Deposição de filmes finos

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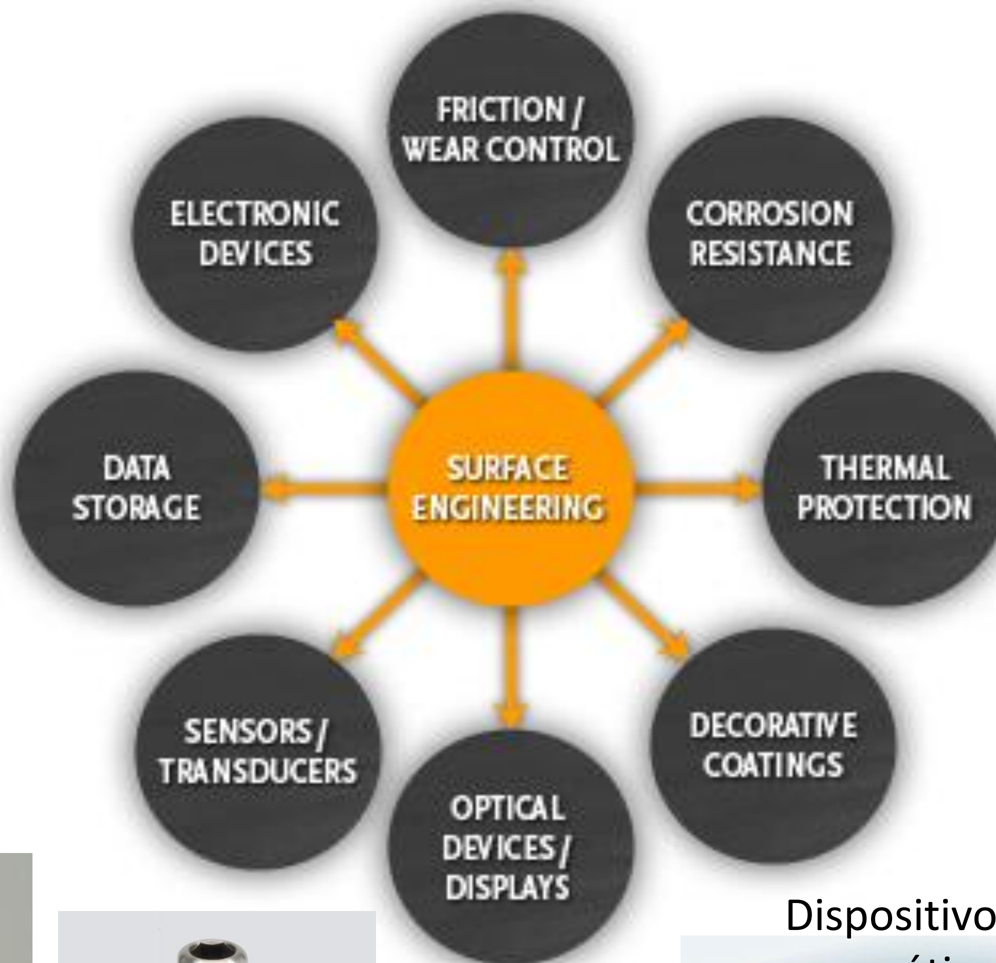
Filmes Finos

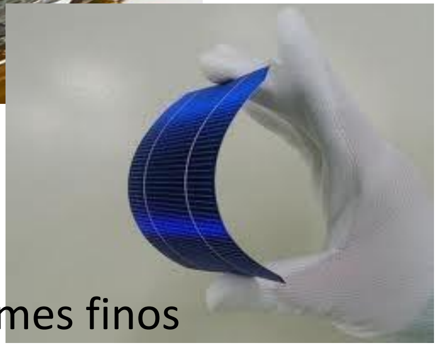
Recobrimentos ou Filmes finos

Definição: Filme fino é uma fina camada de material que varia de frações de um nanômetro (nm, monocamada atômica) para vários micrômetros (μm) de espessura.



