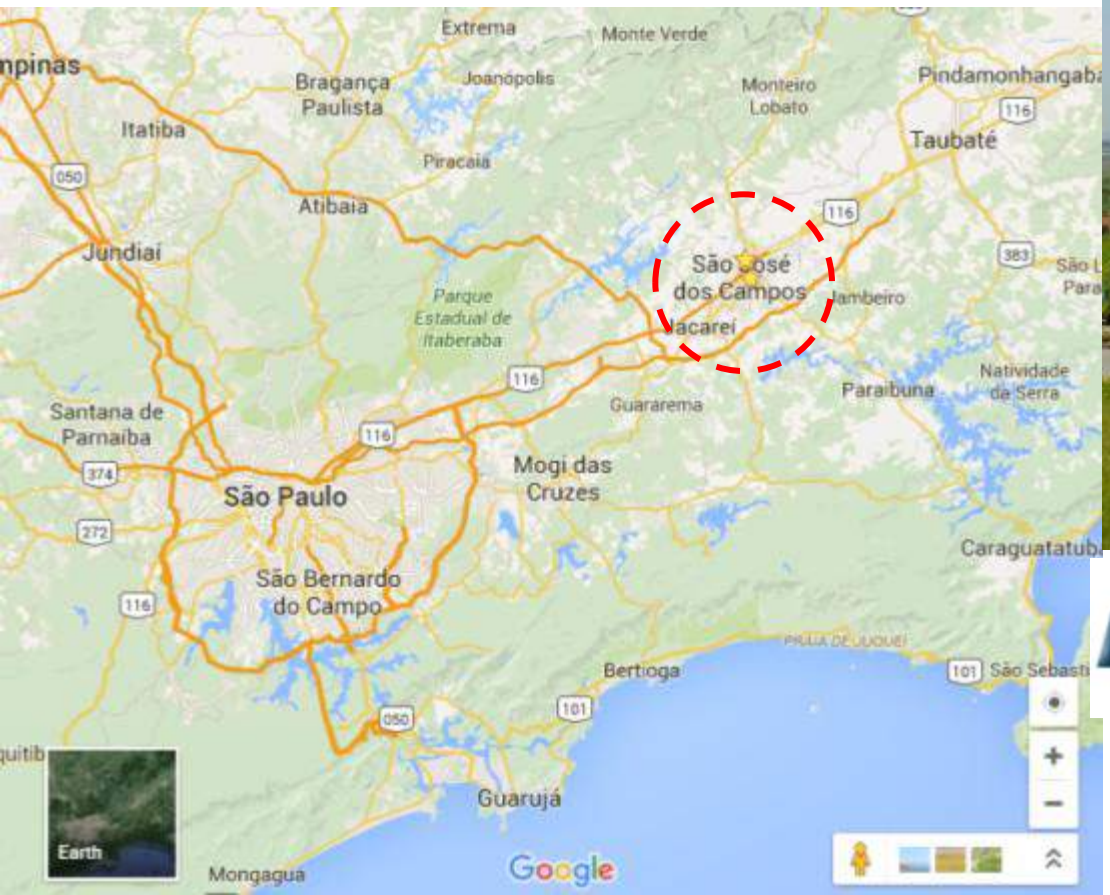
NANOTECPLASMA

LABORATÓRIO DE NANOTECNOLOGIA
E PROCESSOS A PLASMA



UNIVERSIDADE DO VALE DO PARAÍBA
São José dos Campos - SP

NANOTECPLASMA
LABORATÓRIO DE NANOTECNOLOGIA E PROCESSOS A PLASMA

Janeiro de 2011

25 membros

- Professores/Pesquisadores:
Homero Santiago Maciel
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Augusto Luiz Lopes

- Pós-doutorando:
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Everton Diniz (Doutorado)
Gerson Luqueta (Doutorado)
William Chiappim (Doutorado)
Giorgio Testoni (Doutorado)
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Camila Sorge (Mestrado)

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Rachel Carvalho Gonçalves
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Guilherme Torello Cassiano Redi
Larissa Cristina Sant'ana da Cruz
Thais Cristina da Silva
Benilde Hudson Buaca Sinadinse
Lucas Augusto Manfroi
Guilherme Charles Blenco

Linhas de pesquisa

Materiais:

1. Filmes finos processados a plasma: DLC, SiC, TiO_2, Al_2O_3

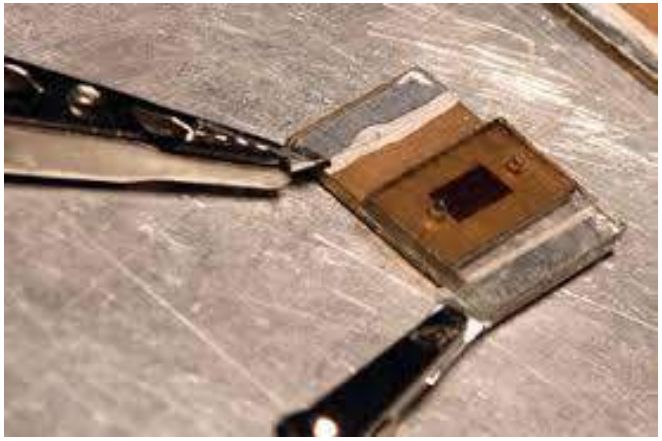
2. Síntese e estudo de materiais nanoestruturados:
   - Aplicação de nanopartículas em filmes de DLC e a-SiC:H;
   - Recobrimentos / microeletrônica.
3. Tribologia e nanotribologia de superfícies.

Engenharia biomédica:

4. Desenvolvimento de plasmas atmosféricos para área médica/biológica;
5. Aplicação de plasmas na biologia:
   - Esterilização de superfícies;
   - Tratamento de superfícies biológicas;
   - Estudo do efeito do plasma em superfícies biológicas.

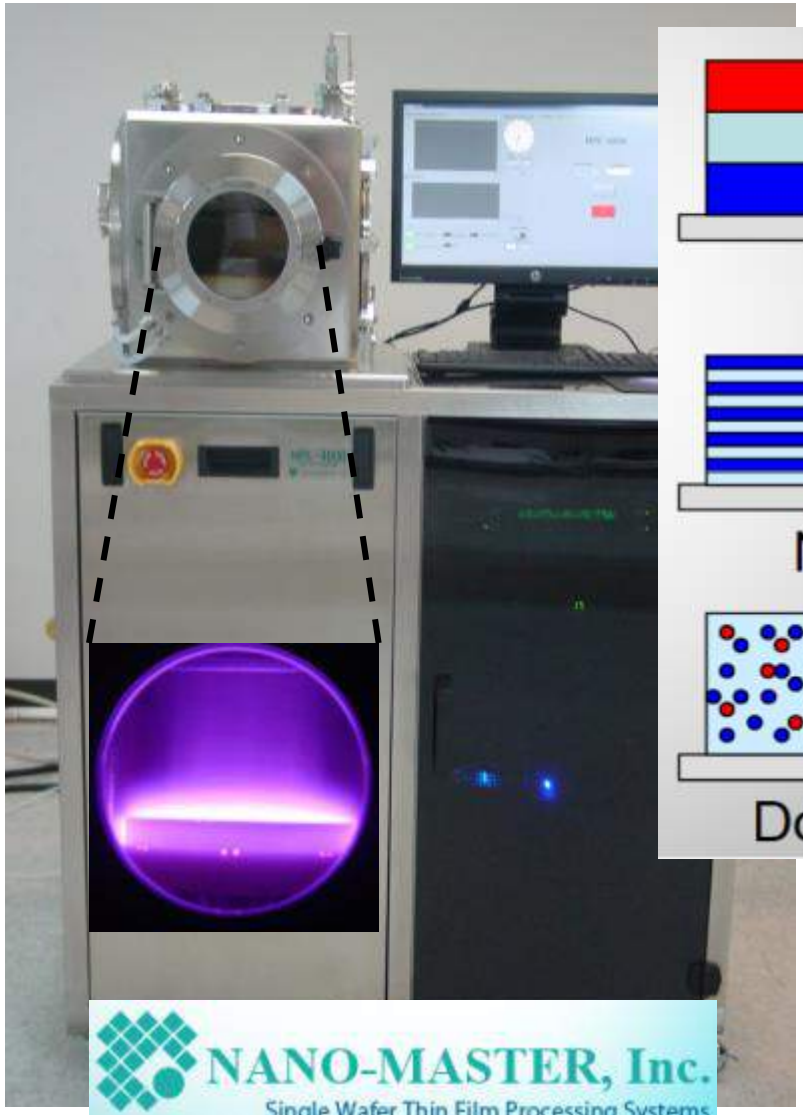
Energia e sustentabilidade:

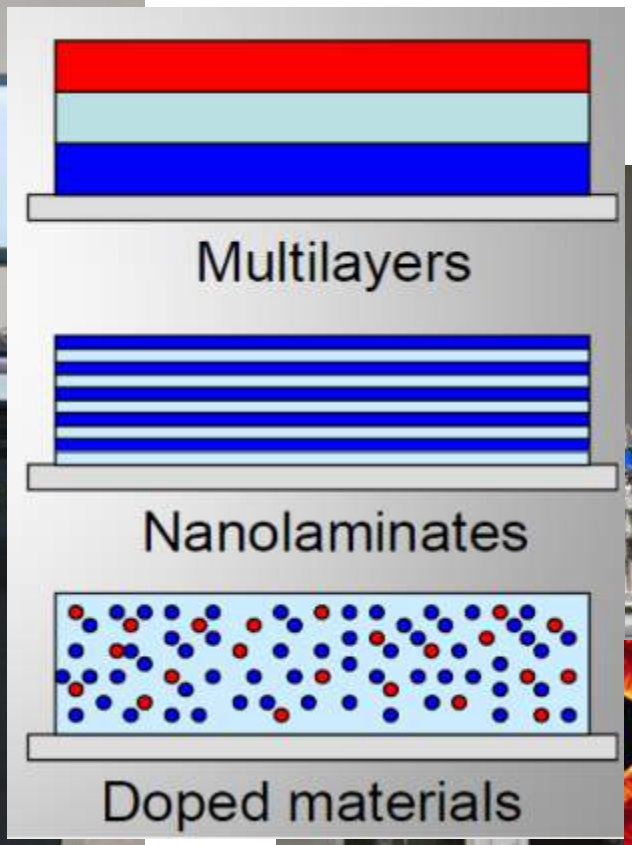
5. Desenvolvimento de tochas de plasmas para tratamento de detritos.
6. Vitrificação de cinzas por plasmas térmicos.
7. Desenvolvimento de células fotoeletroquímicas para geração de H_2 por fotoeletrólise da água;
8. Células solares de 3ª geração.



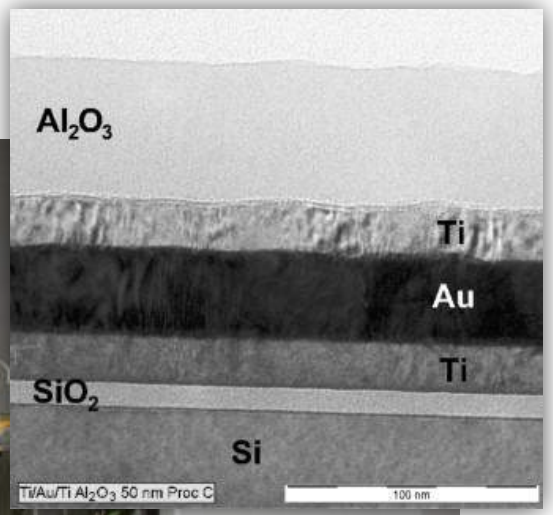
Células solares sensibilizadas com corante

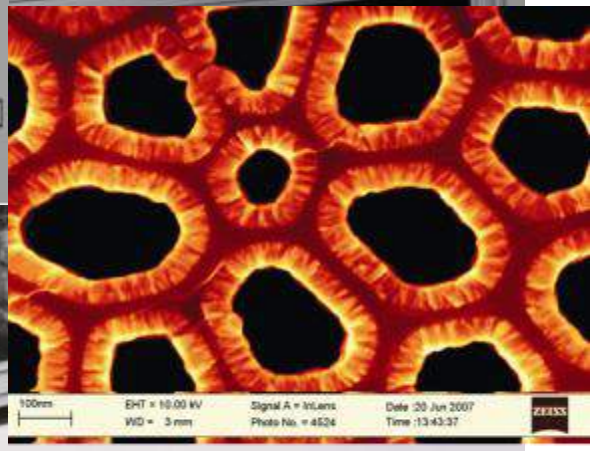
(PECVD) – pulsed DC





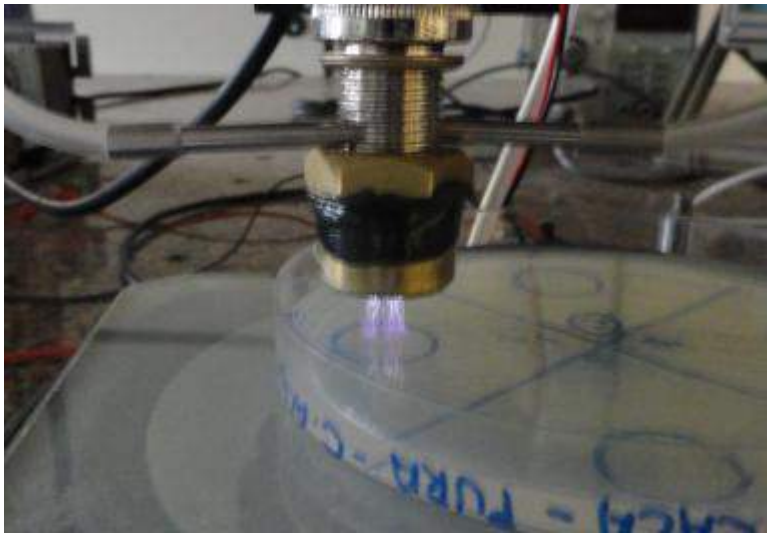
(PEALD) – RF

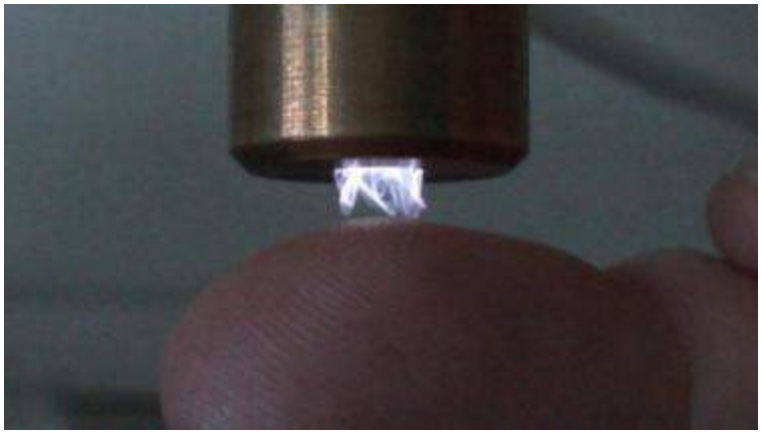


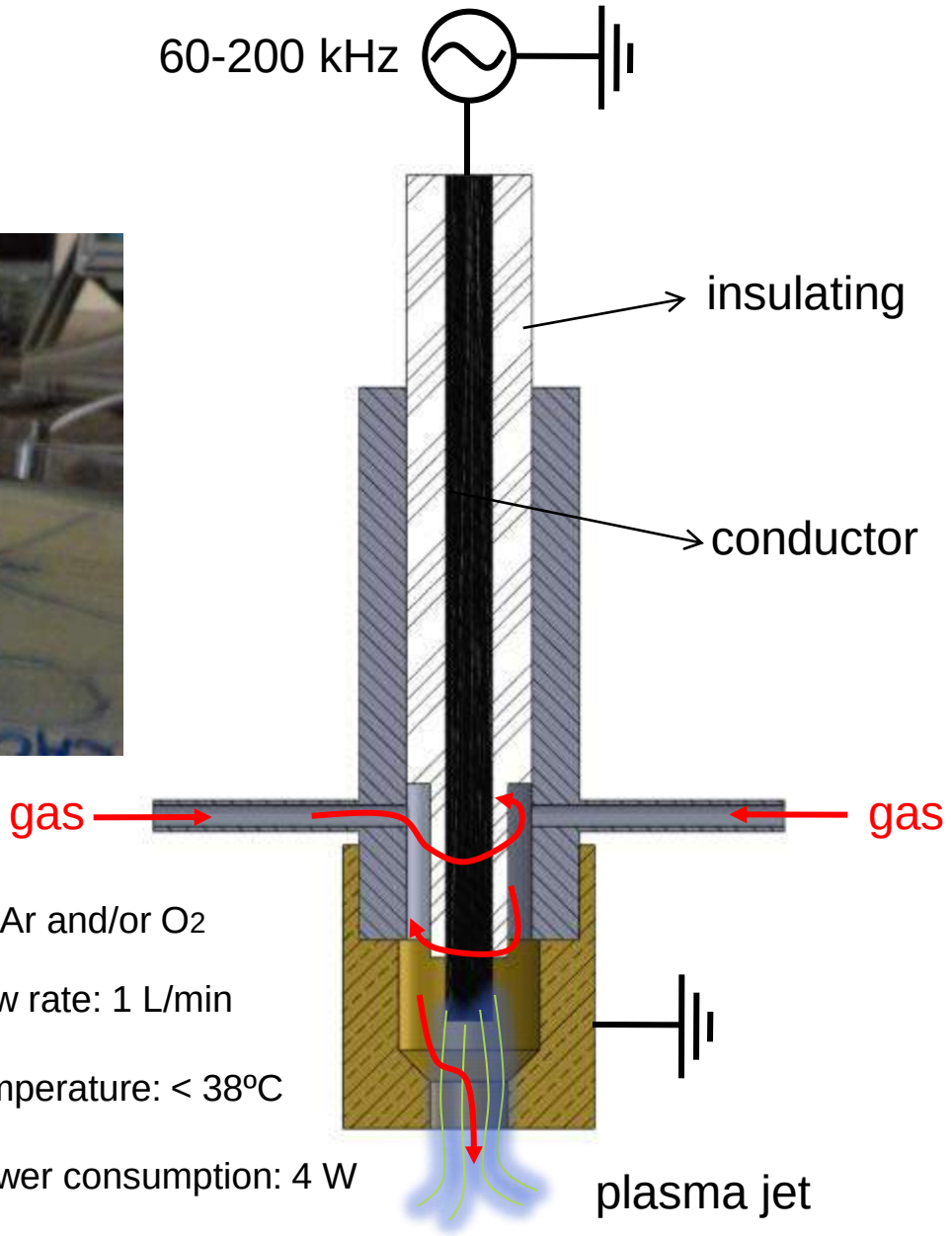


ZnO Coating

Plasma at atmospheric pressure for treating biological surfaces







Gases: Ar and/or O_2

Low flow rate: 1 L/min

Low temperature: < 38ºC

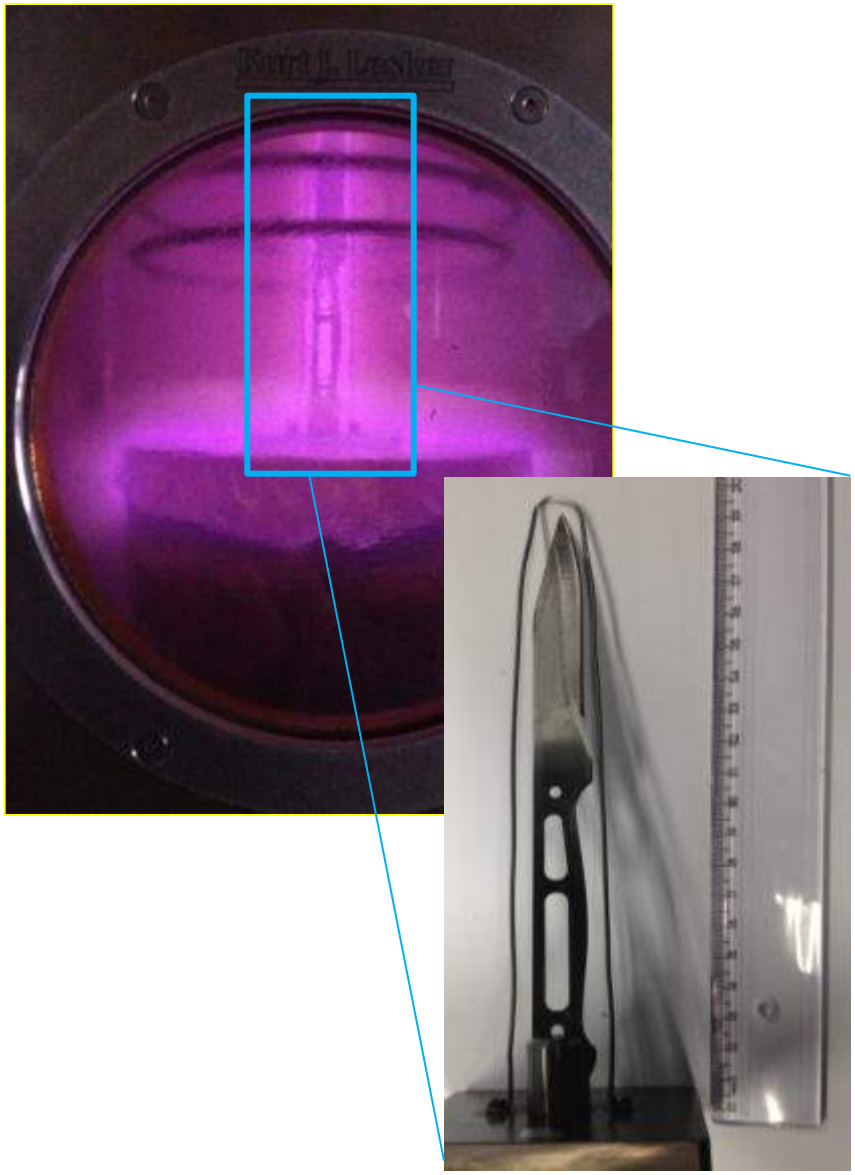
Low power consumption: 4 W

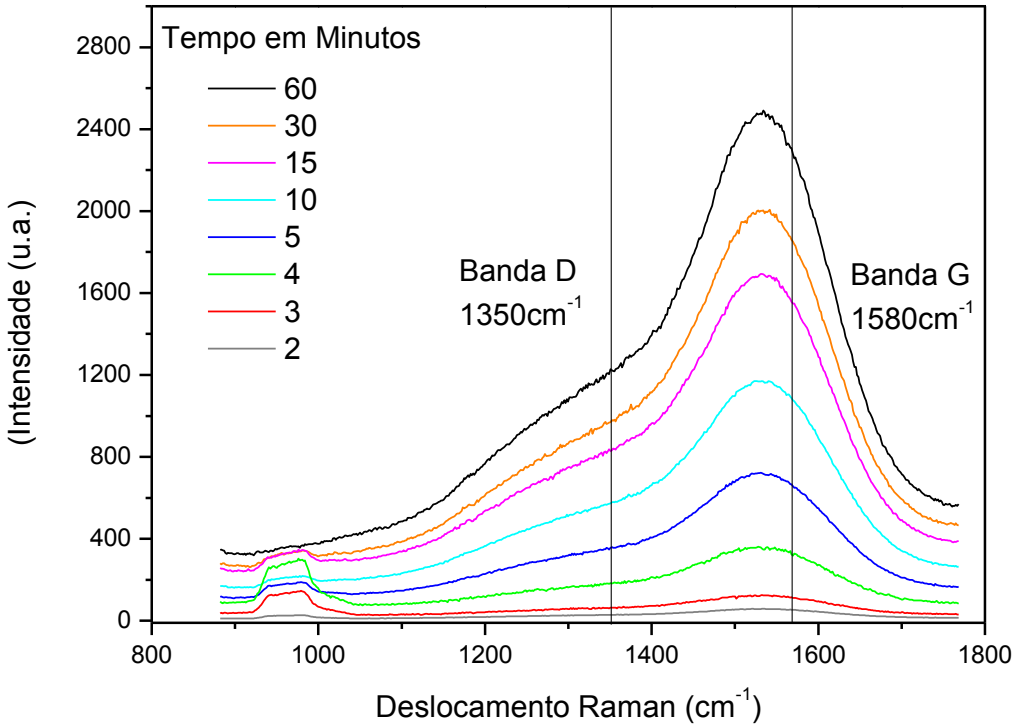
Molecular Beam Mass Spectrometry

- Chemical analysis of atmosferic plasma
- interactions between Plasma, surfaces and powders

Modelo HPR-60, marca Hidden.

