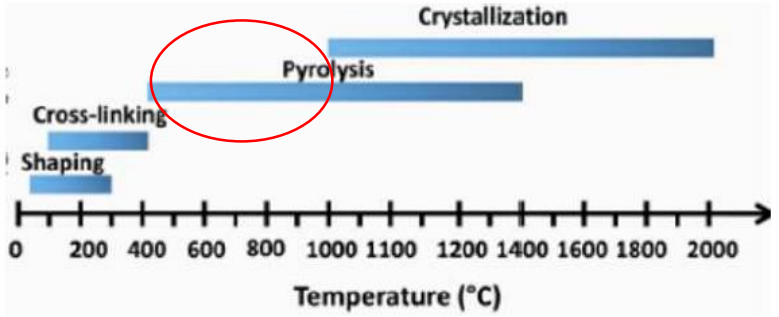
→ Development of a coating based on

- ❑ Preceramic polymer :
  - ✓ Low cost, easily processable
  - ✓ Tailor ceramic at molecular scale
  - ✓ Low temperature conversion into silicon based ceramics
  - ✗ High weight loss and shrinkage

- ❑ Ceramic fillers:
  - chemical barrier
  - anti-wetting
  - thermal & mechanical properties

Polysiloxanes $\xrightarrow{\Delta T}$ SiO_xC_y

Polycarbosilanes $\xrightarrow{\Delta T}$ SiC



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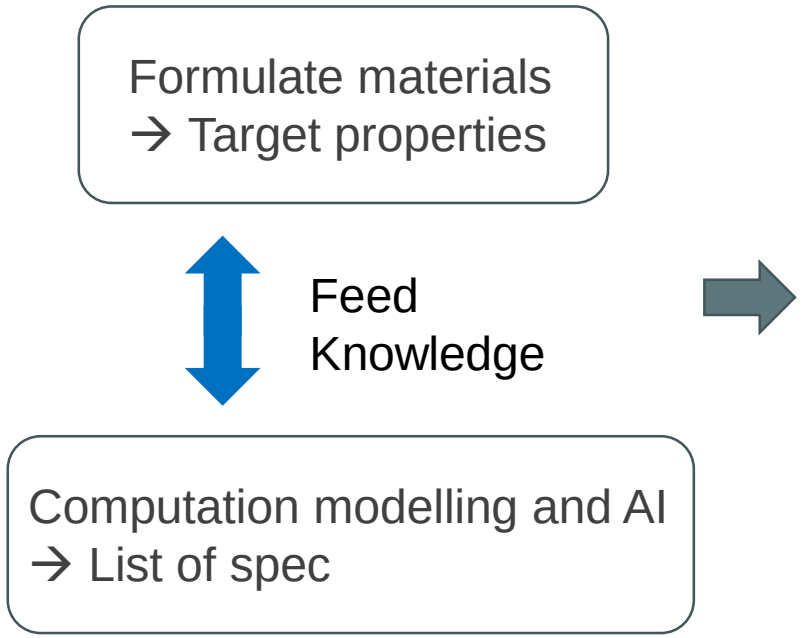
Work plan



Objectives:
- Good adhesion on surface (nature, cleaning, rugosity)
- No delamination during cycles → durability
- Continuous layer with no cracks (porosity, shrinking)
- Coefficient of Thermal Expansion close to the substrate
- Low surface free energy / wettability
- Inertness with liquid phase (chemical reaction, diffusion)

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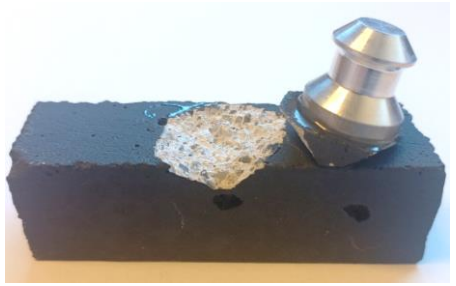
Coating for Foundry user case (melted aluminium)

Protocol of study:

- **Formulating**: preceramic polymer, solvent, fillers, mixing, degassing
- **Deposition on substrates** : refractory, graphite (brush, spray, dip-coating)
- **Thermal treatments**: crosslinking (200°C/air), pyrolysis (700°C/argon)
- **Visual evaluation**
- **Adhesion testings**: Crosscut (ASTM-D3359B), Pull-off testing (ASTM D4541)
- **Microscopy inspection and analysis of phases**: Scanning Electron Microscopy (SEM)
- **Quantitative testing**: rotating brick test, immersion in Al