Aplicações:

Displays flexíveis (OLED)



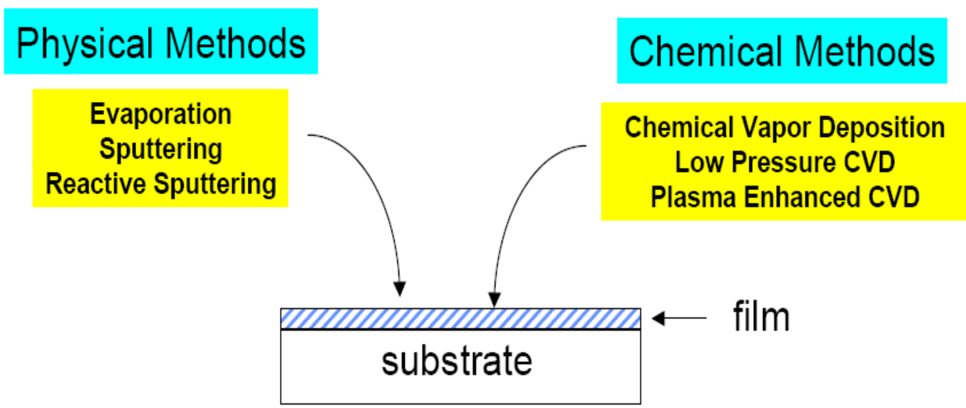
Painéis solares de filmes finos

Controle de desgaste

Dispositivos óticos

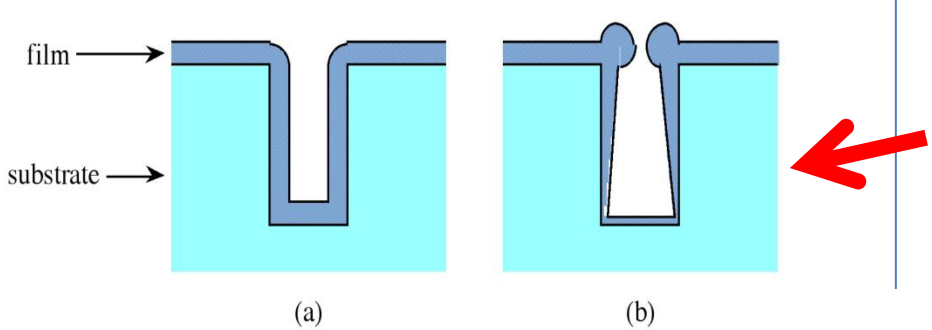
2. Plasma na Engenharia

Técnicas de deposição de filmes finos



Applications:

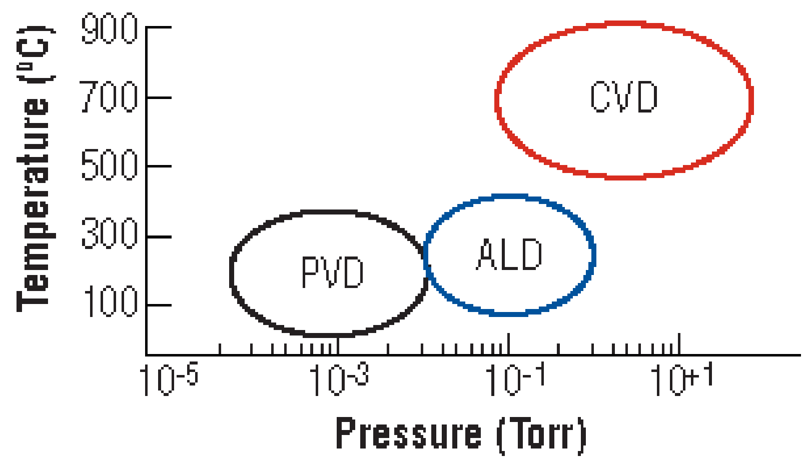
Metalization (e.g. Al, TiN, W, silicide)
Poly-Si
dielectric layers; surface passivation.

