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Plasma Surface Engineering

Wear resistance of an Hyperlox Gold® coating over nitrided martensitic AISI 420 stainless steel

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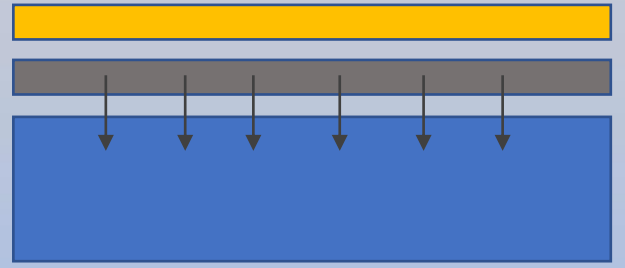
Background

Duplex coatings

Designed to increase adhesion providing a hardness gradient, and to improve performance via good mechanical properties combine with a very hard surface.

- Nitrocarburizing + oxidation
- Nitriding + DLC
- Nitriding + Hard coatings



APPLICATIONS: Severe wear and harsh environments

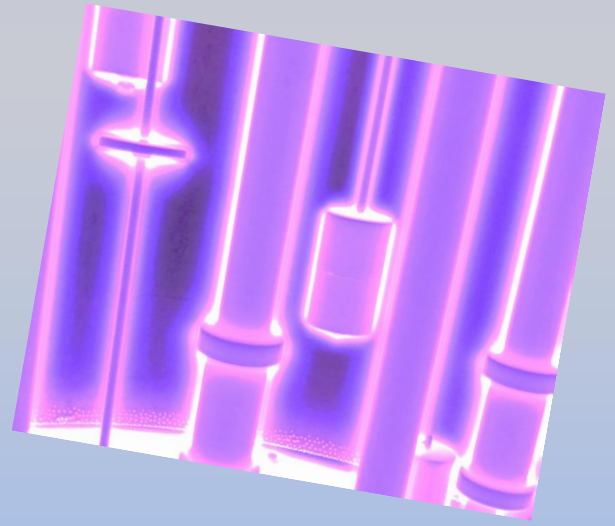
Mechanics, aerospace, plastics, energy, Oil&Gas, construction.

Previous Results

Surface Eng. Group UTN Argentina + AU and BR partners

Plasma nitriding of stainless steels (austenitic, martensitic, PH) obtaining good wear and corrosion properties.

AISI 316L nitrided + TiN
AISI 4140 nitrided + DLC
AISI 420 nitrided + DLC



Motivation

Martensitic stainless steels

Wear

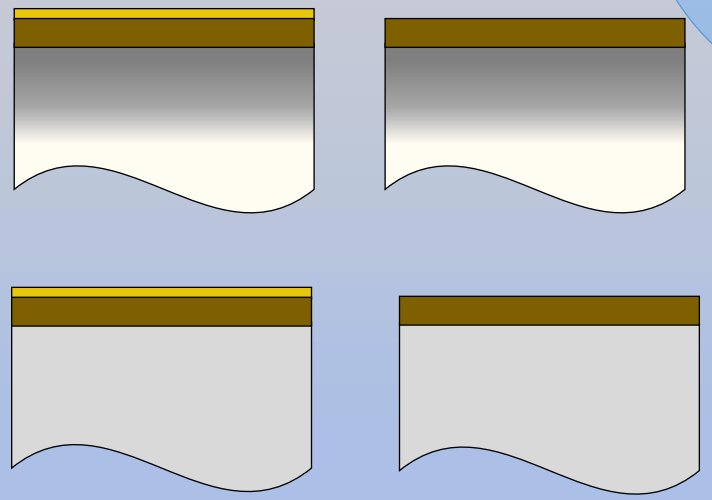
Hard and good mechanical properties

Corrosion

Resistent In different environments

AISI 420 stainless steel

- Nitrided + Coatings
- Not nitrided + Coatings



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 and Hyperlox Gold (Cemecon®).
2. To asses coatings 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% N_2 – H_2, 390 °C, 10 h

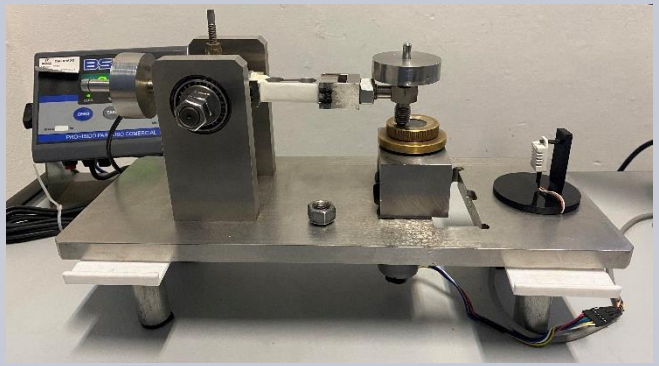
3. **Coating:** PVD PEMS, at Coating.Tech by Tantal-Flubetech (Arg)

4. **Characterization**

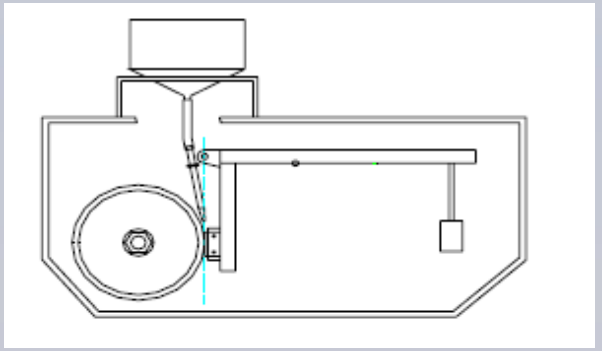
Optical Microscopy, Vickers Hardness, SEM, XRD, Nanoindentation

