



Corrosion behaviour of steels in flowing lead-bismuth

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Presentation Outline

Introduction
Testing equipment
Materials and Experimental
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Conclusion



Introduction

Project IP EUROTRANS: DM 4 DEMETRA 2005-2009

The lead-bismuth eutectic (LBE) is being considered for application as a spallation target and coolant in the new Accelerator Driven Systems (ADS)

- + optimal chemical, thermodynamic, physical and neutron properties
- structural materials in contact with heavy liquid metals (HLM) suffer corrosion due to nickel dissolution and/or LM penetration

AIM : characterisation of corrosion resistance of materials in contact with LBE under the abnormal conditions



simulating accidental conditions



Loss of oxygen

Testing equipment

COLONRI I

Medium: LBE

Temperature:

long-term 550–600°C

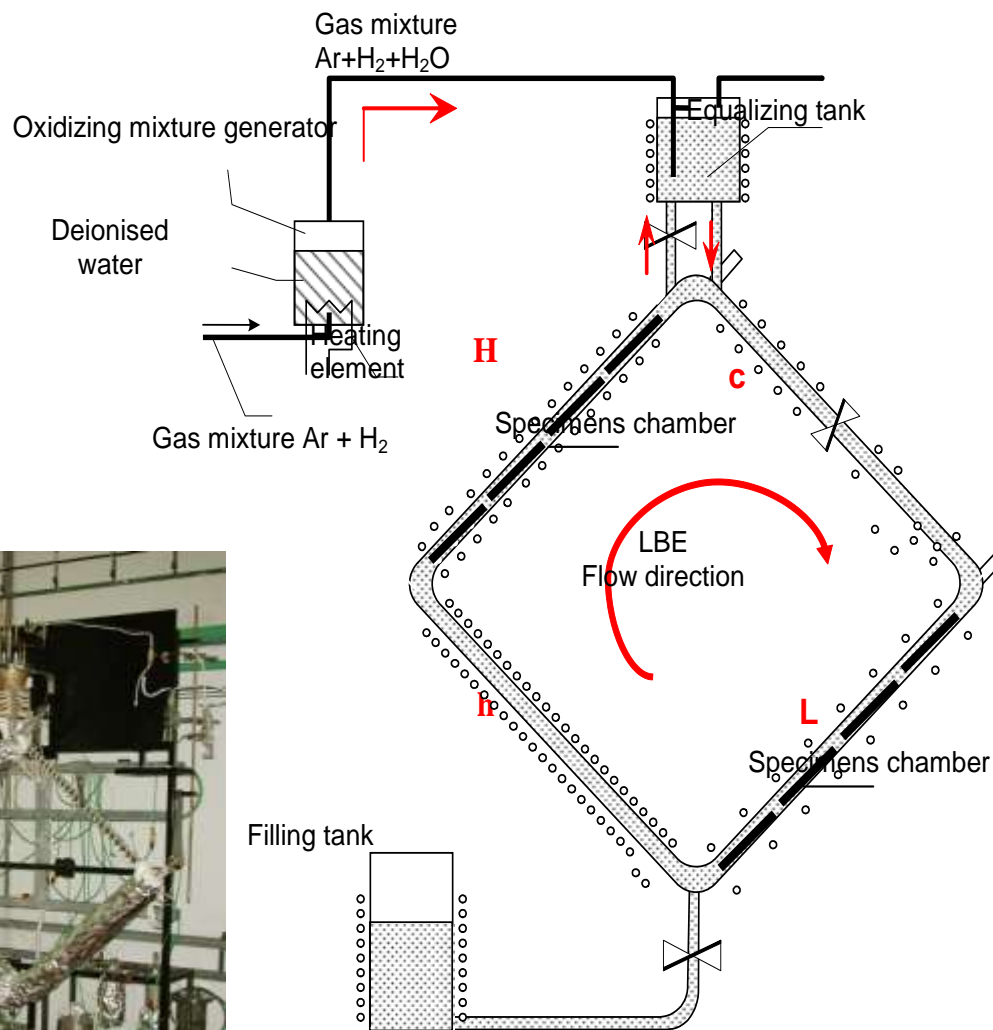
short-term 650–700°C

Temperature gradient:

50 – 150°C

Flow rate:

1-2 cm/s





Materials and Experimental

| Elements (wt.%) | Fe | C | N | P | S | Cr | Ni | Mo | Mn | Si | V | Cu | Nb | Al | W | Ti | Sn | As |
|------------------|------|------|------|------|--------|------|------|-----|-----|-----|-----|------|------|------|------|-------|-------|-------|
| AISI 316L | Bal. | 0.02 | 0.03 | 0.03 | 0.0035 | 16.9 | 10.2 | 2.1 | 1.8 | 0.6 | - | 0.23 | - | 0.02 | 0.02 | 0.006 | - | - |
| T91 | Bal. | 0.1 | 0.04 | 0.02 | 0.0004 | 8.9 | 0.1 | 0.9 | 0.4 | 0.2 | 0.2 | 0.06 | 0.06 | 0.01 | 0.01 | 0.003 | 0.004 | 0.008 |
| T91+GESA | | | | | | | | | | | | | | | | | | |

Surfaces:

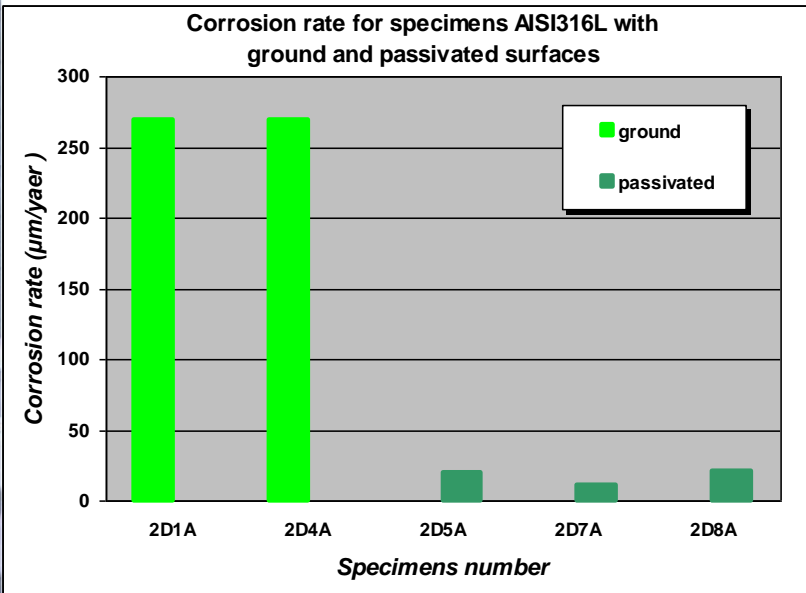
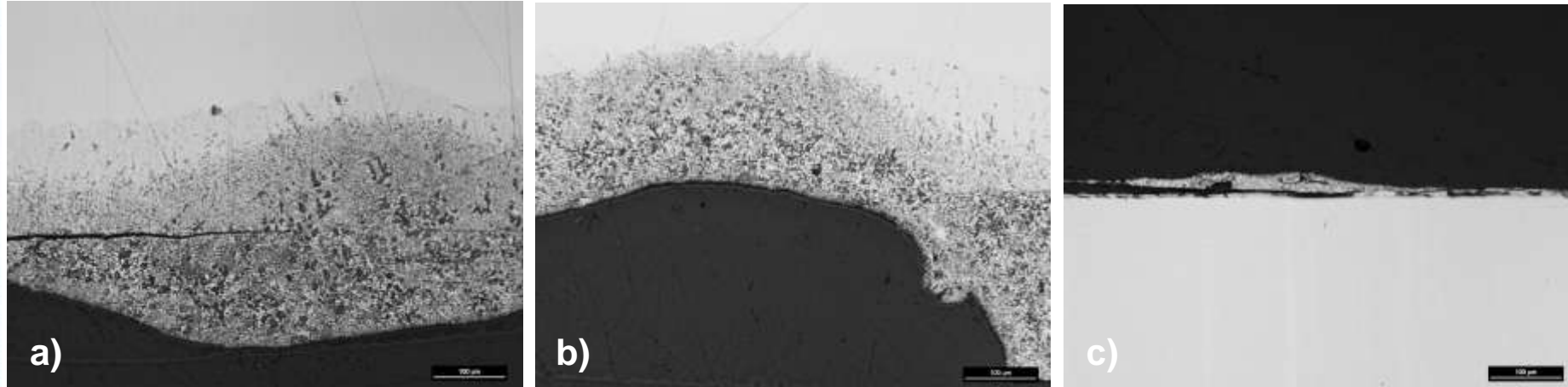
Ground - to 600-grit finish with SiC paper