PECVD Diamond-like carbon coatings in tools

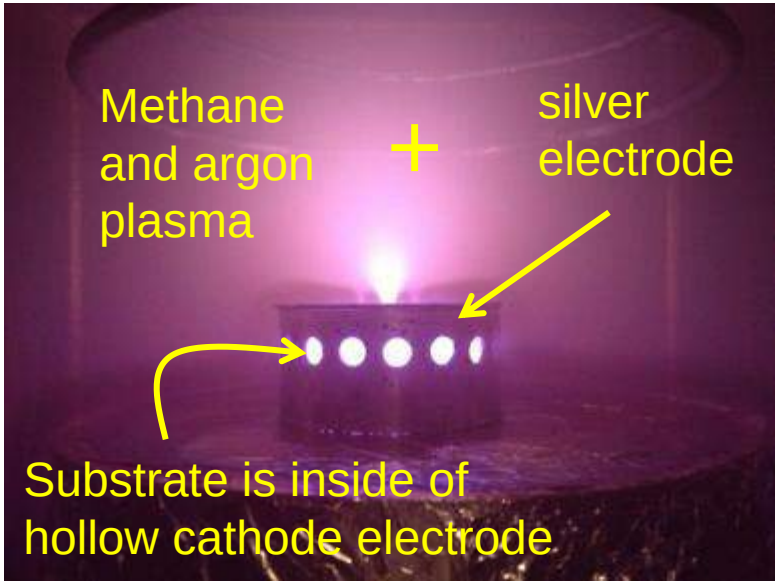


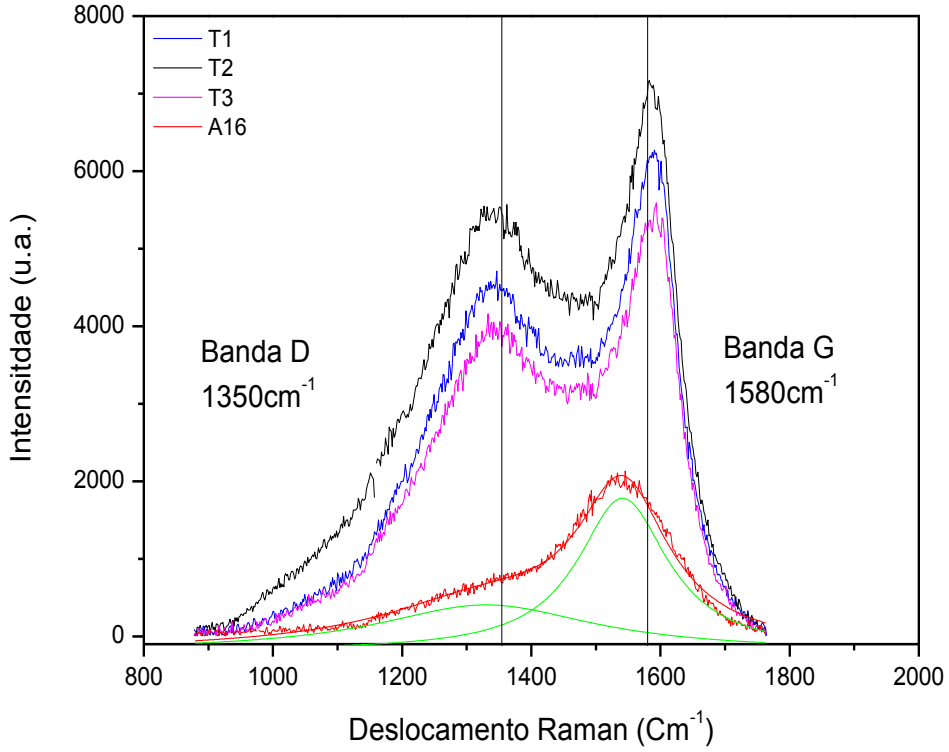


Effect of deposition time in chemical structure of the film

→ Application: reduction in wear of cutting tools

Deposition of diamond-like carbon with silver by PECVD





→Applications: - biomedical implants;
- oxygen etching resistance aerospace devices.

Development of a TiO2-based photoelectrochemical cell for photo-electrolysis of water → H_2 generation

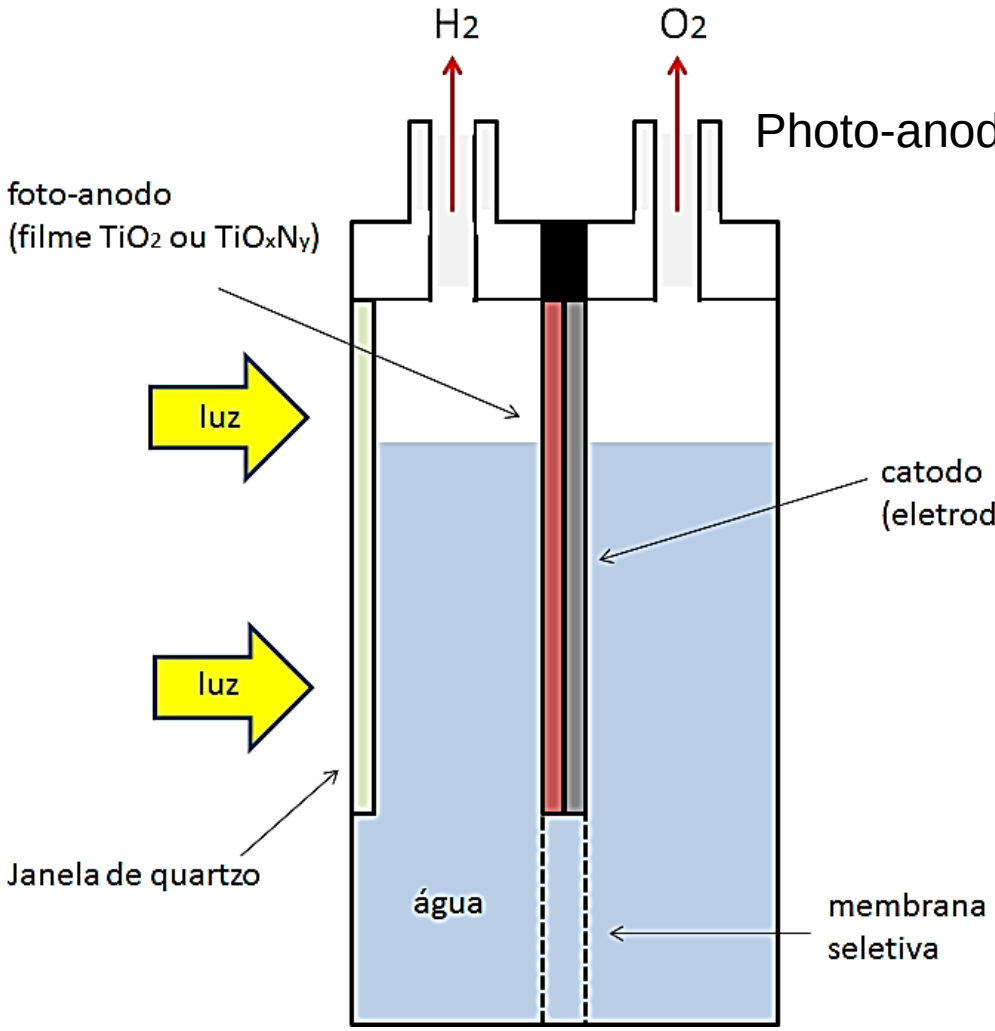
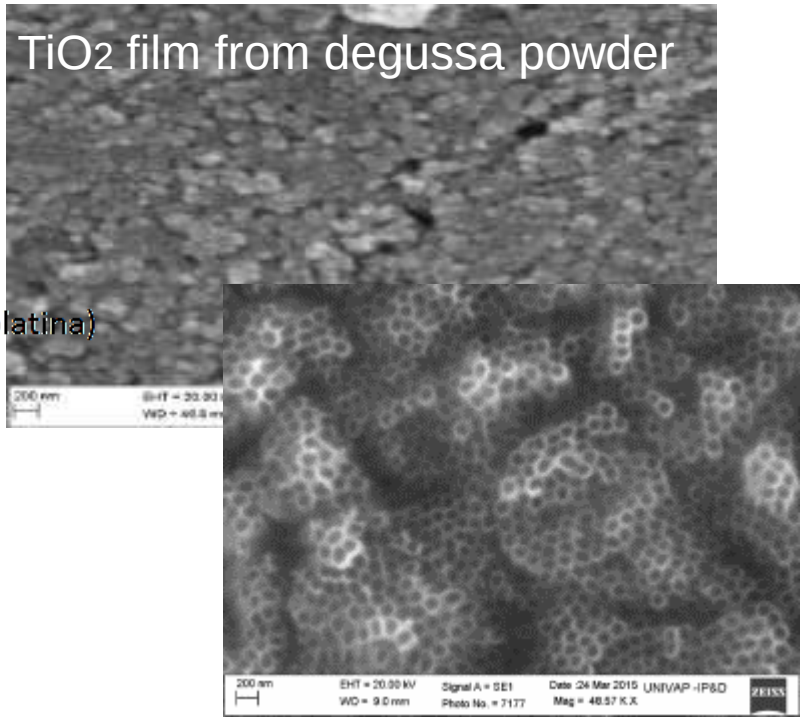
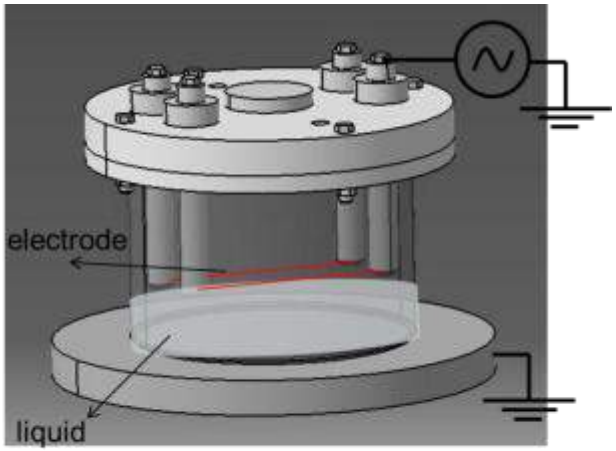


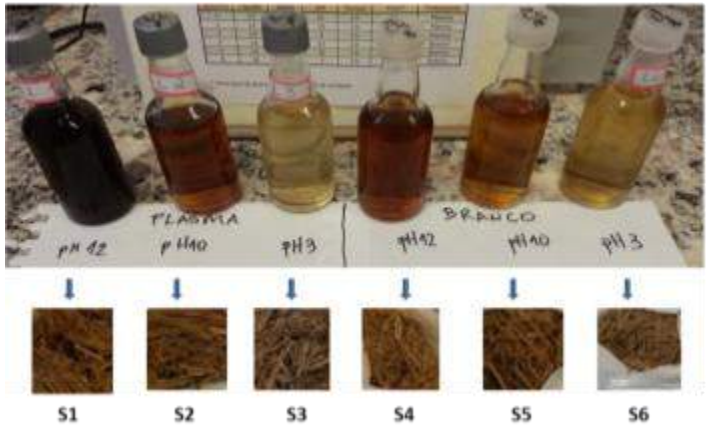
Photo-anode is based in TiO_2 nanostructured films:

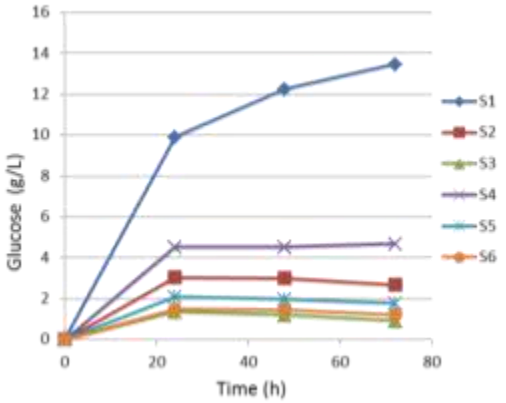


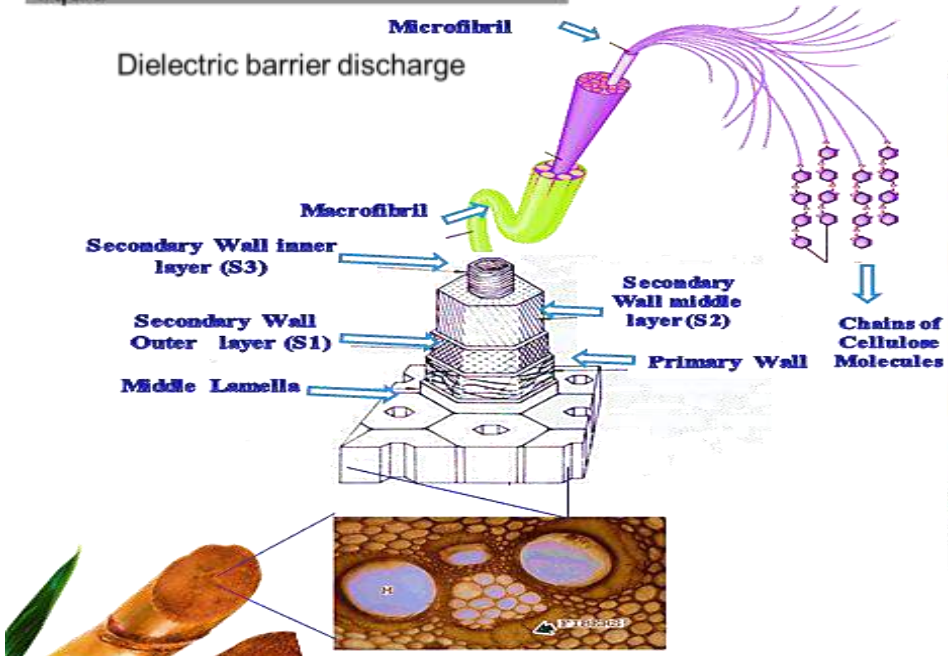
TiO_2 nanotubes produced by electroanodization process

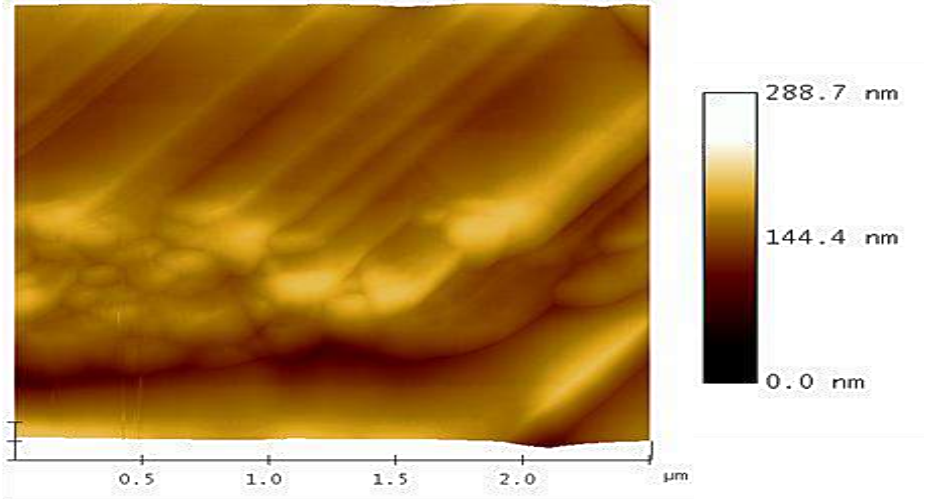
Plasma pre-treatment process of sugarcane bagasse in liquid



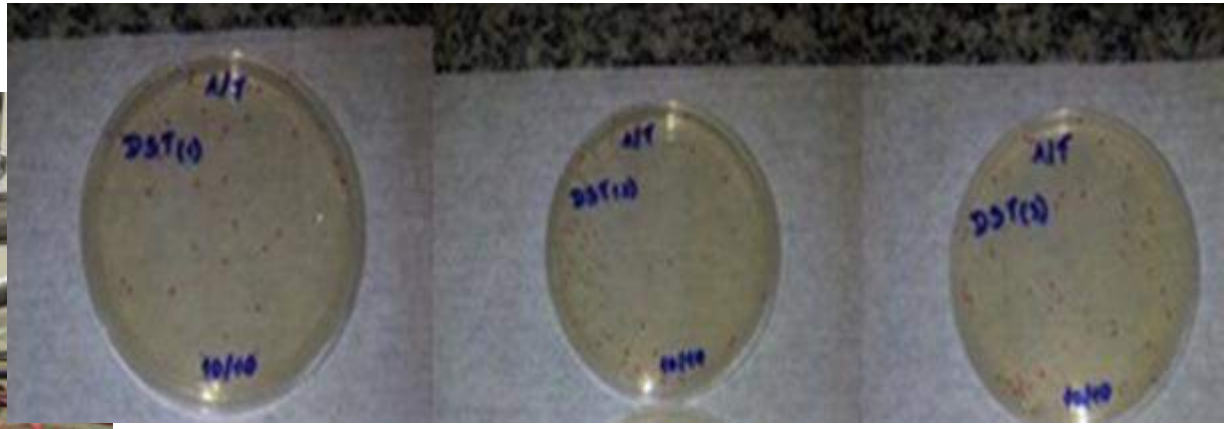


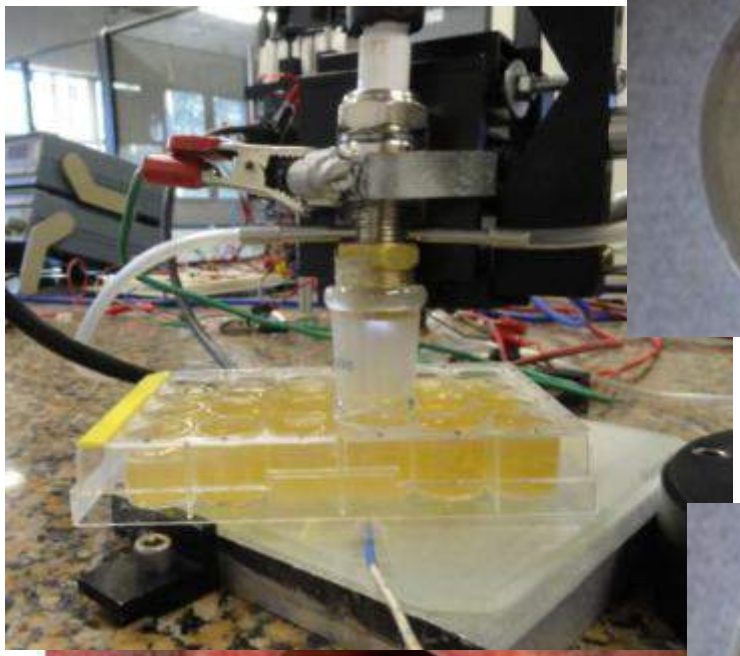




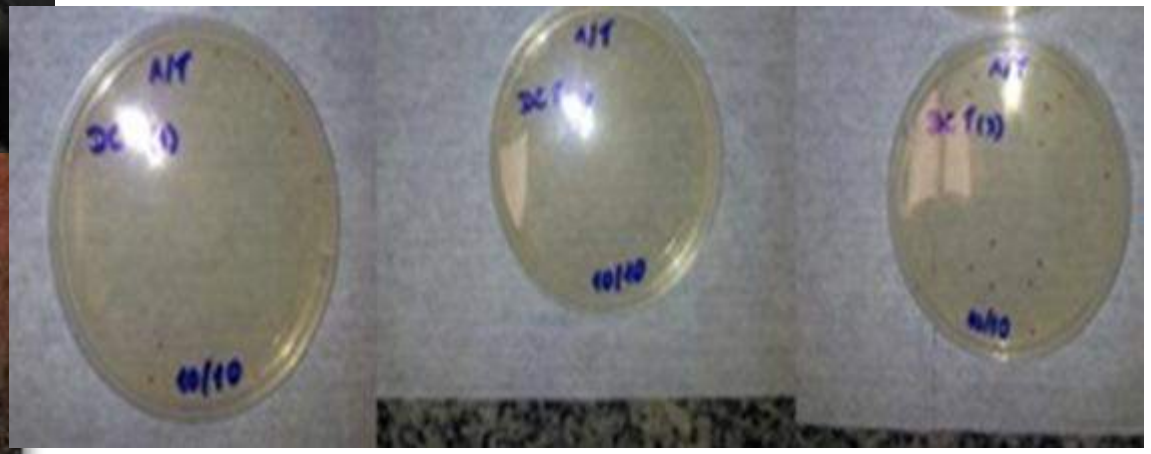


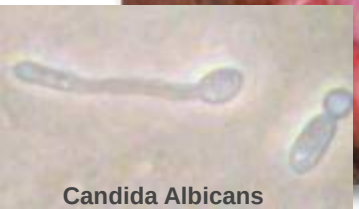
Inactivation of the candida albicans fungus