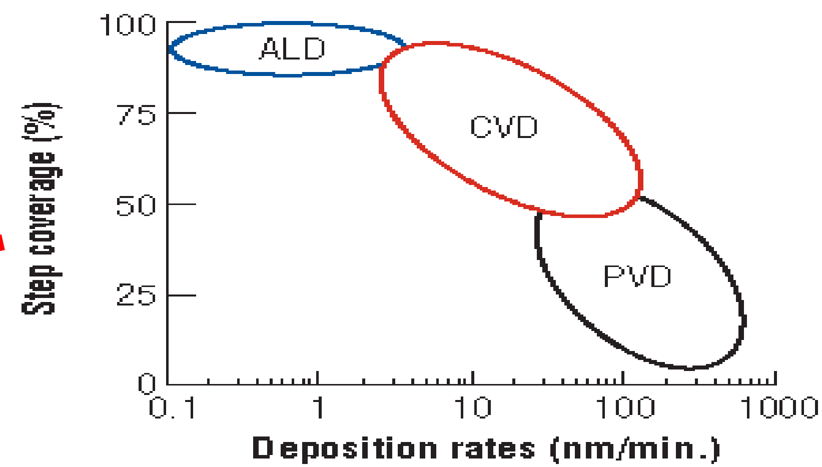


ALD – Atomic layer deposition

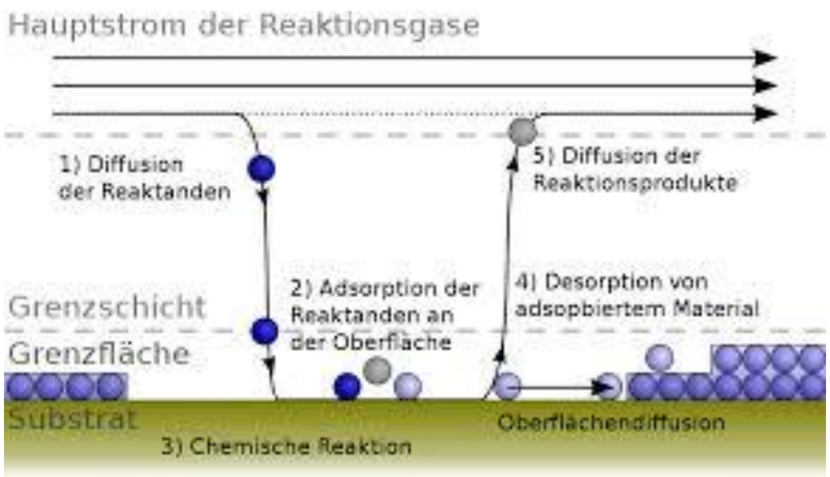
CVD – Chemical vapor deposition

PVD – Physical vapor deposition

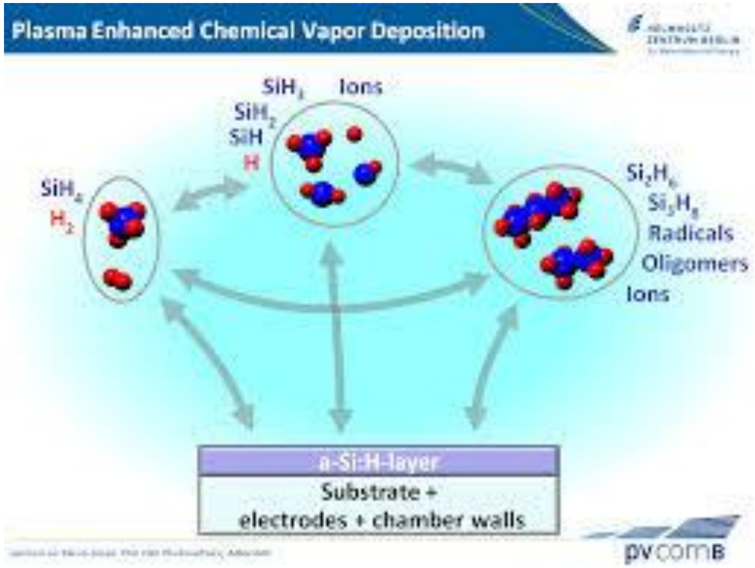




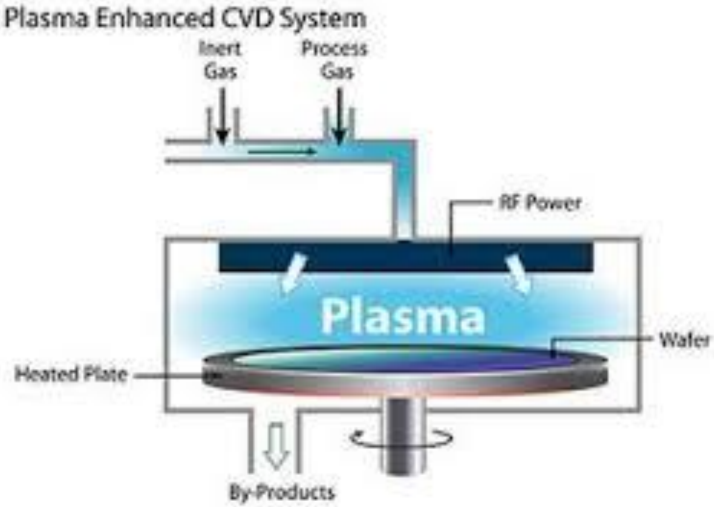
CVD e PECVD



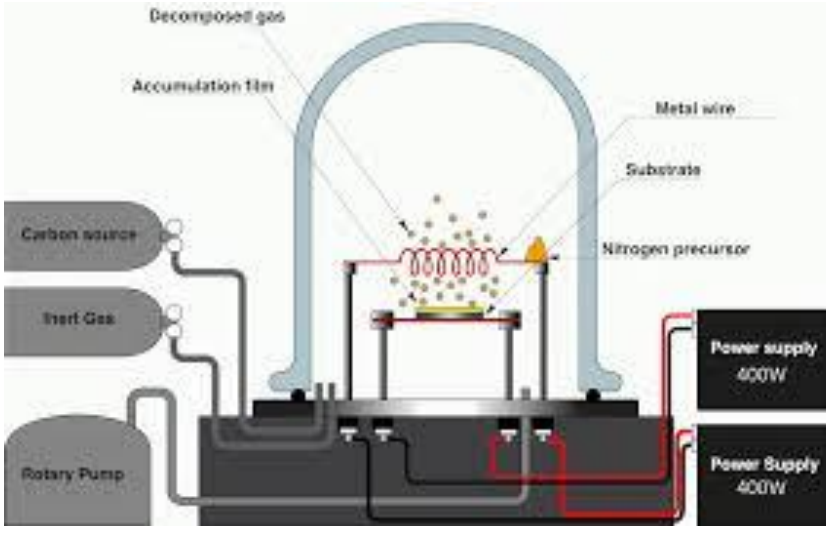
Hauptstrom der Reaktionsgase
1) Diffusion der Reaktanden
5) Diffusion der Reaktionsprodukte
2) Adsorption der Reaktanden an der Oberfläche
4) Desorption von adsopbiertem Material
Grenzschicht
Grenzfläche
Substrat
3) Chemische Reaktion
Oberflächendiffusion



Plasma Enhanced Chemical Vapor Deposition
SiH3
Ions
SiH2
SiH
H
SiH4
H2
Si2H6
Si3H8
Radicals
Oligomers
Ions
a-Si:H-layer
Substrate +
electrodes + chamber walls
pvcomB

