Morphology of Al thin films deposited under different magnetic field configurations by grid-assisted magnetron sputtering

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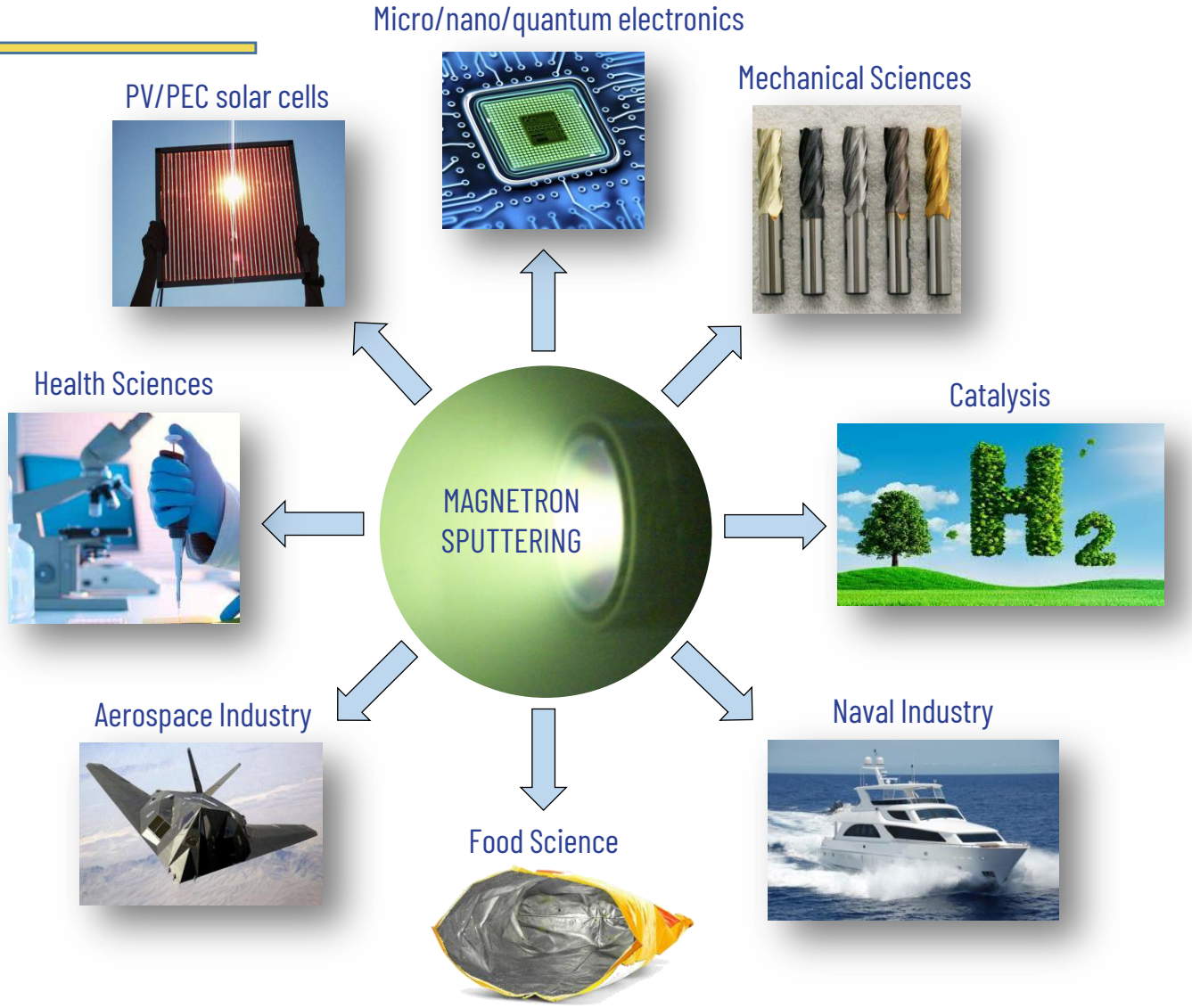
SUMMARY

- MAGNETRON SPUTTERING
- PREVIOUS PUBLICATIONS
- MAIN GOAL
- EXPERIMENTAL SETUP
- RESULTS AND DISCUSSIONS
- FINAL REMARKS
- ACKNOWLEDGMENTS

