Laboratory for Materials Science PHYSICS SECTION



PPPL Graduate Summer School 2020

Plasma Research with a home-built Magnetron Sputtering System – Experiment and Simulation

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Some data about PUCP

- Private University founded at 24 march 1917 by the catholic priest Father Jorge Dintilhac
- At the moment the university has 29 899 students in 65 undergraduate and 170 postgraduate programs
- The university has 2435 professors (part-time and fulltime) 564 of which have a PhD
- There are 19 research centers and institutes as well as 61 laboratories
- At the moment the university has 34 government funded projects as well as 69 internally funded projects





International Cooperations



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• 8 Scientists



• approx. 25 students (undergraduate, master and PhD)



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Photovoltaics



- Enhanced efficiency
- Solar panels in Peru
- Perovskites

Corrosion and protection



- Paints
- Metallic protective Coatings
- Corrosion analyses

Light emitters



- Activation of rare earths
- Electroluminescent devices

Environmental control



- Catalysts
- Absorbers
- Local resources

Applications



- Photo-electrochemistry
- Bio-compatibility
- Tribology

Nano-materials



- 2D materials
- Thin films

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Outline

- 1. Motivation.
- 2. Thin Films
- 3. Plasma
- 4. Magnetron Sputtering
- 5. First Results by Comsol Multiphysics







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1. Motivation



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1. Motivation

Sputtering System – PUCP (Peru)







Thin films deposition methods



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2. $M_{n+1}AX_n$ and MXenes Thin films

Magnuson, D. and Mattesini, M. Thin Solid Films 2017, 621, 108-130.

Naguib, M. et al., Adv. Mater. 2014, 26, 992-1005.



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3. Plasma

Hot













T >100 eV

T <1-10 eV

"Within the plasma the quasi-neutrality condition is met".

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4. Magnetron sputtering



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5. Comsol Multiphysics: Magnetic Field up to 1.5 T

Magnetic Escalar Potential (A)



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5. Comsol Multiphysics: Electric Field



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5. Comsol Multiphysics: Charged Particle Tracing

$$\vec{F_L} = -e\vec{E} - e\vec{v} \times \vec{B}$$



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Conclusions

- Simulation can be performed in Comsol off our magnetron sputtering
- The next step focuses on the interactions of the particles
- Get results of What is the influence of plasma on thin films of Max phases by RF magnetron sputtering



 $M_{n+1} X_n$











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Poincaré Maps of Particle Trayectories

Cut Planes



Cut Plane 2:

(x,y,z) = (0,0, 0.282)m

Normal = (0,0,1)









- DC power
- No collisions





- DC power
- Elastic and Excitation collisions with argon background gas





- RF power
- Elastic and Excitation collisions with argon background gas





- DC power
- Elastic, Excitation and lonization collisions with argon background gas





- RF power
- Elastic, Excitation and lonization collisions with argon background gas



