



# Tribological Behaviour of TiAlN and AlCrN coatings deposited over martensitic stainless steel

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# Introduction

Stainless steel

AISI 420

Industry

Wear situations

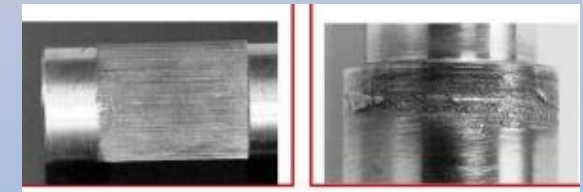
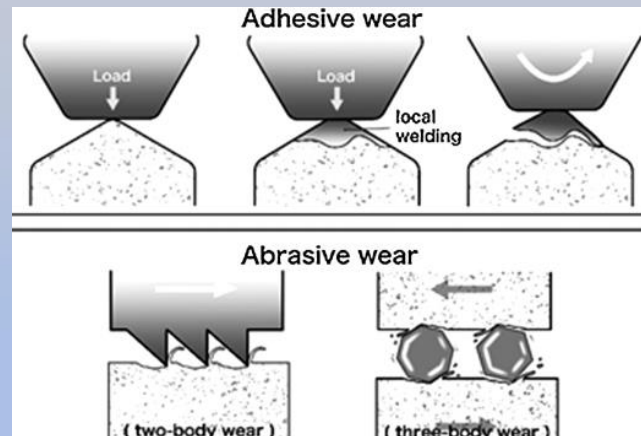
Adhesive

Abrasive

Blades



Moulds for plastic processing

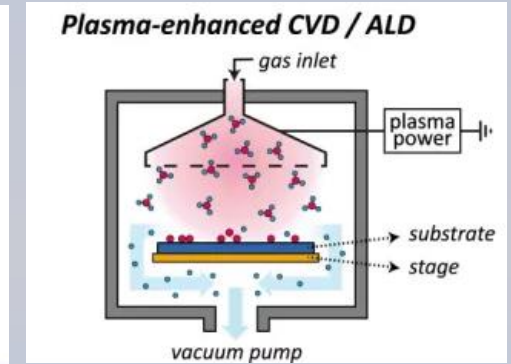
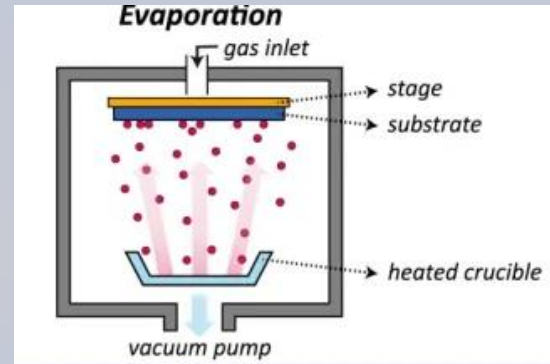


# Motivation

## Steels

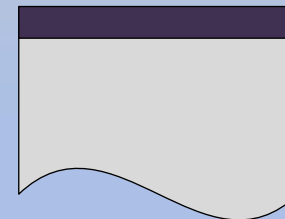
Plasma Treatments

To improve surface properties



Coatings

- PVD coatings  
CrAlN  
TiAlN



Service life  
Failure



# Main Goals



1. To study of the microstructure and surface properties of AlCrN and TiAlN coatings.
2. To evaluate the wear behaviour under different conditions such as rotational sliding and abrasion.
3. To analyze the film adhesion under static and dynamic conditions.



# Experimental

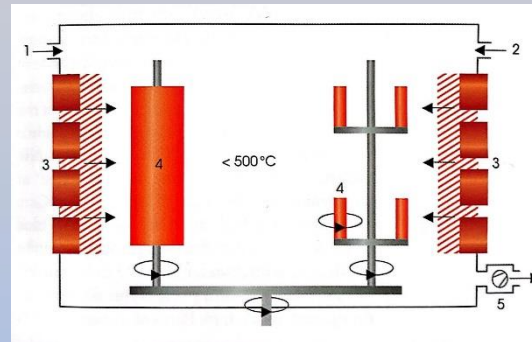
1. **Samples:** Heat treated AISI 420 Steel discs  
Chemical composition

Fe (%)	C (%)	Si (%)	Mn (%)	Mo (%)	Cu(%)	Cr (%)
96.9	0.398	0.304	0.789	0.23	0,142	1.05