Diluted inoculum without plasma treatment

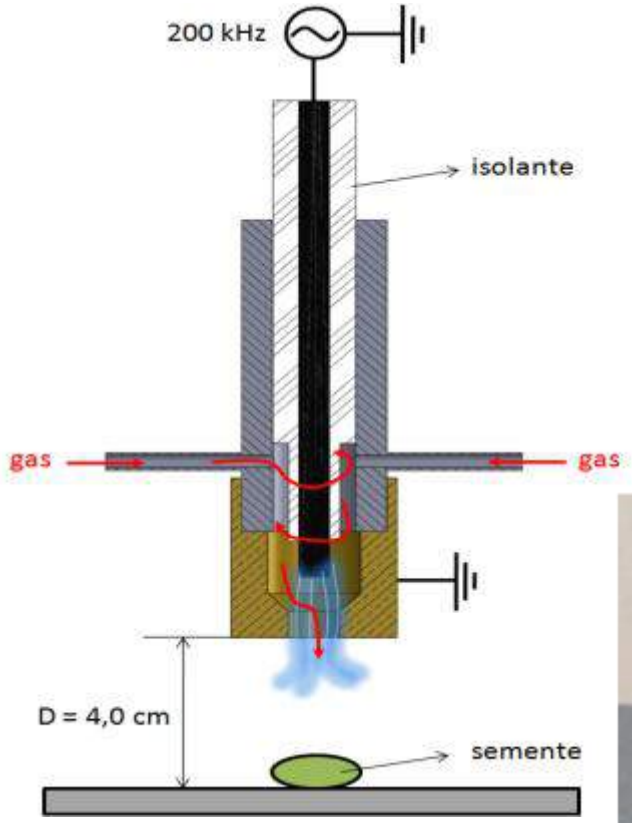


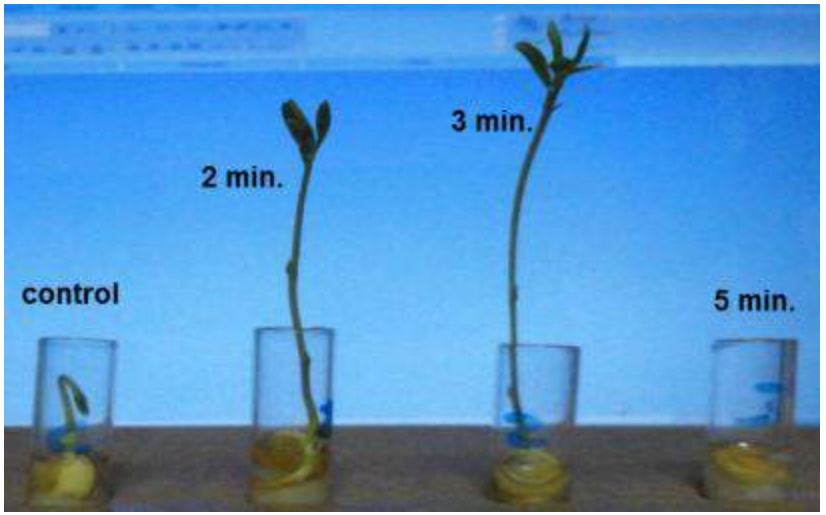


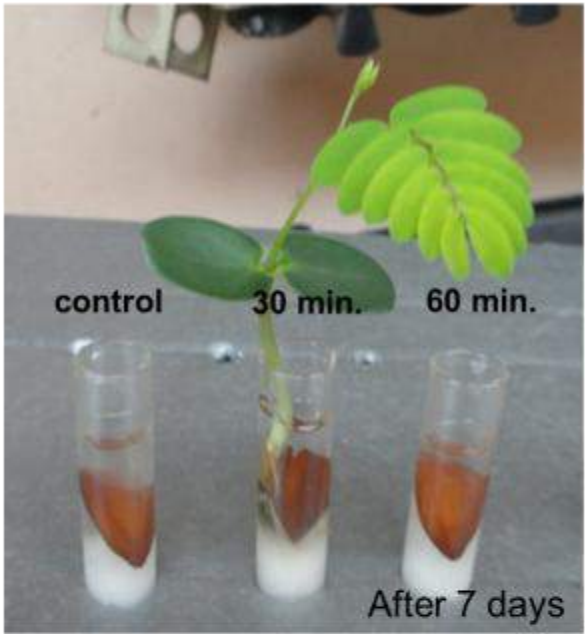
Candida Albicans

Diluted inoculum with plasma treatment

IMPROVING THE GROWTH OF "LENTIL“ AND LEUCAENA BY IRRADIATION OF YOUR SEED BY ATMOSPHERIC ARGON PLASMA







ESTUDO DO EFEITO DA COMPOSIÇÃO DOS FILMES DE DLC EM SUA RESISTÊNCIA À TRIBOCORROSÃO VISANDO APLICAÇÃO EM PRÓTESES.

Polyana

polyradi@gmail.com

Tribocorrosion

Tribology

Friction, Lubrication and Wear

Corrosion

Chemical and Electrochemical interactions with environment

Examples Systems Exposed to Corrosion

Food Processing

Oil Pipeline

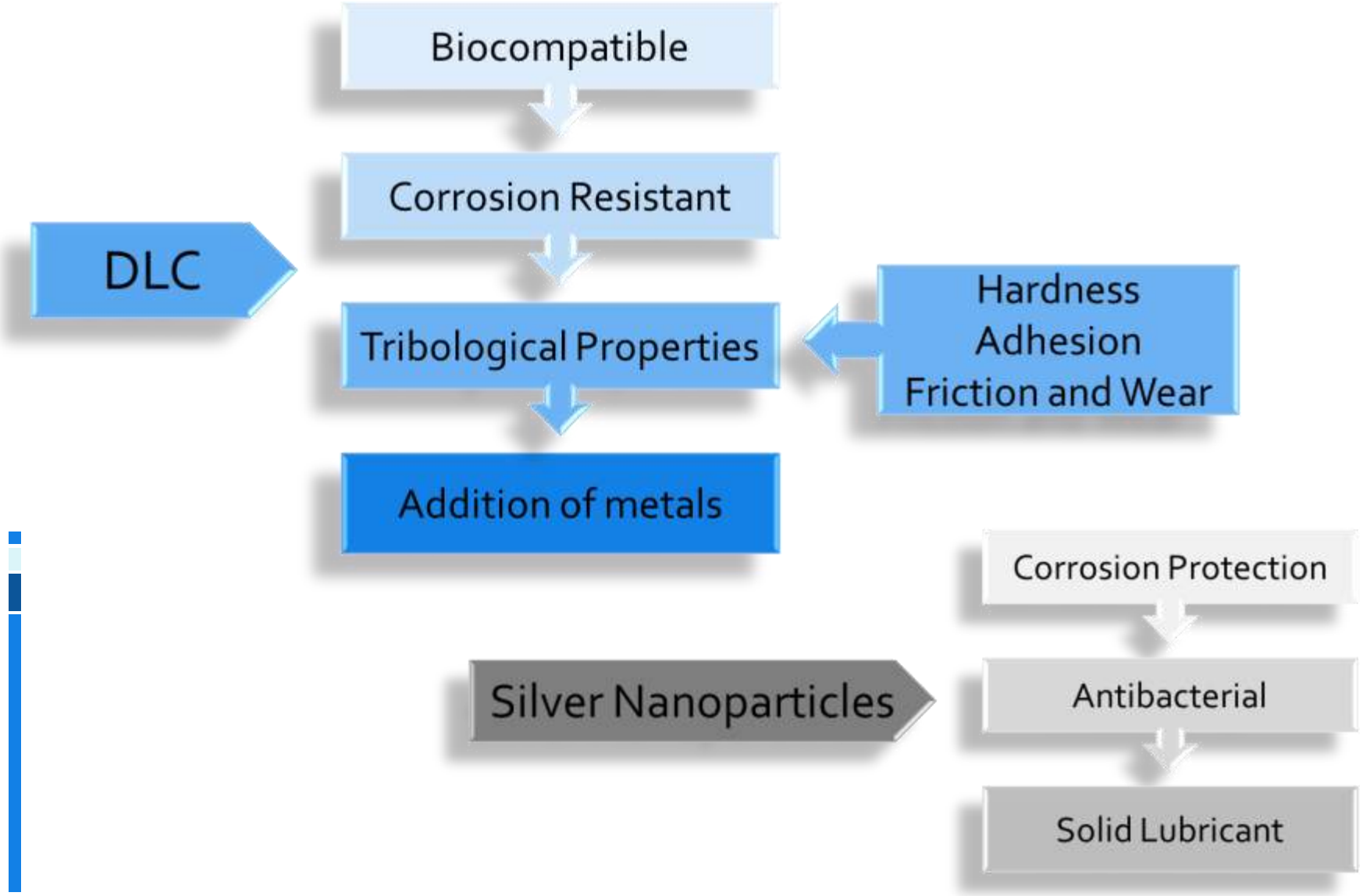
Mining

Biomedical Implants

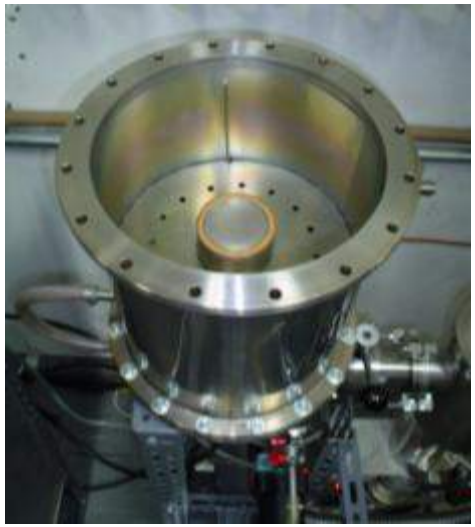
Examples Systems Exposed to Corrosion

Próteses de joelho

Motivation


Biocompatible
Corrosion Resistant
DLC
Tribological Properties
Hardness
Adhesion
Friction and Wear
Addition of metals
Corrosion Protection
Silver Nanoparticles
Antibacterial
Solid Lubricant

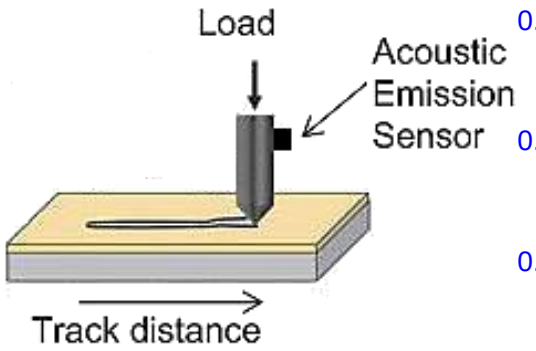
Film Deposition

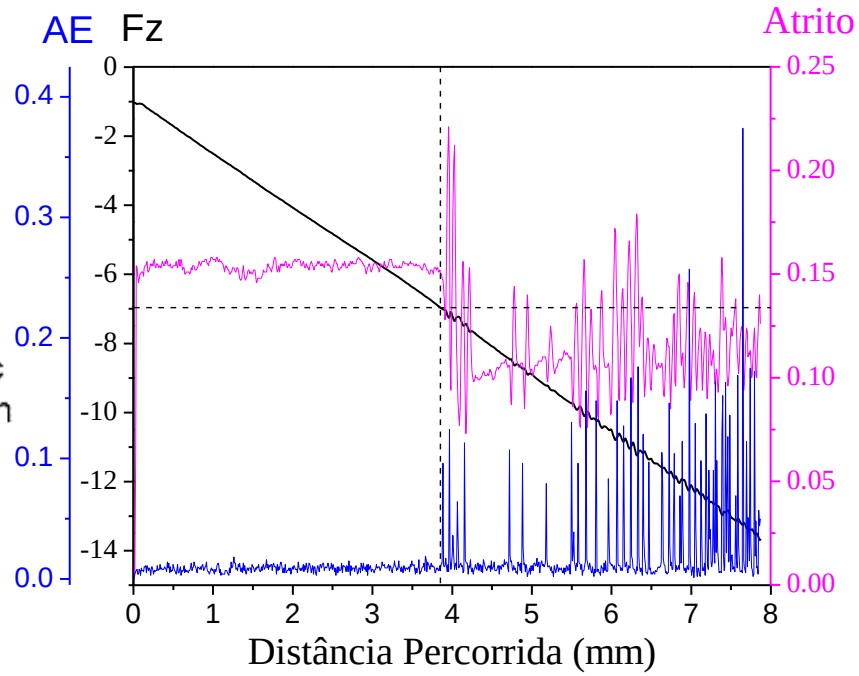


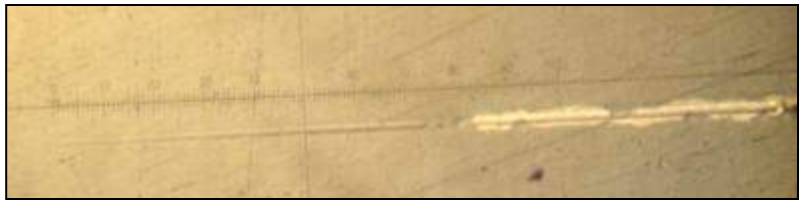
- Ti6Al4V plate – substrate;
- PECVD;
- Pressure: $8x10^{-2}$ Torr;
- 3 µm thickness;
- 40 – 200 nm Silver Nanoparticles

	Precursor	Time	Self-bias (V)
Cleaning	Argon	30 min	700
Silicon Interlayer	Silicon	10 min	700
DLC Growth	Hexane	2 hours	400
DLC Ag Growth	Hexane with NanoSilver	2 hours	400

Scratching Test



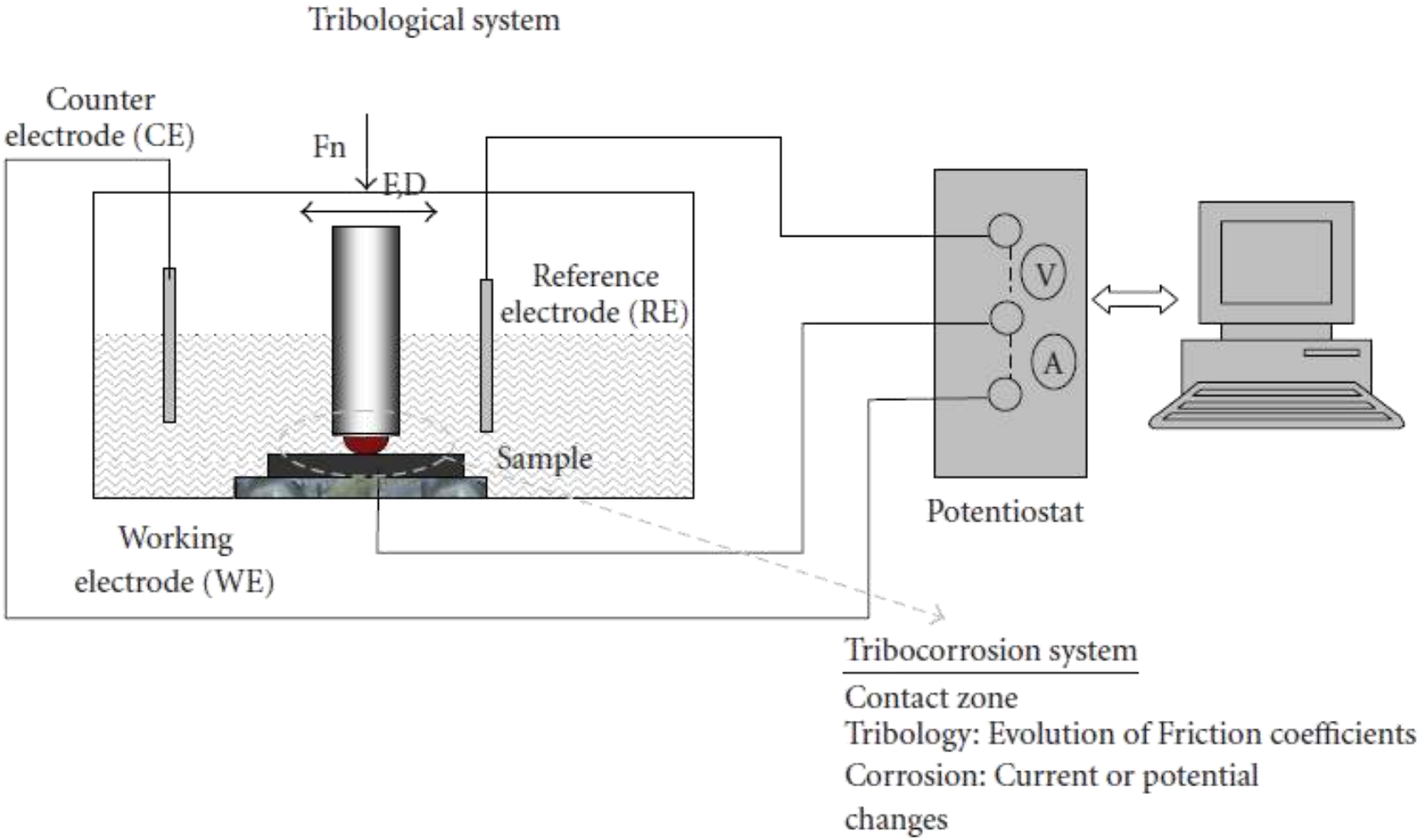




Load	2-50 N
Track Distance	10 mm
Sliding Distance	0.1 mm/s
Load Rate	0.5 N/s

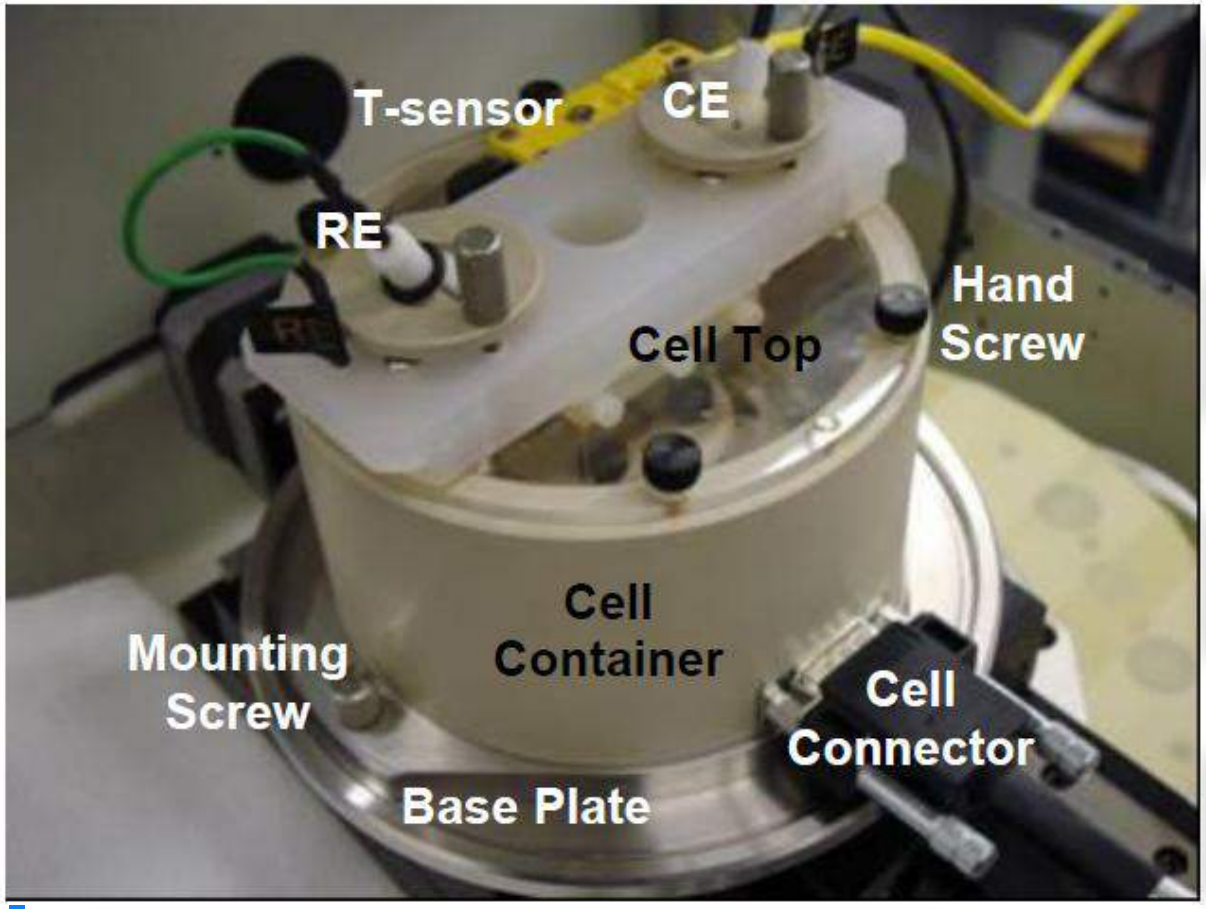
ASTM C1624

TribocorrosionTest



M. T. Mathew, P. Srinivasa Pai, R. Pourzal, A. Fischer, and M. A. Wimmer, “Significance of Tribocorrosion in Biomedical Applications: Overview and Current Status,” *Advances in Tribology*, vol. 2009, Article ID 250986, 12 pages, 2009. doi:10.1155/2009/250986

TribocorrosionTest



Load	5 N
Track Distance	2 mm
Frequency	0,5 Hz

T1: OCP Measurements

T2: Electrochemical Polarization-No-Wear

-2,5 - 2,5V

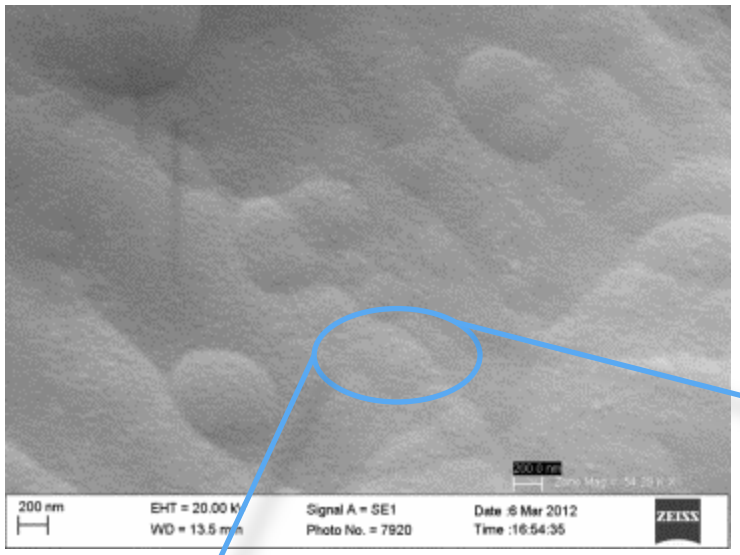
T3: Electrochemical Polarization-with-Wear