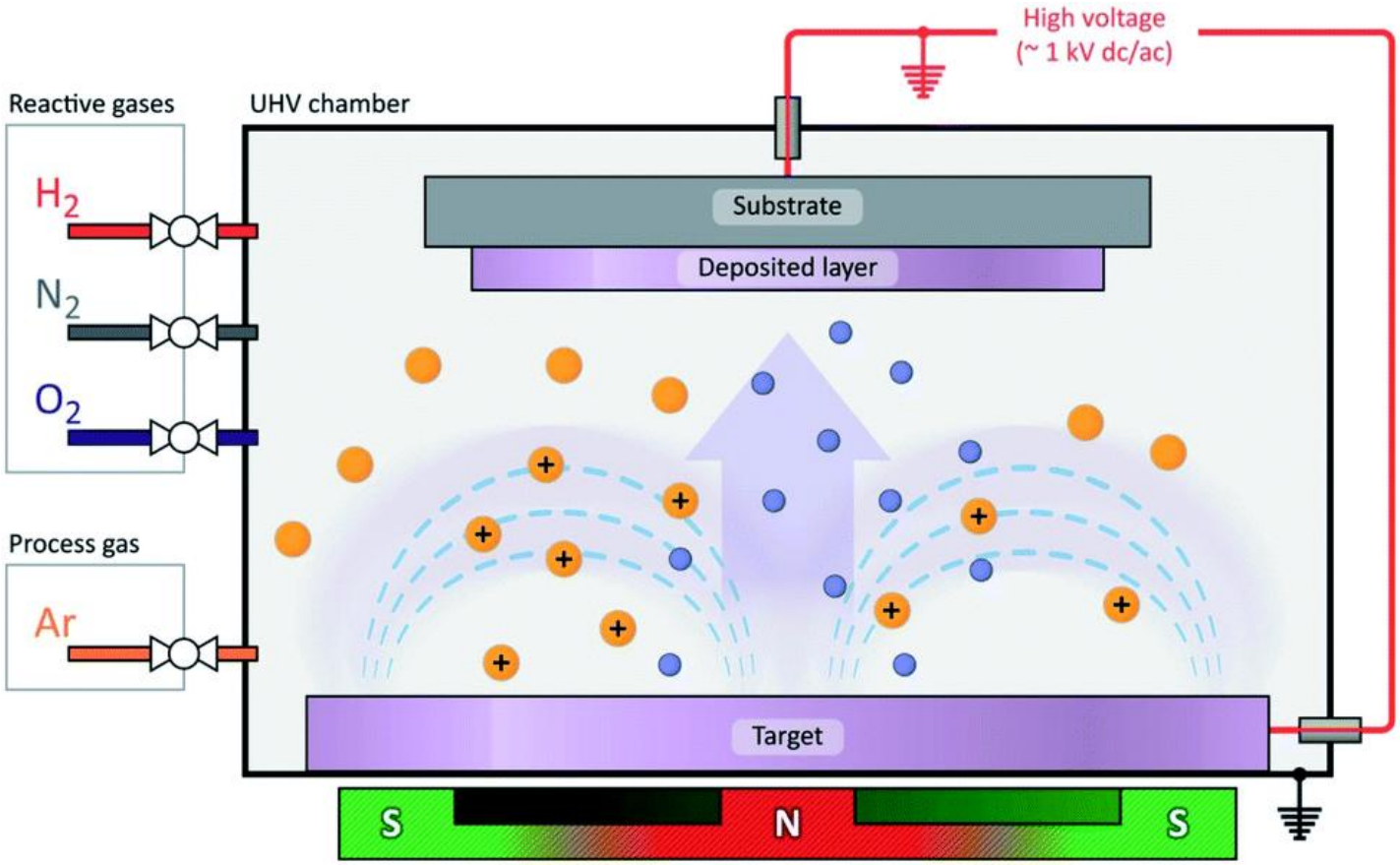
MAGNETRON SPUTTERING

Applications



MAGNETRON SPUTTERING

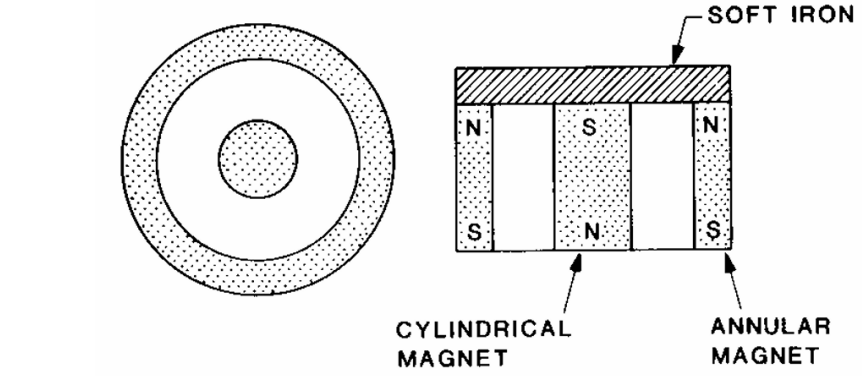
Fundamentals

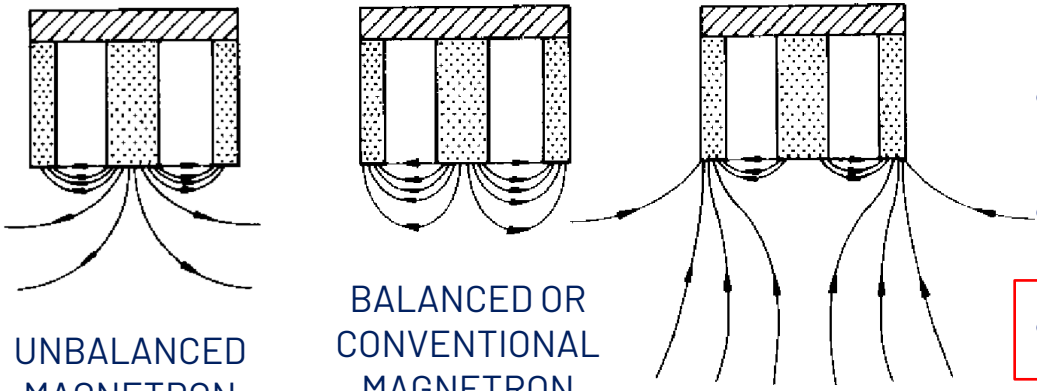


F. Wang et al. J. Mater. Chem. A, 8 (2020) 20260-20285

MAGNETRON SPUTTERING

Magnetic field configuration





UNBALANCED MAGNETRON TYPE-1 (UBM type-1)

BALANCED OR CONVENTIONAL MAGNETRON (CM)