Passivated – for 50 hours at 350°C, in a gaseous mixture of steam containing 5% of H₂

Coated - GESA

| | Loss of oxygen | |
|--|--------------------|--------------------|
| | LBE | |
| Liquid medium | PHASE 1 | PHASE 2 |
| T _{test section} (°C) | 550 | 550 |
| Duration (h) | 1000 | 10 |
| Velocity (cm/s) | 1-2 | |
| Ratio H ₂ /H ₂ O | 1:746 | 1:7.46 |
| Oxygen (wt.%) | 1x10 ⁻⁶ | 1x10 ⁻⁸ |

Results AISI 316L



GROUND SURFACE – a) and b)

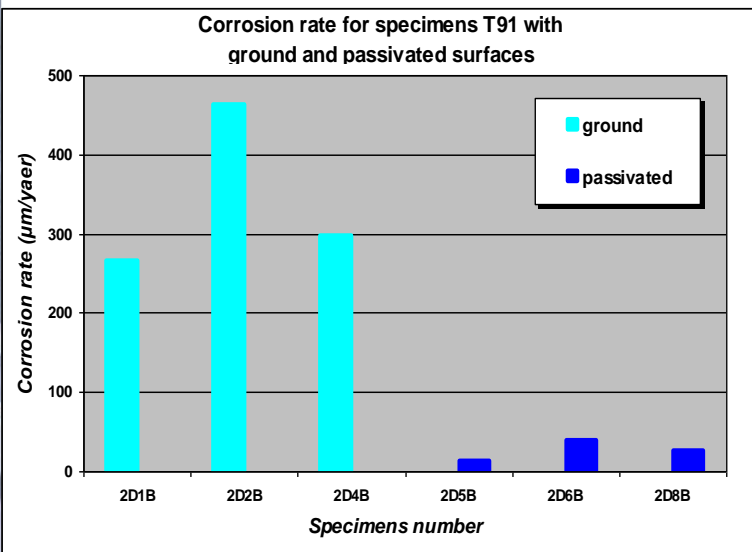
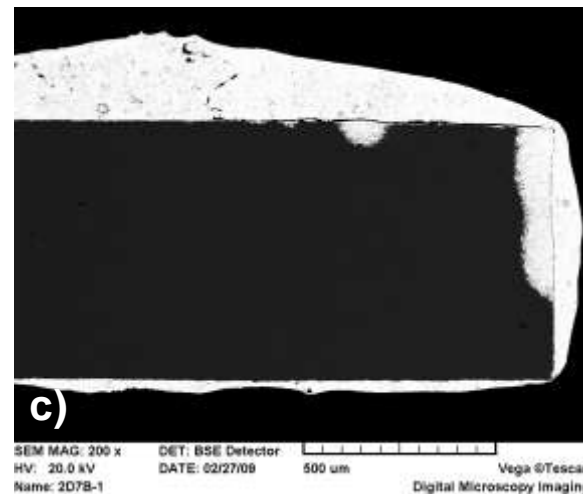
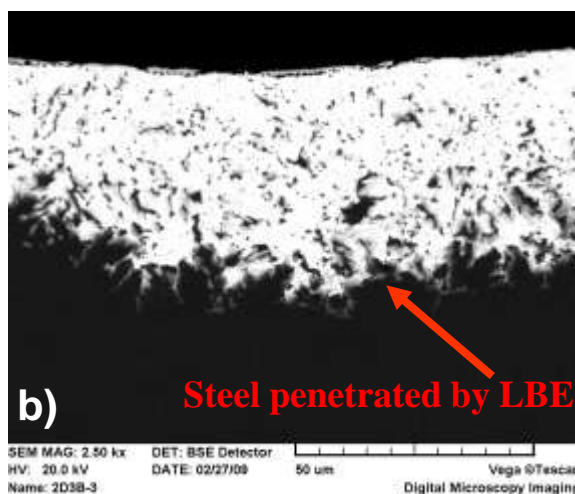
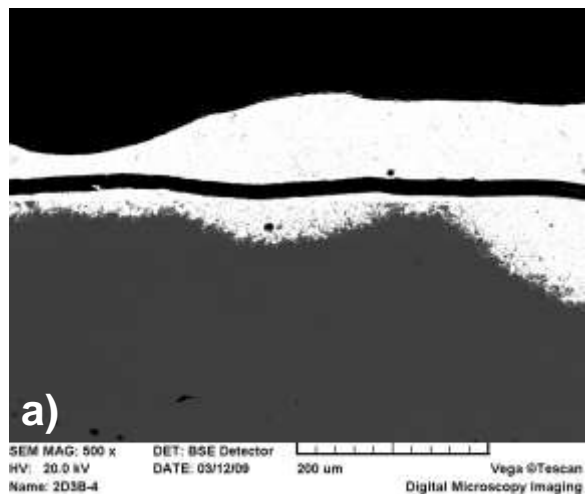
Penetration of LBE in bulk of material.
Two layers on the surface.