Experimental

Wear



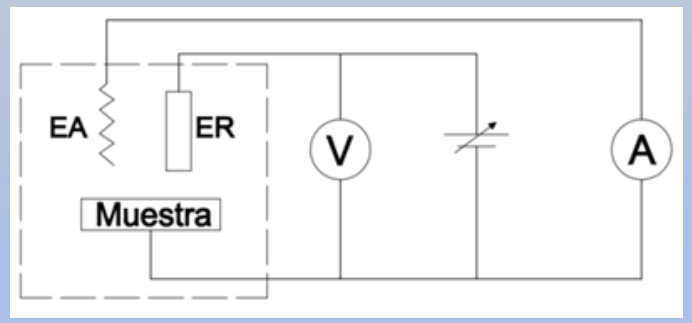
Adhesive
Pin-on-Disk
ASTM G99



Abrasive
ASTM G65
Dry sand/
Rubber Wheel

Corrosion

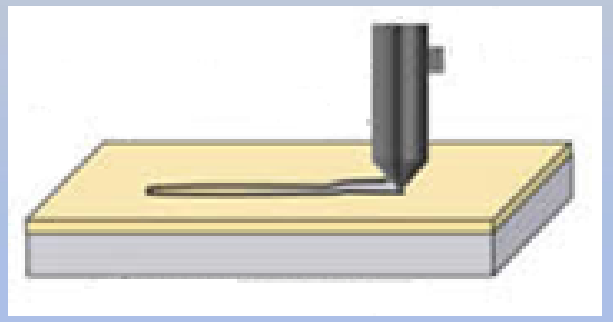
Potentiodynamic polarization



In NaCl 3,5%

Adhesion

ASTM C1624



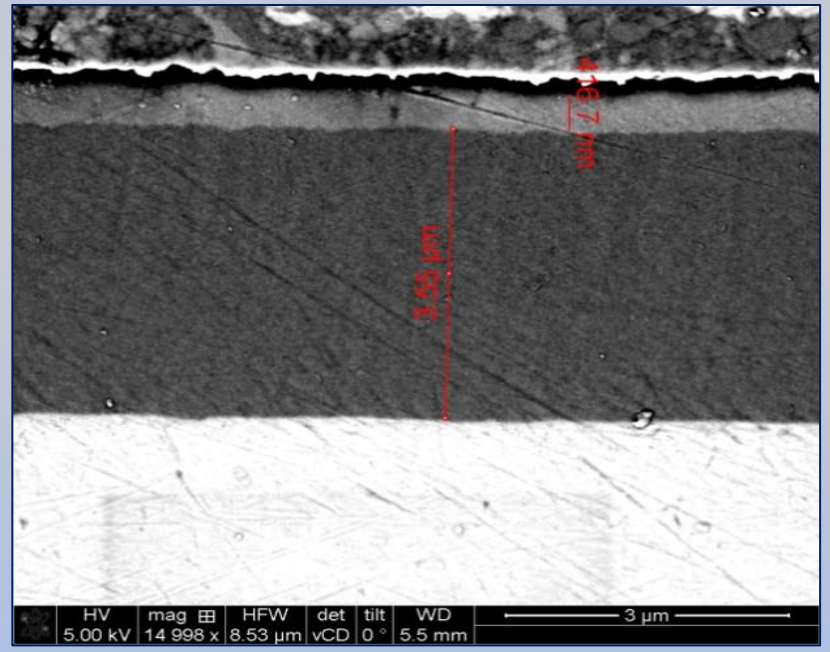
Scratch Test, constant load

Adhesion
VDI 3198

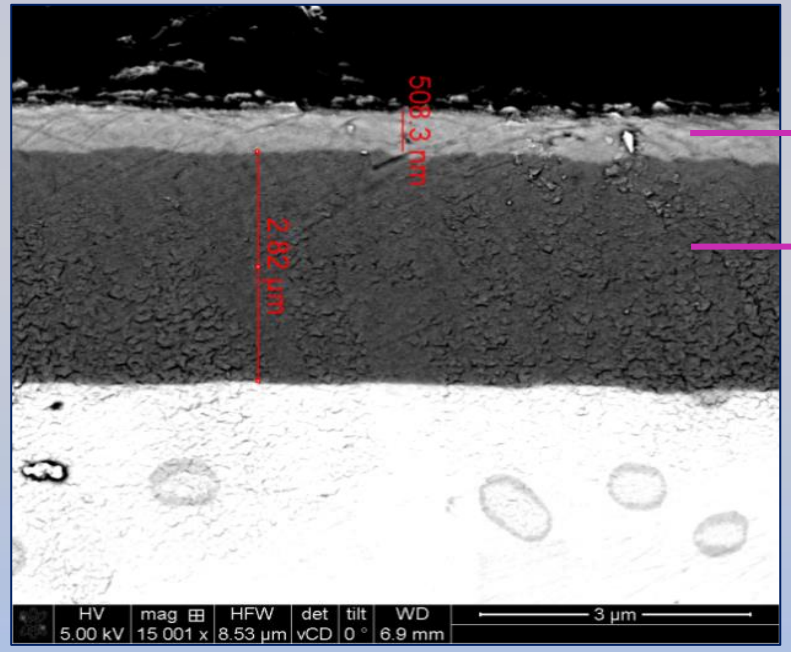
Rockwell C
Indentation

Results

Microstructure



Previously nitrided



Non nitrided

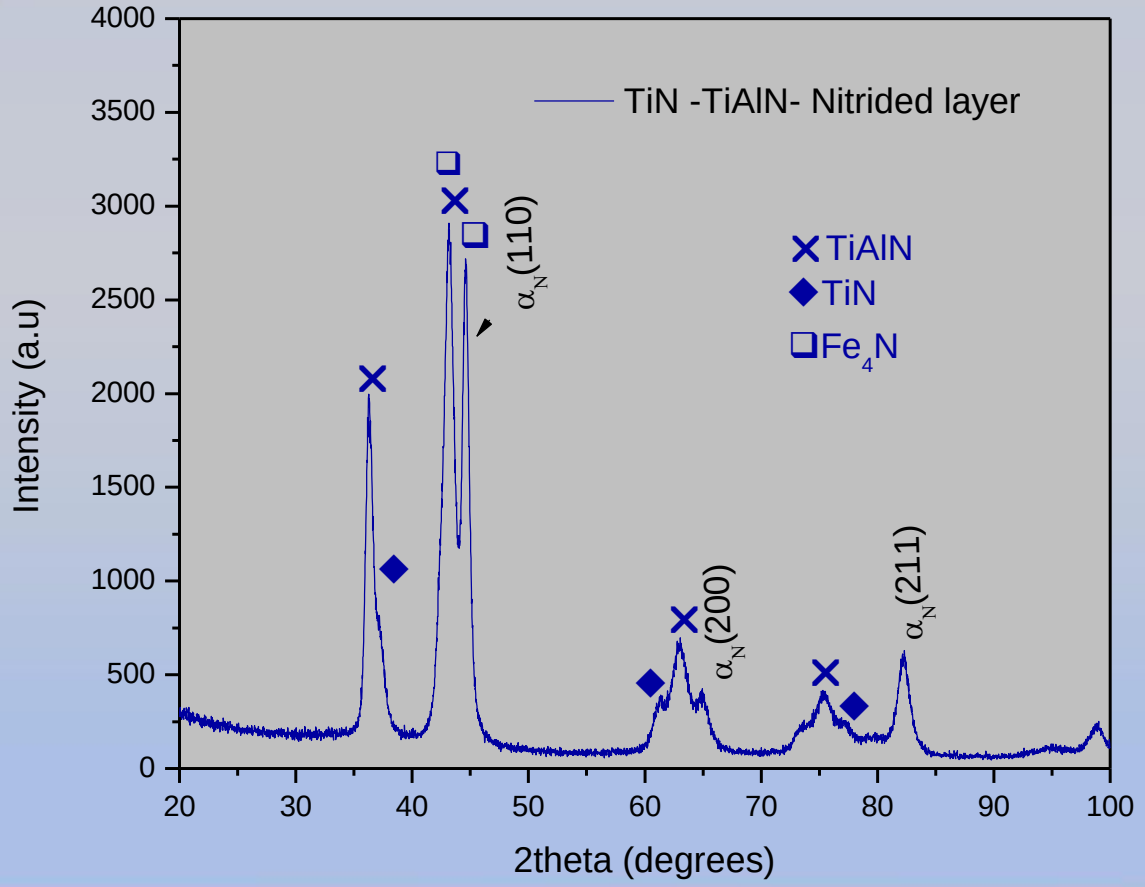
TiN Top Coating ≈ 0,5 µm

Hyperlox Coating ≈ 2,8 to 3,5 µm