UNBALANCED MAGNETRON TYPE-2 (UBM type-2)

The magnetic field balancing can be evaluated by the following equation:

$$K = \frac{\int_{S_{outer}} \vec{B}_{outer} \cdot d\vec{S}}{\int_{S_{inner}} \vec{B}_{inner} \cdot d\vec{S}}$$

where:

- UBM type-1 if $K < 1$
- CM if $K = 1$
- UBM type-2 if $K > 1$

→ This is our target!

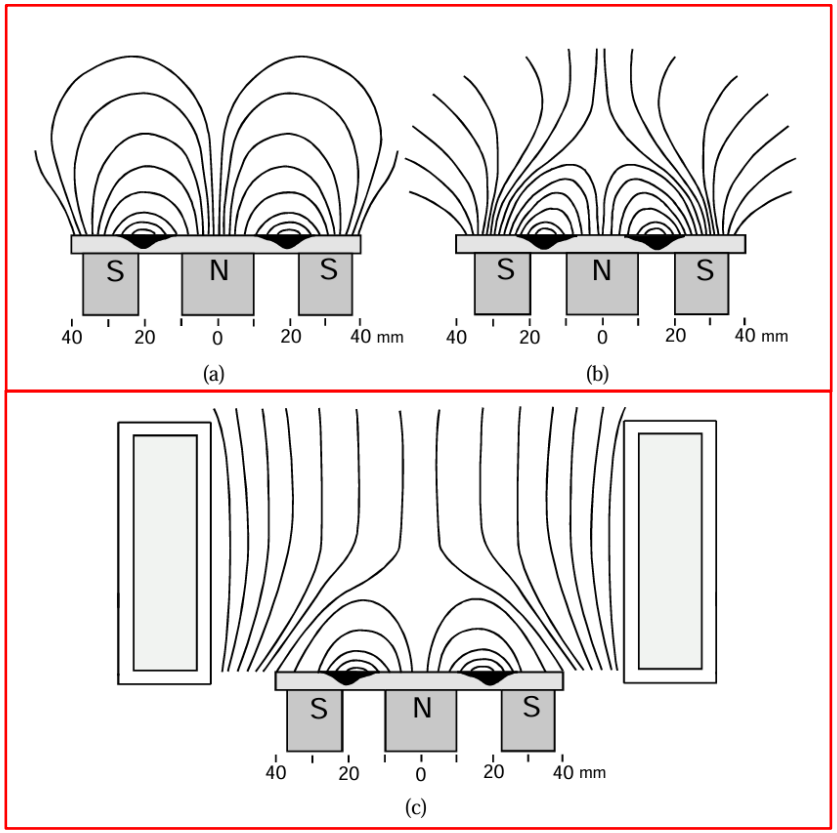
B. Window and N. Savvides, J. Vac. Sci. Technol. A, 4 (1986) 196.