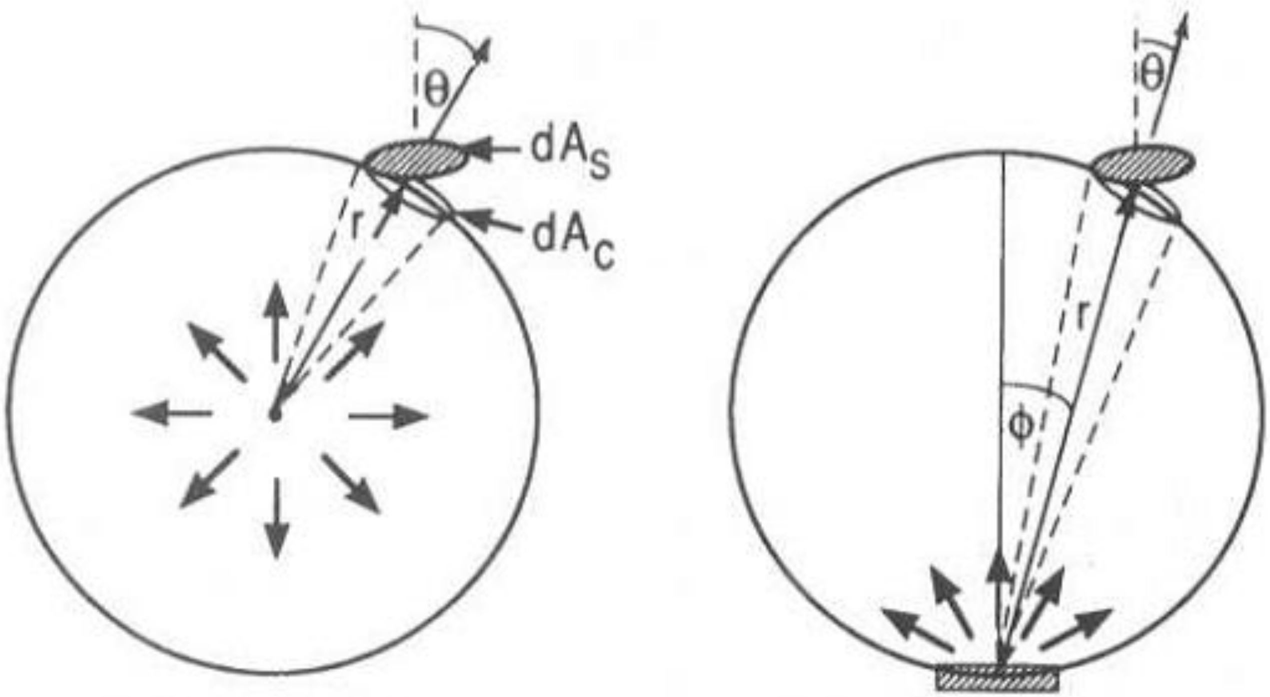


Plasma Enhanced CVD System
Inert Gas
Process Gas
RF Power
Plasma
Wafer
Heated Plate
By-Products



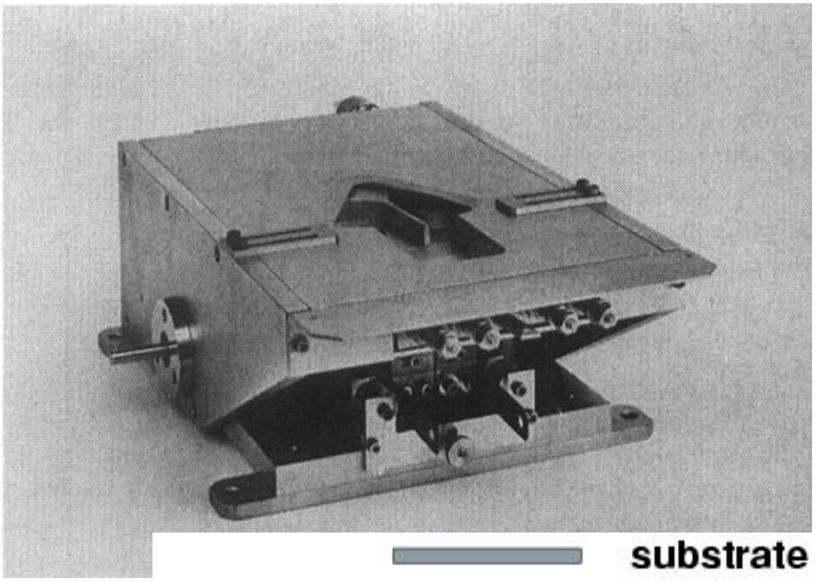
Decomposed gas
Accumulation film
Metal wire
Substrate
Carbon source
Nitrogen precursor
Inert Gas
Power supply
400W
Power Supply
400W
Rotary Pump