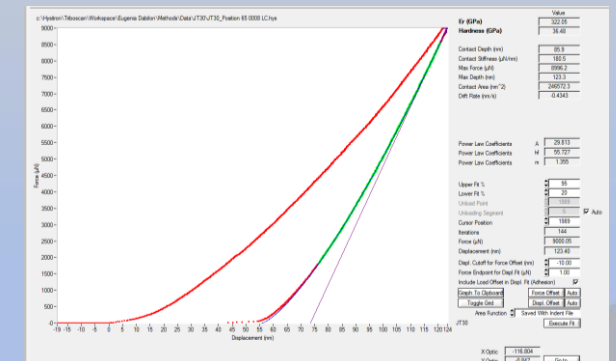
2. **PVD coatings: TiAlN and AlCrN**  
Arc PVD, Oerlikon Balzers, Argentina

3. **Characterization**

Optical Microscopy, SEM, XRD



## Nano Hardness

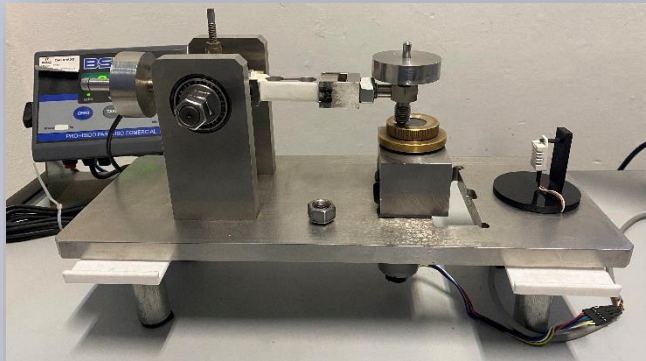




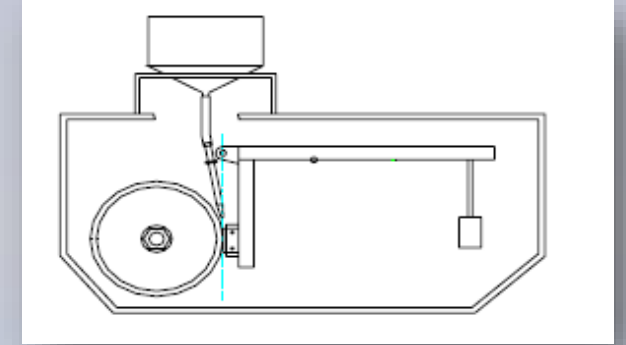
# Experimental

## Wear

Adhesive  
Pin-on-Disk  
ASTM G99

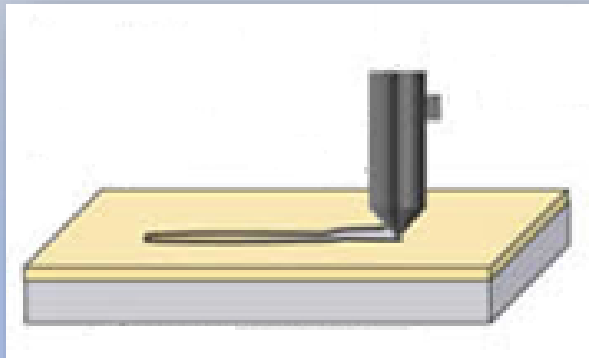


Abrasive Wear test  
ASTM G65-94  
“Dry Sand- Rubber  
Wheel”