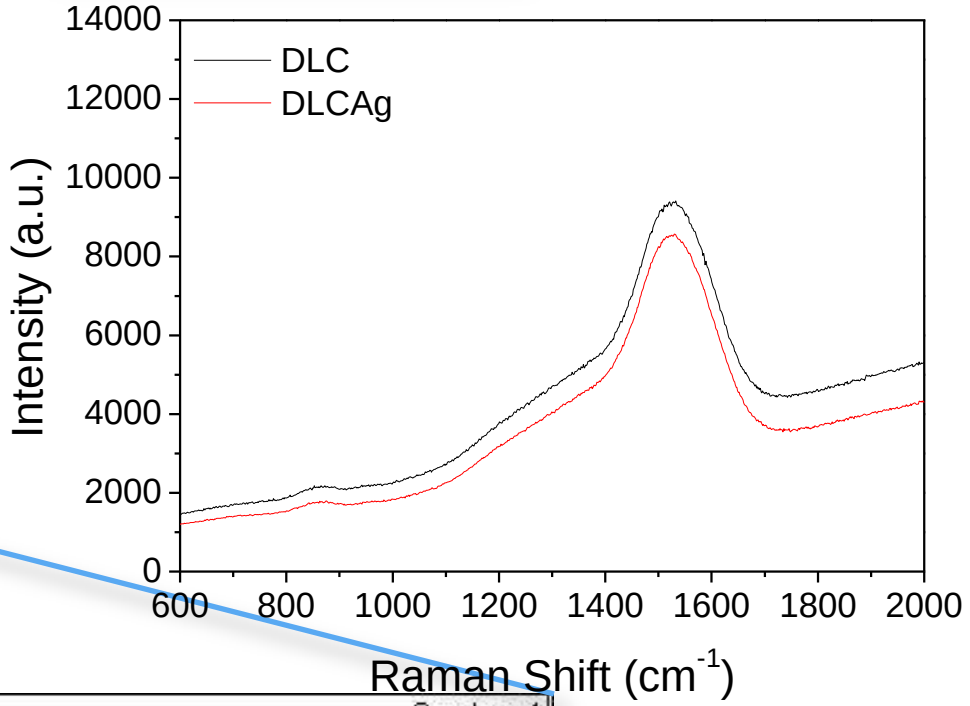
-2,5 - 2,5V

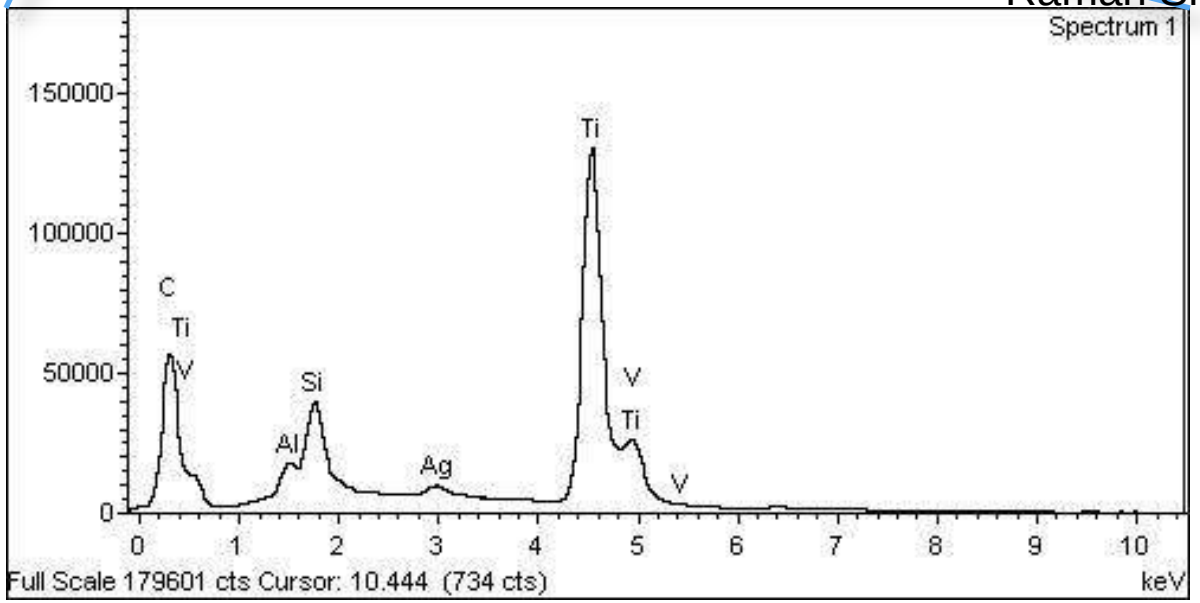
T4: Wear 1V-Cathodic

T5: Tribocorrosion

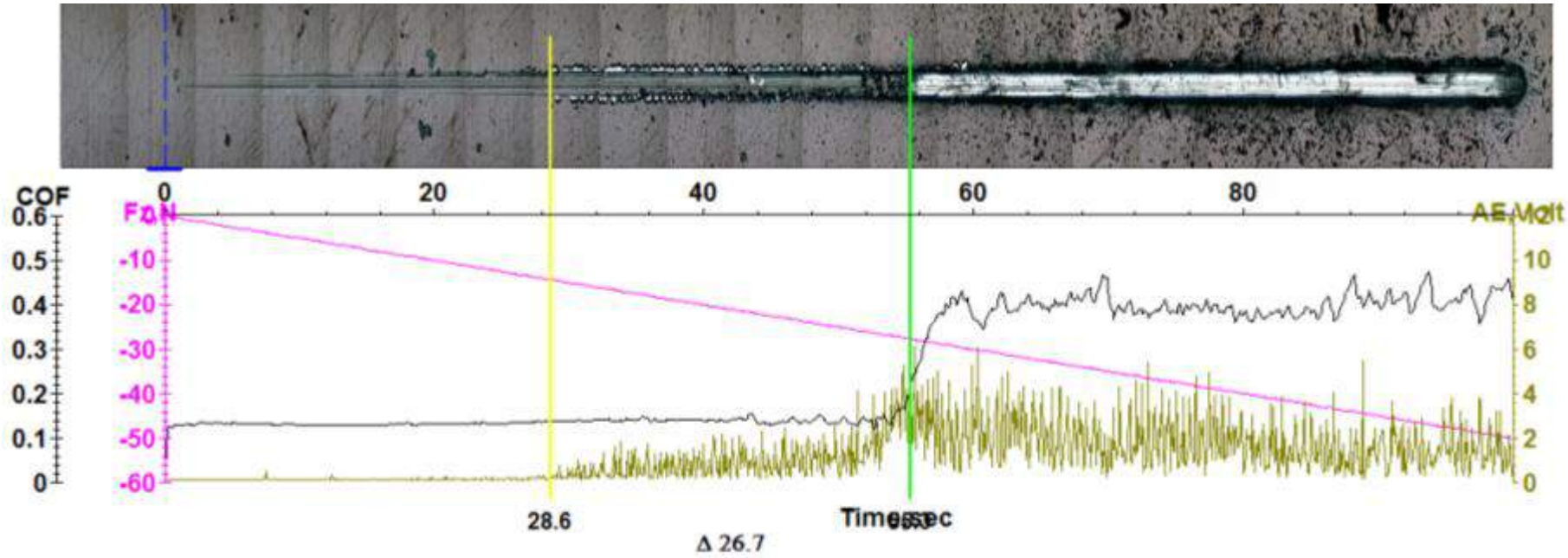
DLC


200 nm
EHT = 20.00 kV
WD = 13.5 mm
Signal A = SE1
Photo No. = 7920
Date :6 Mar 2012
Time :16:54:35
ZEISS


DLC
DLCAg
Intensity (a.u.)
Raman Shift (cm-1)
14000
12000
10000
8000
6000
4000
2000
0
600
800
1000
1200
1400
1600
1800
2000

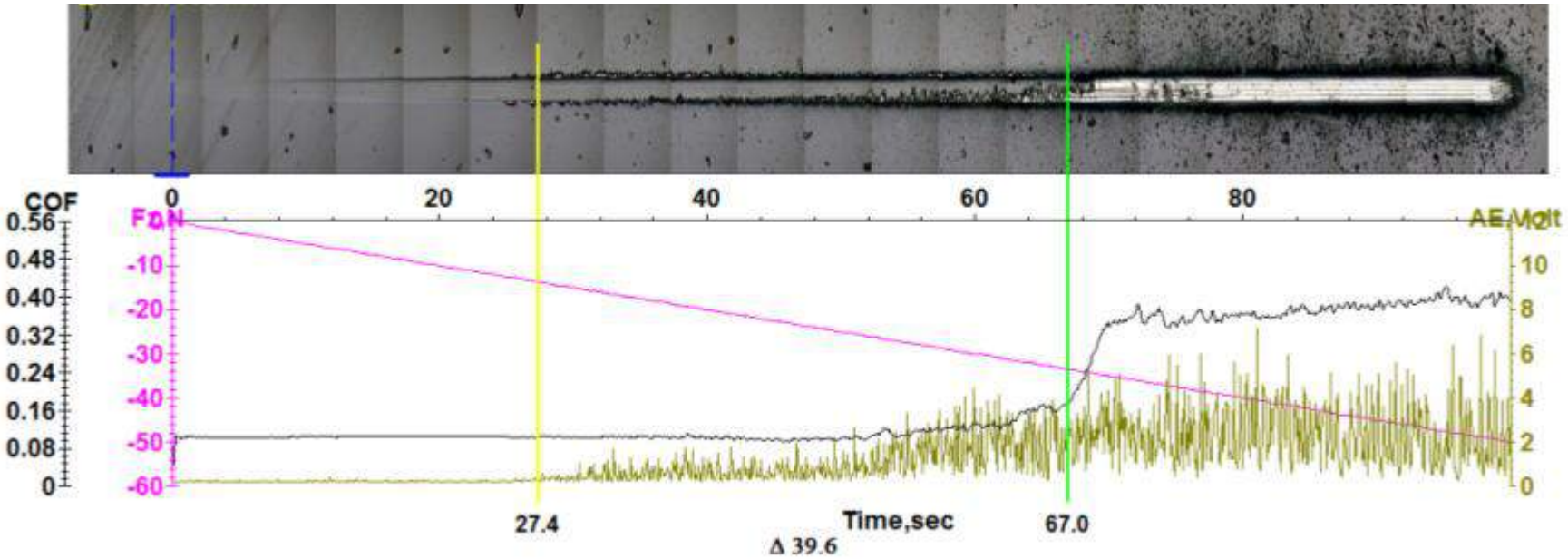

Spectrum 1
C
Ti
V
Al
Si
Ag
Ti
V
Ti
V
150000
100000
50000
0
0
1
2
3
4
5
6
7
8
9
10
Full Scale 179601 cts Cursor: 10.444 (734 cts)
keV

Scratching Test : DLC



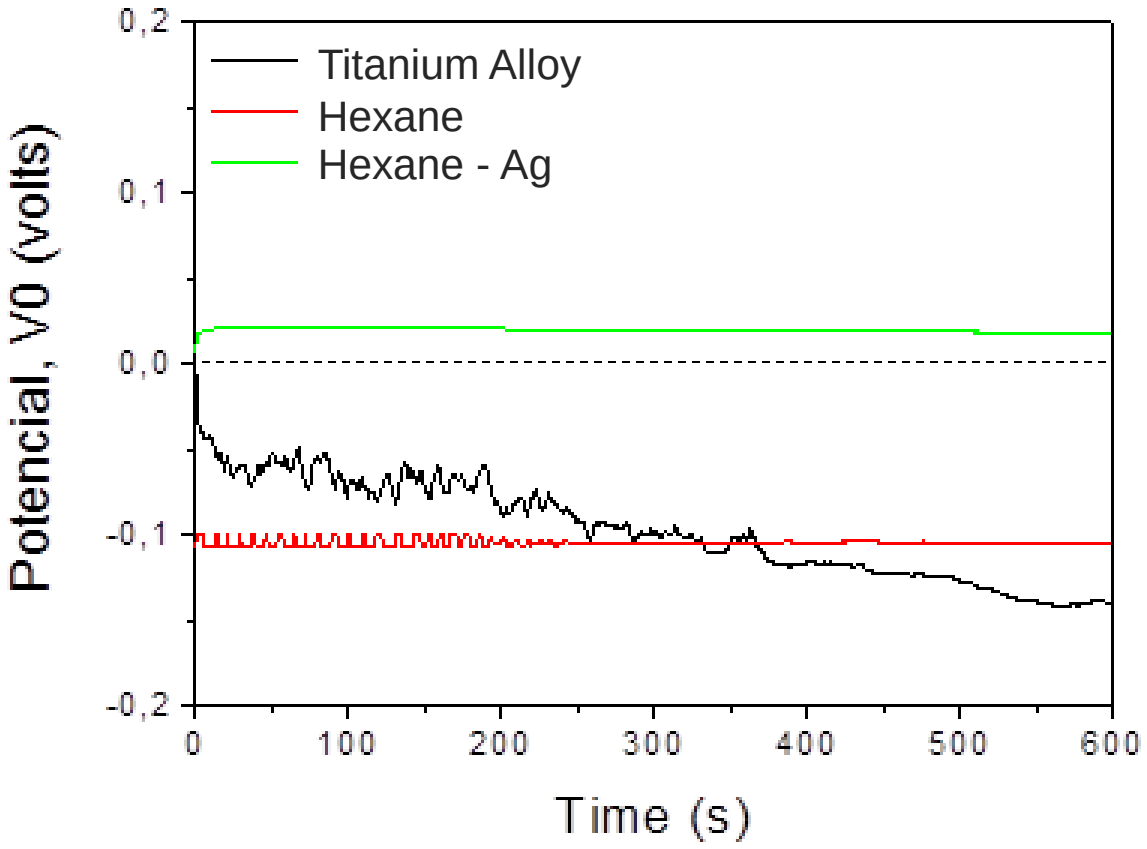
Hexane	
LC1	14,31 N
LC2	27,81 N

Scratching Test : DLC-Ag



Hexane - Ag	
LC1	14,31 N
LC2	33,27 N

Open Circuit Potential Measurements



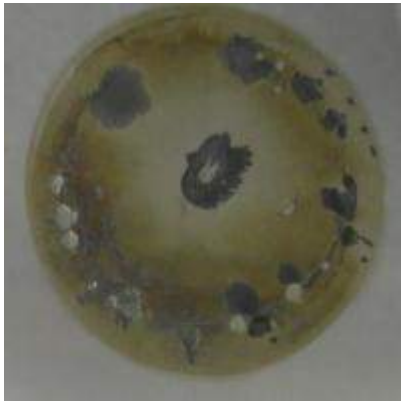
Electrochemical Polarization-No-Wear

Alloy Ti6Al4V

Ti-DLC

Ti-DLC-Ag

Electrochemical Polarization-with-Wear



Alloy Ti6Al4V

Ti-DLC

Ti-DLC-Ag

Wear 1V-Cathodic

Alloy Ti6Al4V

Ti-DLC

Ti-DLC-Ag

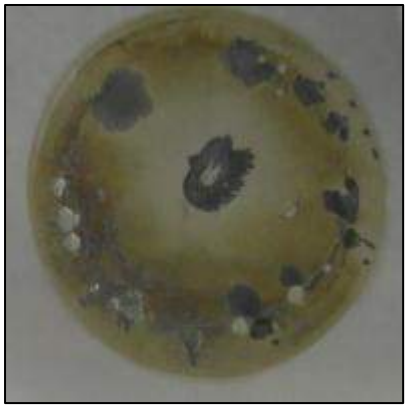
Tribocorrosion

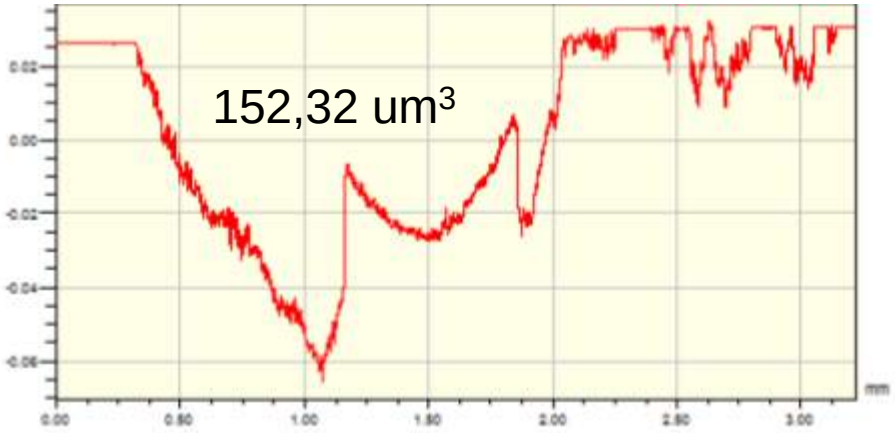
Alloy Ti6Al4V

Ti-DLC

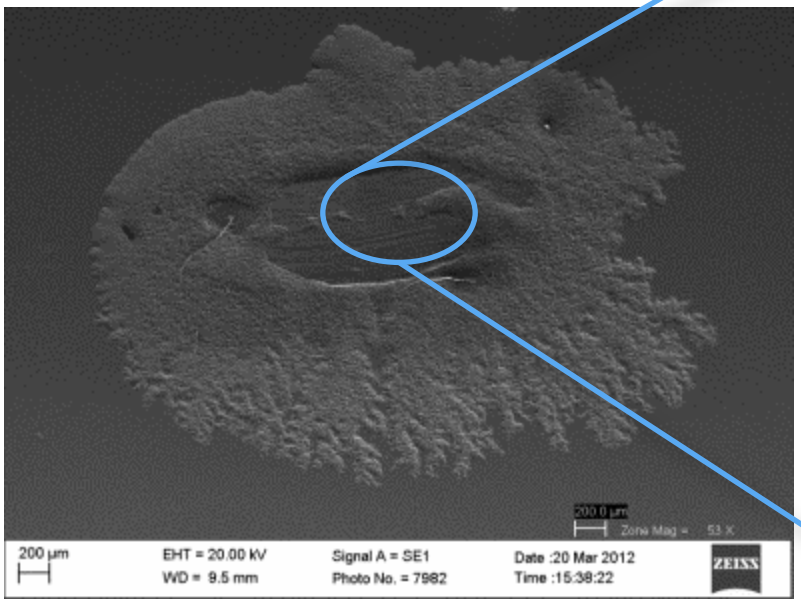
Ti-DLC-Ag

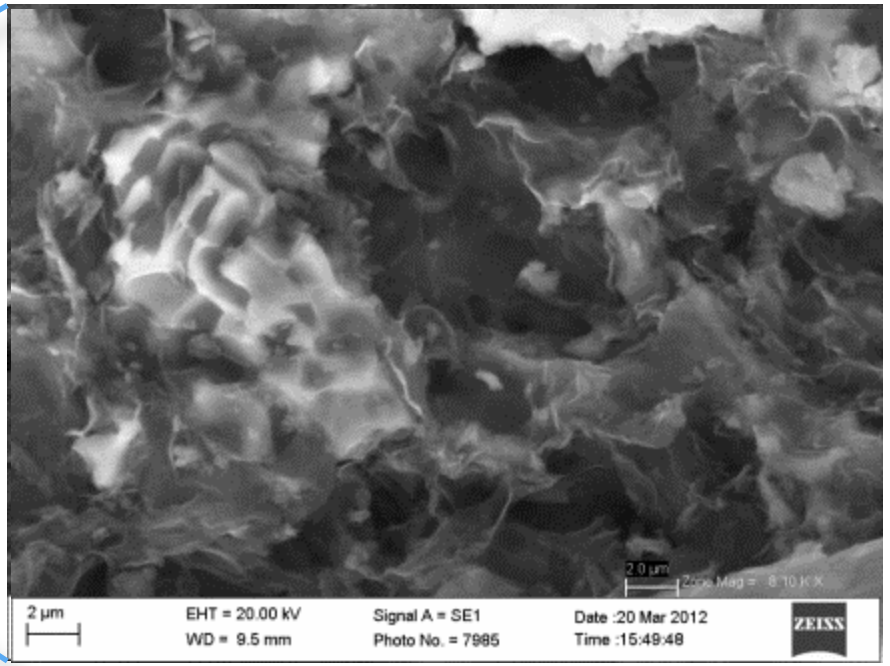
Titanium Alloy - Electrochemical Polarization-with-Wear