I. V. Svadkovski et al. Vacuum, 68 (2002) 283.

MAGNETRON SPUTTERING

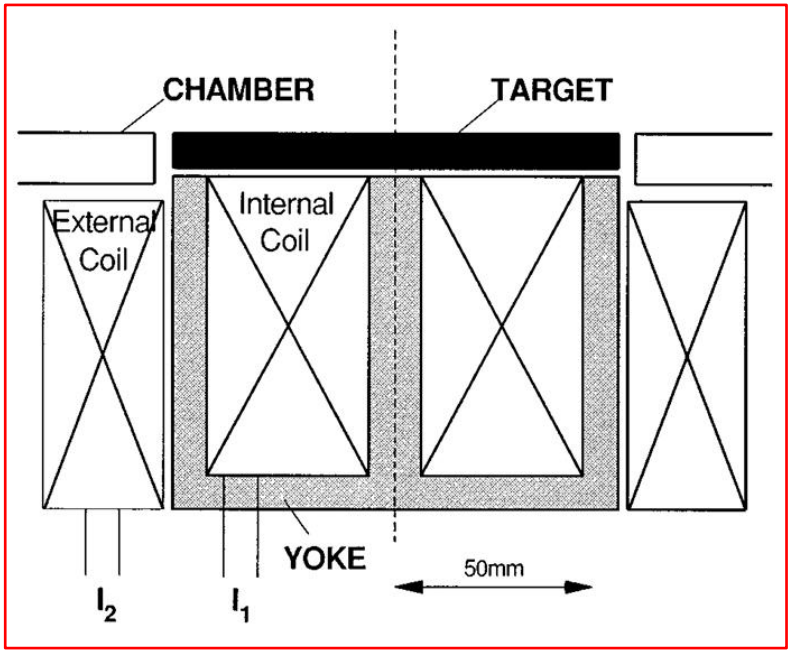
Magnetic field production

only permanent magnets



Combination of electro and permanent magnets

only electromagnets



B. Window and N. Savvides, J. Vac. Sci. Technol. A, 4 (1986) 196.

S. Kadlec and J. Musil, J. Vac. Sci. Technol. A, 13 (1995) 389

PREVIOUS PUBLICATIONS

by our research group

Revista Brasileira de Aplicações de Vácuo, v. 27, n. 2, 91-95, 2008.

EFEITOS DO CONFINAMENTO ELETROMAGNÉTICO DO PLASMA NO BOMBARDEAMENTO DO SUBSTRATO EM UM SISTEMA TRIODO MAGNETRON SPUTTERING

D.A. Duarte[1]; M.J. Cinelli[1]; J.C. Sagás[2]; L.C. Fontana[1*]
[1]*UDESC - CCT, Laboratório de Física de Plasmas, 89.223-100, Joinville, SC*
[2]*CTA - ITA, Laboratório de Plasmas e Processos, 12.228-900, São José dos Campos, SP*

