GROM #030

High temperature oxidation resistance of metallic materials by PVD coatings: influence of the initial substrate roughness.

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Introduction

The application of a coating to the surface of metallic materials can improve some properties, such as high temperature (800-1000 °C) resistance. The preparation of the substrate and its initial surface state play a major role in the continuity and conformity of the deposited PVD layer. In this study, K41X steel substrates were prepared with three different surface finishing (unpolished, P60 and mirror polished). They were then coated by sputtering and finally oxidized at high temperature. Surface topography and cross section morphology analyses were performed by optical profiler and SEM on the bare substrates, after coating and after oxidation.

Approach

Surface préparation

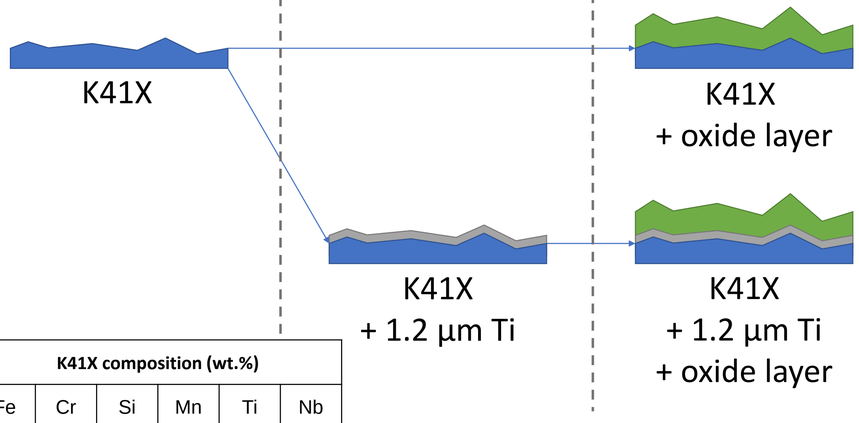