Abundant metal loss.

Ni and Cr depletion

PASSIVATED SURFACE – c)

Slightly damaged on the specimen surface



GROUND SURFACE – a) and b)

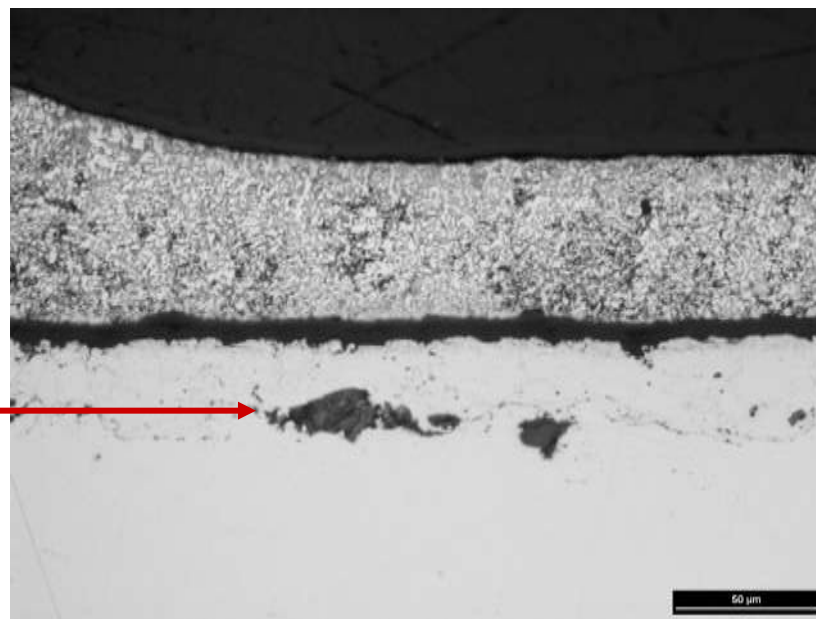
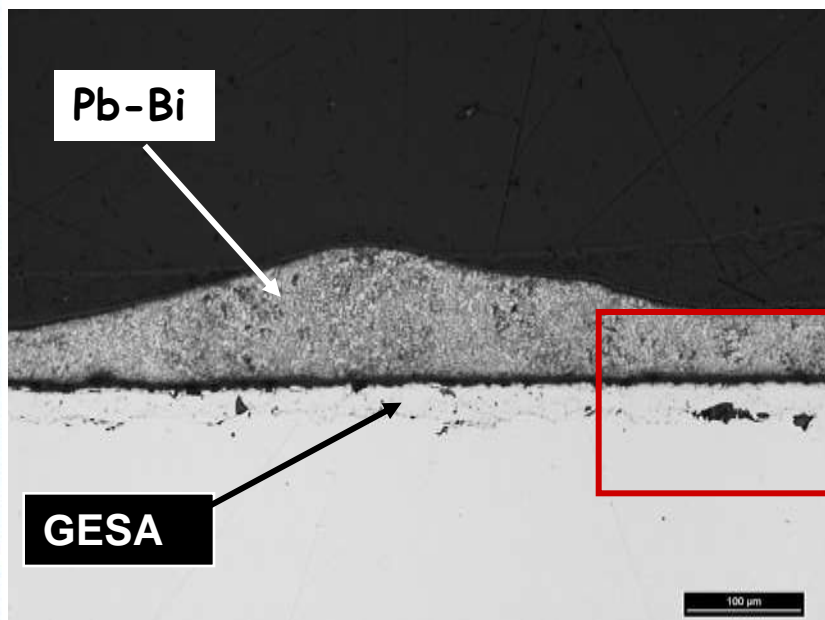
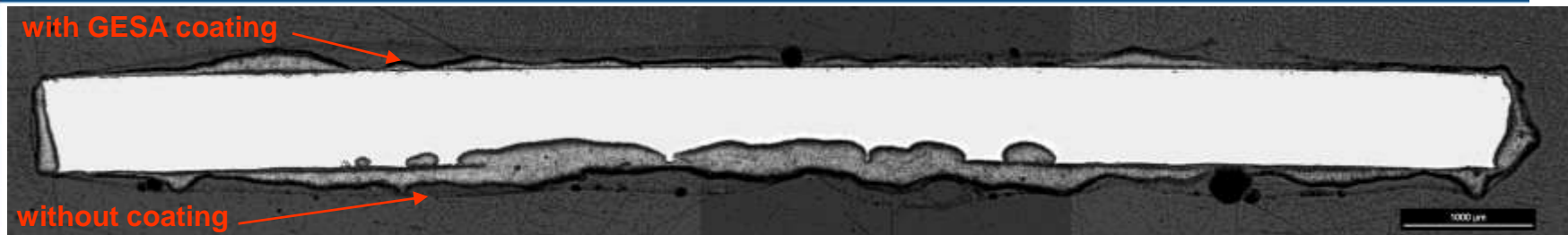
LBE penetration along grain boundaries and localised pits were observed.