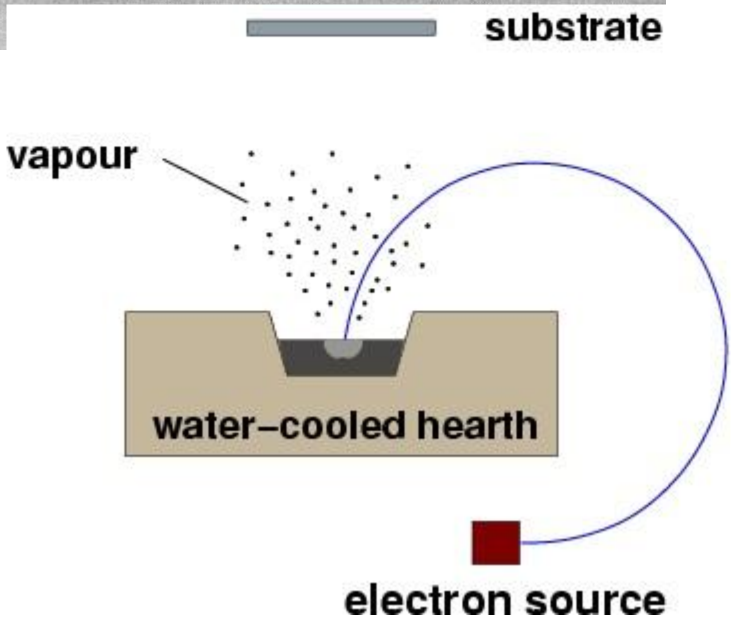
PVD - Evaporation

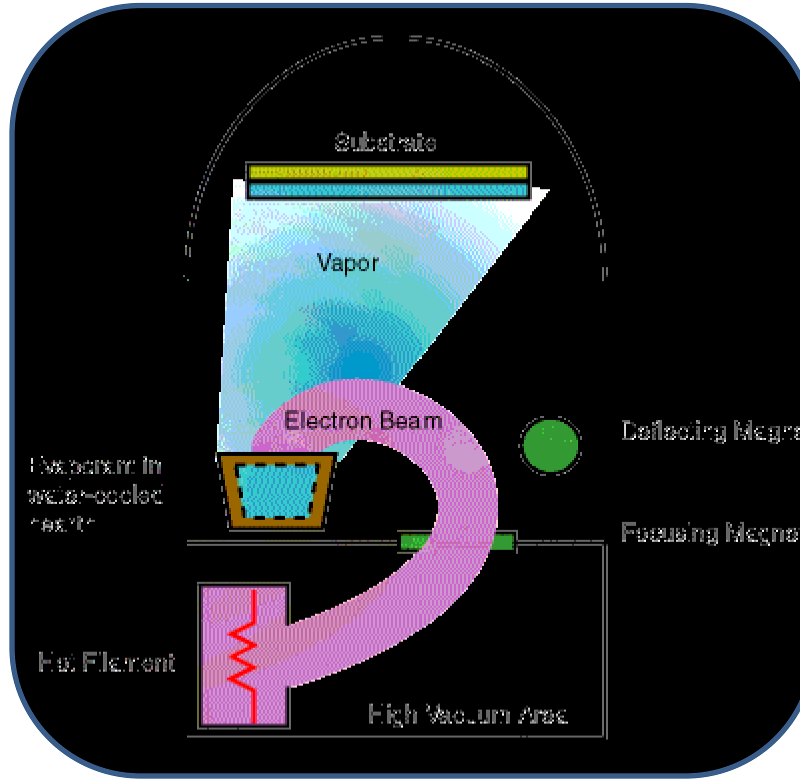


POINT SOURCE SURFACE SOURCE

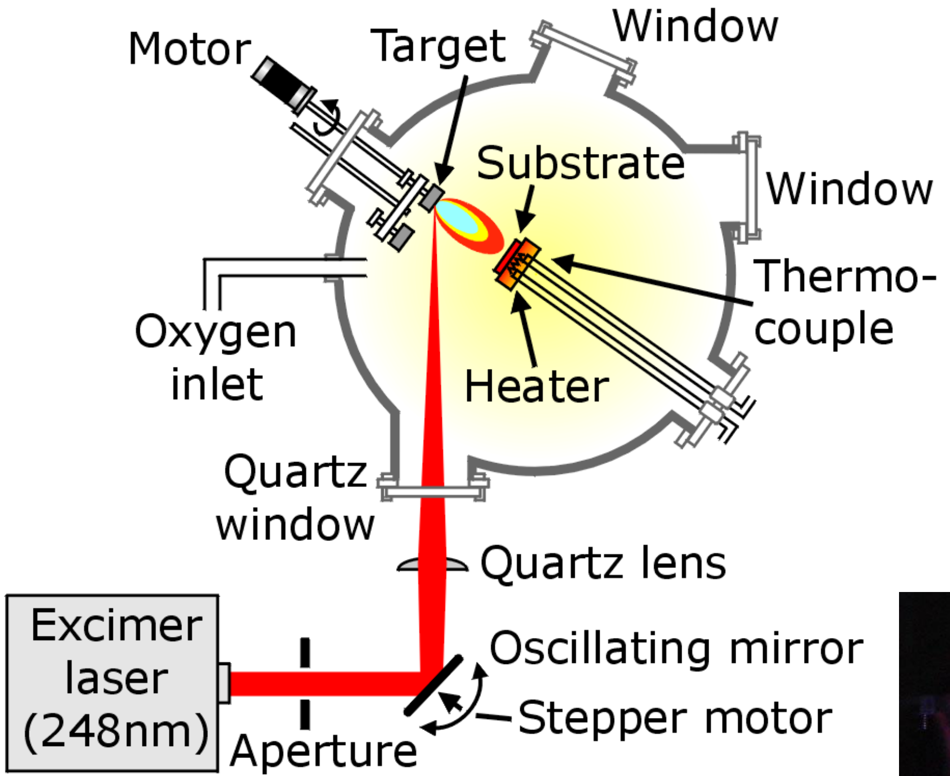
