Duplex treatment - plasma nitriding plus TiAlN coating - to protect martensitic stainless steel from severe wear and corrosion

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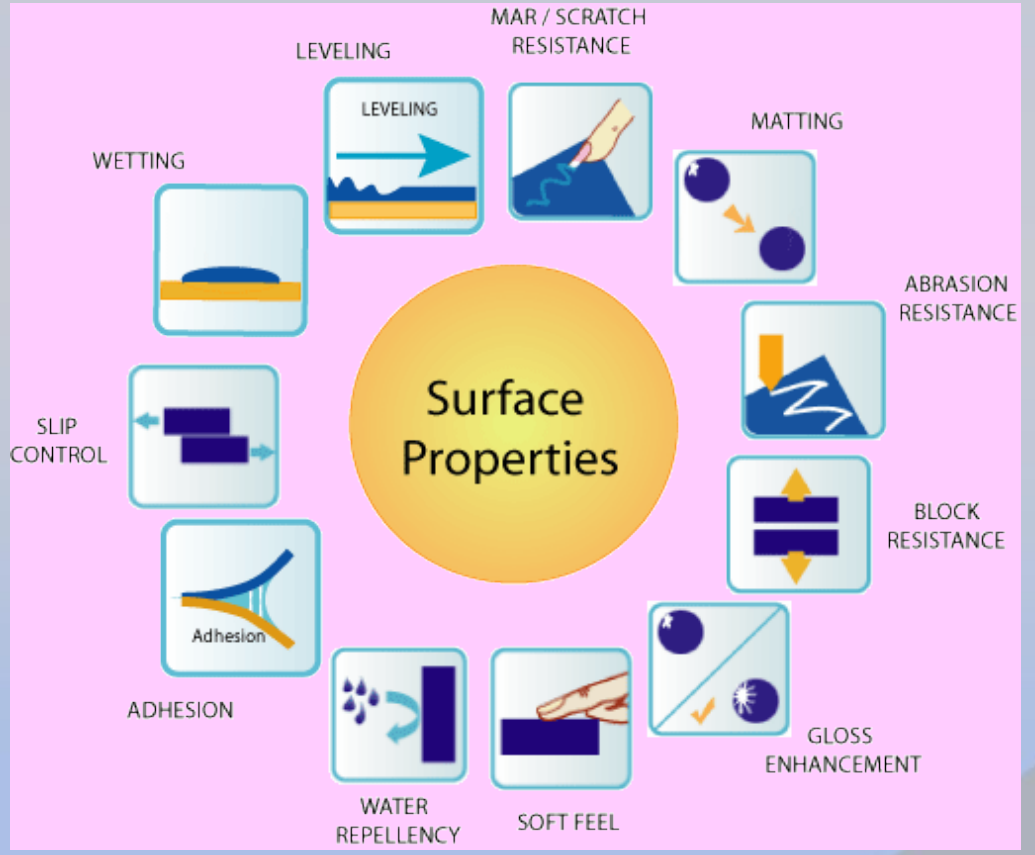
Background

Surface Engineering

Design of the material´s surface structure, chemistry and properties in order to improve performance or to achieve a new functionality

- Finishing
- Surface modification
- Coating

APPLICATIONS: Mechanics, aerospace, medicine, plastics, energy, decoration, construction, optics, electronic devices…



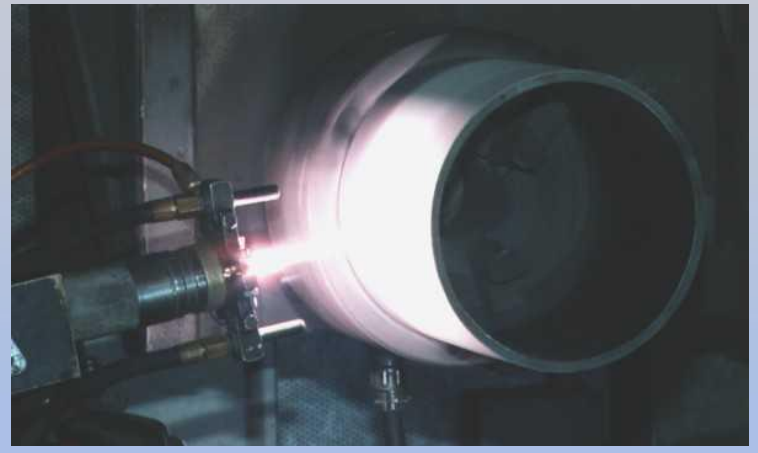
Background

Plasma Surface Engineering

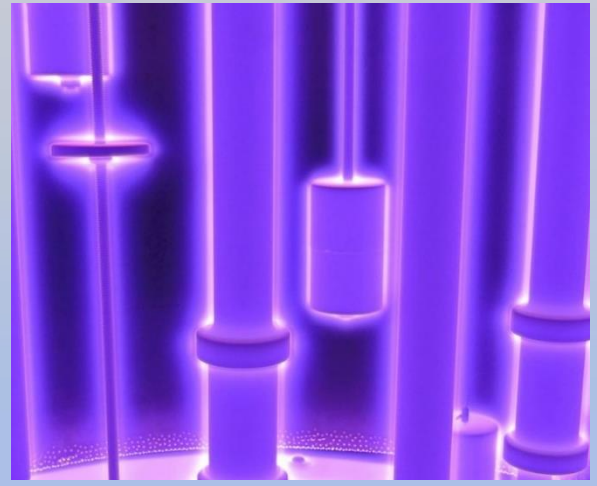
Plasma assisted processes to improve wear and corrosion resistance in steels

PVD and PACVD processes
Thin films

Plasma spray
Thick films



Plasma diffusion processes
Ion Nitriding and Carburizing
Plasma Oxidizing



Motivation

Martensitic stainless steels

Wear

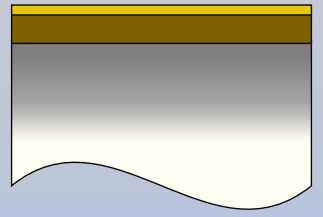
In adhesive or abrasive situations

Corrosion

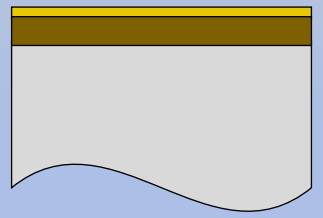
In different environments

Coating over AISI 420 stainless steel

→ Nitrided



→ Not nitrided



Hyperlox® Coatings

Cutting and milling tools

Coating behavior in harsh wear and corrosion environments……..