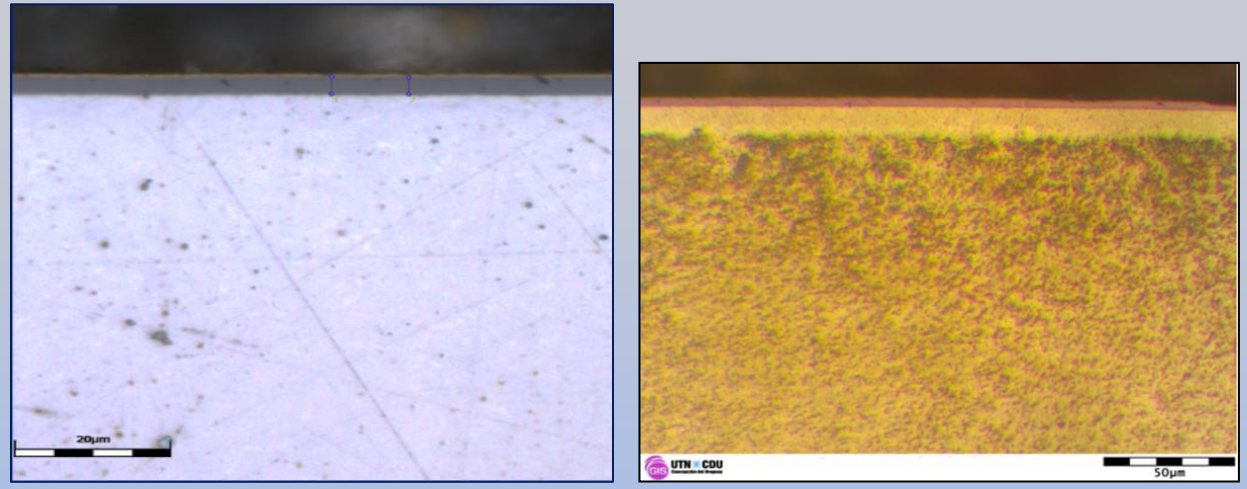
Coating SEM images on different samples

Results

Microstructure



XRD in Bragg Brentano Configuration



Optical micrographs

Results

Hardness and mechanical properties

Vickers microindenter

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

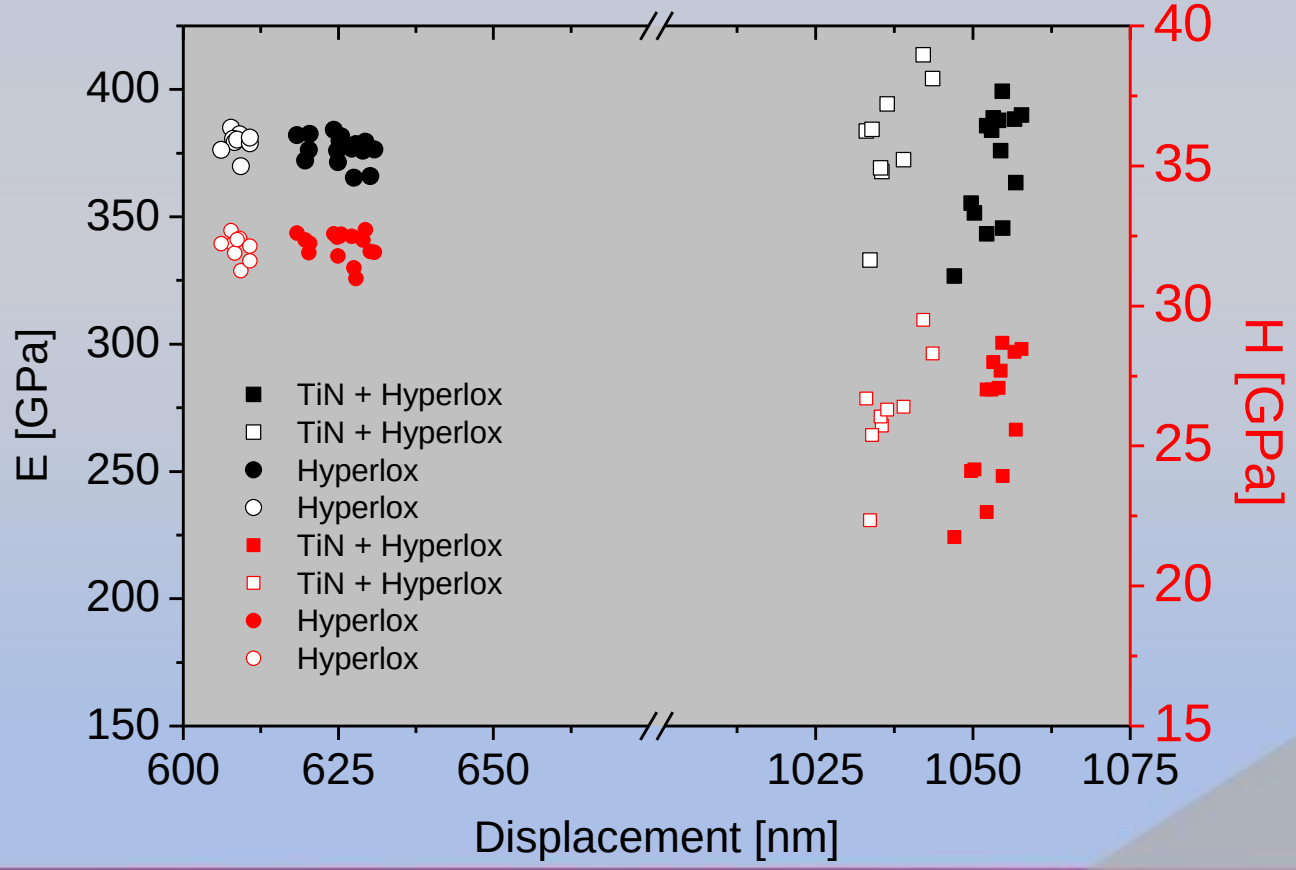
AISI 420 stainless Steel (Q&T): (500 ± 20) $HV_{0,05}$.

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

HyP + TiN: E=(375 ± 20) H= (26,2 ± 0,4) GPa

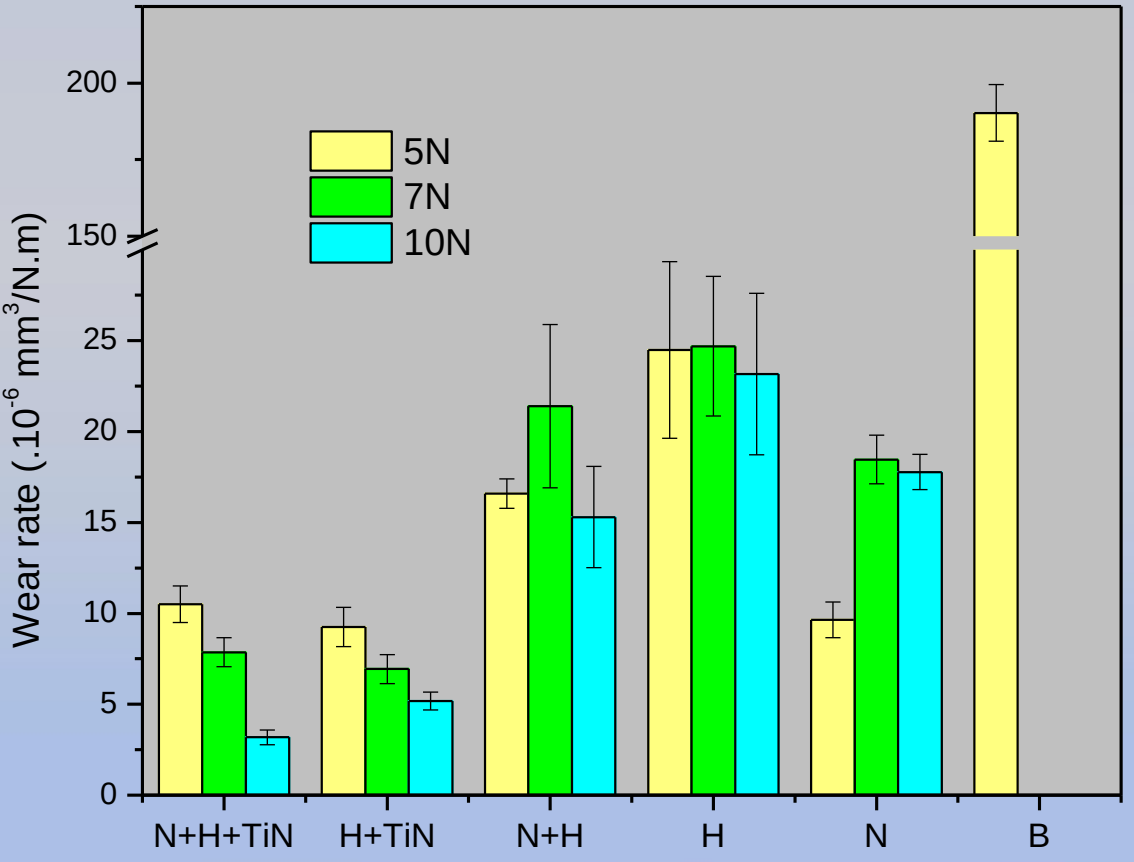
Hyperlox: E= (377 ± 20) H= (32,1 ± 0,5) GPa