Recebido: 7 de janeiro, 2007; Revisado: 28 de junho, 2008

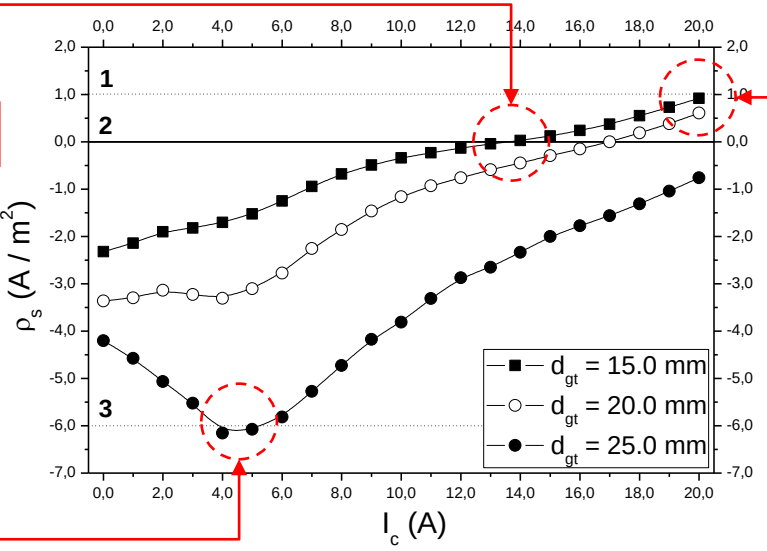
Effect of the magnetic field configuration on the electrical current collected by the substrate

(my first paper)

Neutral net current

Ion bombardment

Electron bombardment



K = 11.0 (no coil current)
UBM type-2

PREVIOUS PUBLICATIONS

by our research group

Effect of the magnetic field configuration on the substrate temperature.

Eur. Phys. J. Appl. Phys. **52**, 31001 (2010)
DOI: 10.1051/epjap/2010149

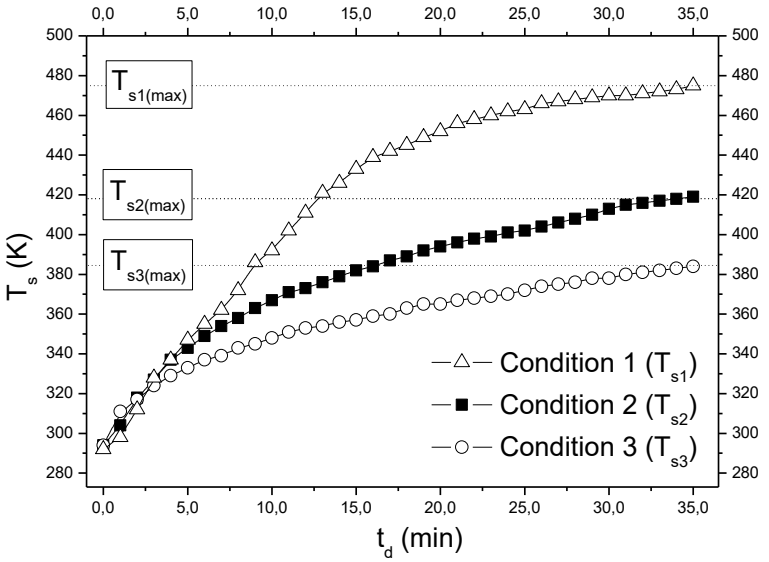
THE EUROPEAN PHYSICAL JOURNAL APPLIED PHYSICS

Regular Article

Control of the substrate temperature using a triode magnetron sputtering system

D.A. Duarte[1,2,a], J.C. Sagás[1,2], L.C. Fontana[1], A.S. da Silva Sobrinho[2], and M.J. Cinelli[1]

[1] Santa Catarina State University, Plasmas Physics Laboratory, 89223-100 Joinville, SC, Brazil
[2] Technological Institute of Aeronautics, Plasma Science and Technology Laboratory, 12228-900 S.J. dos Campos, SP, Brazil



Ion bombardment ~ 200°C

Neutral net current ~ 145°C

Electron bombardment ~ 110°C

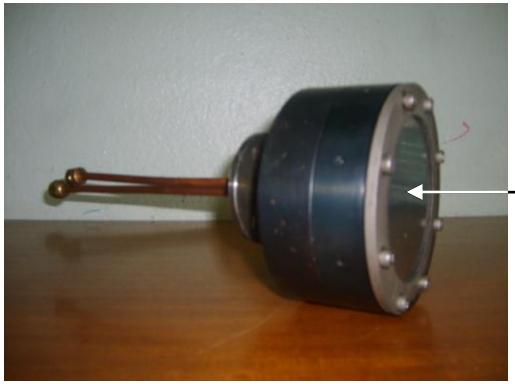
MAIN GOAL

Investigate the effect of the magnetic field configuration on film properties.