Main Goals

1. To analyze the sliding wear and abrasive wear behaviour of nitrided and non nitrided AISI 420 Stainless Steel coated with Hyperlox Gold (Cemecon®).
2. To asses coating adhesion to the nitrided steel compared to the non nitrided material.
3. To evaluate corrosion behaviour of the coating compared to the nitrided steel in saline environments.

Experimental

1. **Samples:** AISI 420 Stainless Steel discs

Fe (%)	C (%)	Si (%)	Mn (%)	P (%)	S (%)	Cr (%)
86	0,346	0,400	0,331	0,0306	<0,0030	12,4

Heat Treatment: Air quenching form 1050 °C, tempering at 260 °C, 2 x 2 h

2. **Nitriding:** IONAR SA (Arg), DC pulsed plasma nitriding
   20% N2 – H2, 390 °C, 10 h

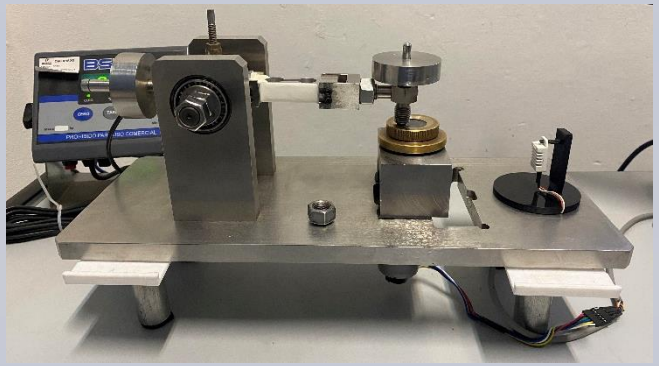
3. **Coating:** PVD PEMS, at Coating.Tech by Tantal-Flubetech (Arg)

4. **Characterization**

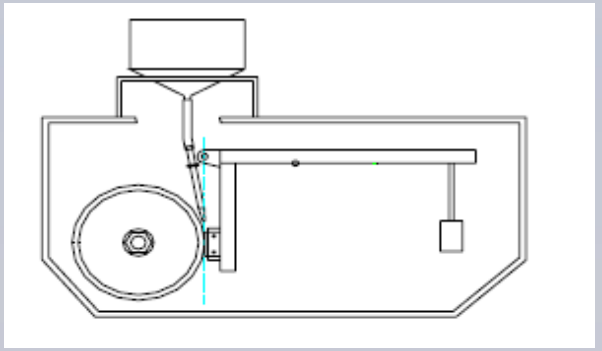
Optical Microscopy, Vickers Hardness, SEM, XRD, Nanoindentation