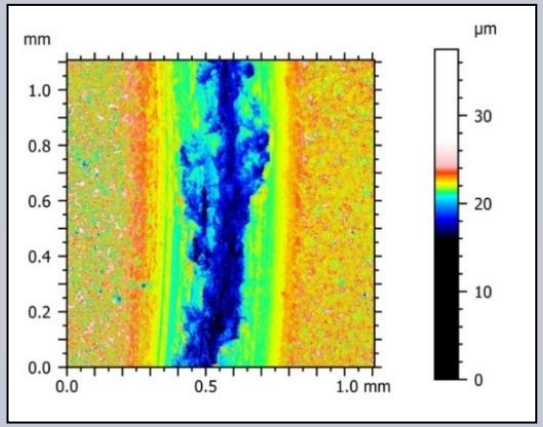
Nanoindentation

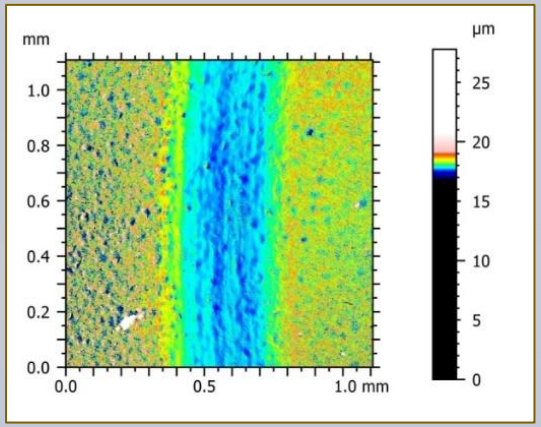


Results

Wear – Pin on Disk

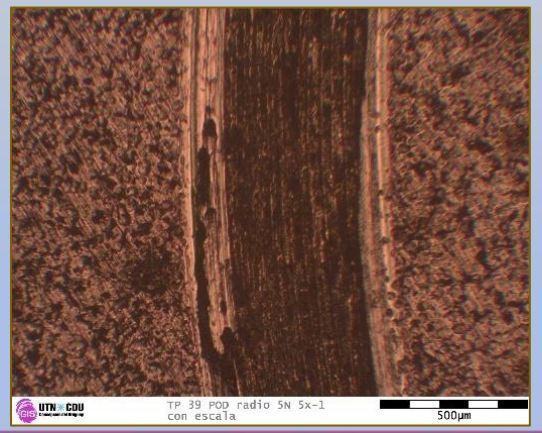


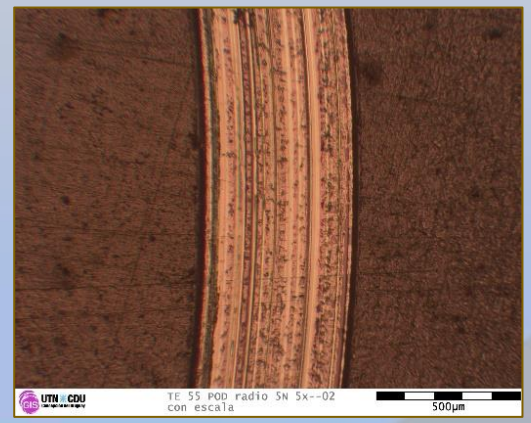




Coated

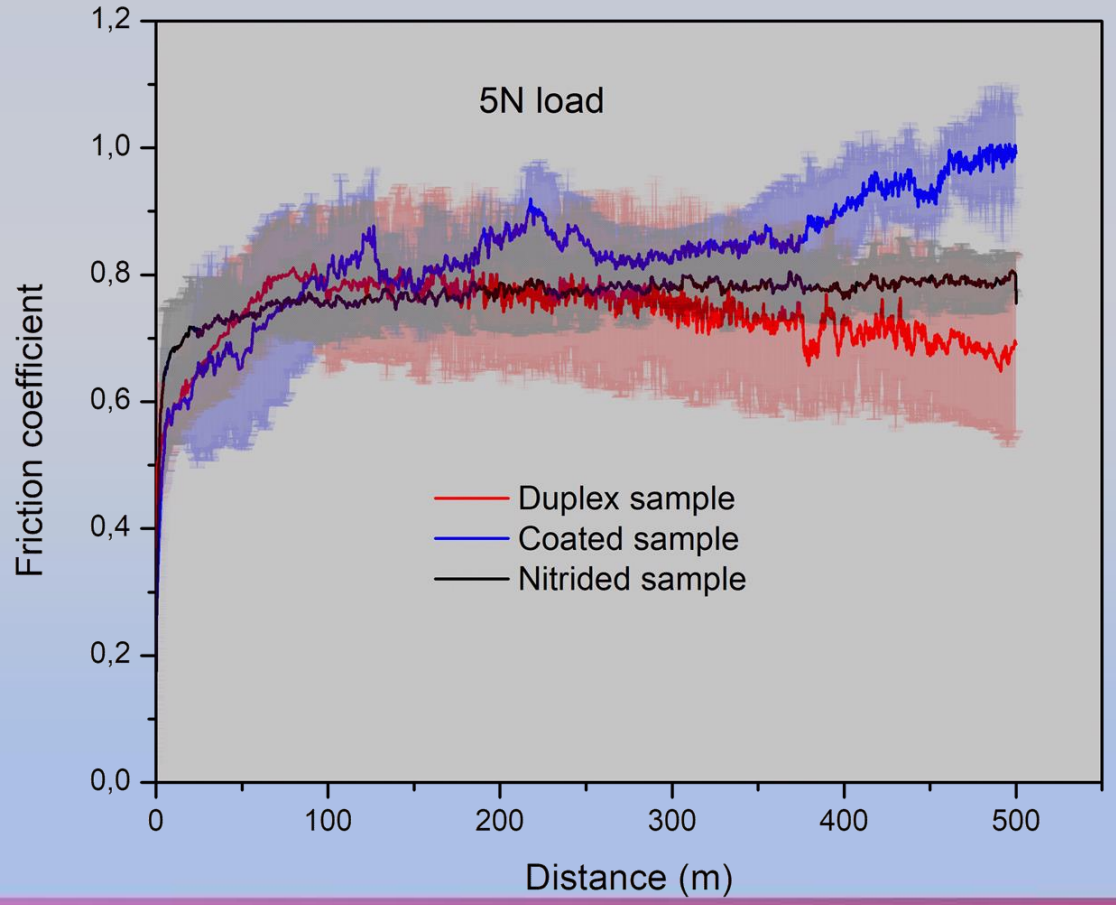
Duplex

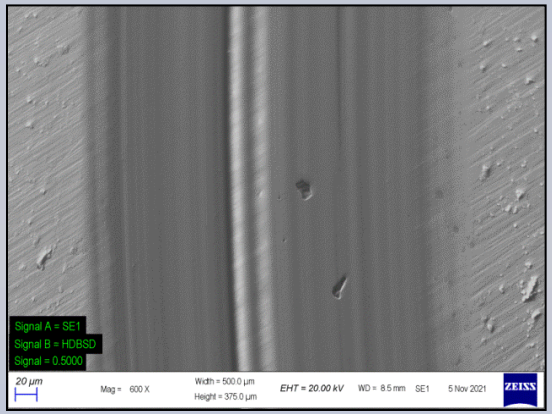




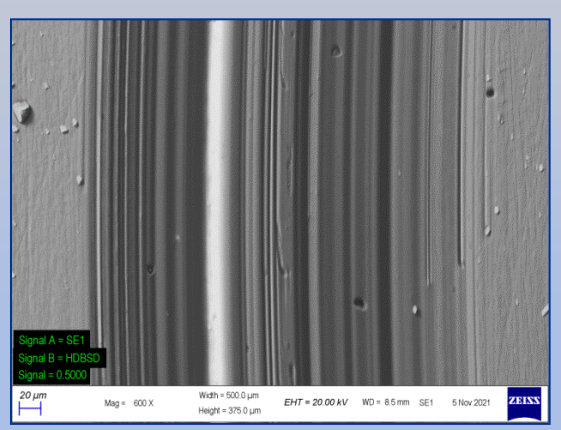