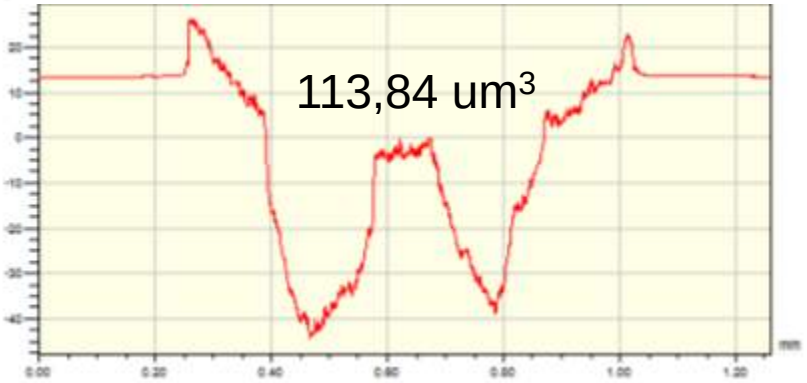


μ: 0,33

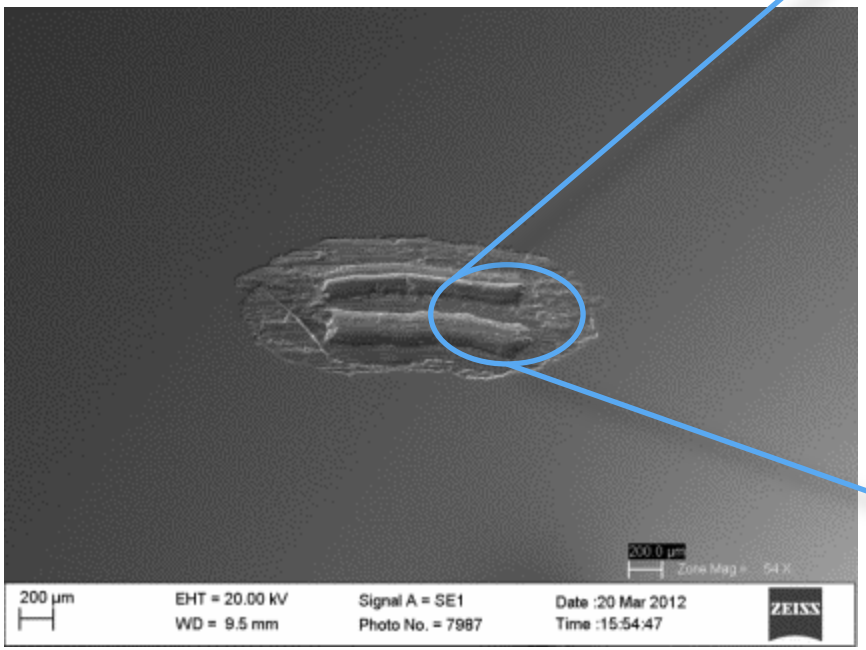


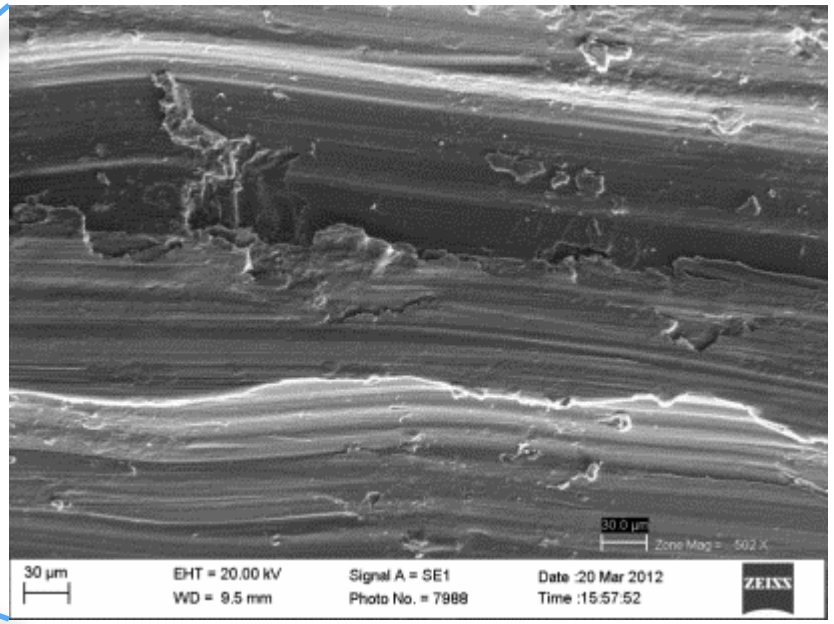


Titanium Alloy - Wear 1V-Cathodic

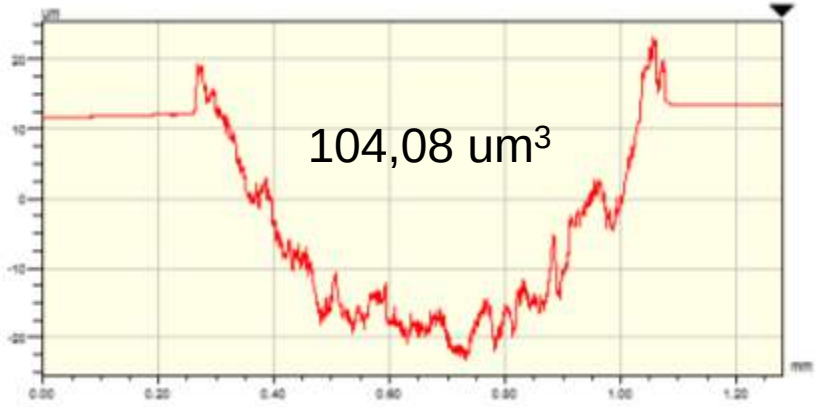


μ: 0,40

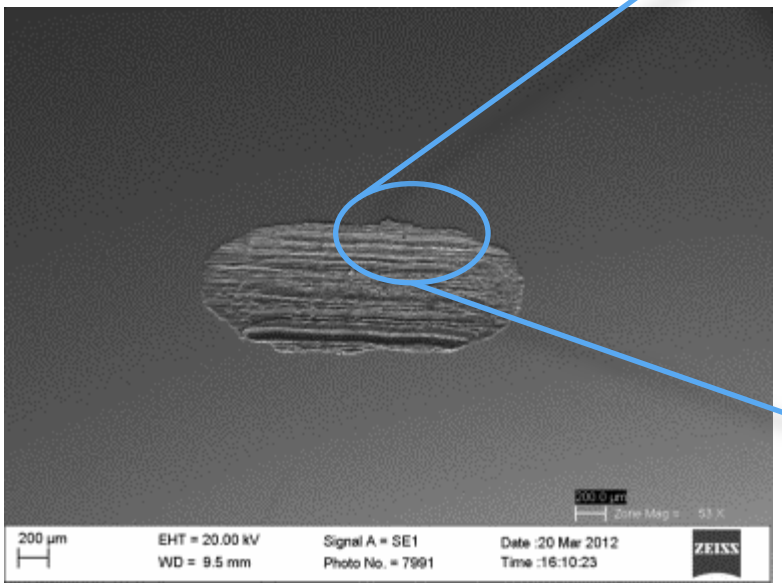


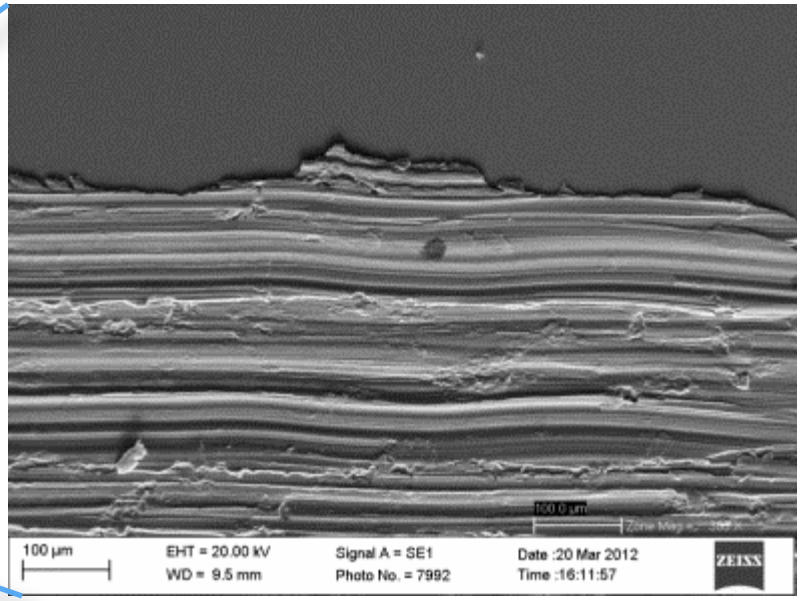


Titanium Alloy - Tribocorrosion



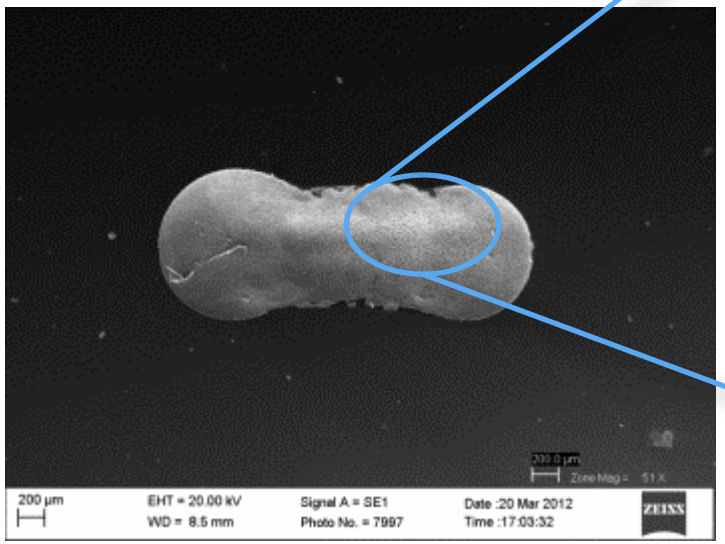
μ: 0,32

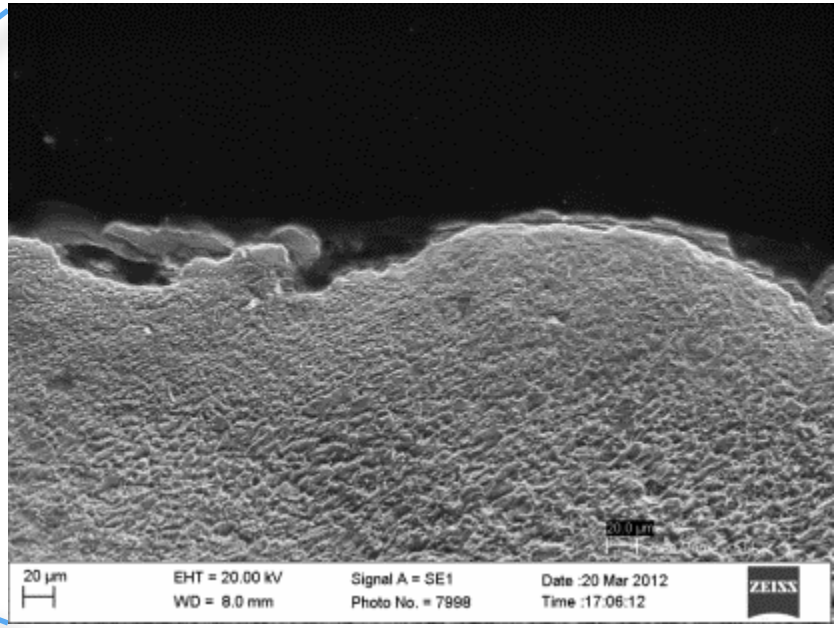




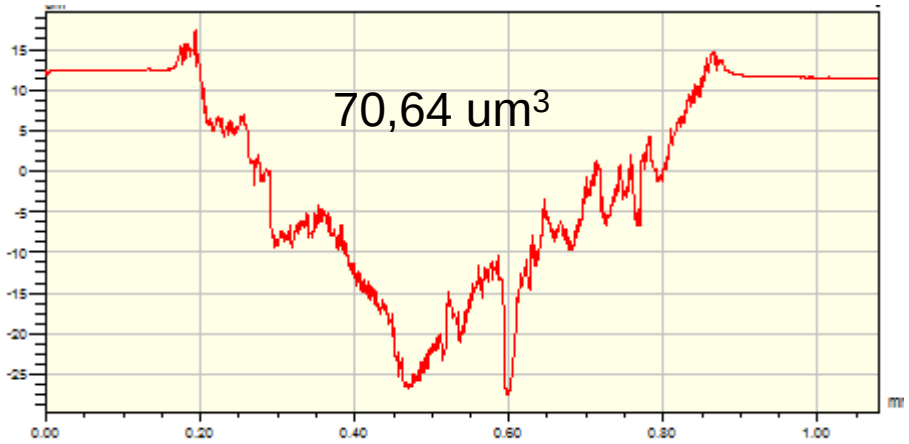
DLC- Electrochemical Polarization-with-Wear