Experimental

Wear



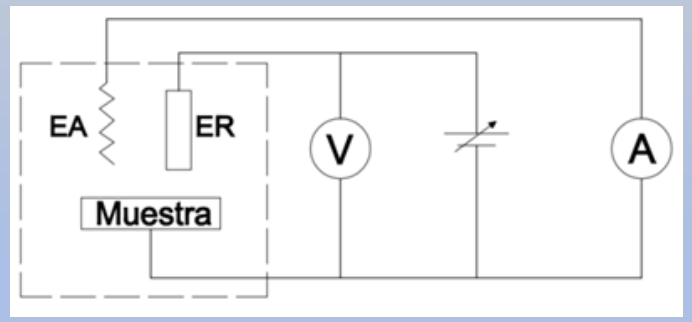
Adhesive
Pin-on-Disk
ASTM G99



Abrasive
ASTM G65
Dry sand/
Rubber Wheel

Corrosion

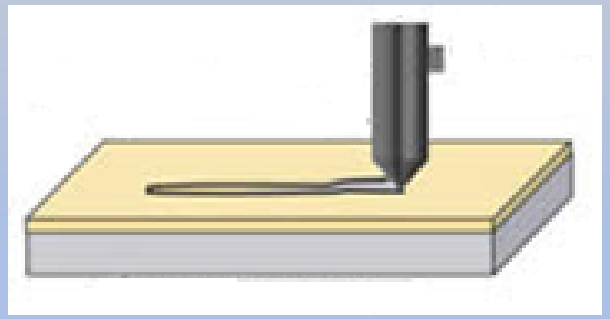
Potentiodynamic polarization



In NaCl 3,5%

Adhesion

ASTM C1624



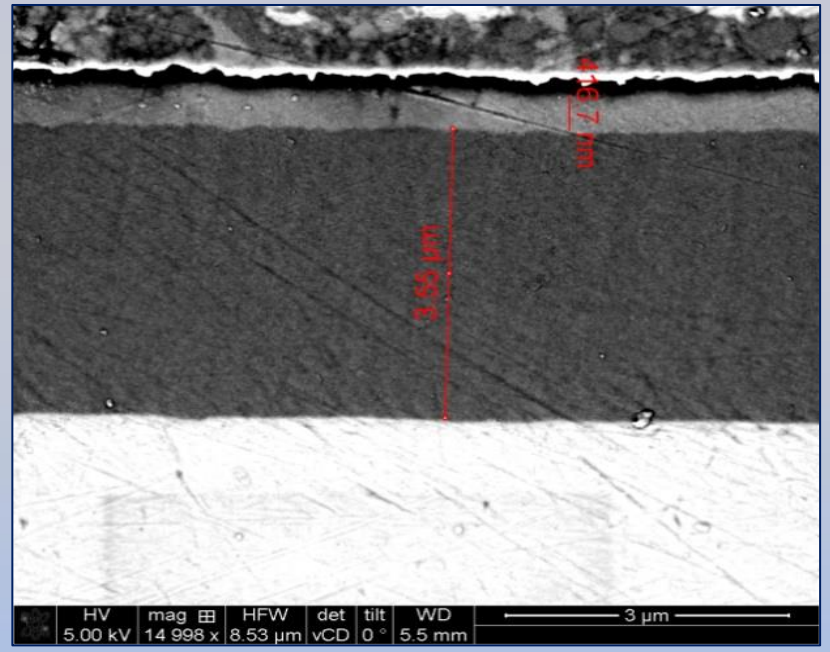
Scratch Test, constant load

Adhesion
VDI 3198

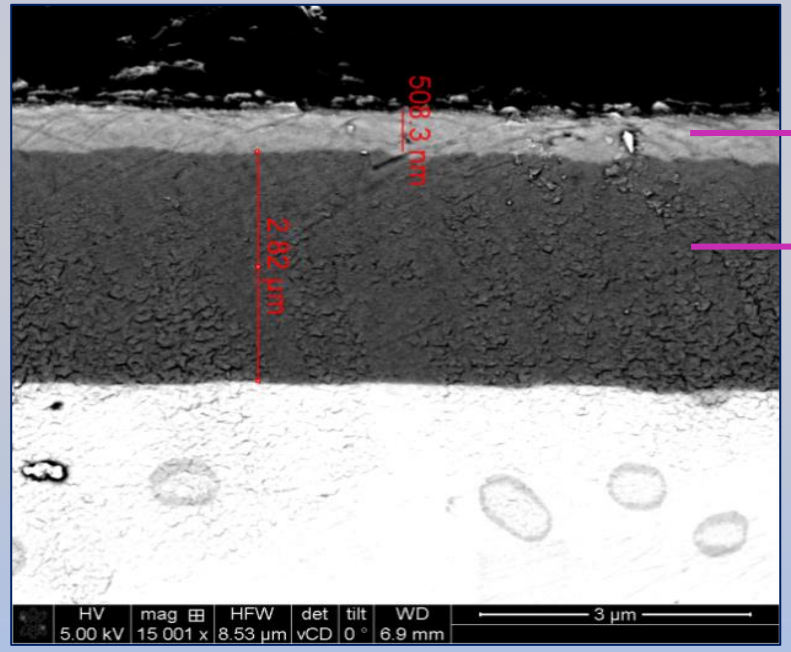
Rockwell C
Indentation

Results

Microstructure



Previously nitrided



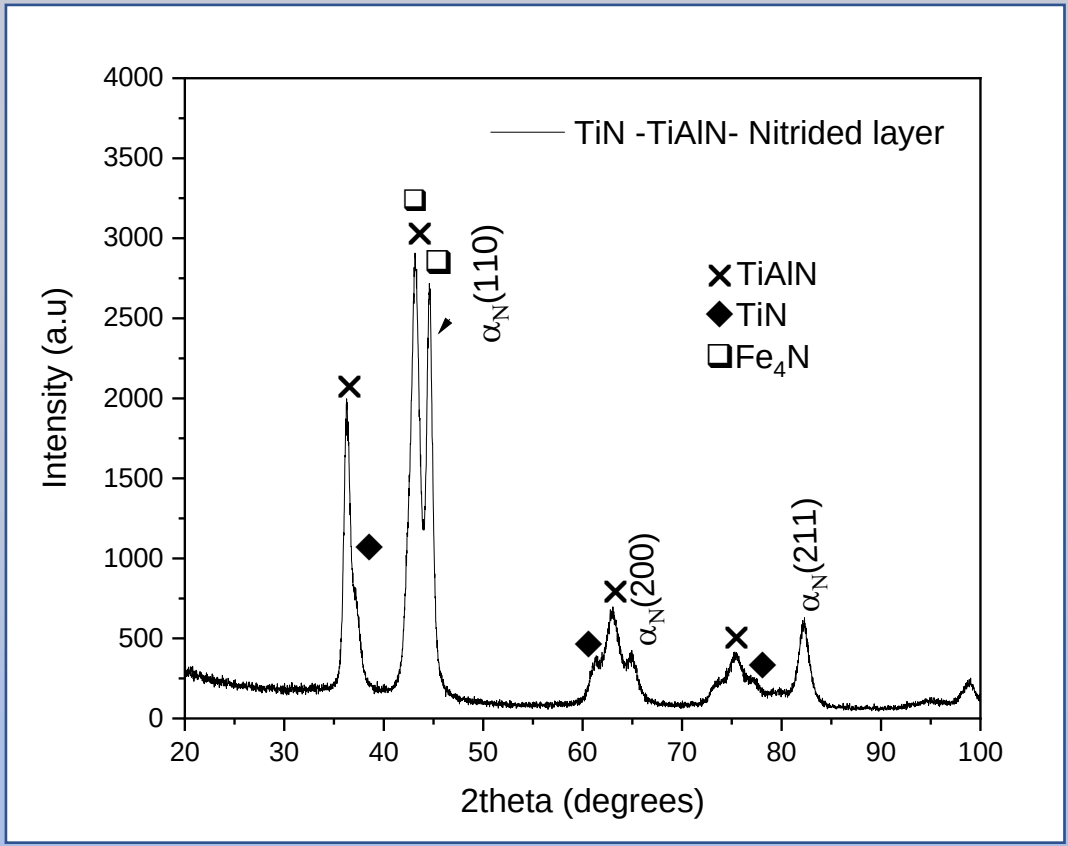
Non nitrided

- TiN Top Coating ≈ 0,5 µm
- Hyperlox Coating ≈ 2,8 to 3,5 µm