## Adhesion

Scratch test

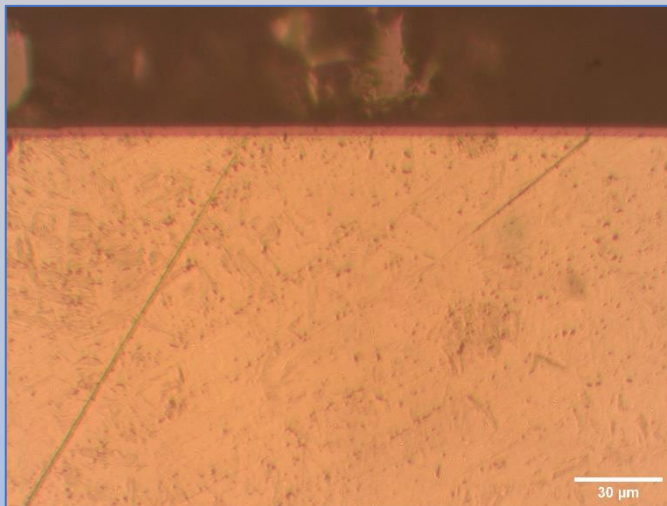


Rockwell C Indentation

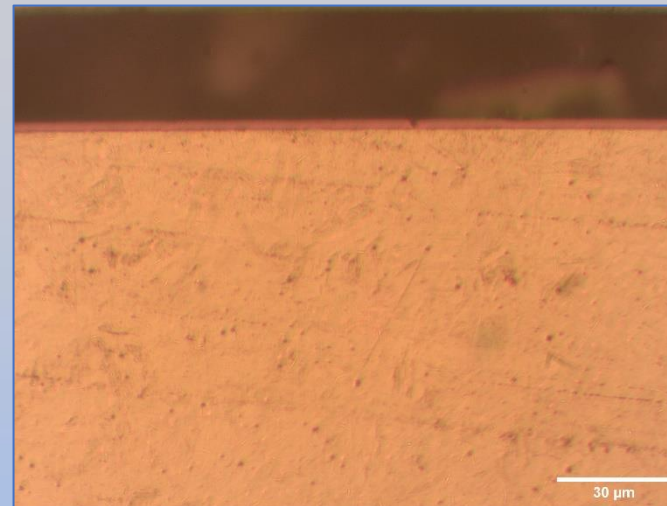
# Results

## Microstructure

OM images on different samples



AlCrN coating



TiAlN coating

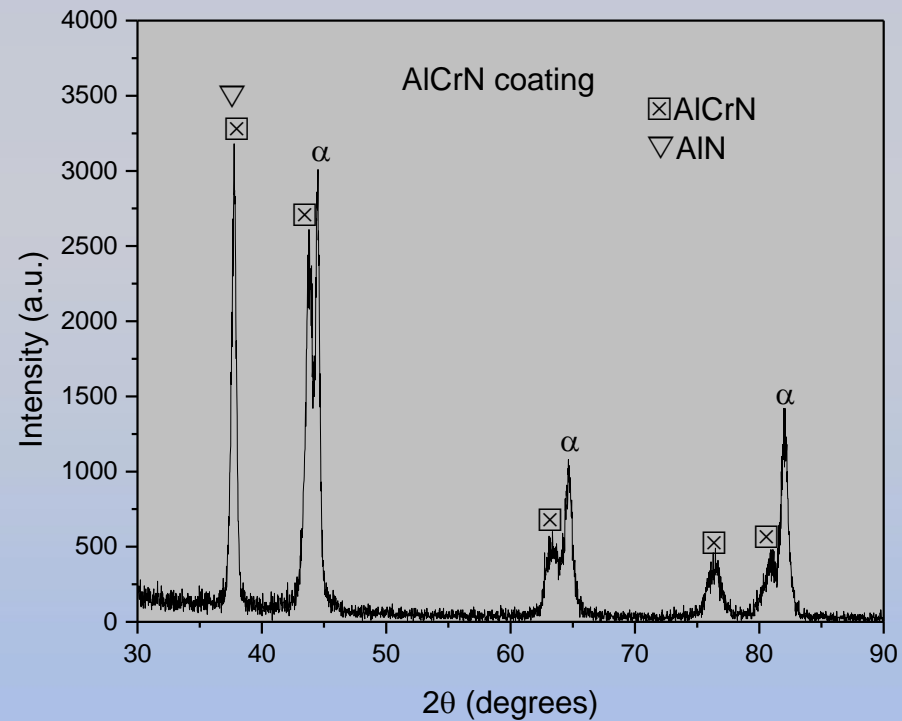
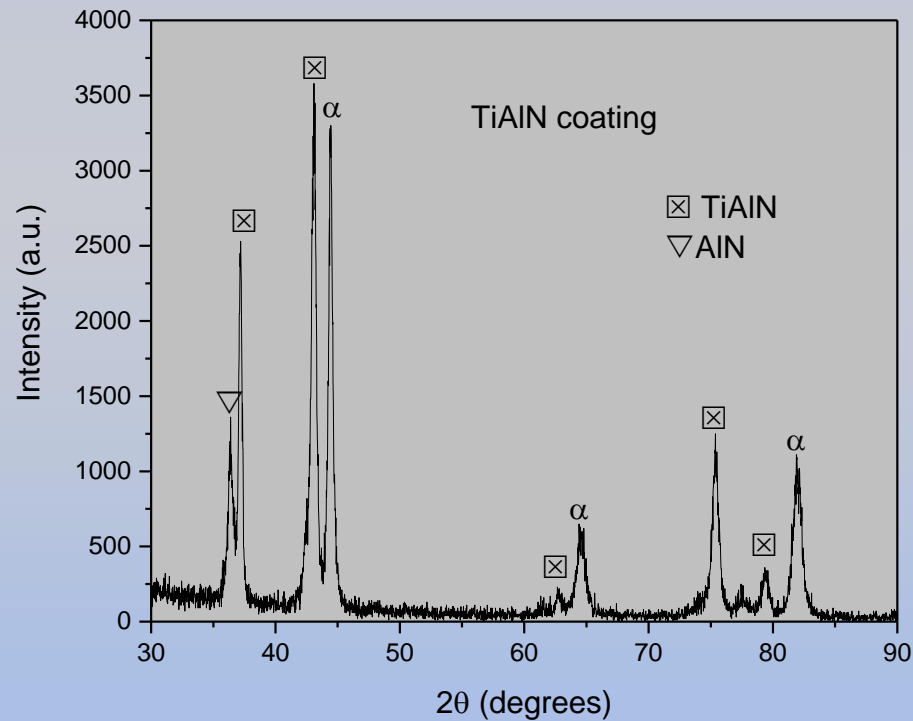
### Thickness