Results

Wear and Friction





Duplex coated

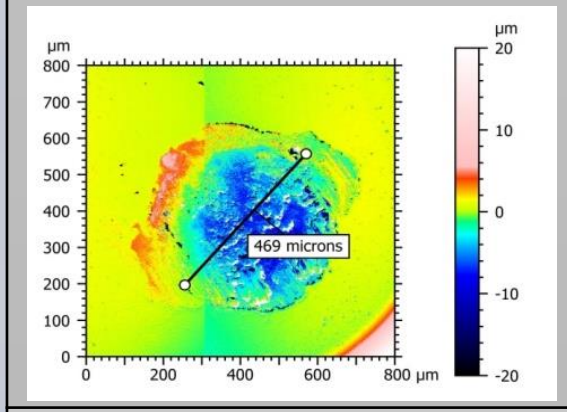
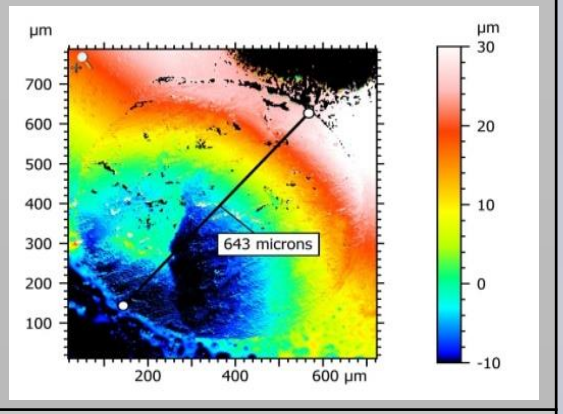
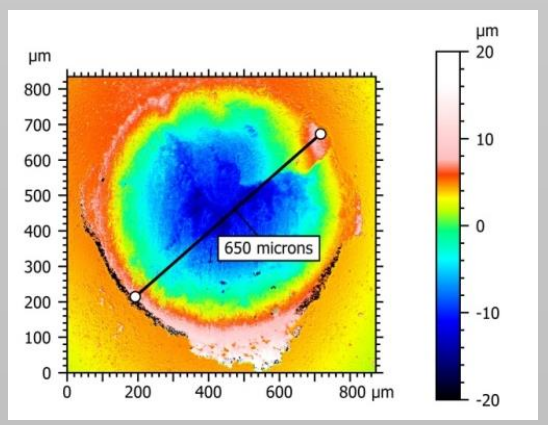
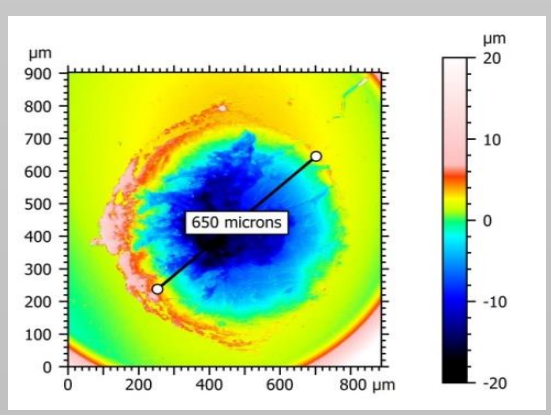


H + TiN Coated

Results

Counterpart analysis

Confocal Microscope images

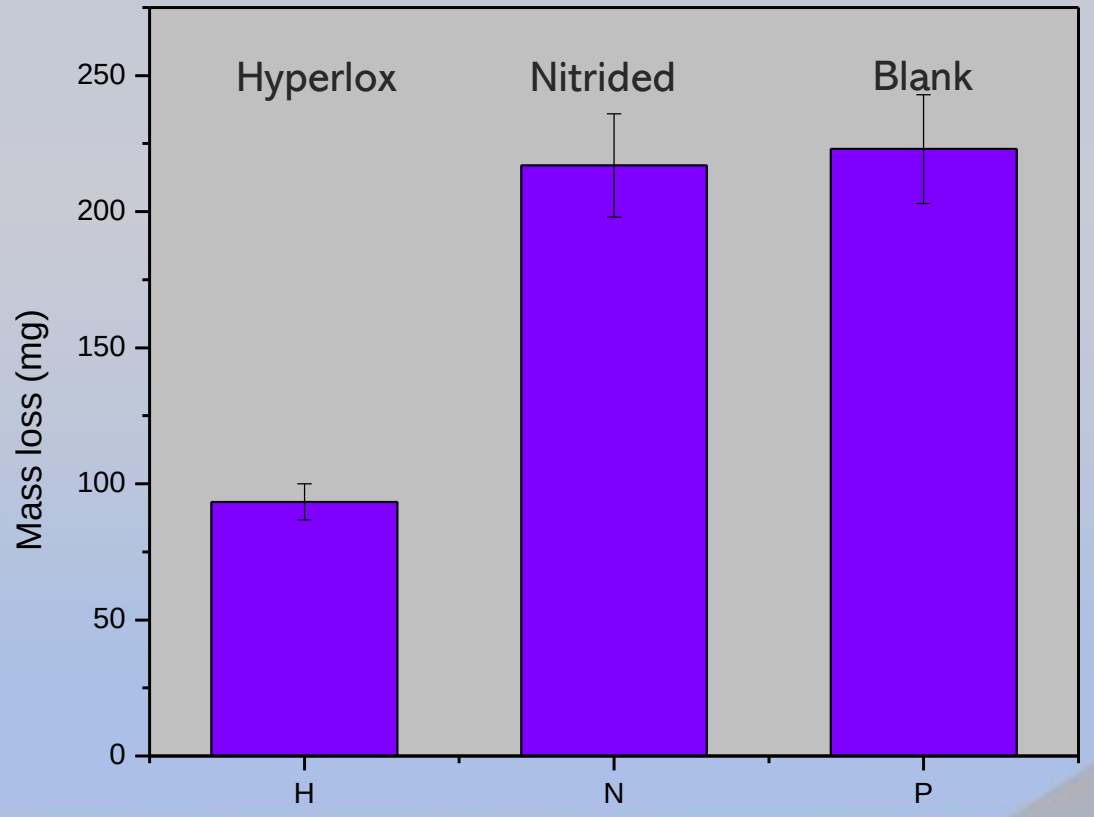
5N	10 N
	
	