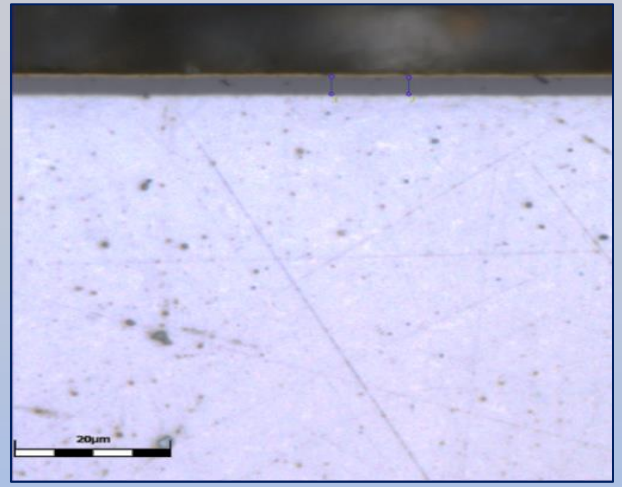
Coating SEM images on different samples

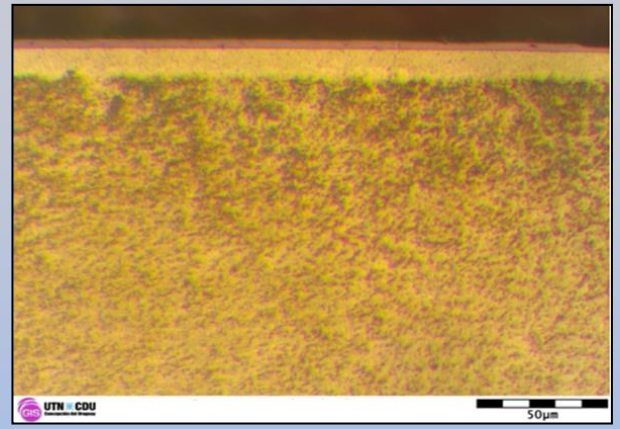
Results

Microstructure



XRD in Bragg Brentano Configuration





Optical micrographs

Results

Hardness and mechanical properties

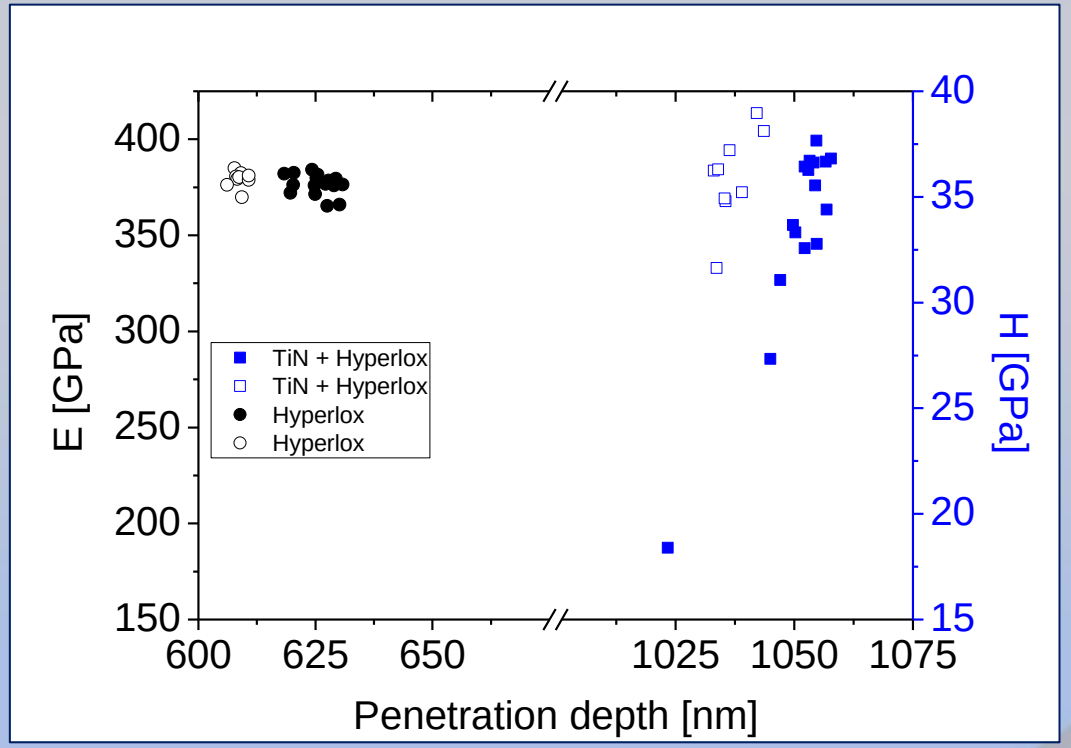
Vickers microindenter

Nitrided layer hardness (on top): (1180 ± 40) $HV_{0,05}$

AISI 420 stainless Steel (Q&T): (500 ± 20) $HV_{0,05}$.

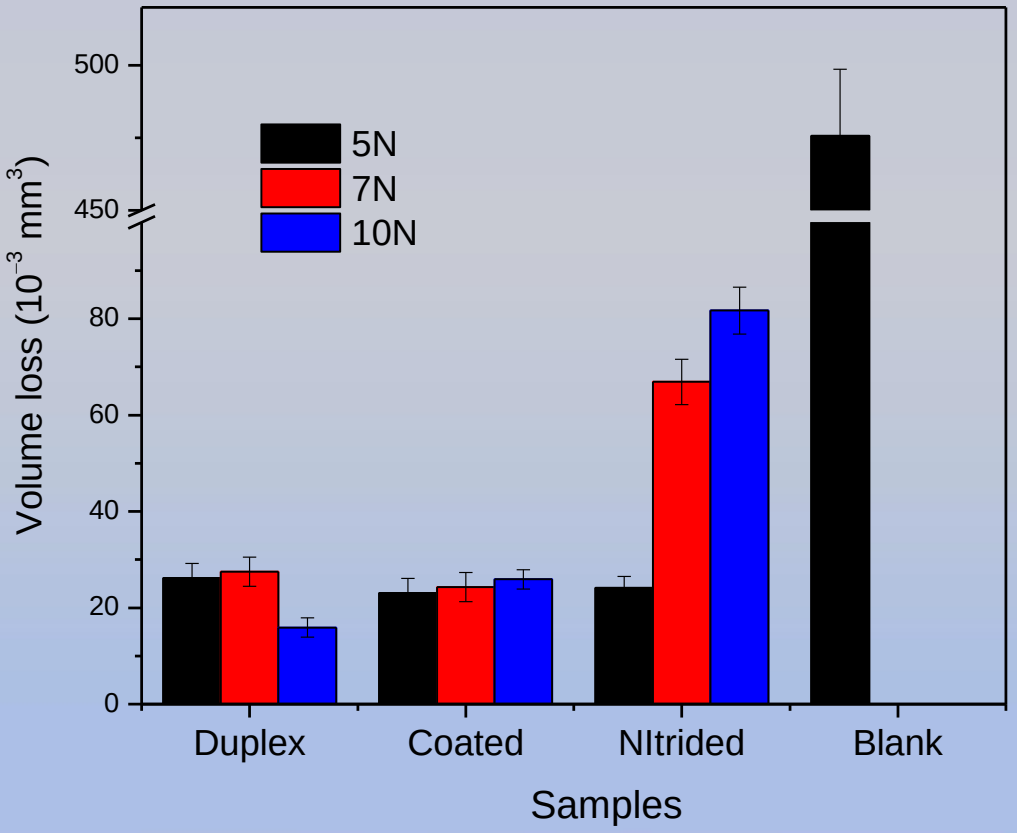
Nitrided layer	
Nanohardness (GPa)	17 ± 1
Young Modulus (GPa)	182 ± 5
Penetration Depth (nm)	124 ± 3