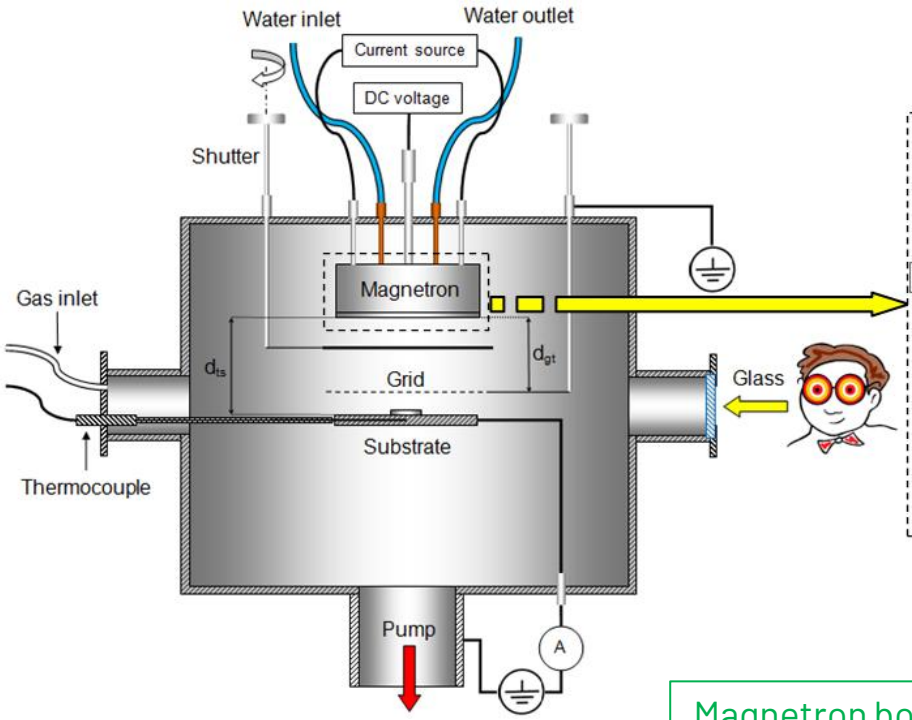
Today, we will discuss the surface morphology evaluated by AFM!