PASSIVATED SURFACE – c)

Slightly damaged on the specimen surface



Results T91 + GESA

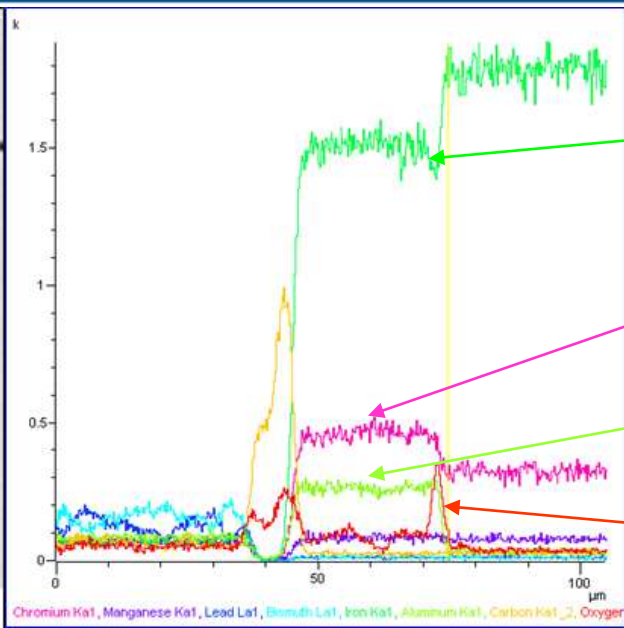
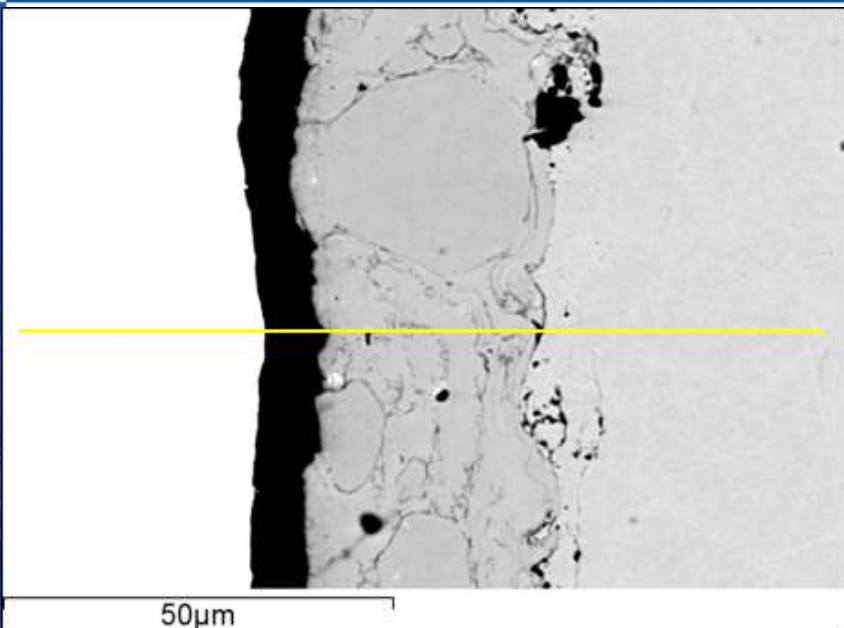