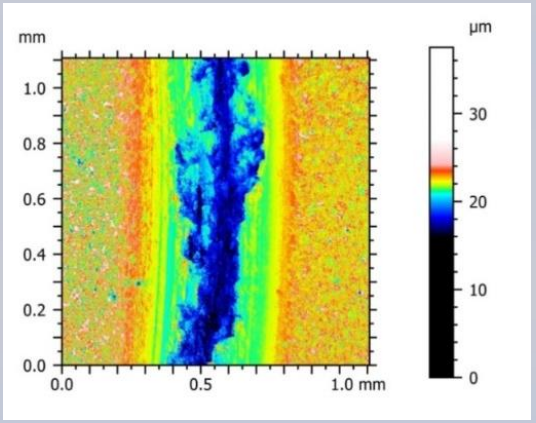
Nanoindentation



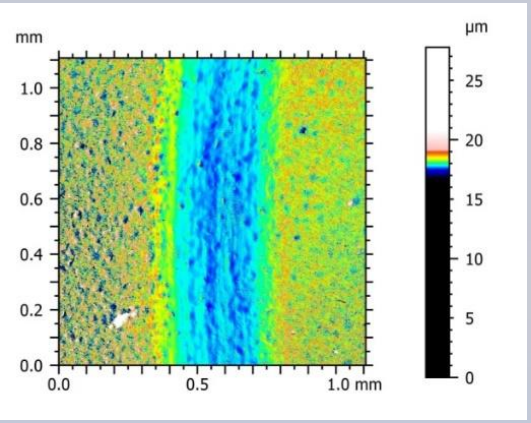
Results

Wear – Pin on Disk

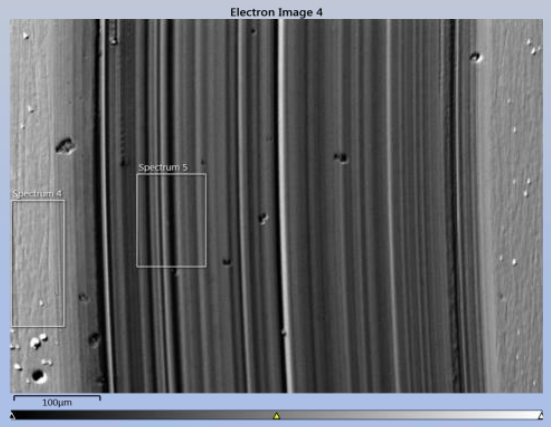


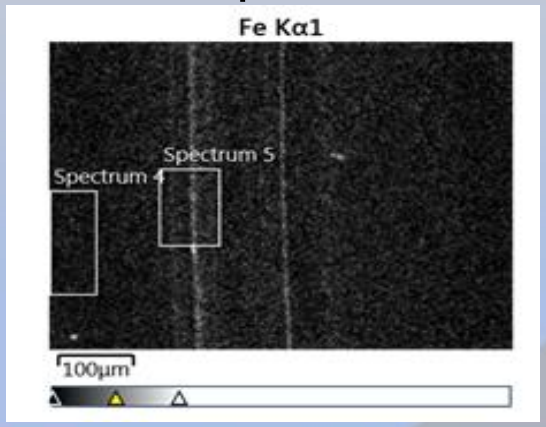


Coated



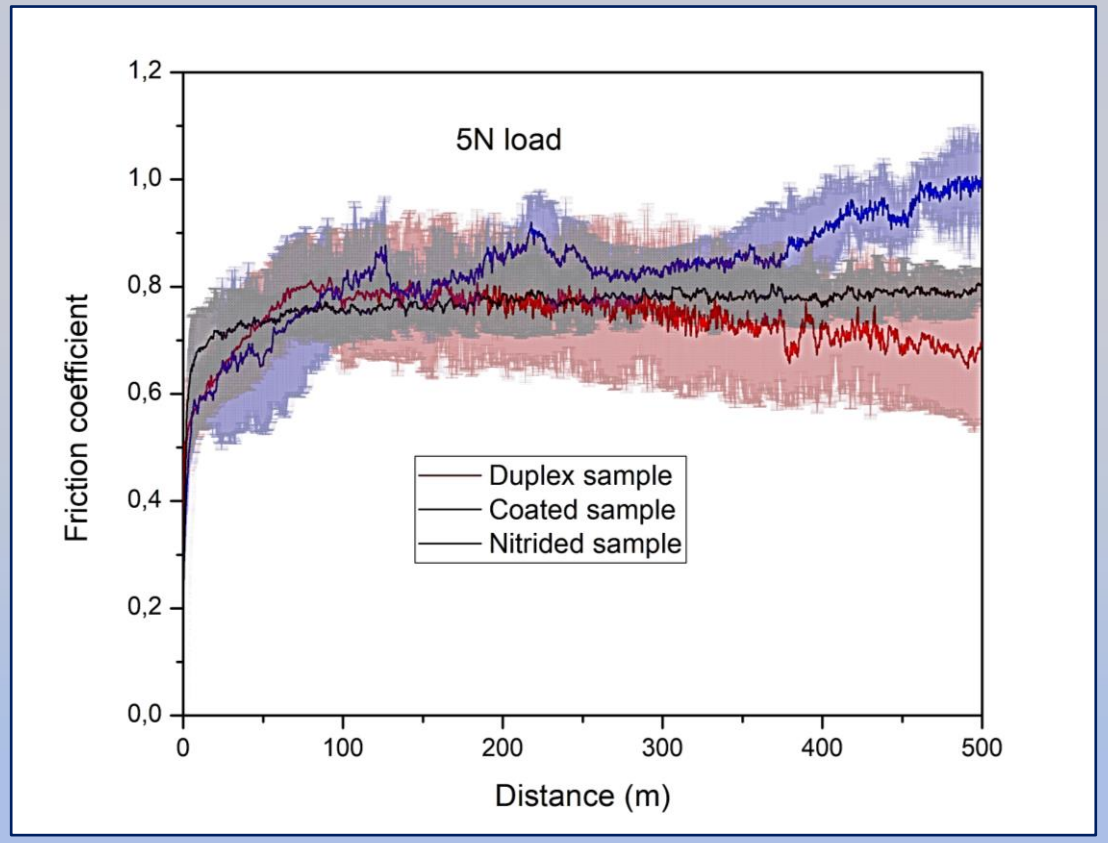
Duplex

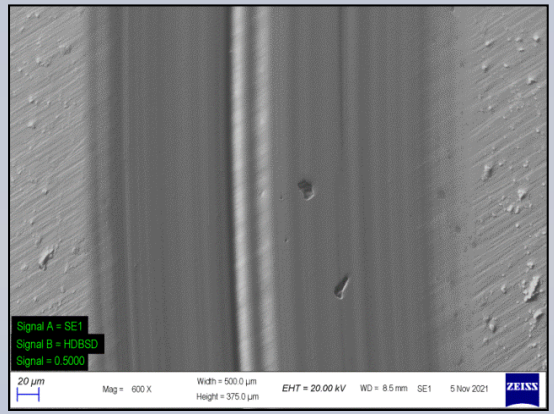




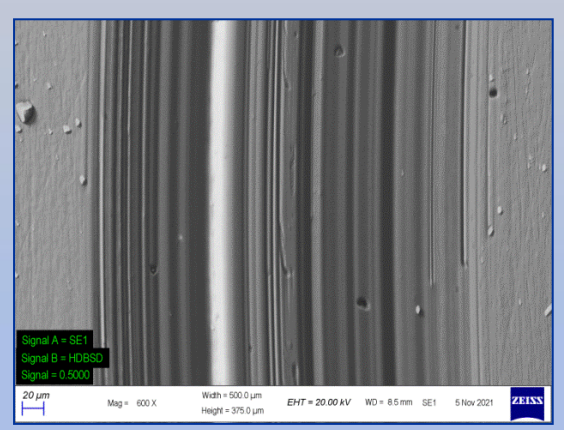