Duplex

Coated

Results

Abrasive Wear G65

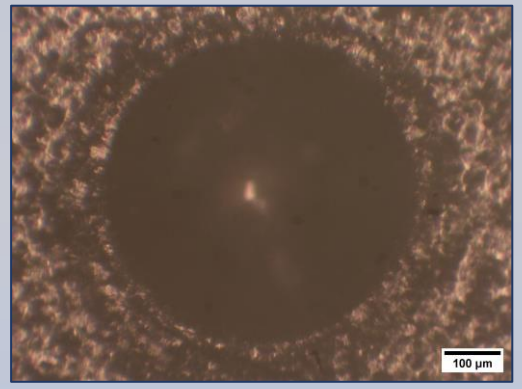


Results

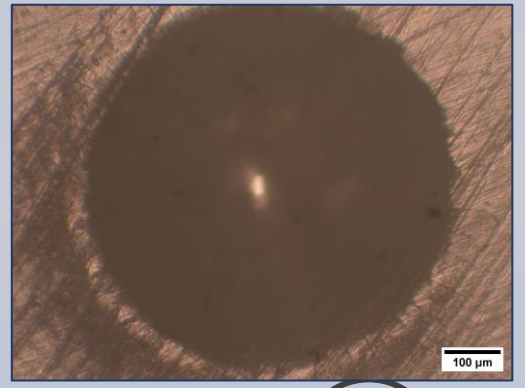
Adhesion

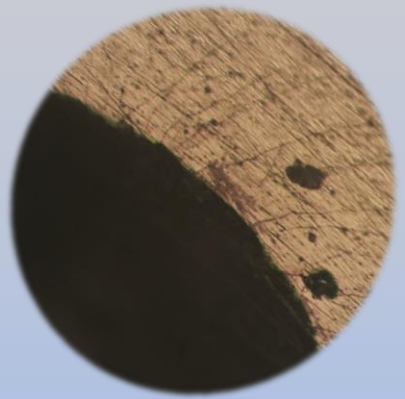
Rockwell C – Indentation - 150 kg

N + H



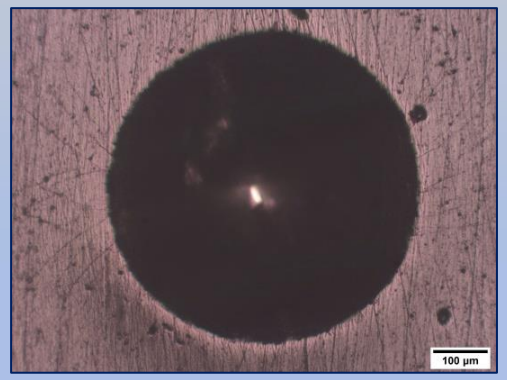
H



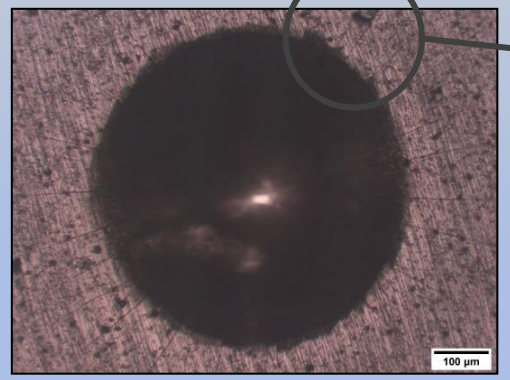


Radial cracks

N + H + TiN

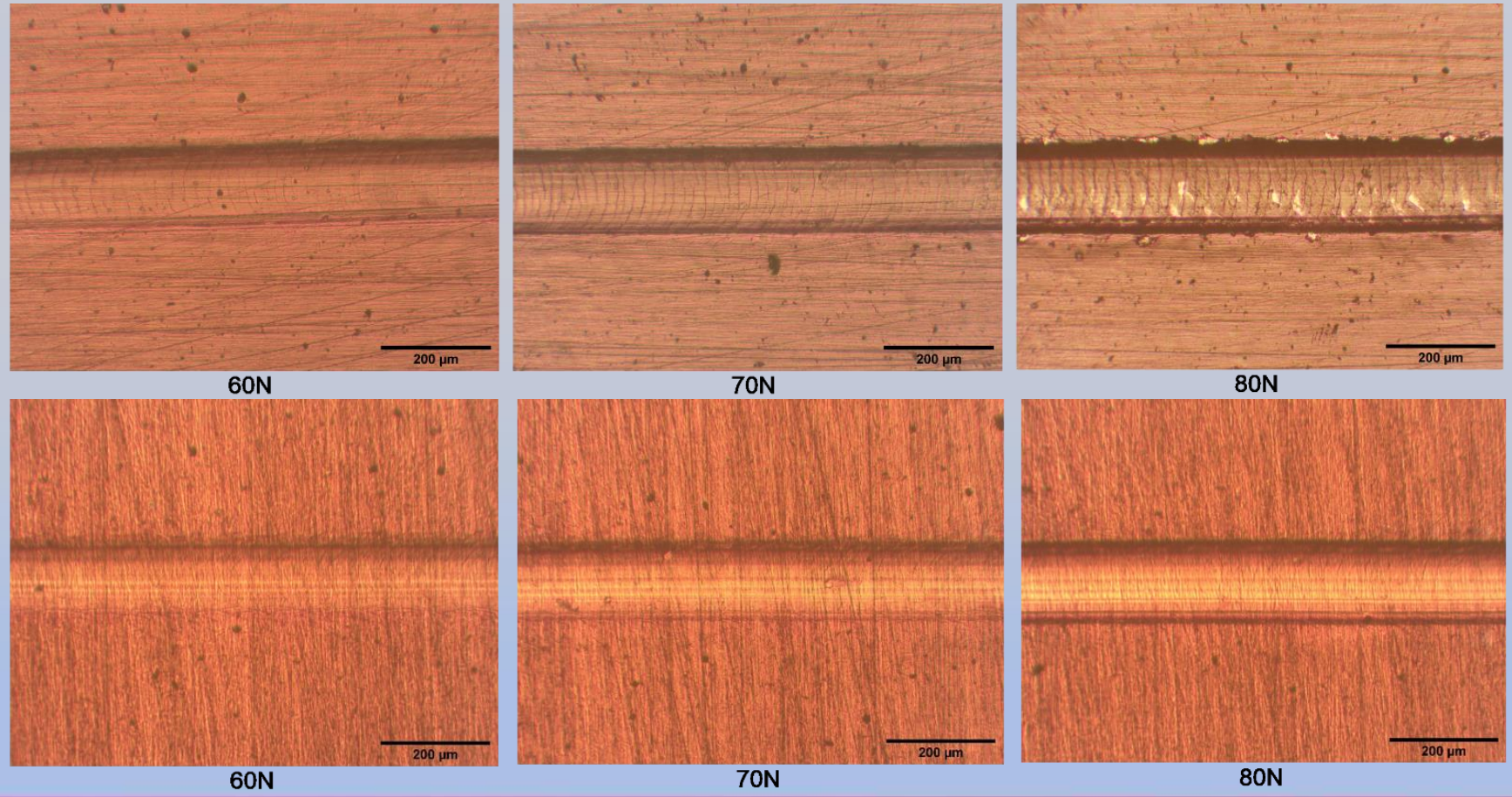


H + TiN



Results

Adhesion

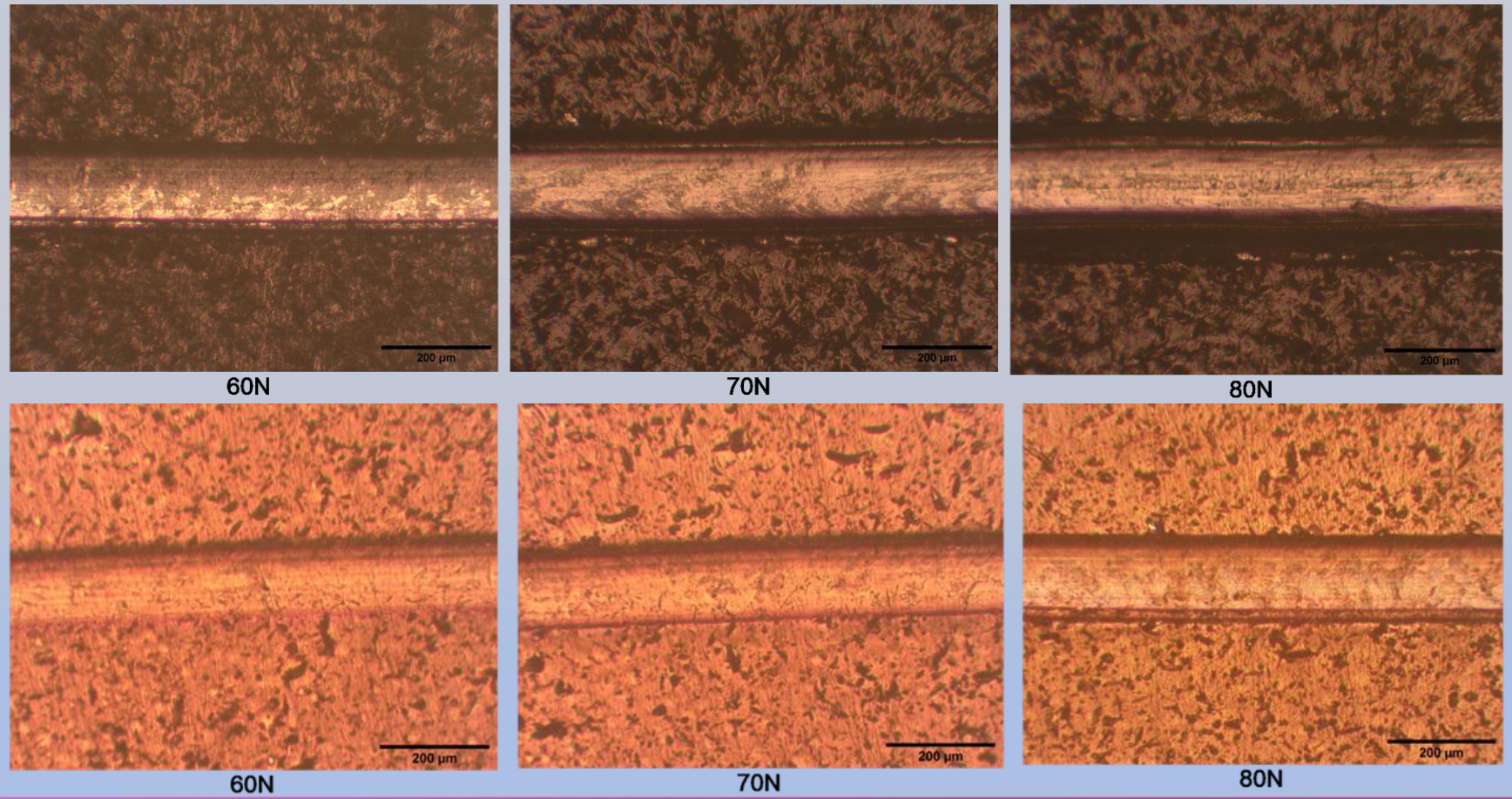


N + H

N + H+ TiN

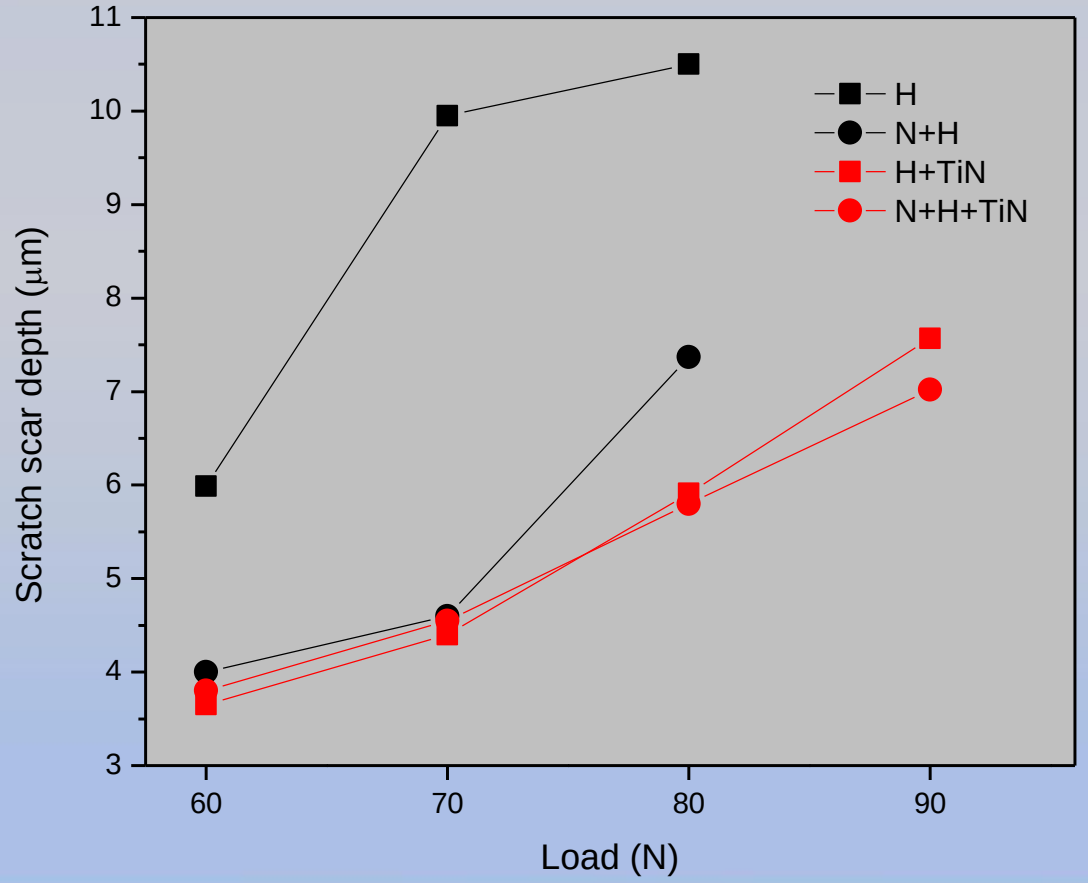
Results