TiAlN coating ( $3.3 \pm 0.3$ )  $\mu\text{m}$

CrAlN coating ( $3.1 \pm 0.2$ )  $\mu\text{m}$

# Results

## Microstructure



Diffractograms of the coatings



# Results

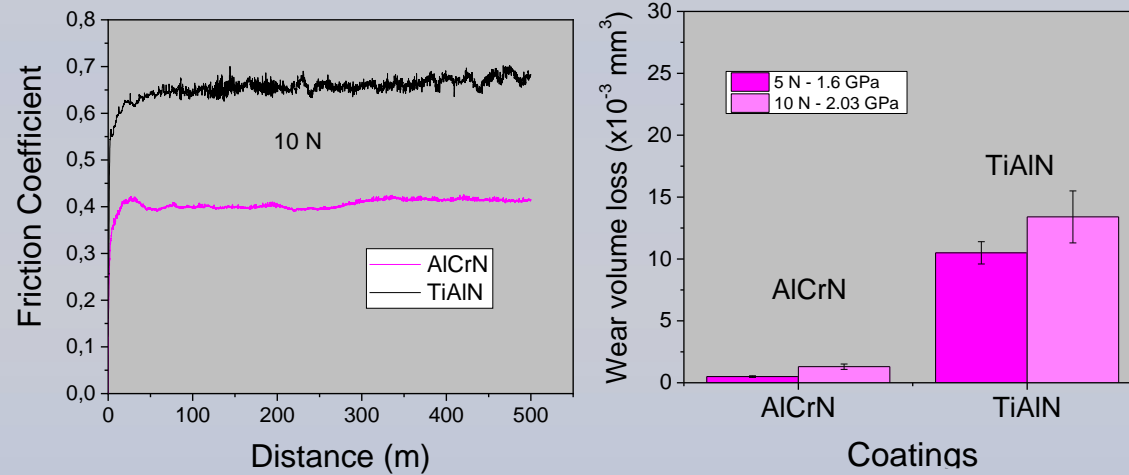
## Surface nanohardness

Samples	Nanohardness (GPa)	Young Modulus (GPa)	H/E	Contact depth (nm)
TiAlN coating	$41 \pm 5$	$348 \pm 29$	0.117	$81 \pm 6$
AlCrN coating	$45 \pm 7$	$349 \pm 33$	0.129	$76 \pm 7$
AISI 420 stainless steel	$5 \pm 1$	$200 \pm 10$		

# Results

## Pin on disk test

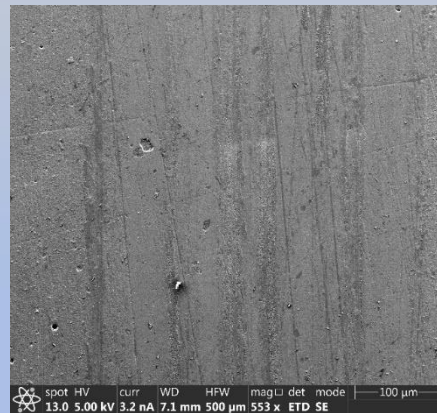
Friction coefficient  
Wear volume loss



Maximum depth of wear track  
TiAlN coating:  $(2.1 \pm 0.4) \mu\text{m}$   
AlCrN coating:  $(0.30 \pm 0.03) \mu\text{m}$