Results

Wear and Friction





Duplex

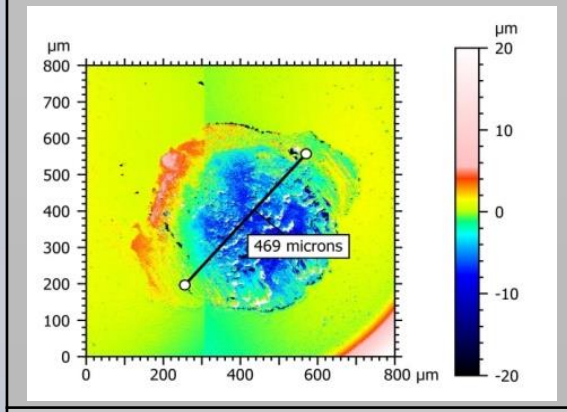
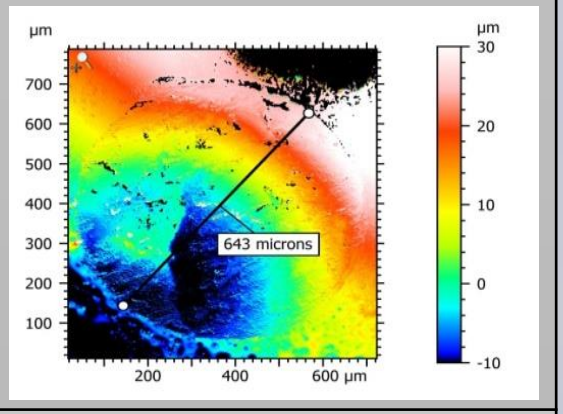
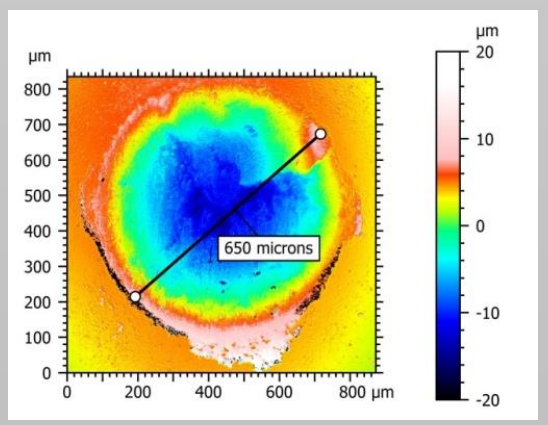
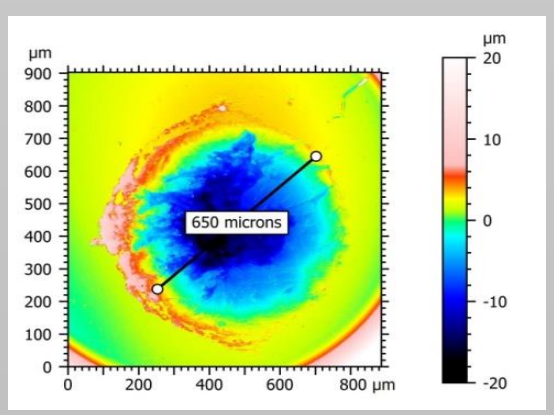


Coated

Results

Counterpart analysis

Confocal Microscope images

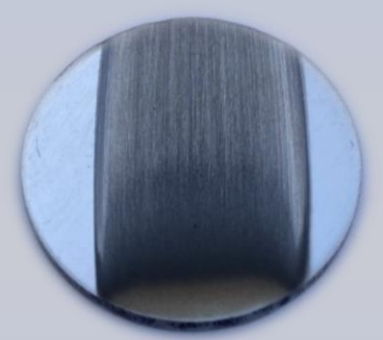
5N	10 N
	
	