- Unpolished
- P60
- Mirror polished

PVD deposition

P = $4.4 \cdot 10^{-3}$ mbar
U = 334 V
I = 4.5 A
Scan +15°/-15°

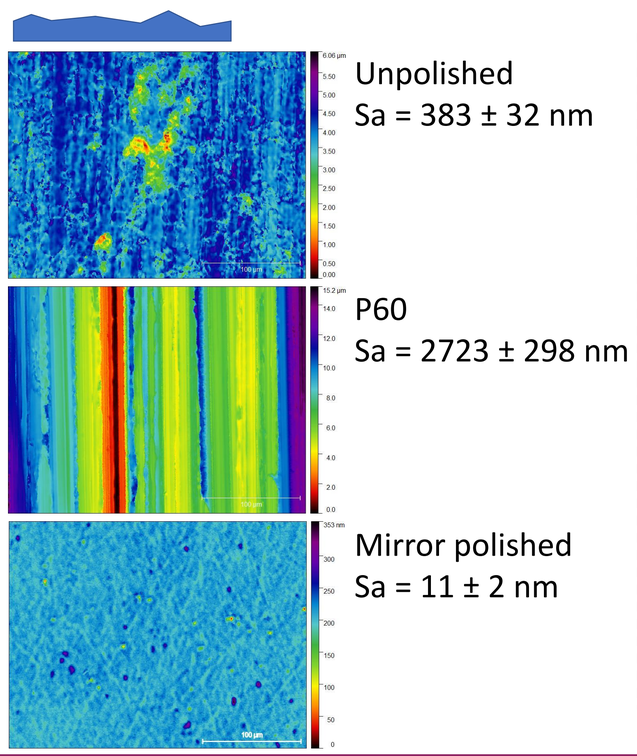
Oxidation

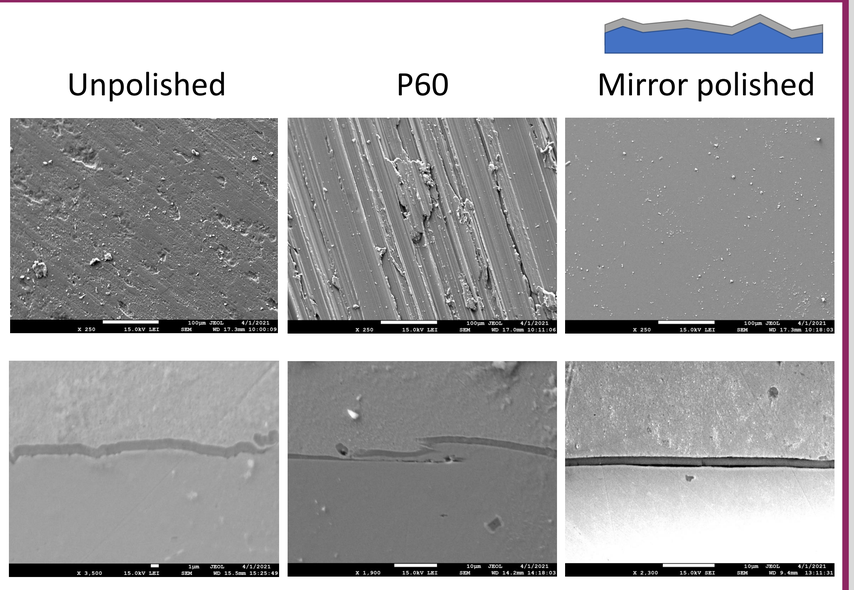
T = 800 °C
t = 100 h
Air



K41X composition (wt.%)					
Fe	Cr	Si	Mn	Ti	Nb
Base	17.51	0.58	0.25	0.14	0.52

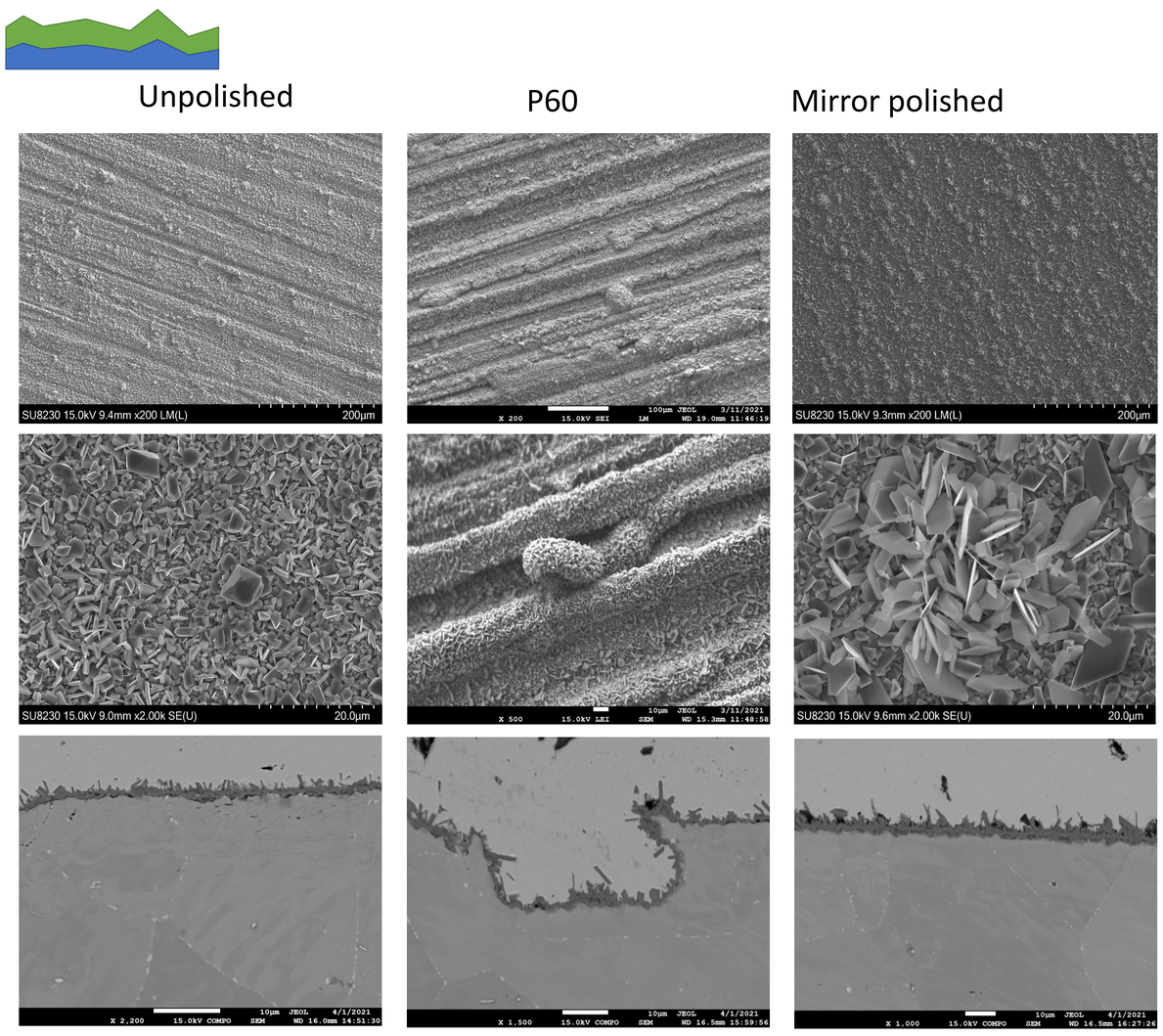
Surface Preparation and deposition



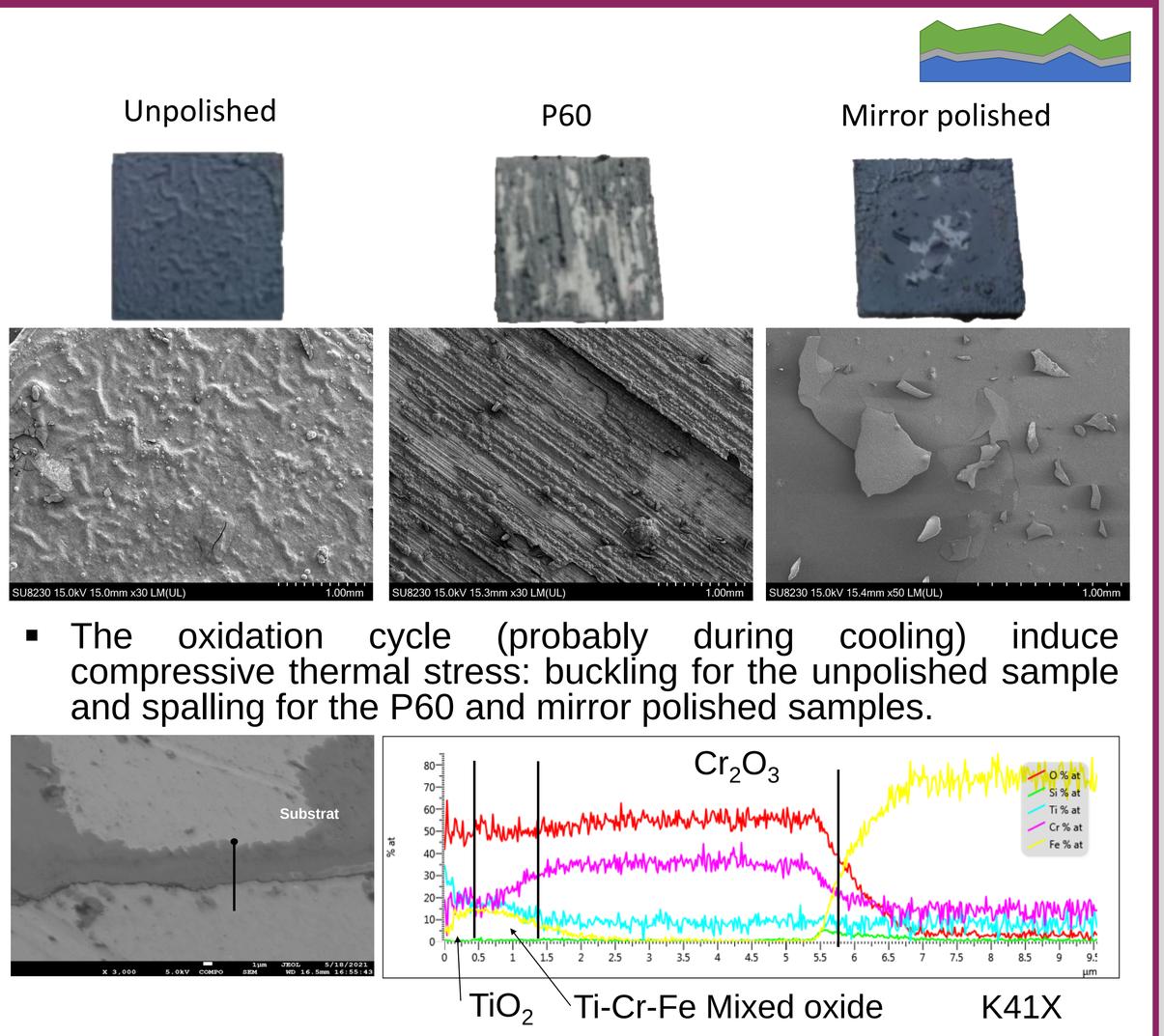


- Good comformity.
- No significative changes in roughness.
- Presence of open porosities due to local heterogeneities.

Oxidation



- Presence of $(Cr,Mn)_3O_4$ (prismatic cristals) and Cr_2O_3 (platelets).
- Presence of $(Cr,Fe)_2O_3$ in the edges on the P60 sample.
- The oxide layer is thicker for the mirror polished sample.



- The oxidation cycle (probably during cooling) induce compressive thermal stress: buckling for the unpolished sample and spalling for the P60 and mirror polished samples.

- Oxidation mechanism starts with the formation of TiO_2.
- Excess oxigen react with the substrate under the Ti film:
  - Ti-Cr-Fe Mixed oxide
  - Cr_2O_3

Conclusions

- Three surface preparations were performed on K41X substrates: unpolished, P60, mirror polished.
- 1.2 µm of pure titanium was deposited on the samples. Local heterogeneities break the film continuity.
- Oxidation of the K41X without Ti film shows the presence of $(Cr,Mn)_3O_4$ and Cr_2O_3. The oxide layer is thicker for the mirror polished sample.
- The coated sample are stressed after oxidation: buckling (unpolished sample) and spalling (P60 and mirror polished samples).
- Ti film is fully oxidized and a Cr_2O_3 layer is found below.

→ Need of more investigations on the effect of the surface preparation

Acknowledgements

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