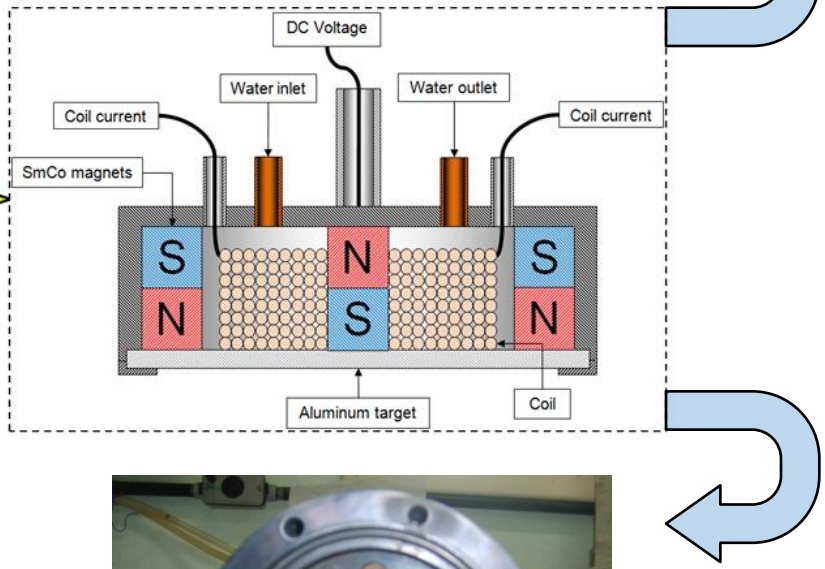
EXPERIMENTAL SETUP

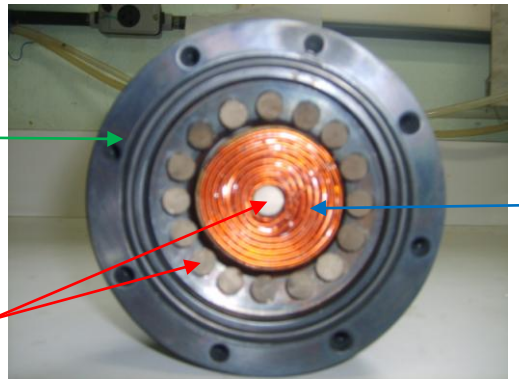
GAMS system



Al target







Magnetron body

Coil

SmCo permanent magnets

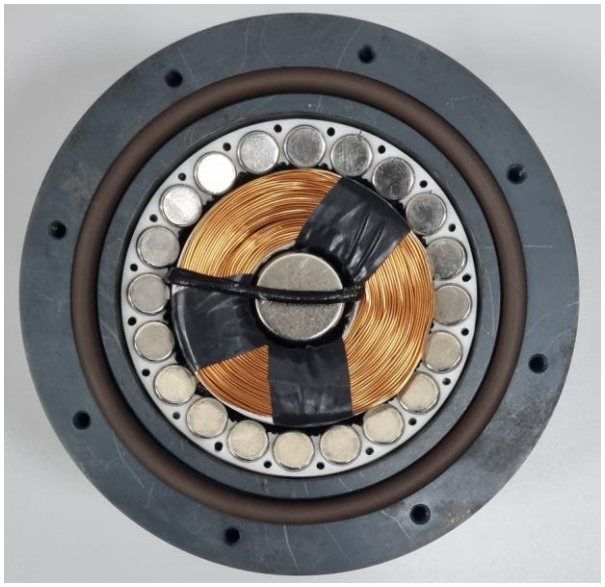
EXPERIMENTAL SETUP

just for the sake of curiosity...

2006

K = 11.0 (no coil current)

2024



K = 1.5 (no coil current)

Data presented here were produced with magnetron from 2006!

EXPERIMENTAL SETUP

Deposition conditions and characterization

UBM type-2

Electron bombardment

Sample	I_c (A)	K	ρ_t (mA/cm^2)	d_{gt} (mm)	ρ_s (mA/cm^2)	T (°C)
1	5.0	8.9	15.0	25.0	-0.6	110
2	14.0	5.8	15.6	15.0	0	145
3	20.0	4.4	30.0	15.0	+0.1	200

CM

Ion bombardment

I_c: coil current
ρ_s: substrate current density
ρ_t: target current density
V_t: target voltage
V_s: substrate voltage
K: balance coefficient
d_{gt}: grid-to-target distance (GAMS parameter)
d_{ts}: target-to-substrate distance
T: substrate temperature
p: gas pressure
t: deposition time

Common parameters:

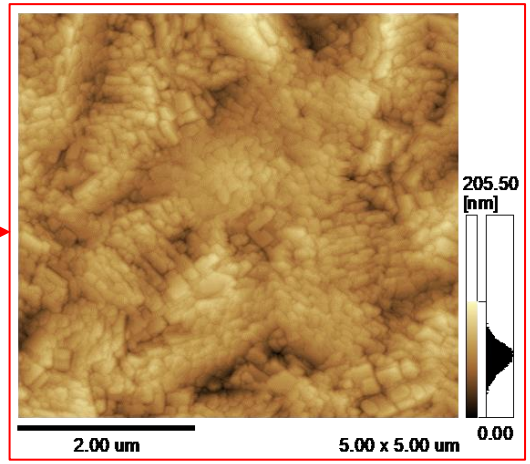
Substrate	V_t (V)	V_s (V)	p (mtorr)	d_{ts} (mm)	Gas	Target	t (min)
Si	-600	0	3	60	Ar	Al	35

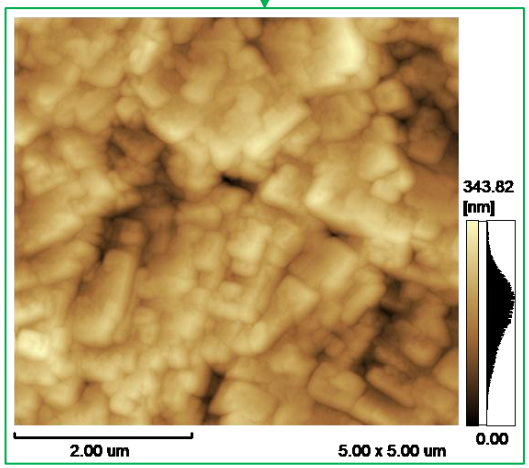
Films morphology was investigated by AFM!