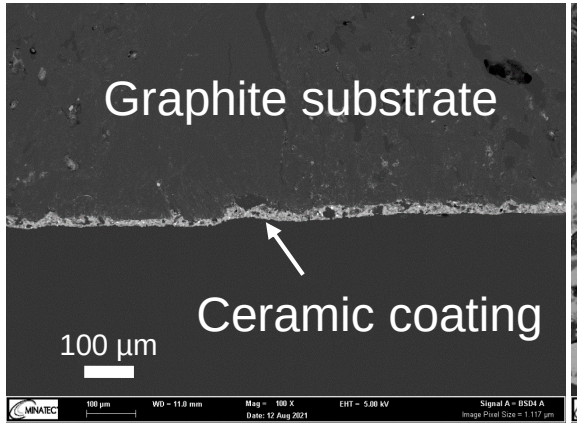
Adhesion testing

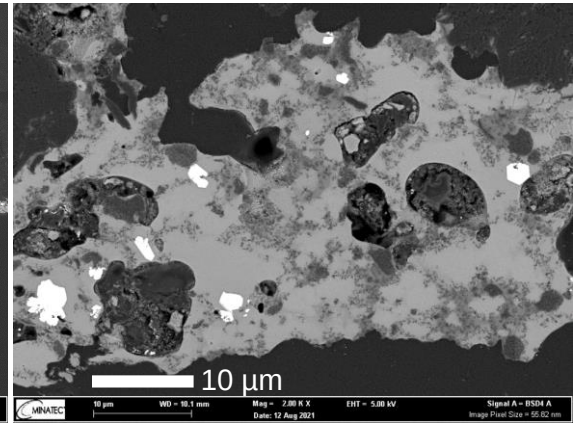


Graphite sample + coating

x hours in melted aluminum

SEM inspection





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Coating against corrosion of steel in acidic environment

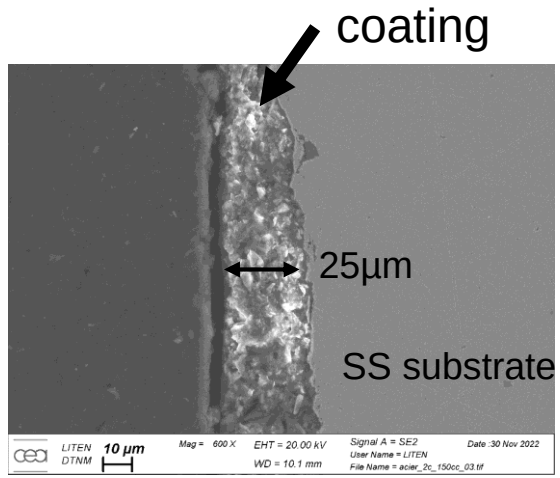
Protocol of study:

- **Formulating**: preceramic polymer, solvent, fillers, mixing, degassing
- **Deposition on substrates** : Steel plates, tubes (brush, spray)
- **Thermal treatments**: crosslinking (200°C/air), pyrolysis (700°C/argon)
- **Visual evaluation**
- **Adhesion testings**: Crosscut (ASTM-D3359B), Pull-off testing (ASTM D4541)
- **Microscopy inspection and analysis of phases**: Scanning Electron Microscopy (SEM)
- **Quantitative testing**: immersion in HCl, dew-point test, EIS (WP6)

EIS measurements in HCl 2M at 60°C

Coating	Contact angle in water (°)	Corrosion rate (mm/year)	Weight loss (%)
Without	80.0	30.2	72h – 0,74%
PDC1	137.6	4.0	96h – 0,15%

Objective < 3.6 mm/year



Adhesion Crosscut testing

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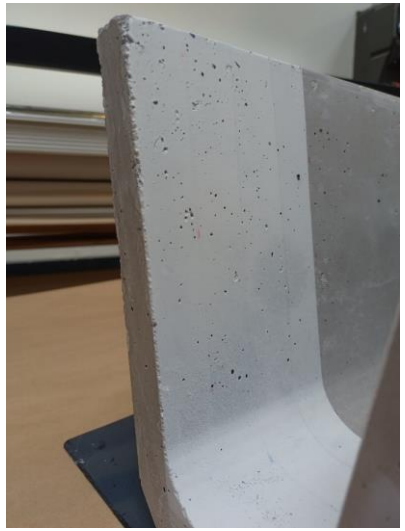
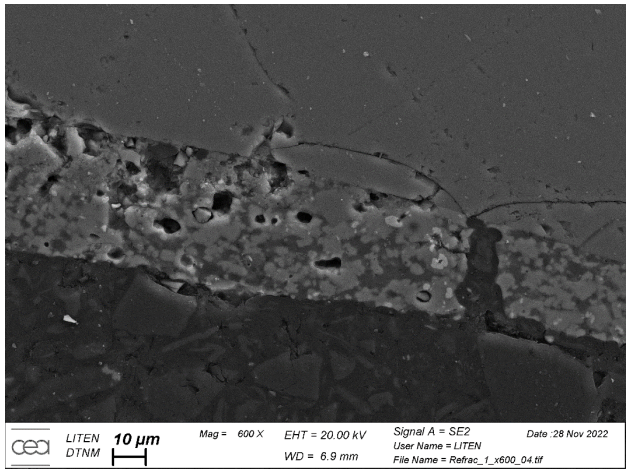
Scaling up the method of deposition