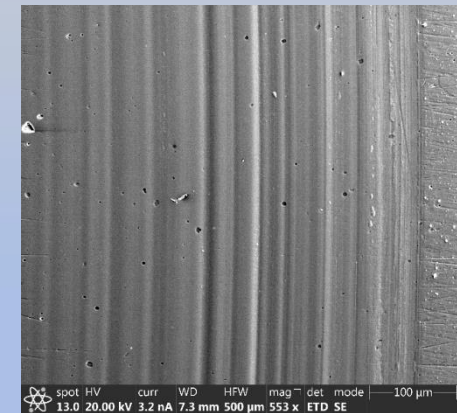
Wear tracks

SEM images



AlCrN coating

TiAlN coating



# Results

## Scratch tests tracks

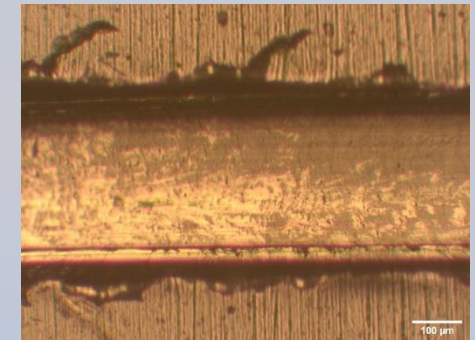
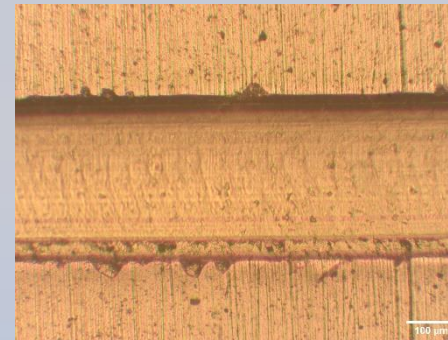
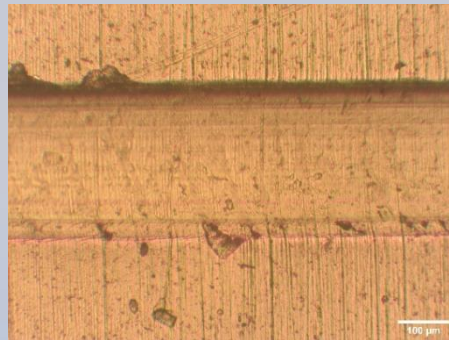
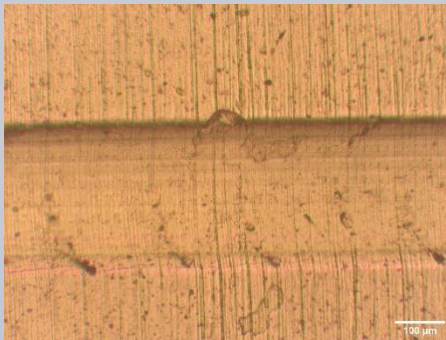
60N

70N

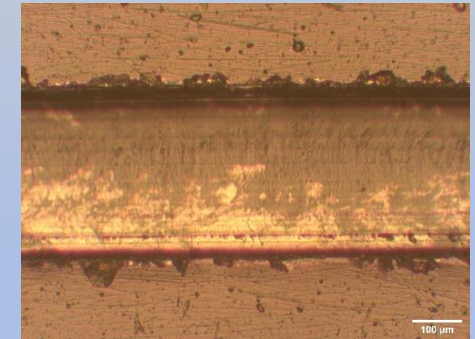
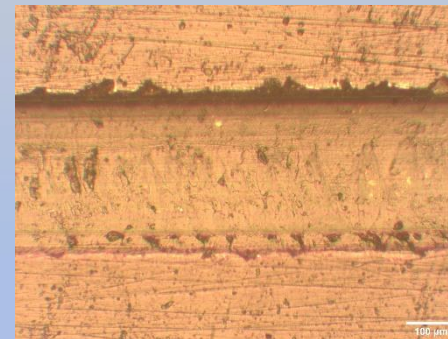
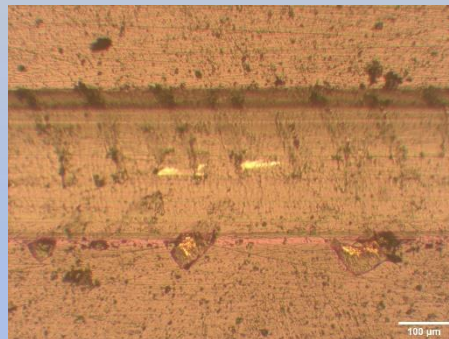
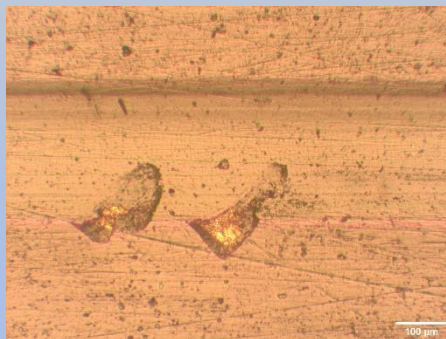
80N