μ: 0,09

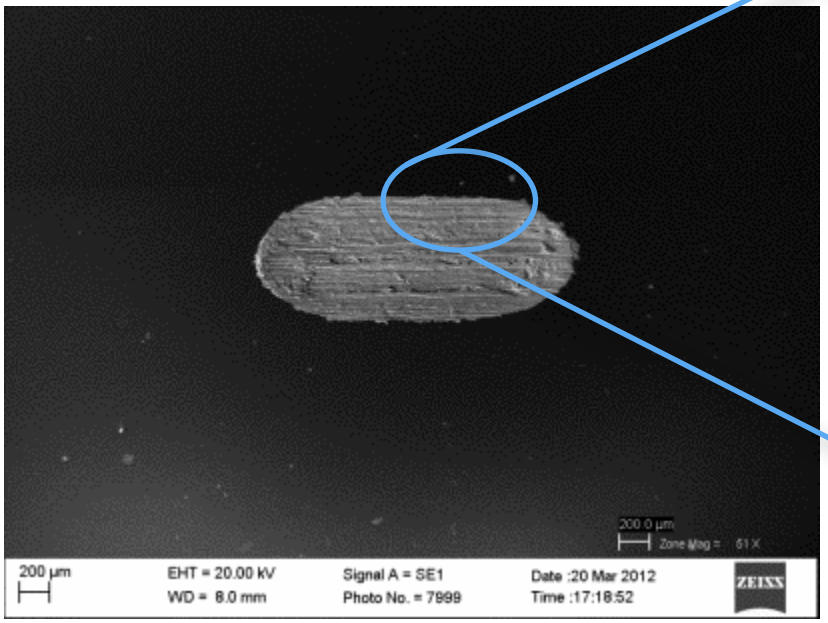


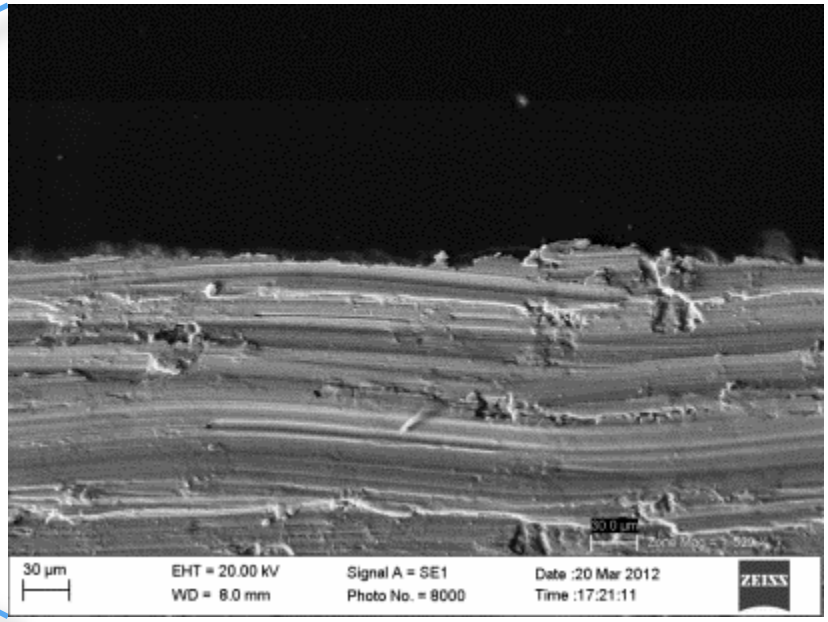


DLC-Wear 1V-Cathodic



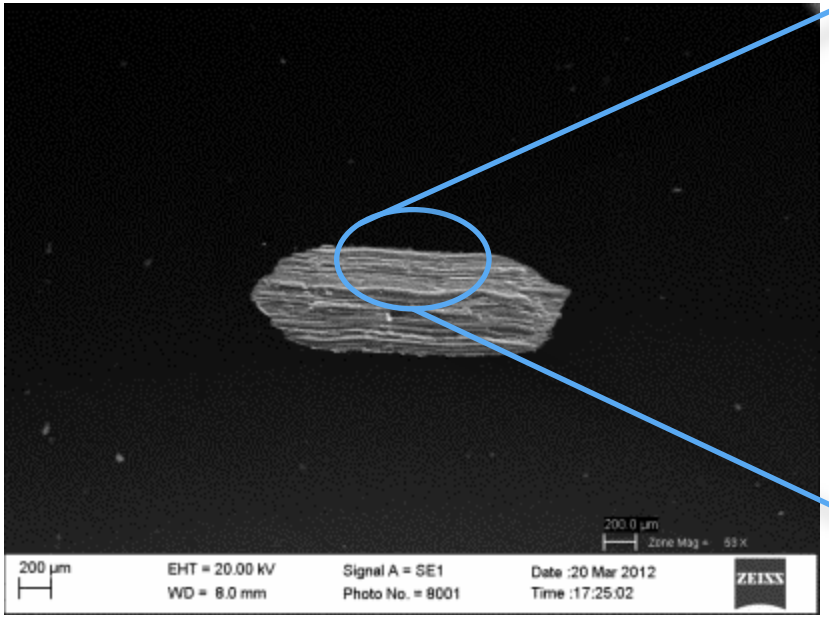
μ: 0,25

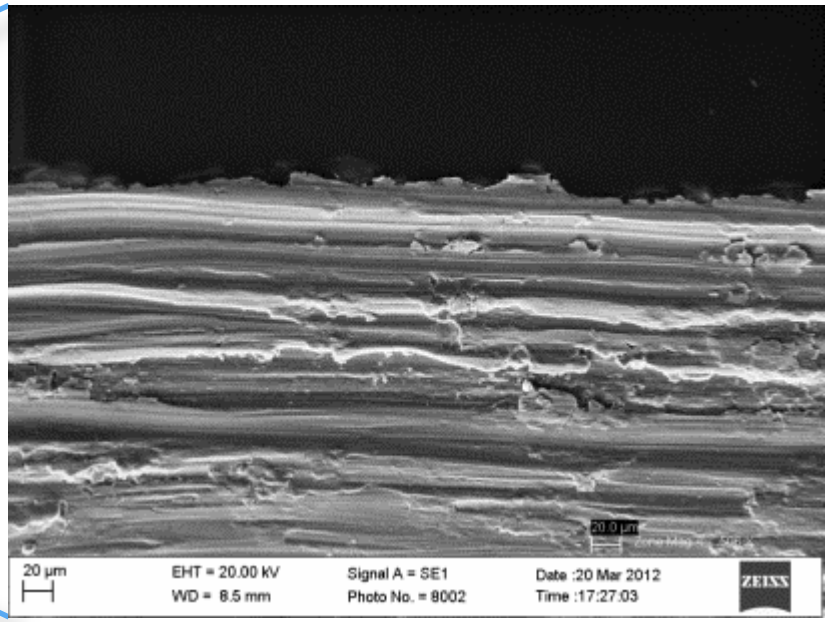




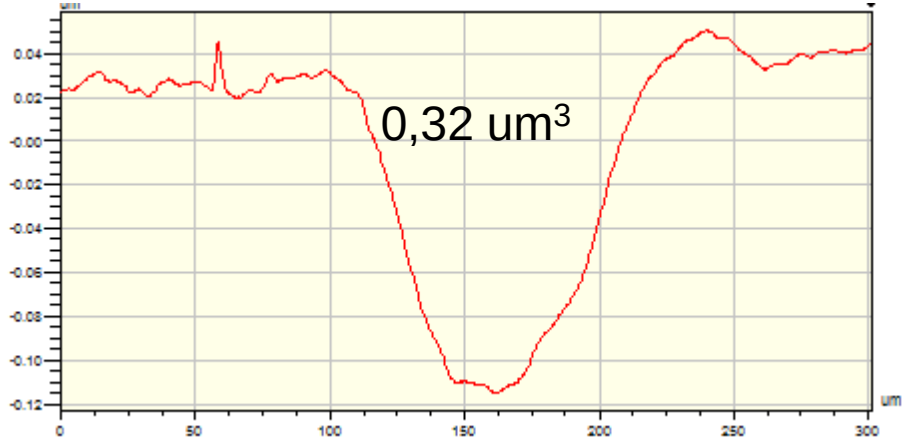
DLC-Tribocorrosion

μ: 0,32

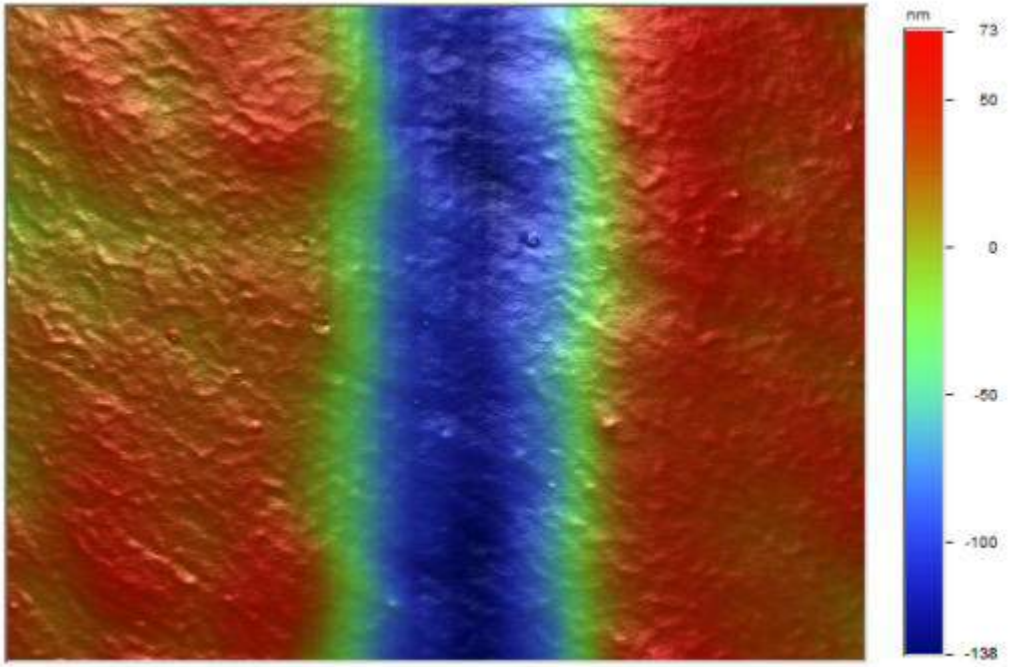




DLC-Ag: Electrochemical Polarization-with-Wear

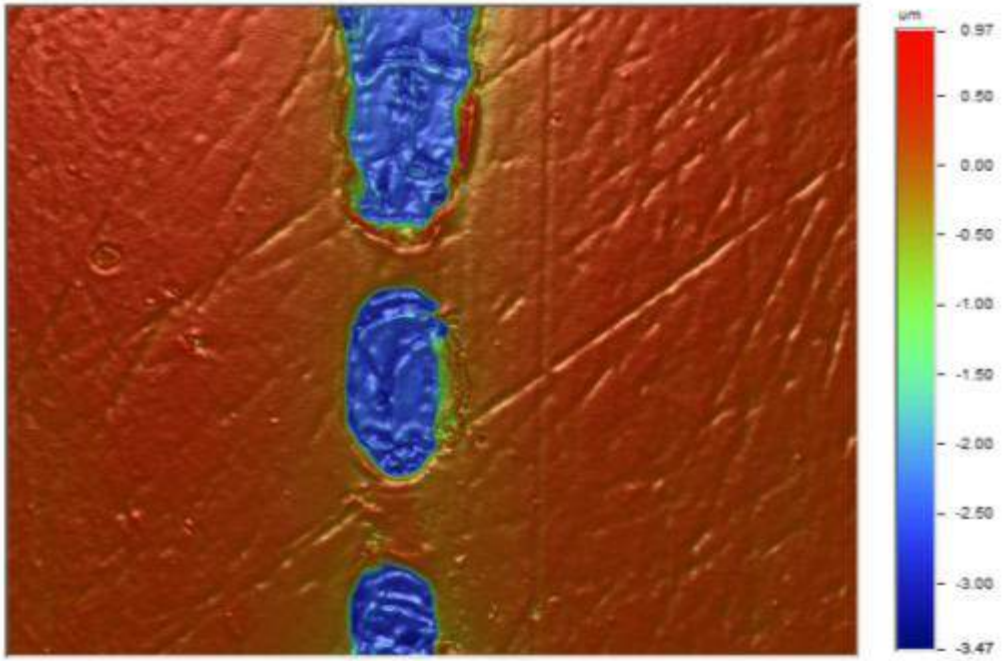


μ: 0,07



DLC-Ag: Wear 1V-Cathodic

μ: 0,08



DLC-Ag: Tribocorrosion

μ: 0,08

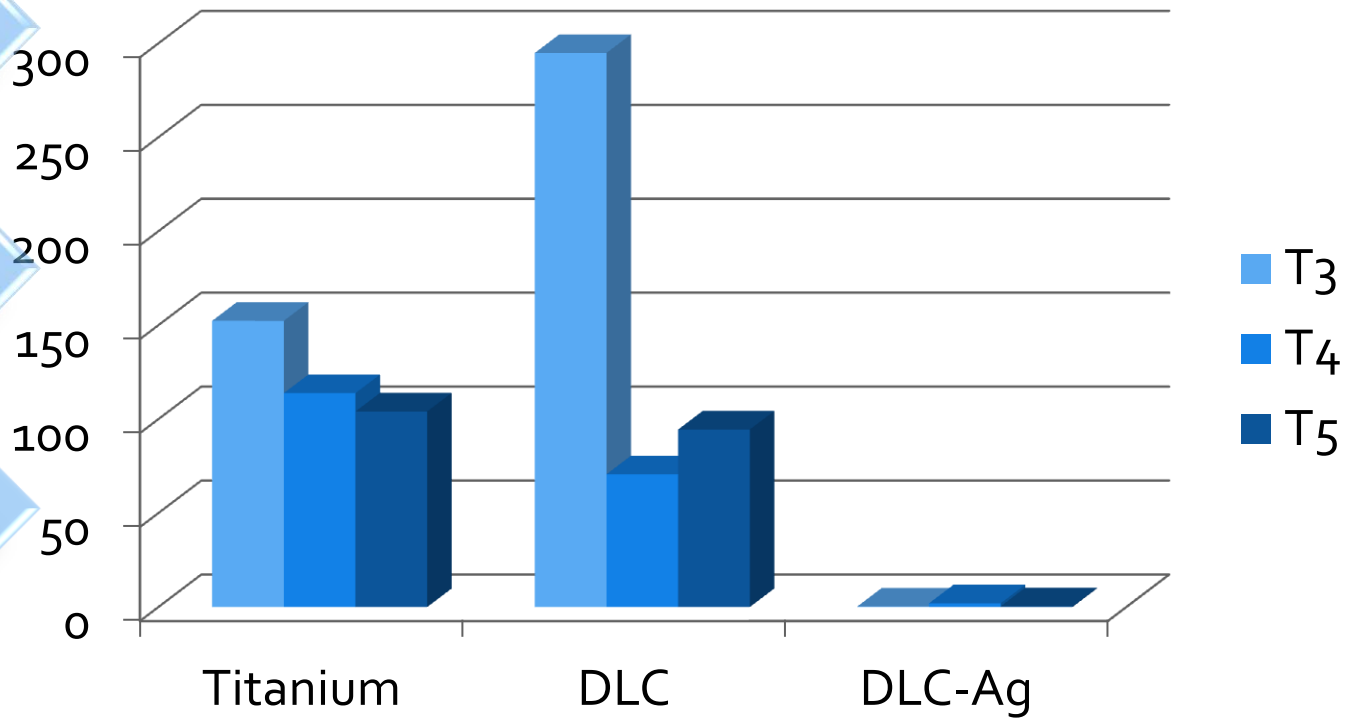
Conclusions – Wear Volume

T3: Electrochemical Polarization-with-Wear

-2,5 - 2,5V

T4: Wear 1V-Cathodic

T5: Tribocorrosion



	Titanium	DLC	DLC-Ag
T3	152,32	294,88	0,32
T4	113,84	70,64	2
T5	104,08	94,48	0,4

Conclusions – Protective efficiency

$$Ef(\%) = \left[1 - \left(\frac{i_{corr}}{i^{0}_{corr}}\right)\right] x100$$

filme

substrato

EFICIÊNCIA PROTETIVA (%)		
Filme	PE	PE+A
DLC	15	2
DLC-Ag	19	2

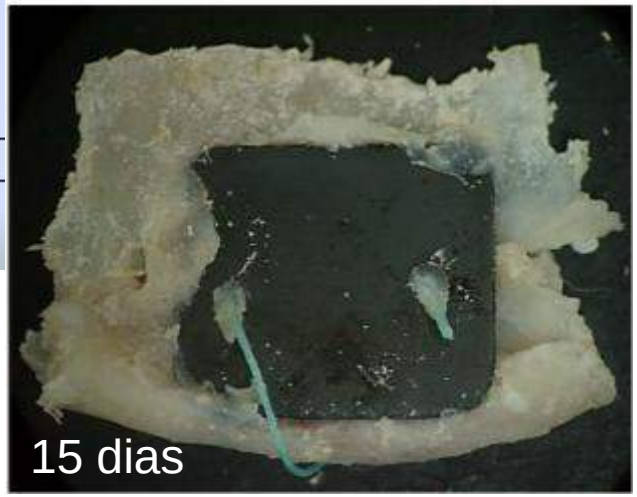
Aplicação

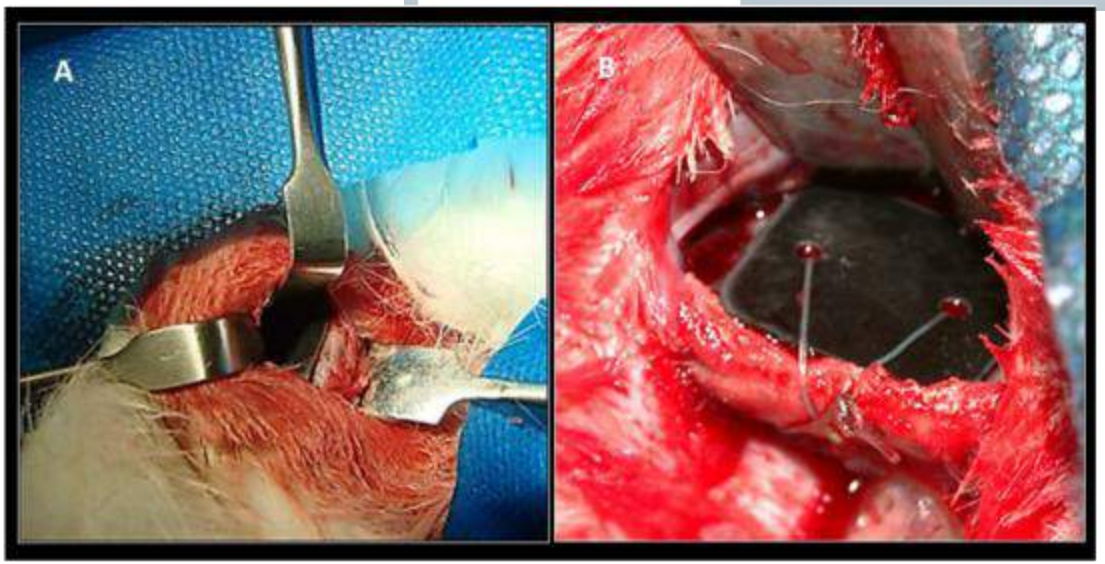
Prótese de estoque W. Lorenz

Prótese Customizada - TMJ Concept

Aplicação

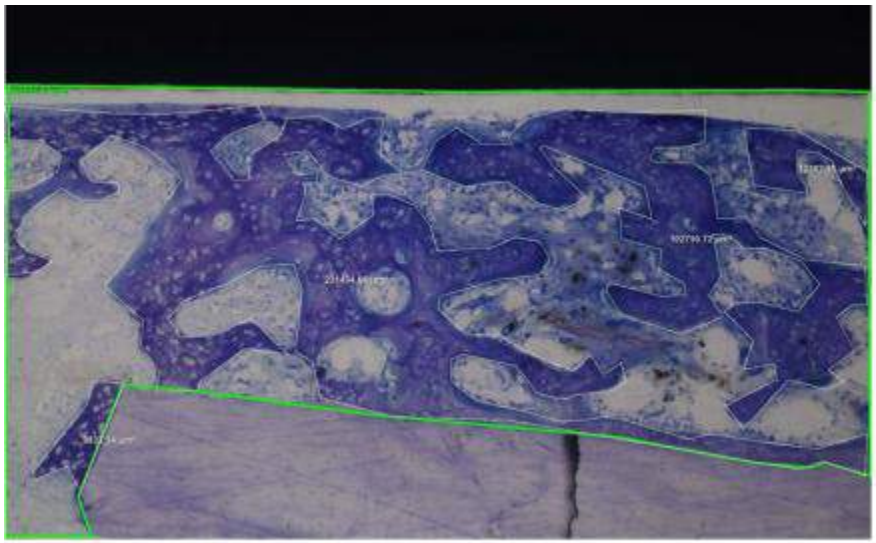
50 AMOSTRAS ($Ti6Al_4V$)
15 COM DLC
15 DLC-Ag
20 CONTROLES



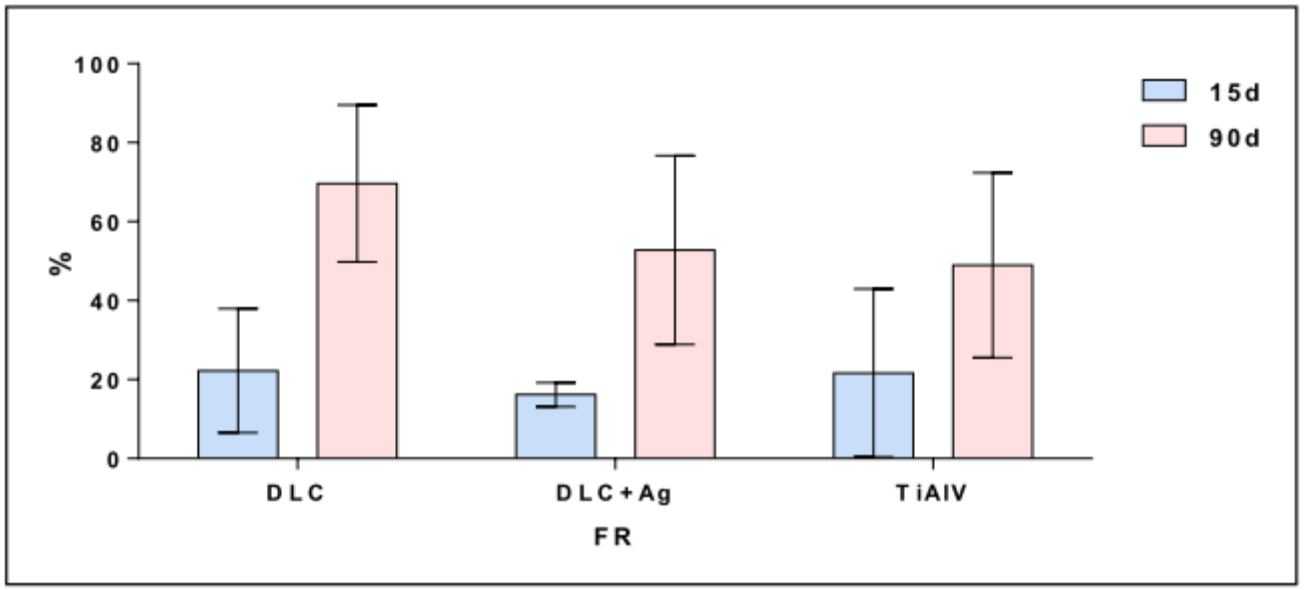


A) Amostra posicionada no osso na região do ângulo mandibular do coelho; e B) Amostra fixada.

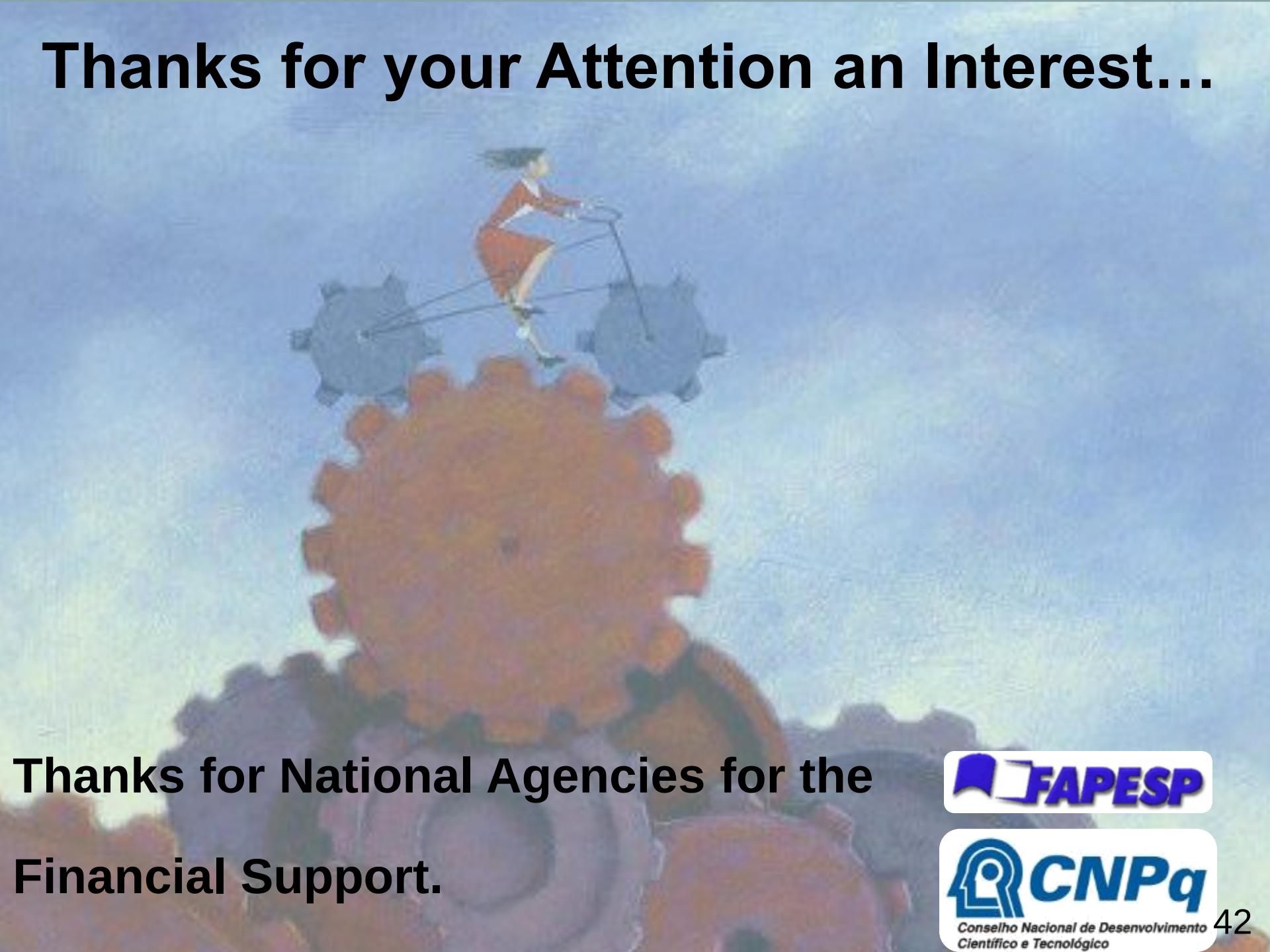
Neoformação óssea



Corados em azul de toluidina, mostrando linha verde delimitando área total da interface osso-amostra e linha branca contornando áreas de neoformação óssea. Aumento original de 10x.



Thanks for your Attention an Interest…



Thanks for National Agencies for the Financial Support.

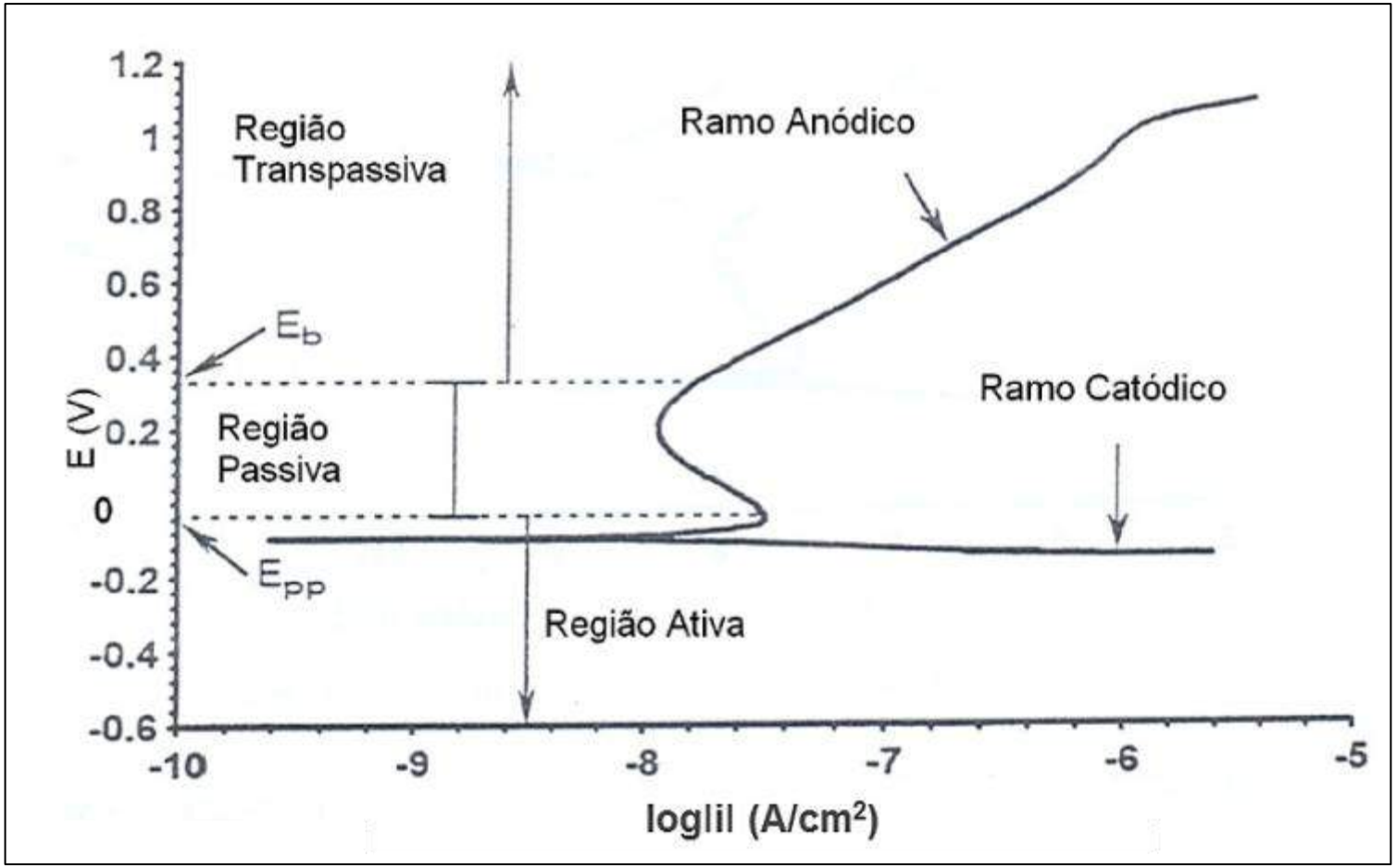
FAPESP

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico

Tribocorrosão e Sinergia

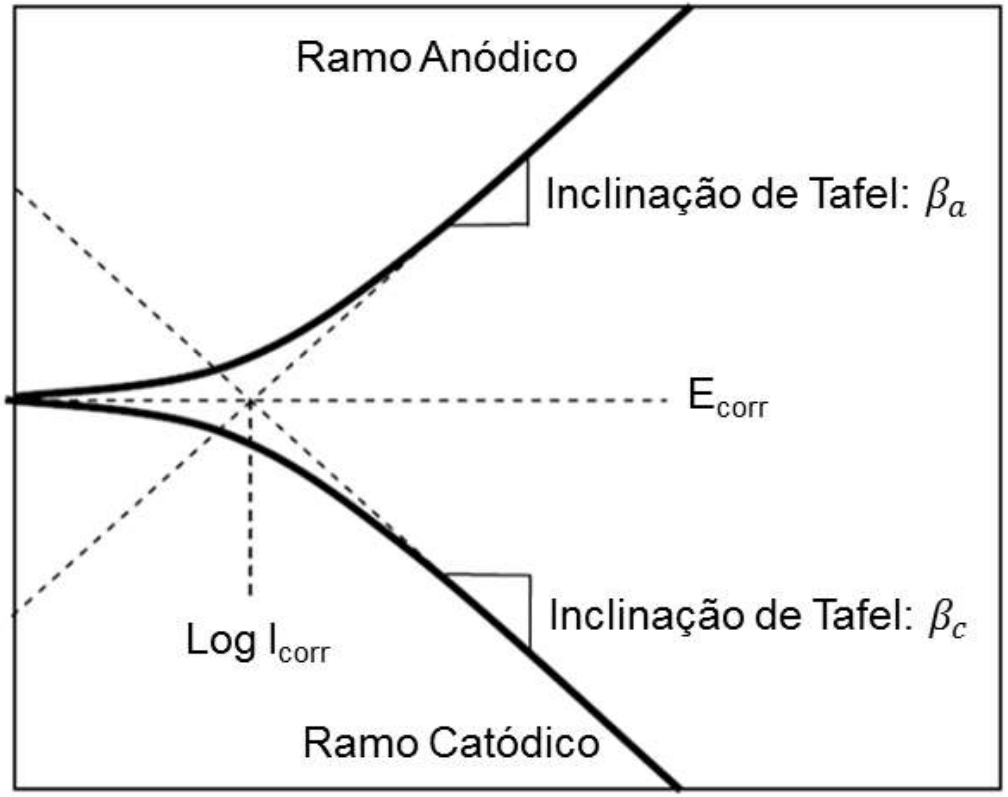
OCP	• Nem potencial e nem corrente são aplicados
Polarização Eletroquímica	• Varredura entre duas tensões determinadas
PE + desgaste	• Varredura entre duas tensões + atrito
Desgaste (+1 V)	• Atrito com proteção catódica
Tribocorrosão	• Atrito sem aplicação de potencial

Corrosão



MORONA, M. T. Ensaios Eletroquímicos e Influência da Nitretação a. Plasma na Resistência à corrosão do Aço Inoxidável ISO 5832-1. 2007. 111 f.