Robotic Arm deposition

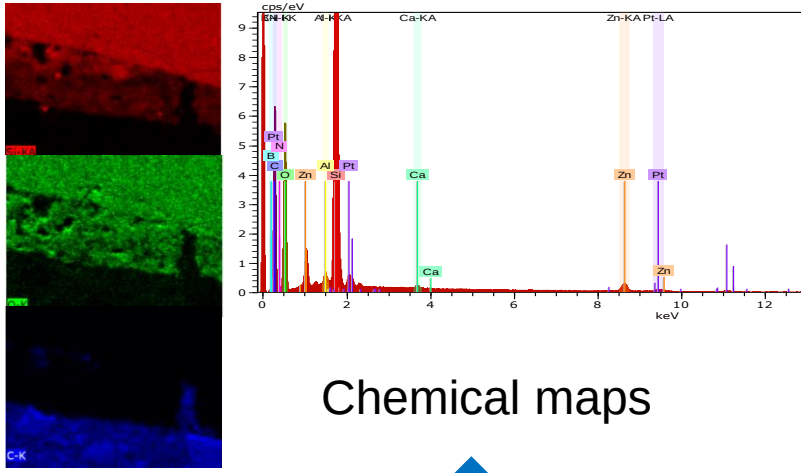
Creation of trajectory



Evaluation of aspect and thickness with spraying parameters (20-30 µm)



Thermal treatment and evaluation of coating homogeneity



Chemical maps

Computation modelling of thermomechanical properties

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Future work

- Test the last developed coatings into melted aluminum (graphite and refractories)

- Test steel samples into the new test bench (Dew point corrosion test bench)
  - ❑ More representative of the real corrosion conditions

- Enhance stability in time of large batch
  - ❑ Use of additives to limit sedimentation and agglomeration

- In association with other WP
  - ❑ Embeding sensors (temperature, EIS)
  - ❑ Computation modelling of the coating (thermomechanical stresses)

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Thank you

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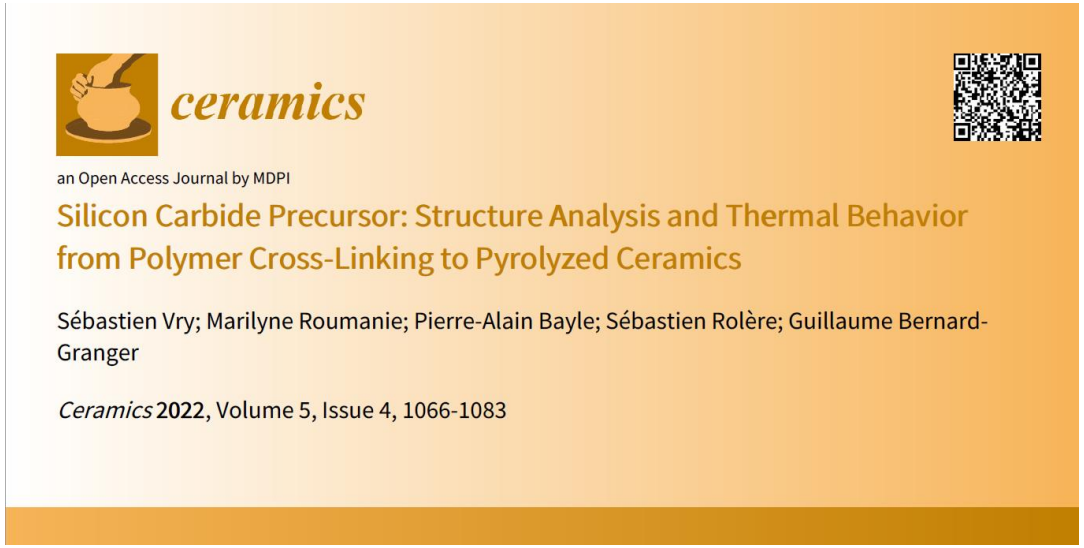

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