90N

AlCrN coating



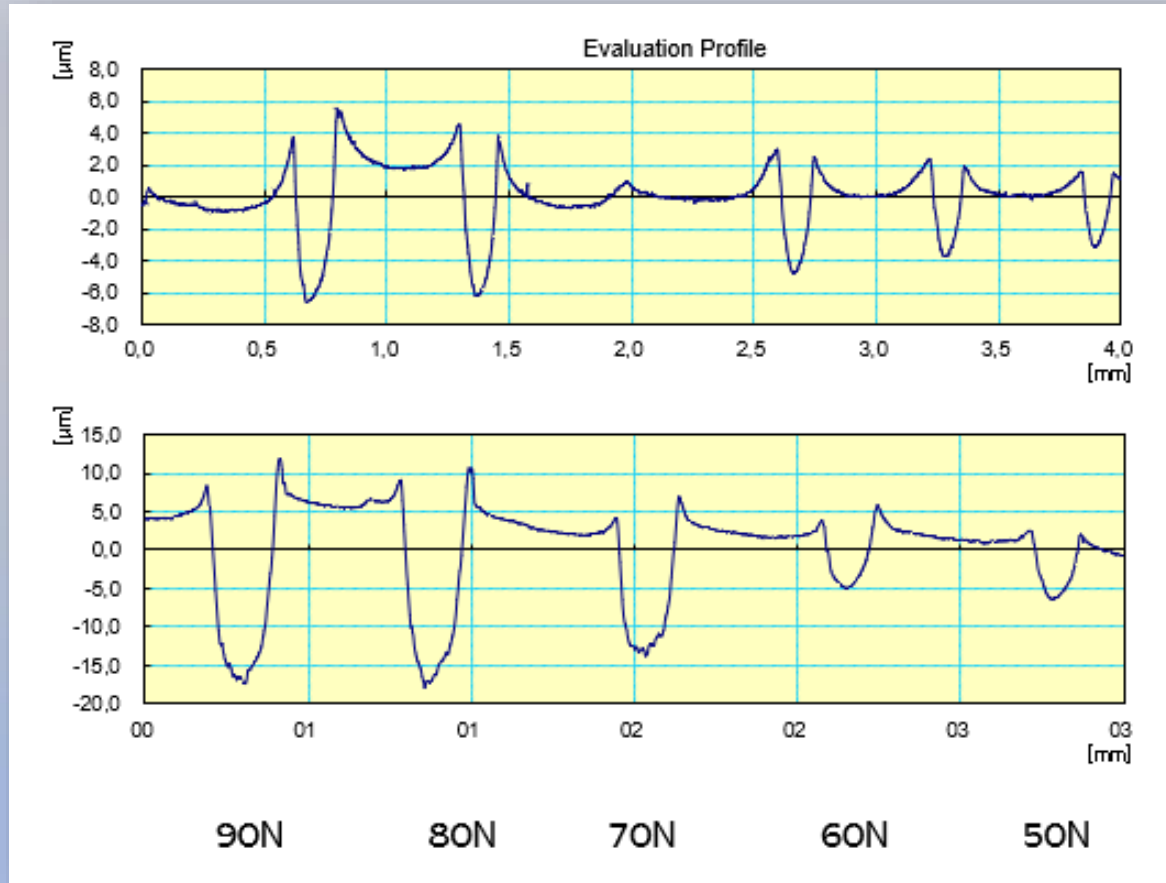
TiAlN coating



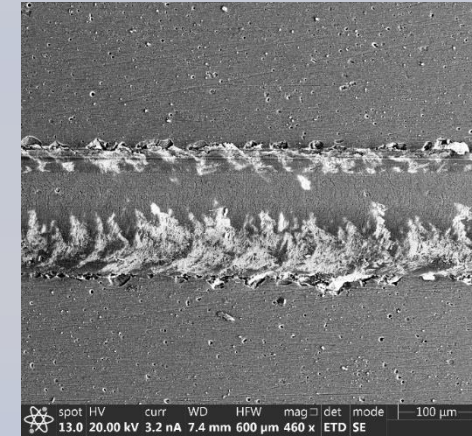


# Results

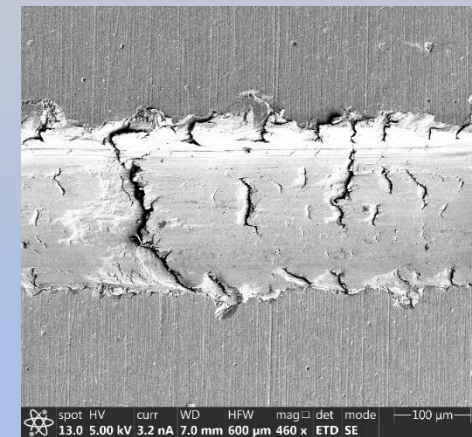
## Scratch tests tracks profiles



TiAlN coating



AlCrN coating