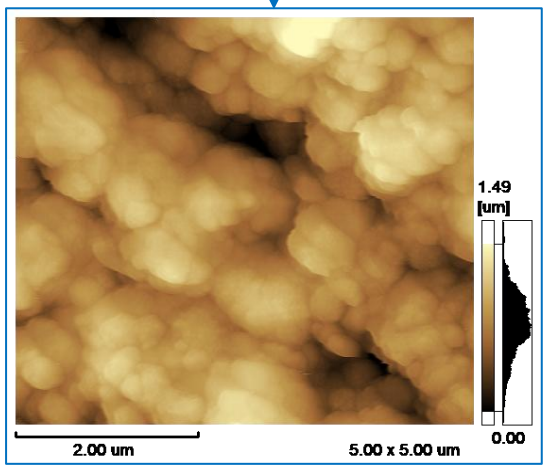
RESULTS AND DISCUSSIONS

Atomic force microscopy

ρ_s (mA/cm^2)	R_a (nm)	Average particle size (μm)	FWHM (μm)
0	18.9	0.21	0.16
–0.6	37.8	0.33	0.31
+0.1	208.9	0.38	0.36







RESULTS AND DISCUSSIONS

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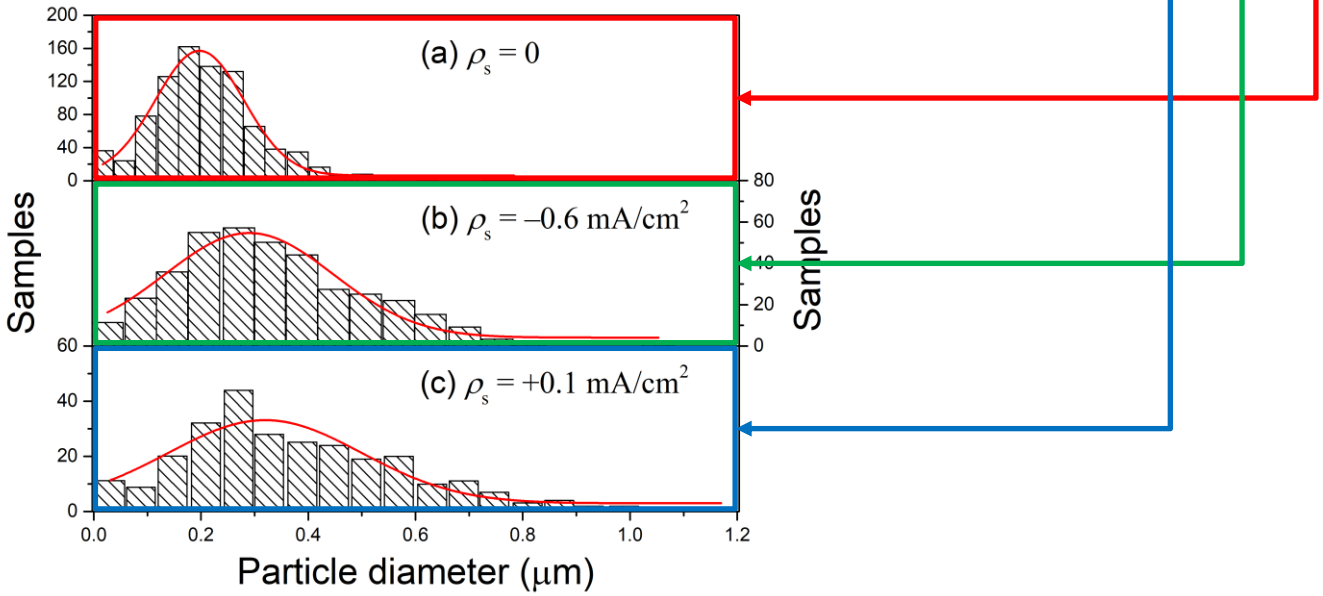

FINAL REMARKS

- Modifications of the magnetic field influences the morphology of the films.
- Highest surface damage with ions bombardment.
- Modification of the surface morphology with grounded substrate.
- Other investigations (films thickness, crystalline structure, chemical composition etc.) must be carried out.

ACKNOWLEDGMENTS

CNPq

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304053/2021-0

FAPESP

2009/15031-3

CAPES

Thank you!

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