Duplex

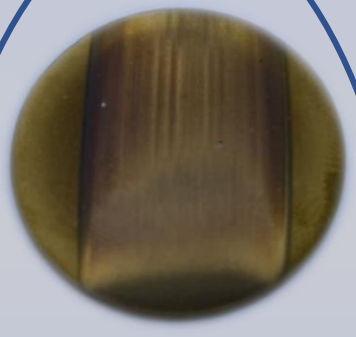
Coated

Results

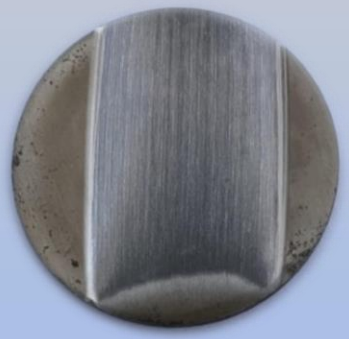
Abrasive Wear G65



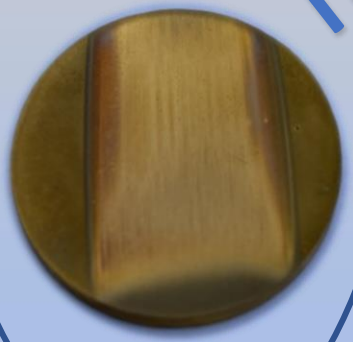
Blank



Coated

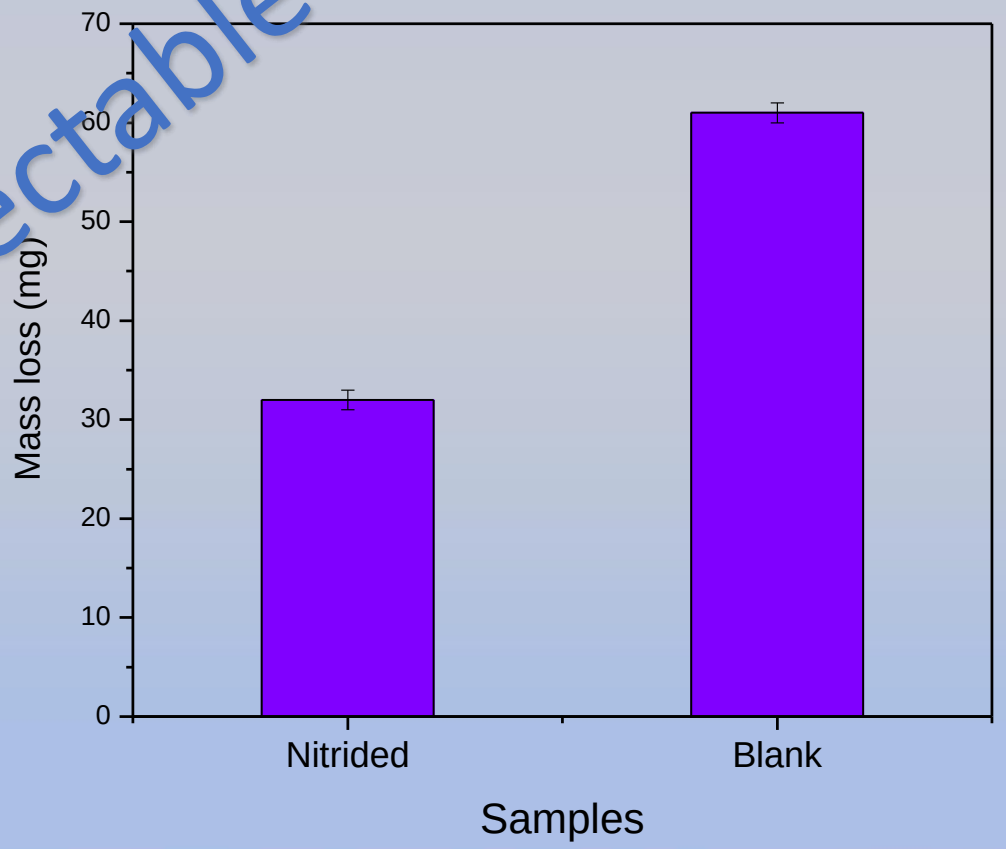


Nitrided



Duplex

Indetectable



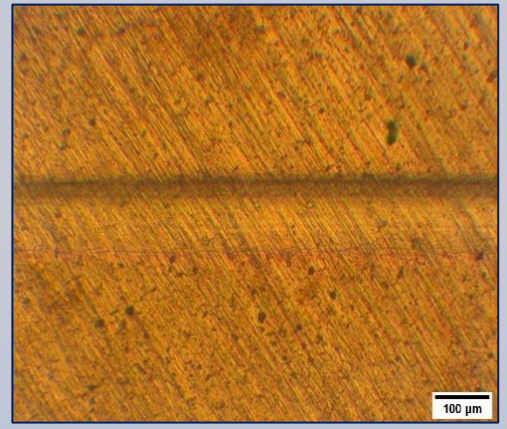
Results

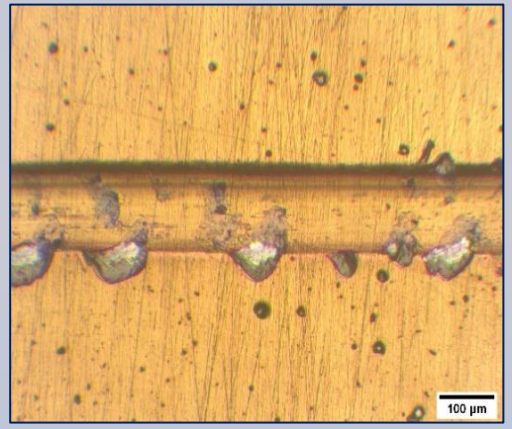
Adhesion

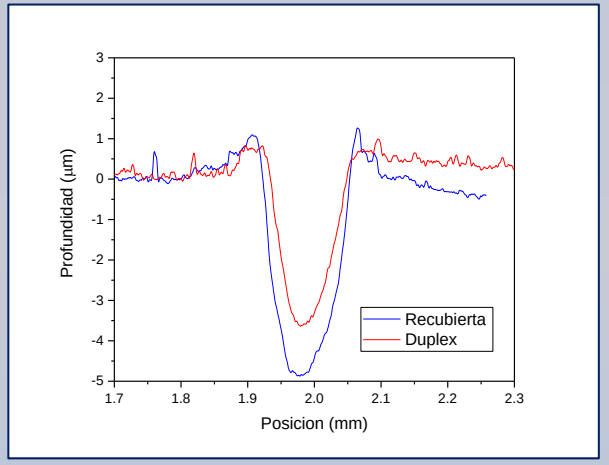
Duplex

Coated

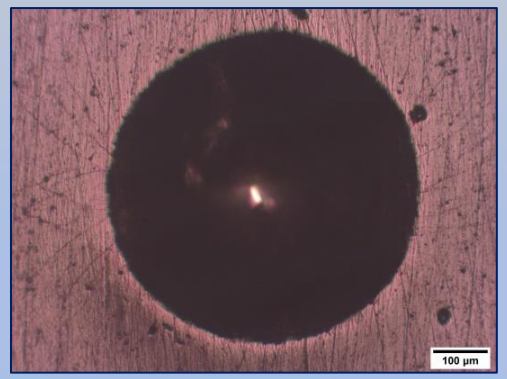
Scratch Test
60 N

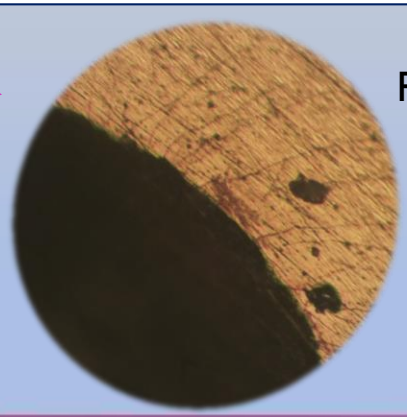






Rockwell C
Indentation
150 kg

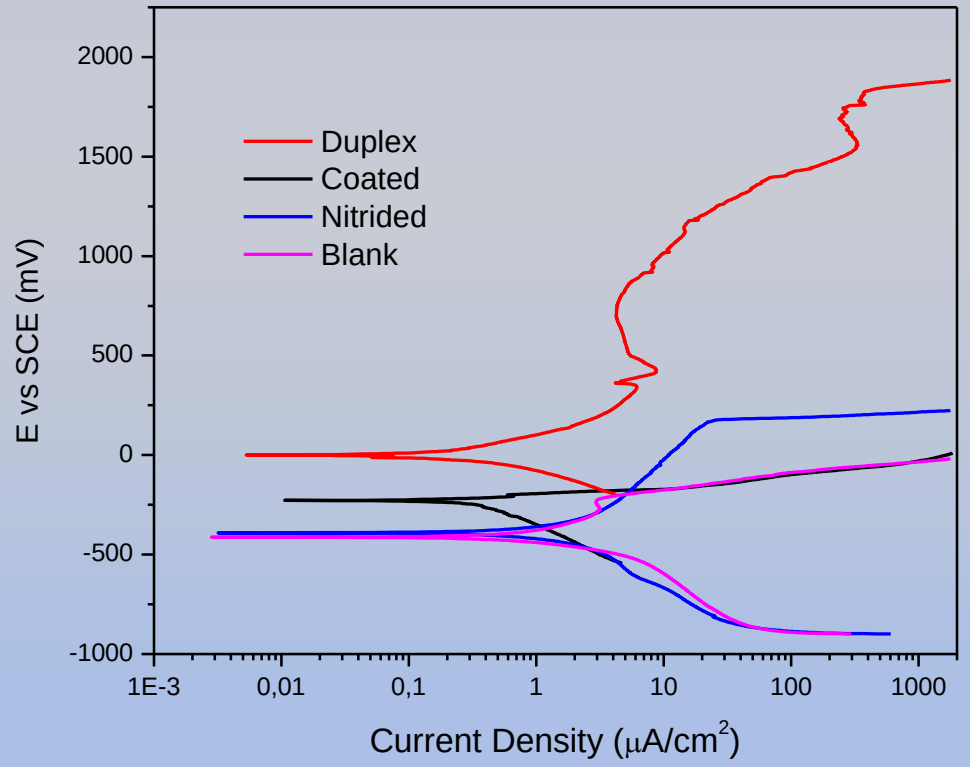




Radial cracks

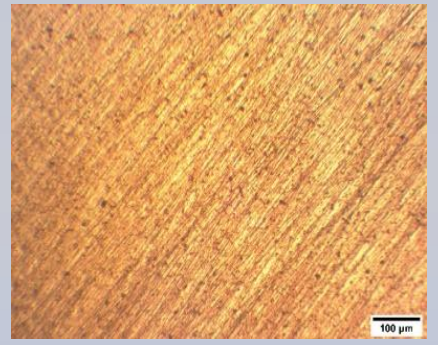
Results

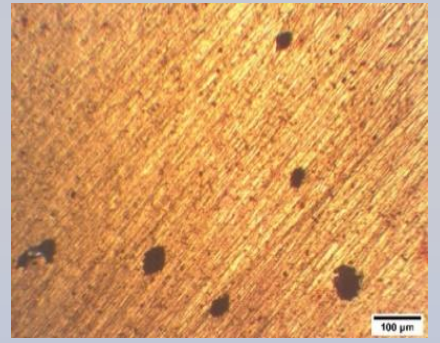
Corrosion