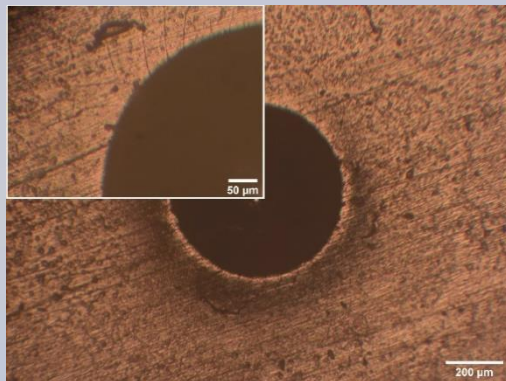


# Results

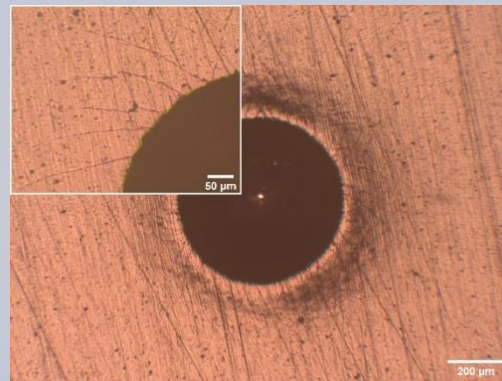
## Indentation Rockwell C

OM images

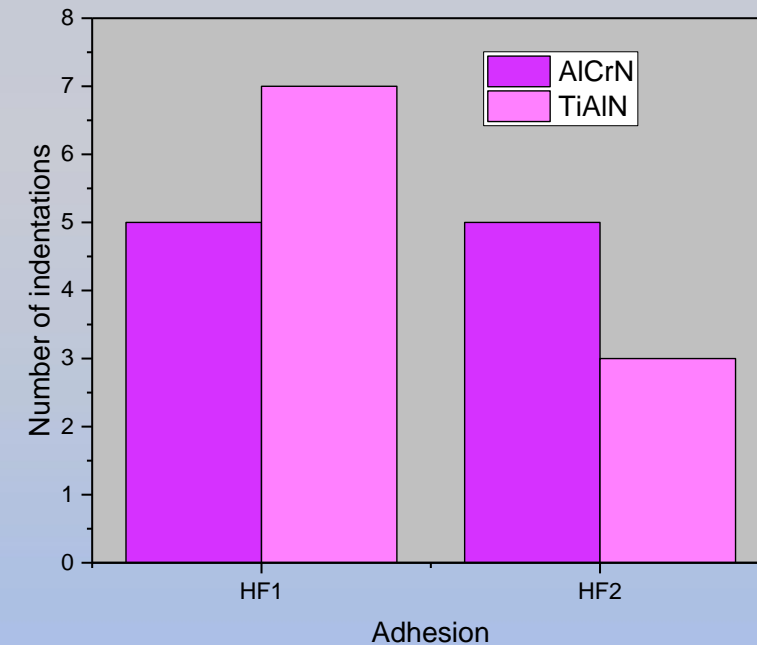
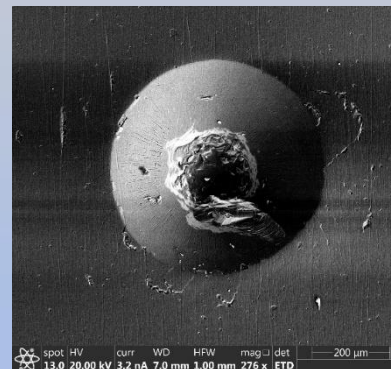
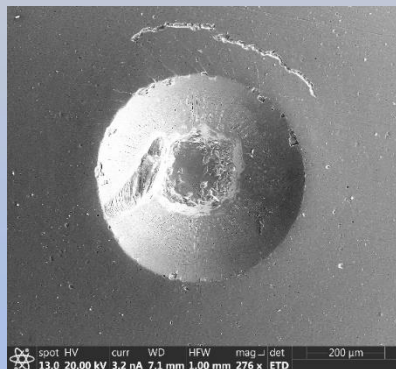
AlCrN coating