Any type of damage of T91+GESA didn't observed on the surface with coating **BUT** 

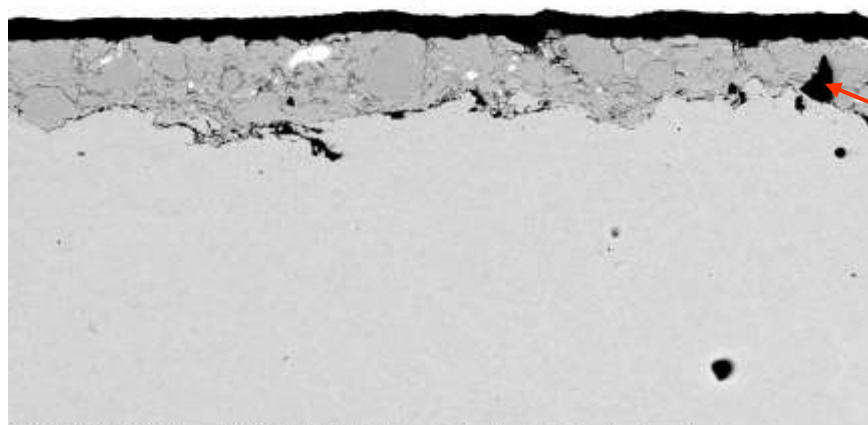


Results T91 + GESA

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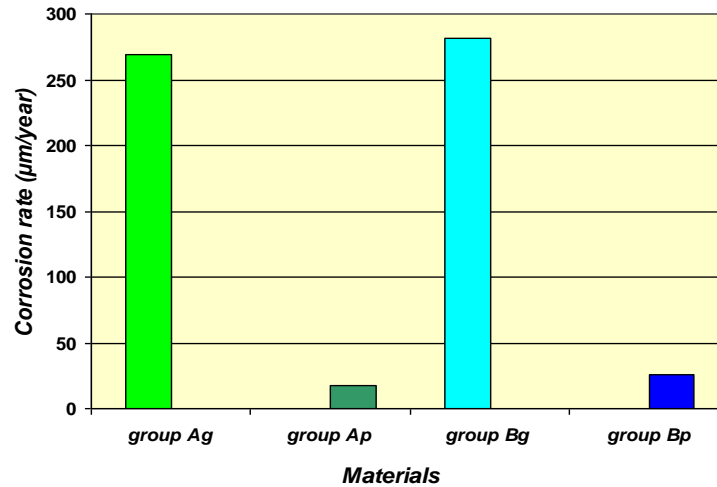
Fe
Cr
Al
O