Extrapolação da curva de Tafel



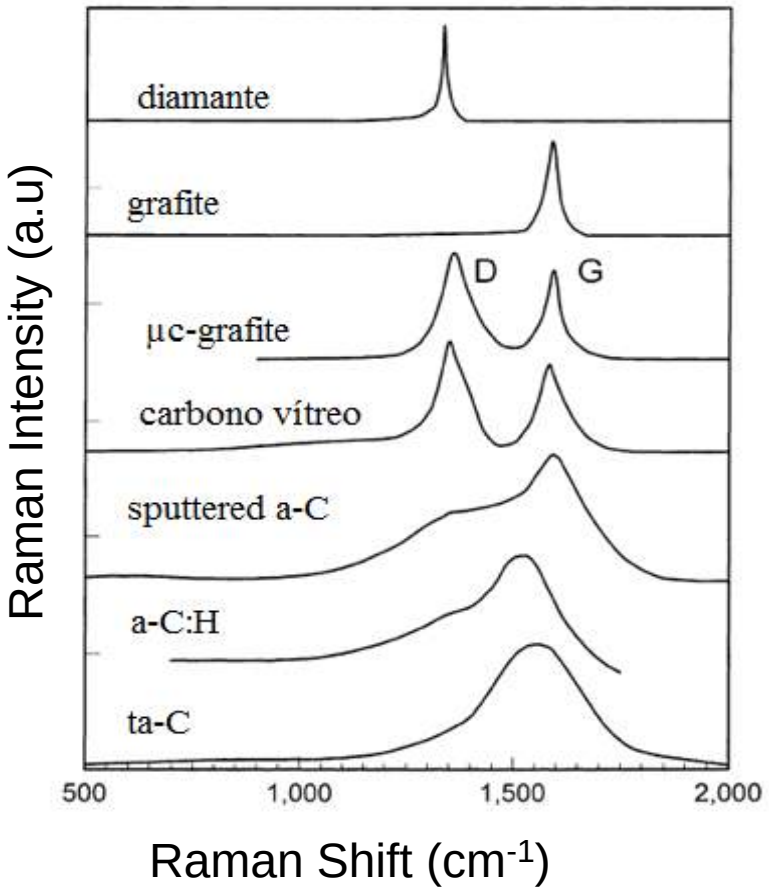
Eficiência protetiva do filme:

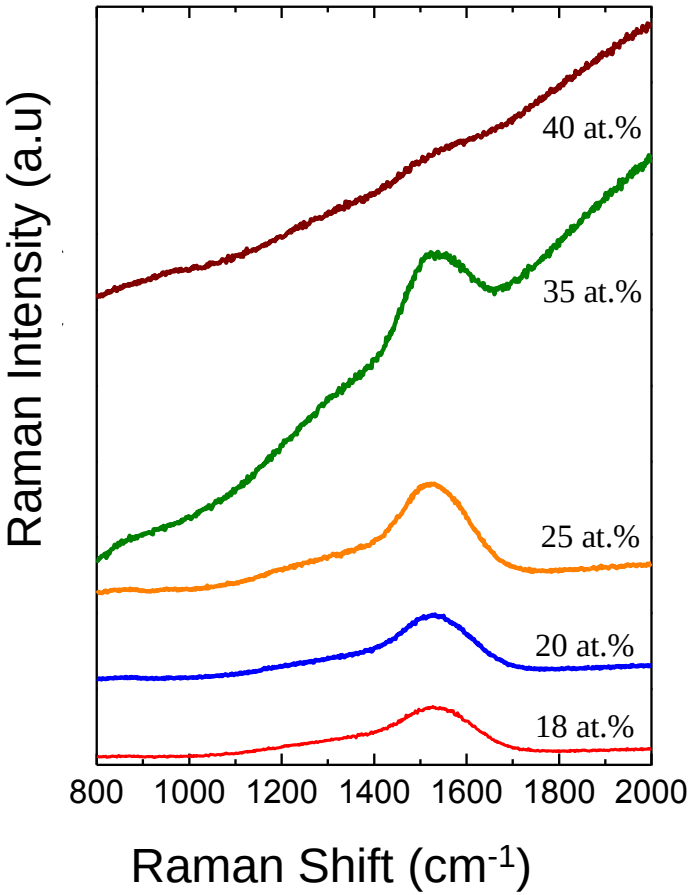
$$Ef(\%) = \left[1 - \left(\frac{i_{corr}}{i^0_{corr}}\right)\right] \text{x}100$$

i_{corr} e i^0_{corr} é a densidade de corrente de corrosão do filme e do substrato

Alberti, E.L. Desenvolvimento de técnicas de diagnóstico da corrosão de pés de torres de linhas de transmissão, por meio de aplicação de técnicas eletroquímicas. Curitiba-PR, UFPR, 2004. 94p.

Film Deposition

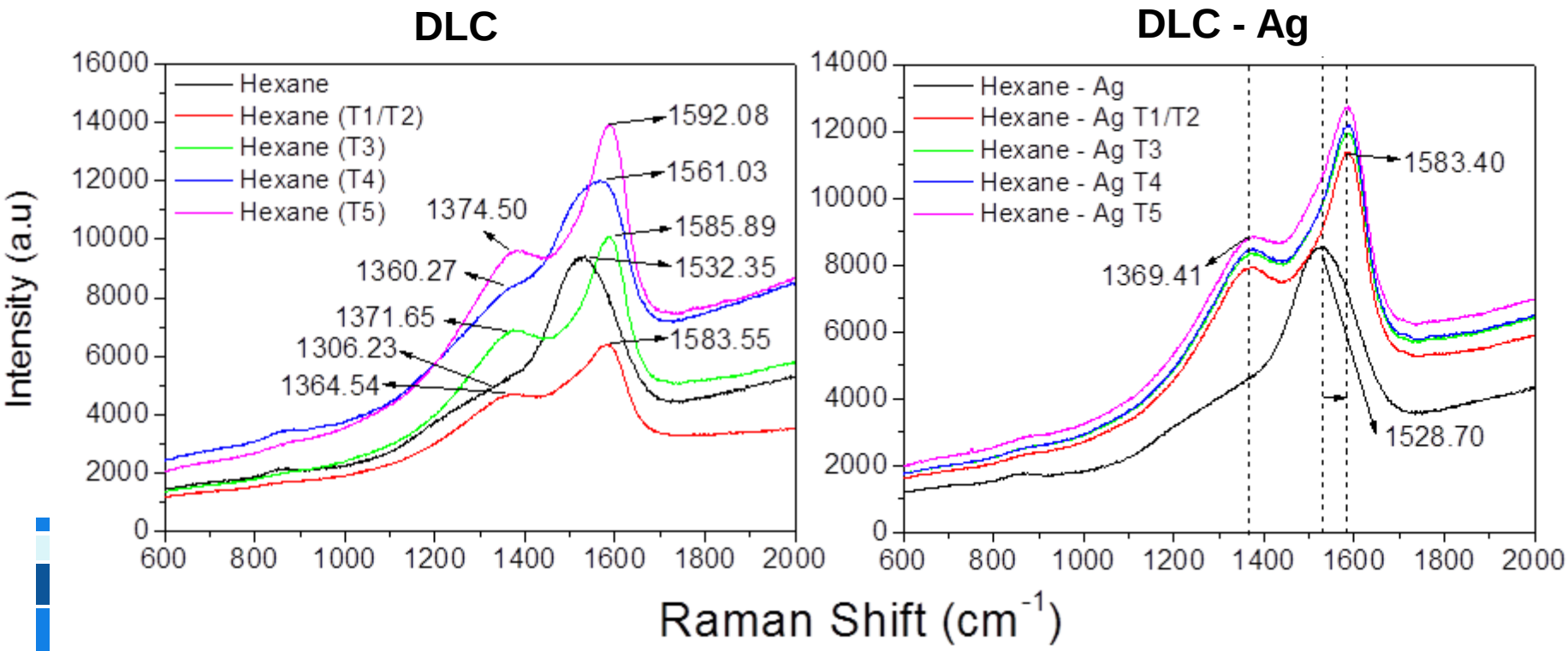




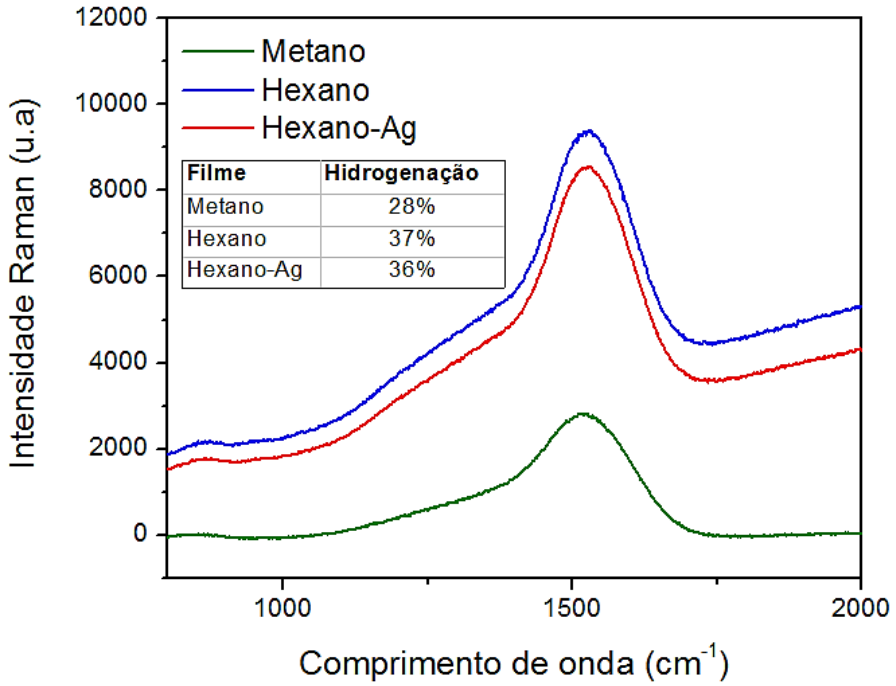
SILVA, S.R.P., ROBERTSON, J., MILNE, W.I., and AMARATUNGA, G.A.J. **Deposition mechanism of diamond-like carbon. In: Amorphous Carbon: State of the Art.** World Scientific Publishing, Singapore, 32-45.

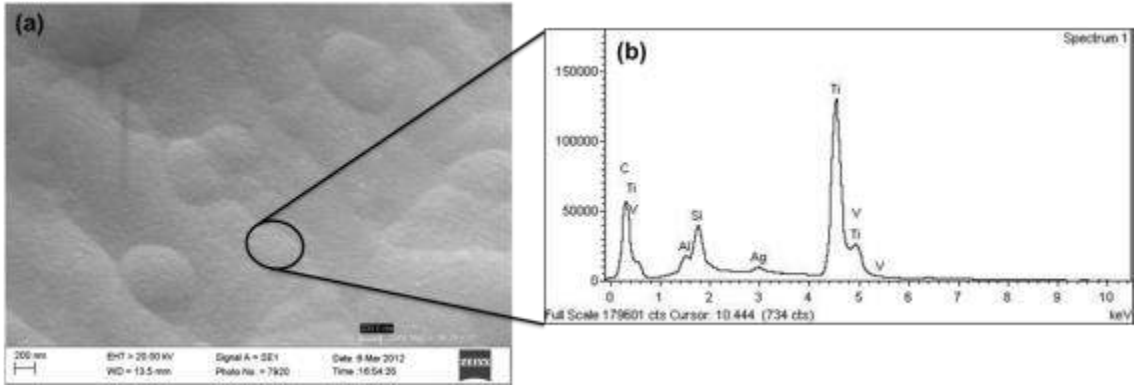
BONETTI, L. F. **Otimização das propriedades mecânicas e tribológicas de filmes de DLC crescidos sobre substratos metálicos objetivando aplicações espaciais e industriais.** Tese (Doutorado em Ciências). Instituto Tecnológico de Aeronáutica, São José dos Campos, 2008.

Raman Analyses



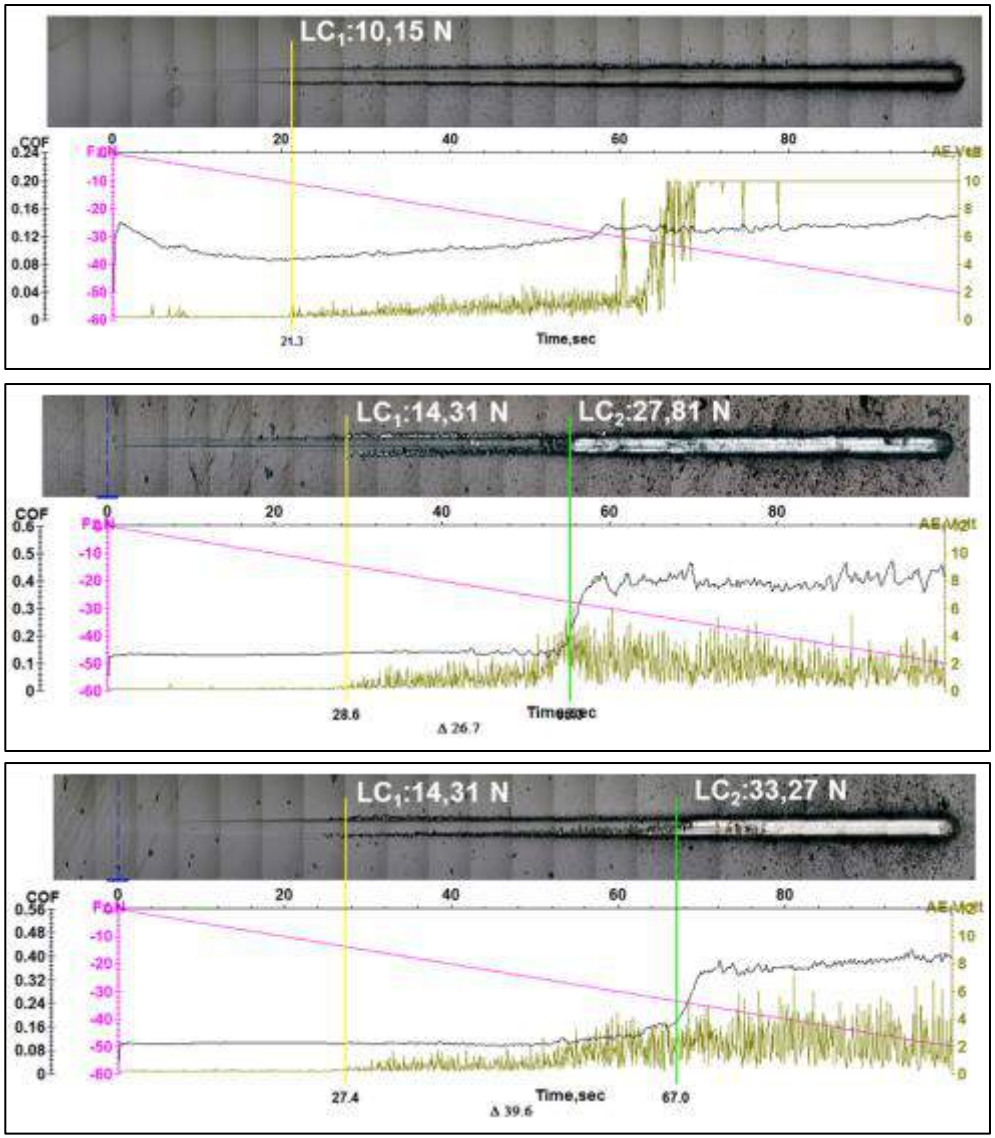
Efeito da Composição do Filme
Resistência à corrosão



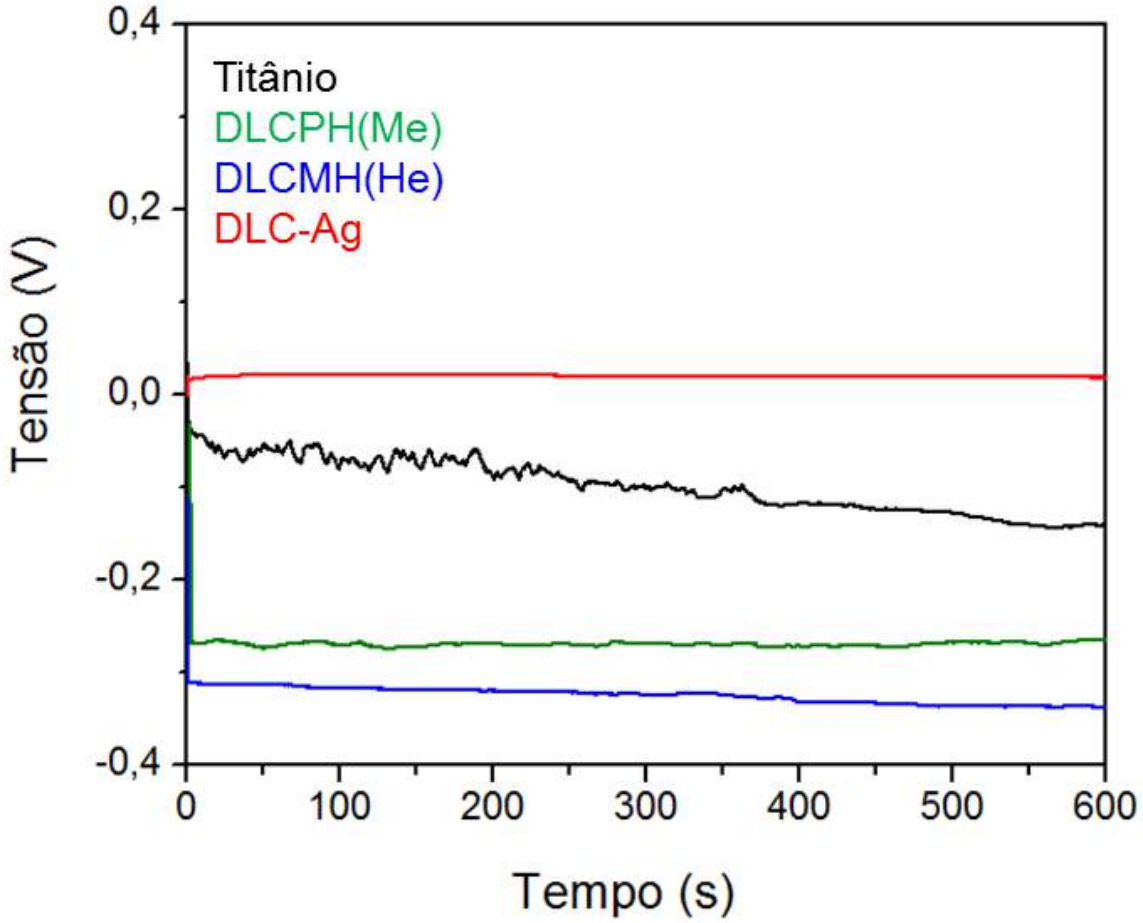


Efeito da Composição do Filme Resistência à corrosão

- DLCPH(ME)
- DLCMH(HE)
- DLC-Ag



Efeito da Composição do Filme
Resistência à corrosão - OCP



Efeito da Composição do Filme
Resistência à corrosão

Polarização Eletroquímica

Titânio	DLCPH(ME)	DLCMH(HE)	DLC-Ag

Polarização Eletroquímica + Atrito

Titânio	DLCPH(ME)	DLCMH(HE)	DLC-Ag

Efeito da Composição do Filme
Resistência à corrosão

Atrito com Potencial Cte (+1 V)