TiAlN coating



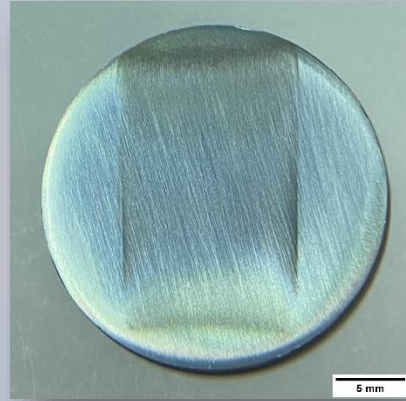
SEM images



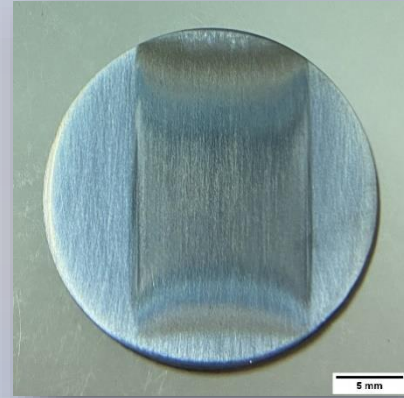


# Results

## Abrasive wear



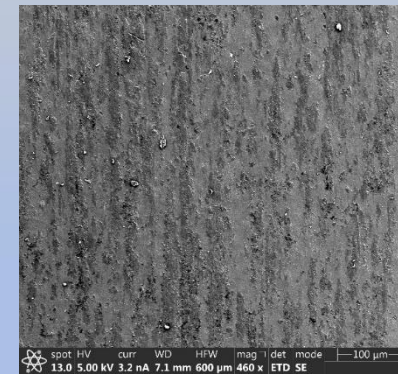
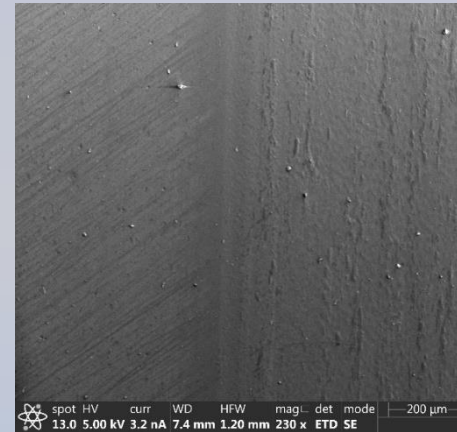
AlCrN coating



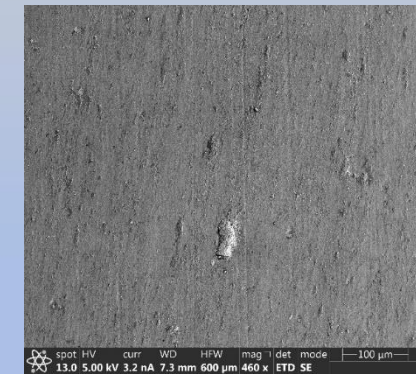
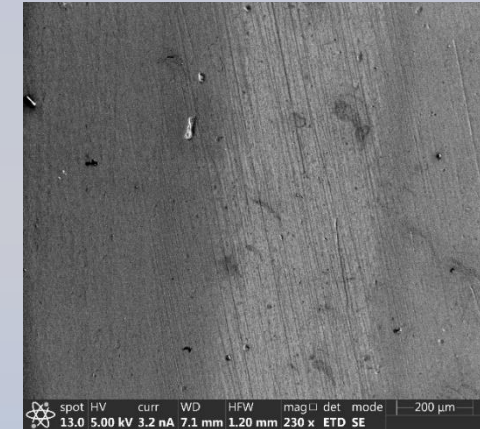
TiAlN coating

*While in the heat treated stainless steel, the mass loss was about 250 mg (130 N, 30 min), in the coated samples, it was undetectable.*

TiAlN coating



AlCrN coating



# Conclusions

1. The thickness reached approximately 3  $\mu\text{m}$  in both coatings.
2. The mass loss was similar for both coatings under abrasive wear ASTM G65.
3. The AlCrN coating has better performance under sliding conditions. The wear volume loss was twenty-five times lower for the AlCrN than the TiAlN in pin on disk tests, under low and high loads, and the steady friction coefficient value was also lower.
4. In the scratch tests, the AlCrN coating failed under a higher load than the TiAlN, which would indicate a higher critical load.
5. Nevertheless, the deformation was greater for AlCrN than TiAlN coatings.



# Thank you!



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



Grupo de Ingeniería de Superficies

# ¡Muchas Gracias!