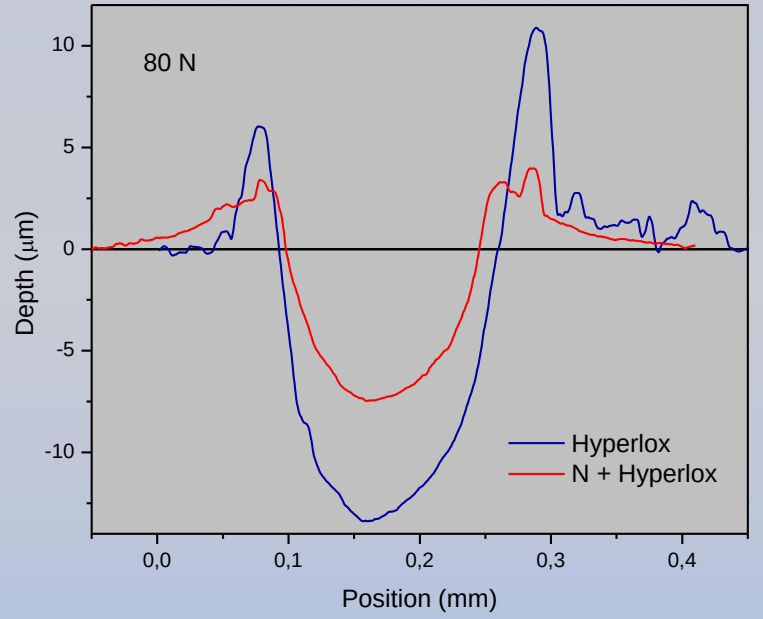
Adhesion



Results

Adhesion

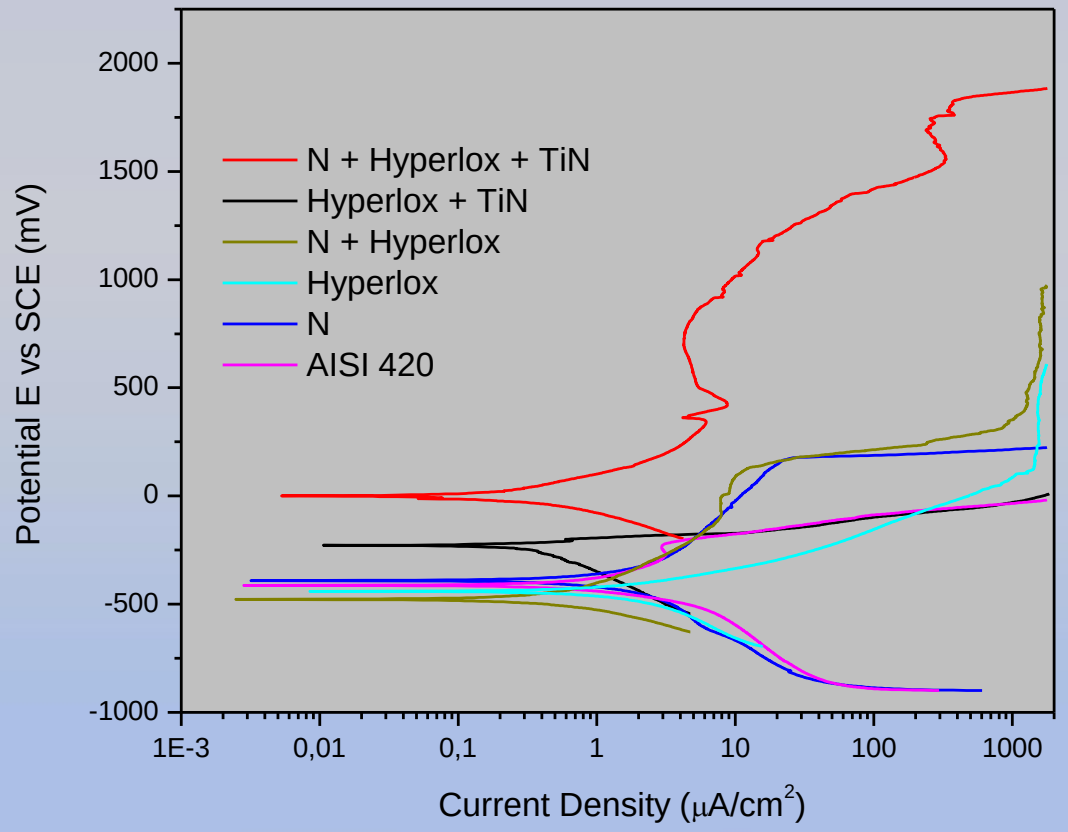




Maximum depth of the scars generated in the Scratch Test at different loads

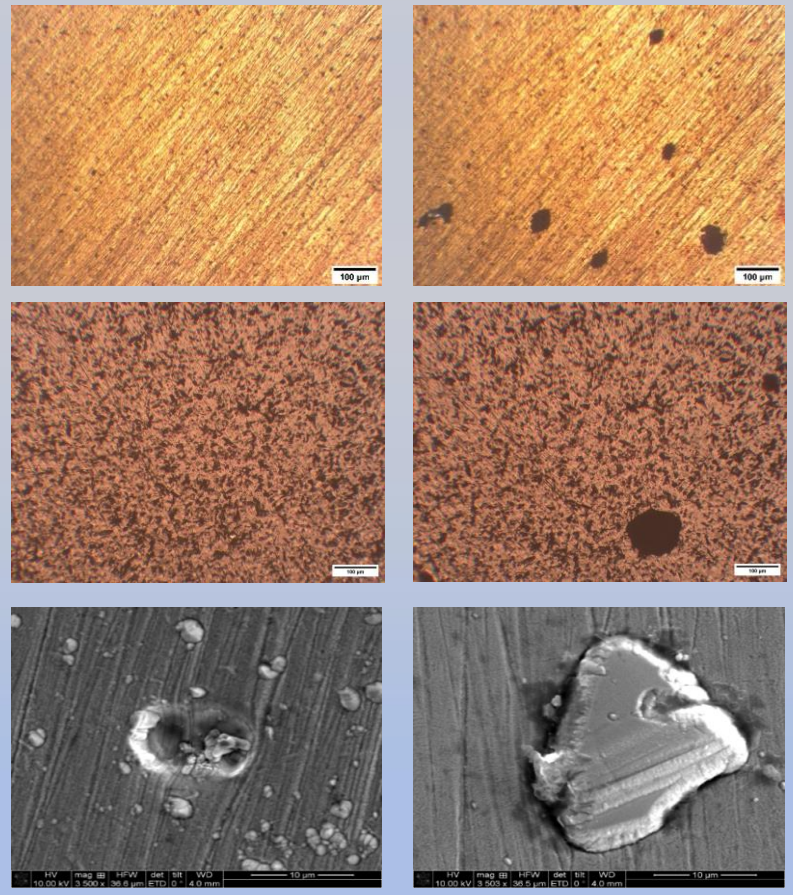
Results

Corrosion



Before

After



N+H+TiN

Pits
OM images
In the same
area

H

Defects
and SEM
images

N+H+TiN

Conclusions

1. The Hyperlox and Hyperlox Gold (+TiN) coatings presented a high Young Modulus. However, the hardness of the TiN coating was lower (32 to 26 Gpa).
2. The Hyperlox (without TiN) failed at the abrasive test when it was deposited without the nitriding pre treatment. The same occurred in the POD tests at high loads.
3. The nitrided layer improved the wear resistance in adhesive pin on disk test at high loads for both coatings.
4. The adhesion was better in the duplex samples (nitriding+coating) in both cases.
5. The duplex sample N + H + TiN resulted to be the best protective system in saline environments, proved in the corrosion tests.

Thank you!

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Grupo de Ingeniería de Superficies

¡Muchas Gracias!