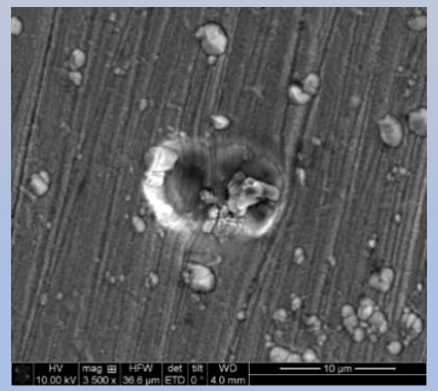
Before

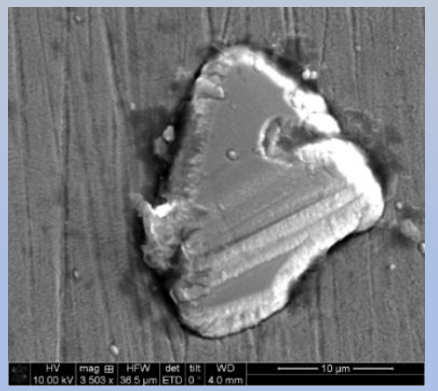
After





Pits
OM images
In the same
area





Defects
and SEM
images

Conclusions

1. The Hyperlox Gold coatings presented a high hardness a high Young Modulus. Over both samples they presented a good resistance to abrasion.
2. The nitrided layer improved the wear resistance in adhesive pin on disk test at high loads.
3. The adhesion was better in the duplex samples (nitriding+coating)
4. The duplex samples resulted to be the best protective system in saline environments, proved in the corrosion tests.

Thank you!

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http://www.frcu.utn.edu.ar/gis

Grupo de Ingeniería de Superficies

¡Muchas Gracias!