Aluminum 50 wt%
Oxygen 49 wt%

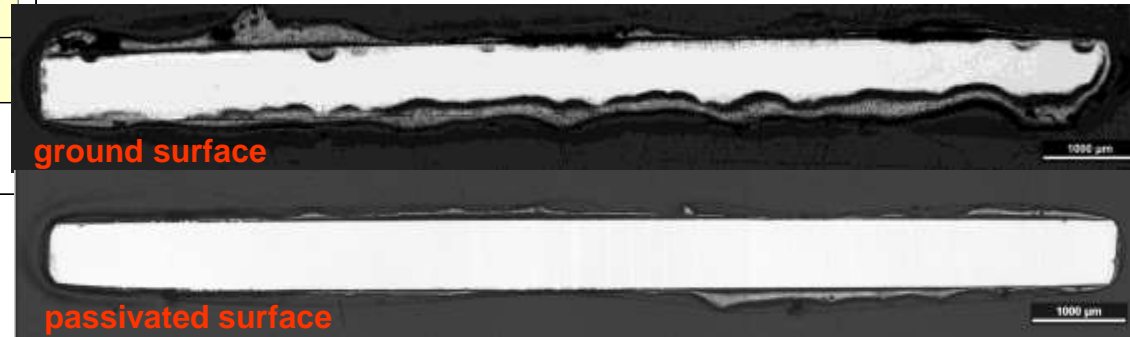
SEM MAG: 1.00 kx DET: BSE Detector
HV: 20.0 kV DATE: 02/26/09 100 μm Vega ©Tescan
Name: 2D3K-7 Digital Microscopy Imaging

Summary results

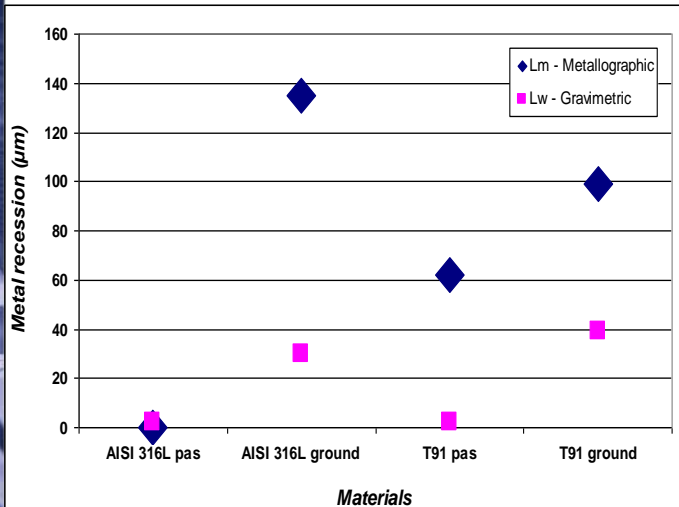
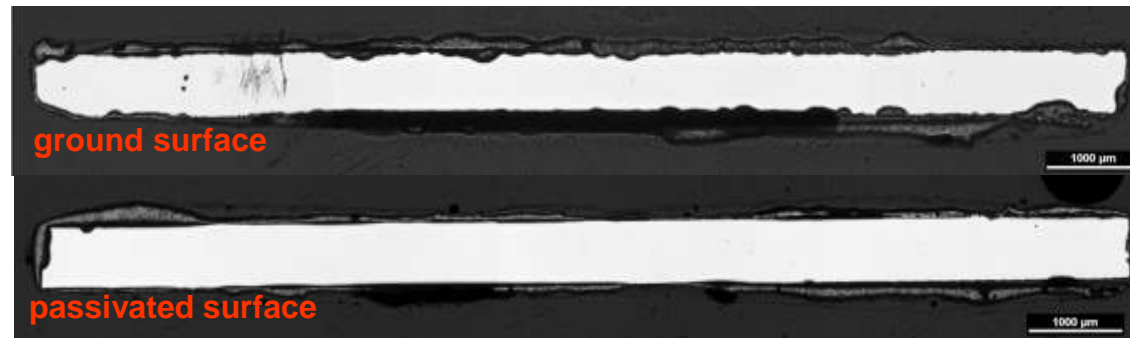


The amount of damage of ground surface was higher (about 10 times) than the damage measured of passivated surface for both material

AISI 316L



T91





Conclusions

- The amount of damage with low oxygen content (1×10^{-8} wt%) was higher than the damage measured with the oxygen content 1×10^{-6} wt%.
- The effect of the loss of oxygen at the temperature 550°C did affect markedly the amount of damage in the specimens.
- The passivated surface specimens of both materials were damaged slightly the specimens with ground surface were damaged about 10 times more than the specimens with passivated surface.
- AISI 316L - characteristics of damages were typical Ni and Cr depletion at the surface layer, LBE penetration and loss of bulk material were observed.
- T91 - LBE penetration along grain boundaries and localised pits were observed.
- The specimens of T91 with GESA coating showed the highest corrosion resistance and any type of damages didn't observe on coated surface.



Thank you for your attention



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