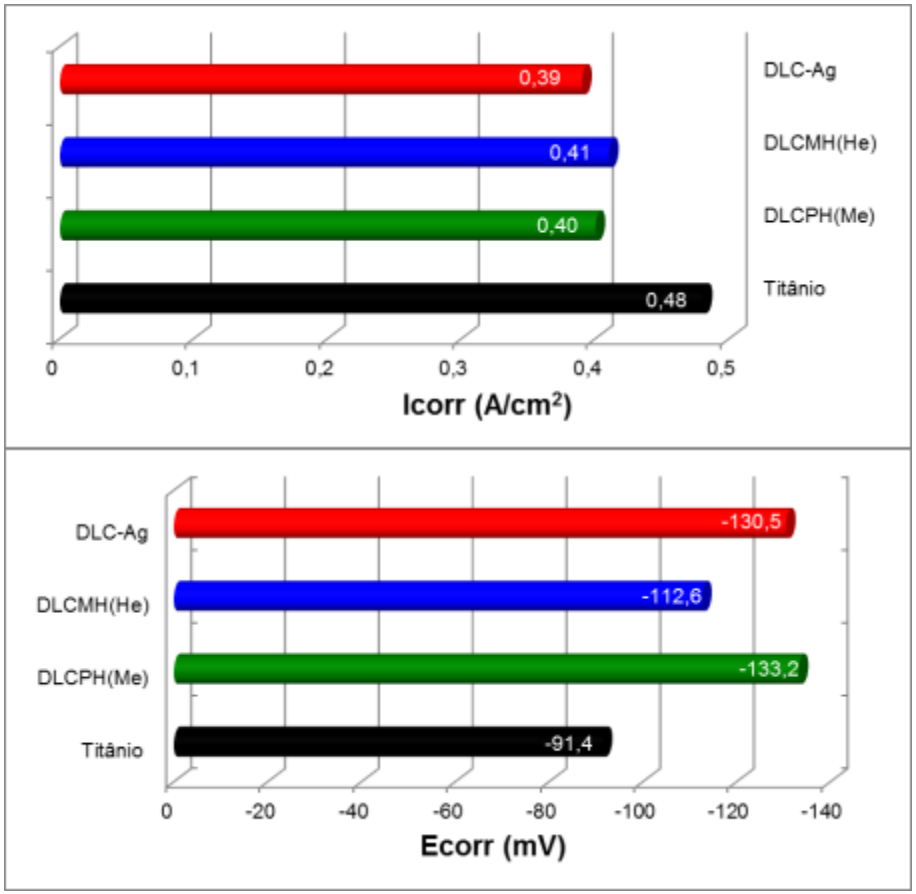
Titânio	DLCPH(ME)	DLCMH(HE)	DCL-Ag

Tribocorrosão

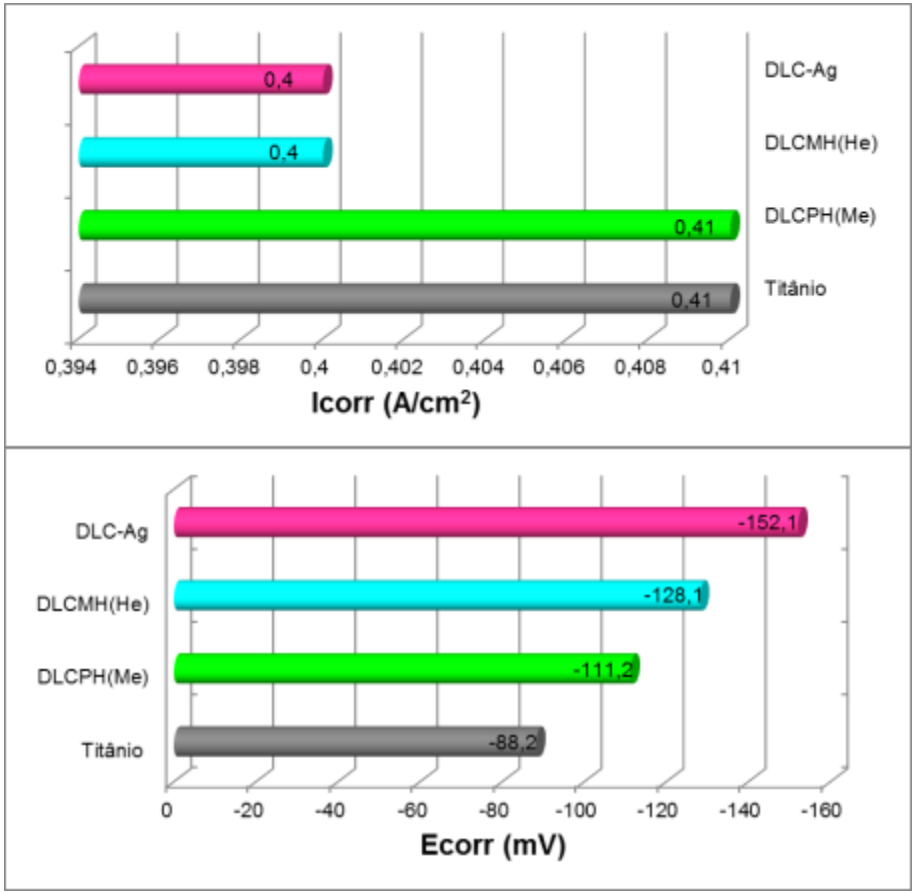
Titânio	DLCPH(ME)	DLCMH(HE)	DLC-Ag

Efeito da Composição do Filme
Resistência à corrosão

Polarização Eletroquímica



Polarização Eletroquímica + Atrito



Efeito da Composição do Filme Resistência à corrosão

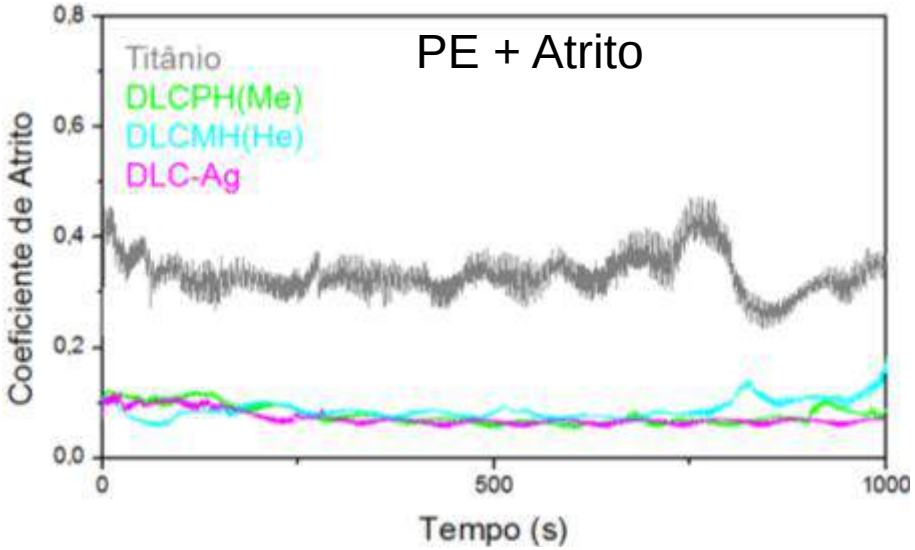
Polarização Eletroquímica

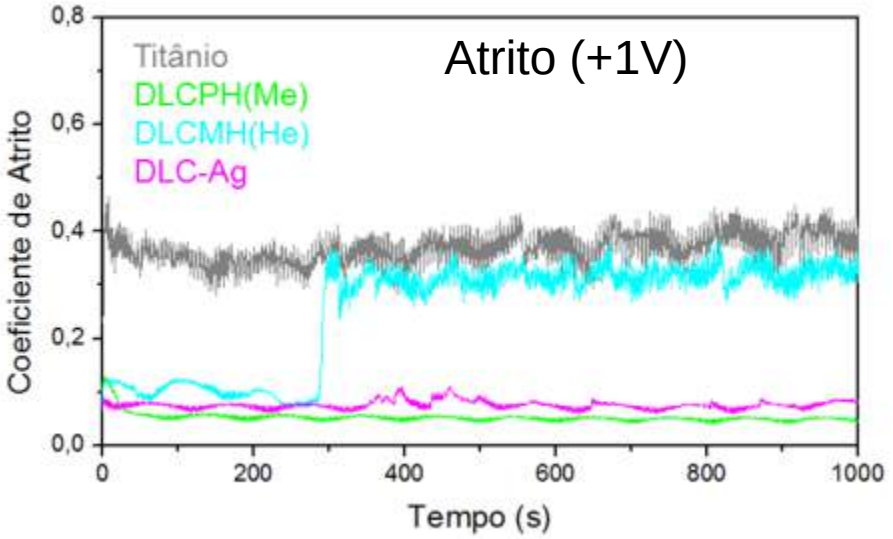
Filme	Eficiência Protetiva (%)
DLCPH(Me)	17
DLCMH(He)	15
DLC-Ag	19

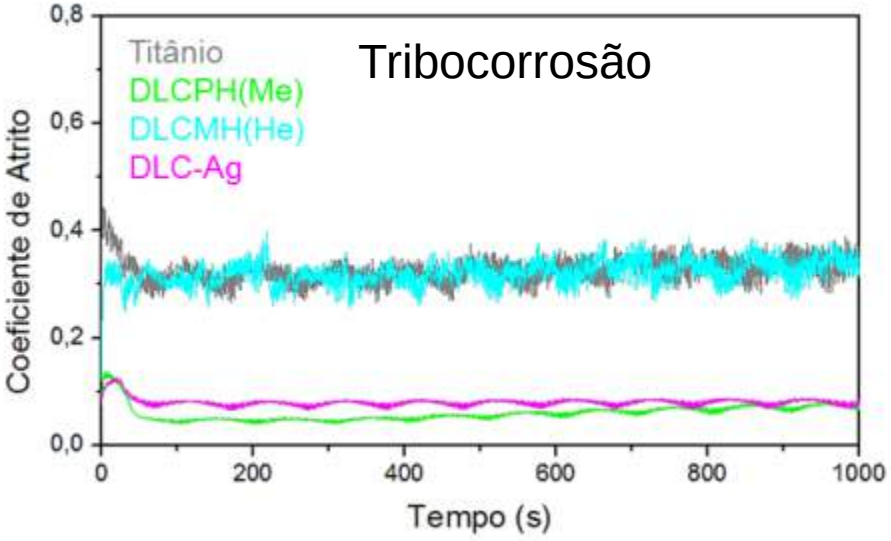
Polarização Eletroquímica + Atrito

Filme	Eficiência Protetiva (%)
DLCPH(Me)	0
DLCMH(He)	2
DLC-Ag	2

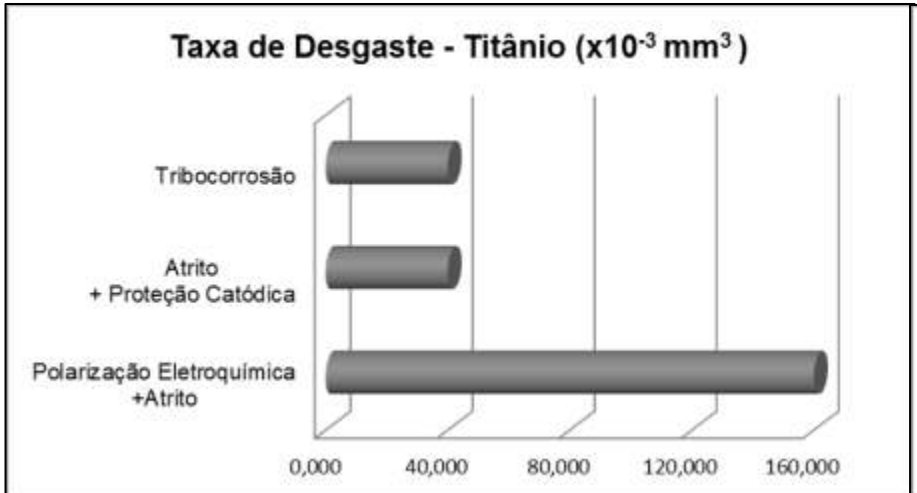
Efeito da Composição do Filme
Resistência à corrosão

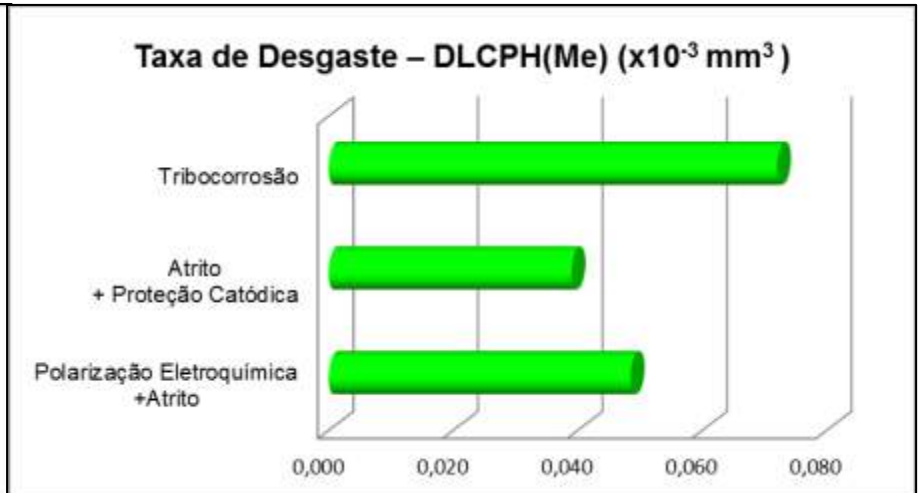


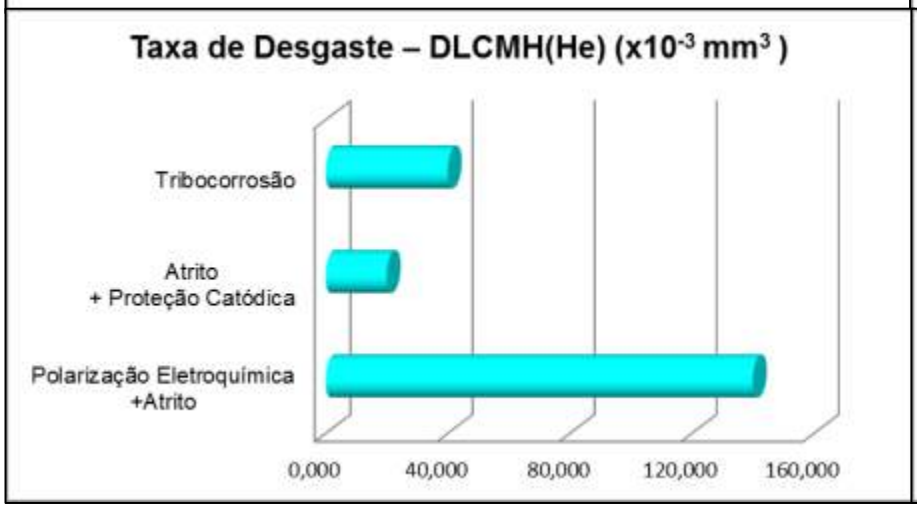


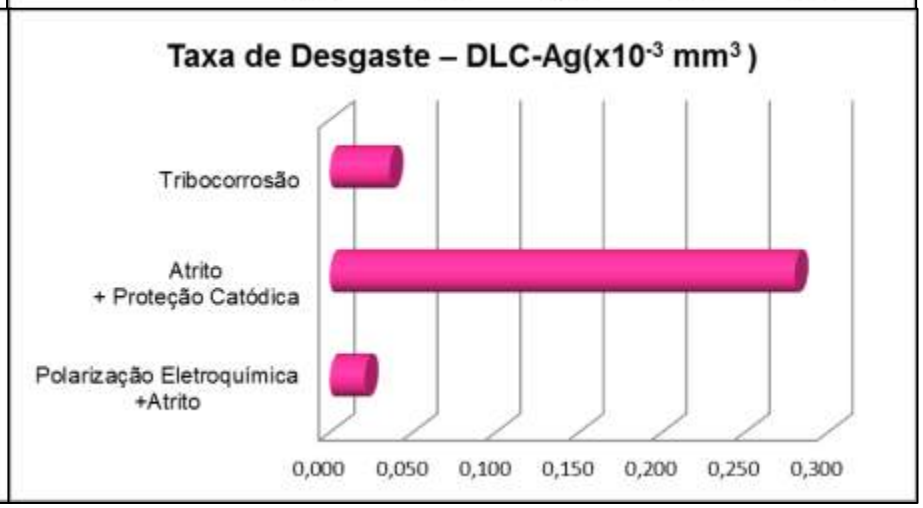


Efeito da Composição do Filme Resistência à corrosão

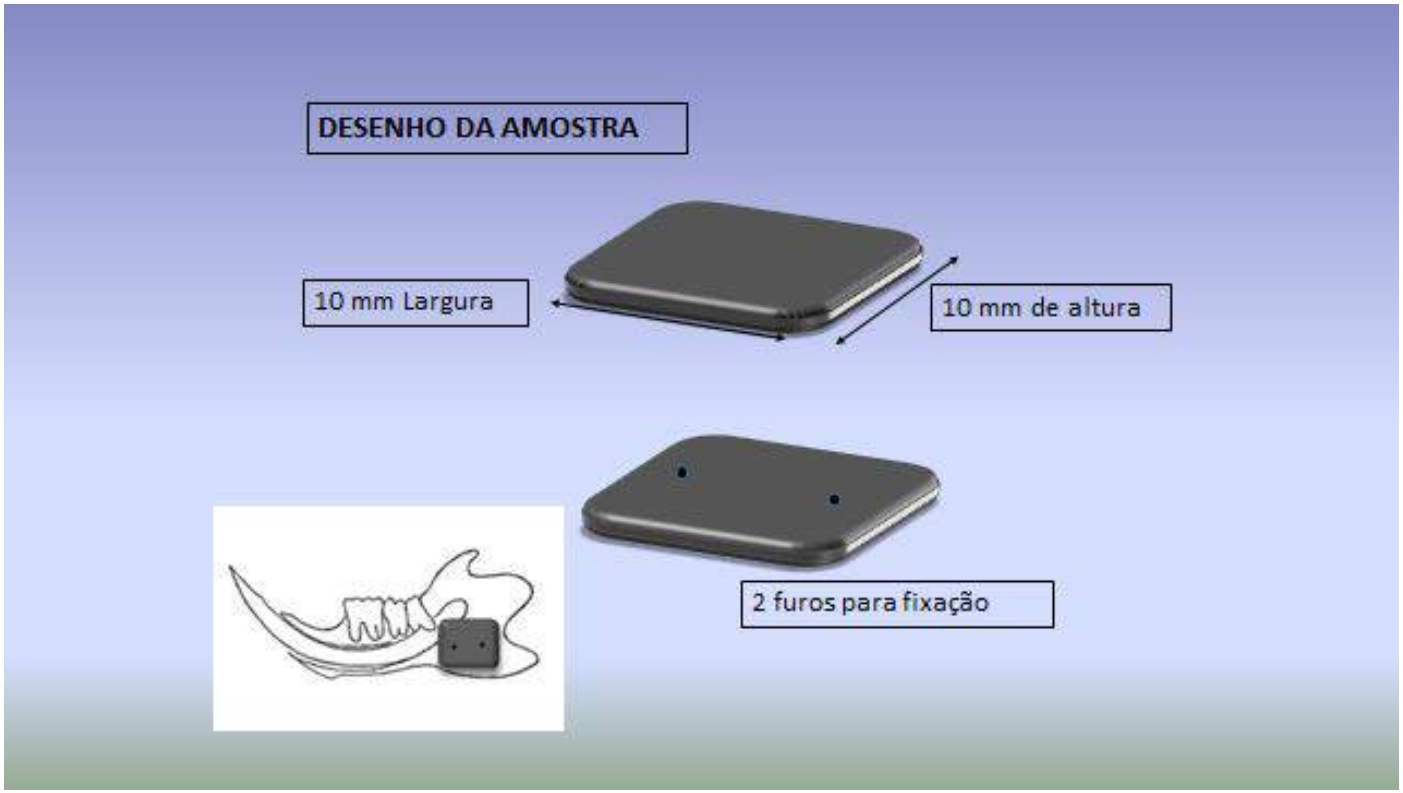








50 AMOSTRAS DE LIGA DE TITÂNIO (Ti6Al4V)
15 COM RECOBRIMENTO DE DLCMH
15 COM RECOBRIMENTO DLCMH-Ag
20 CONTROLES SEM RECOBRIMENTO



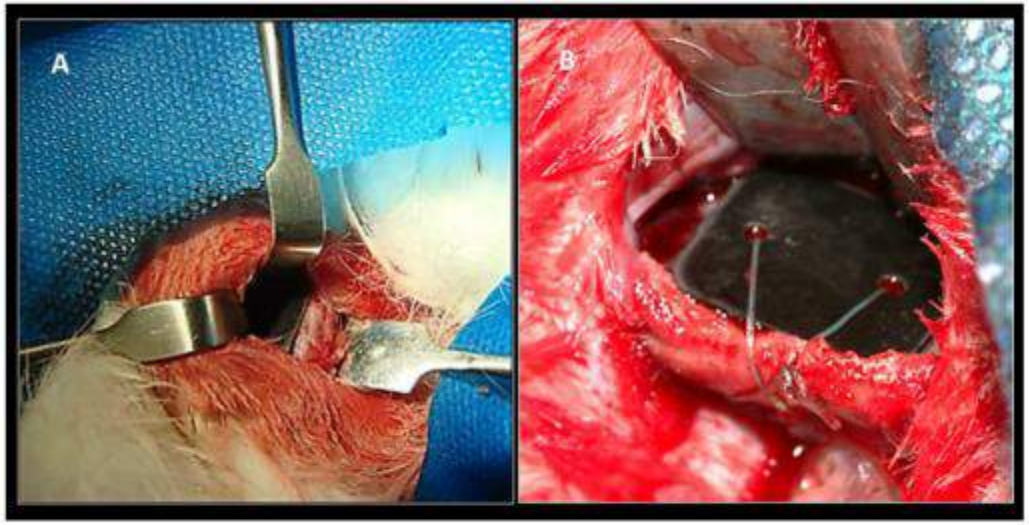


Figura 4. Procedimento cirúrgico. A) Amostra posicionada no osso na região do ângulo mandibular do coelho usando afastadores de Sean Miller; e B) Amostra fixada.

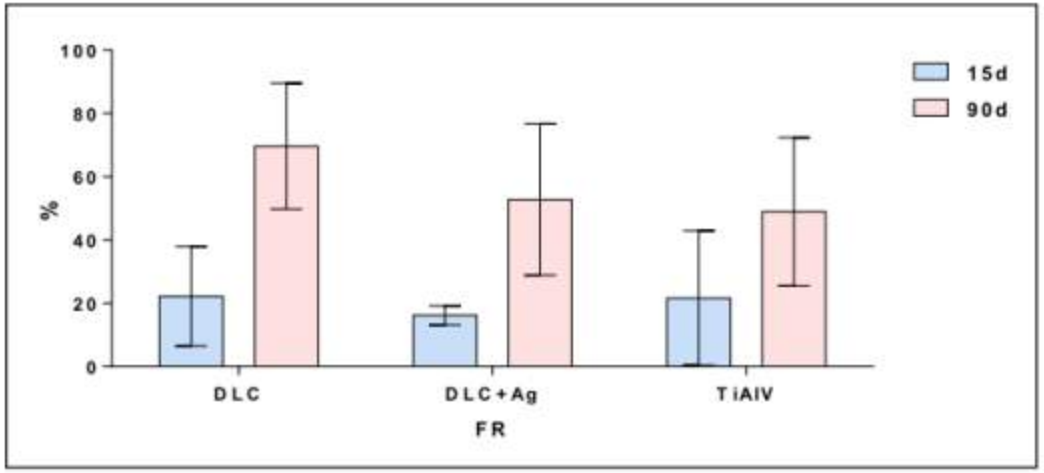


Figura 29.- Gráfico de colunas (média ± dp) dos valores de neoformação óssea, segundo as condições experimentais estabelecidas pelo tipo de amostra e o período.