PVD – Electron beam

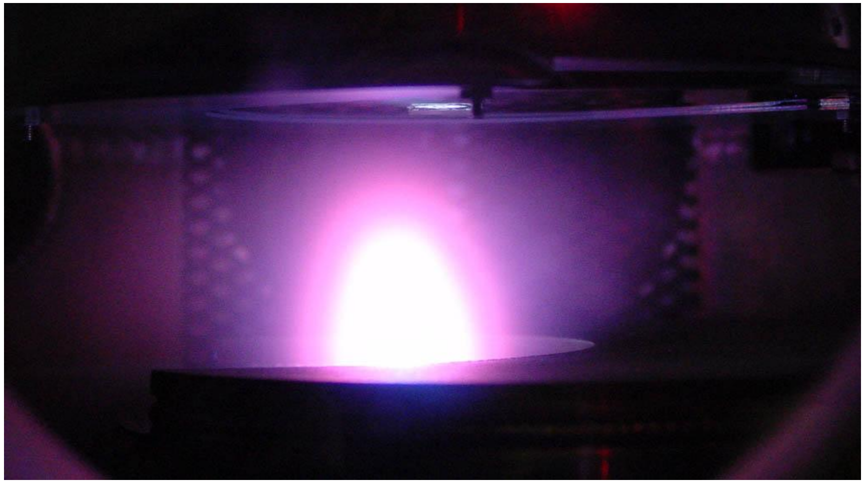




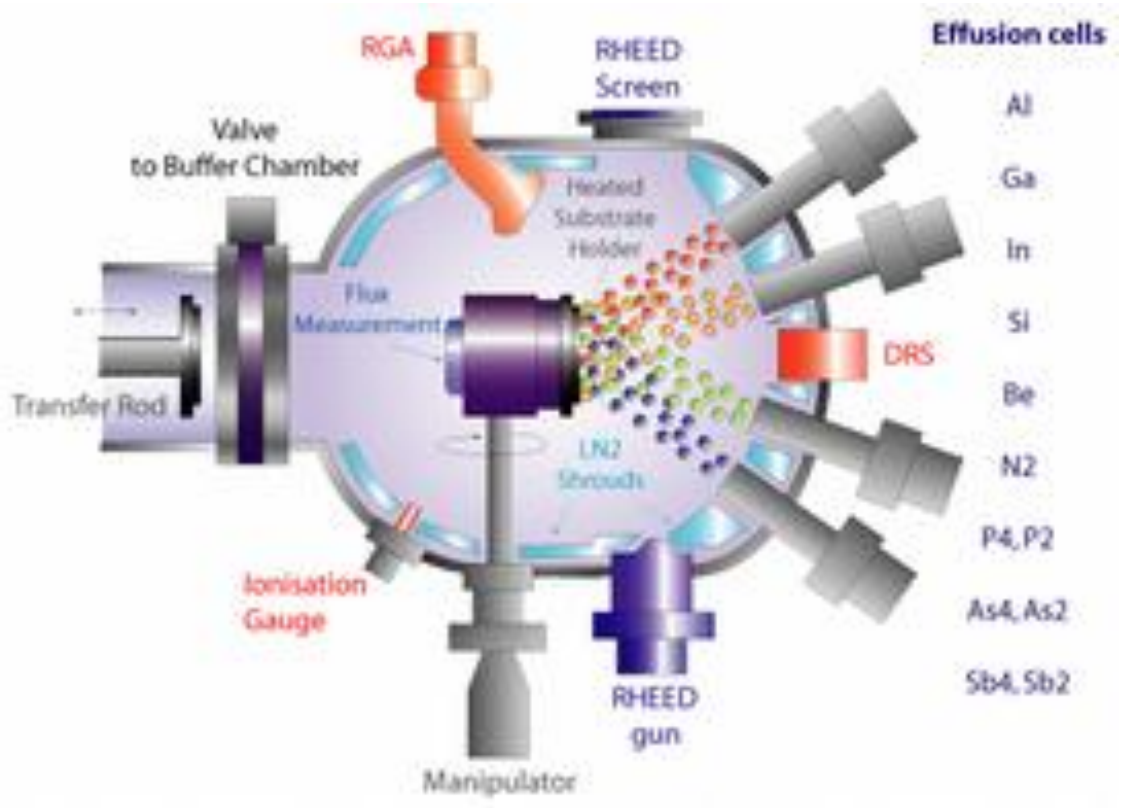


PVD – Pulsed Laser Deposition

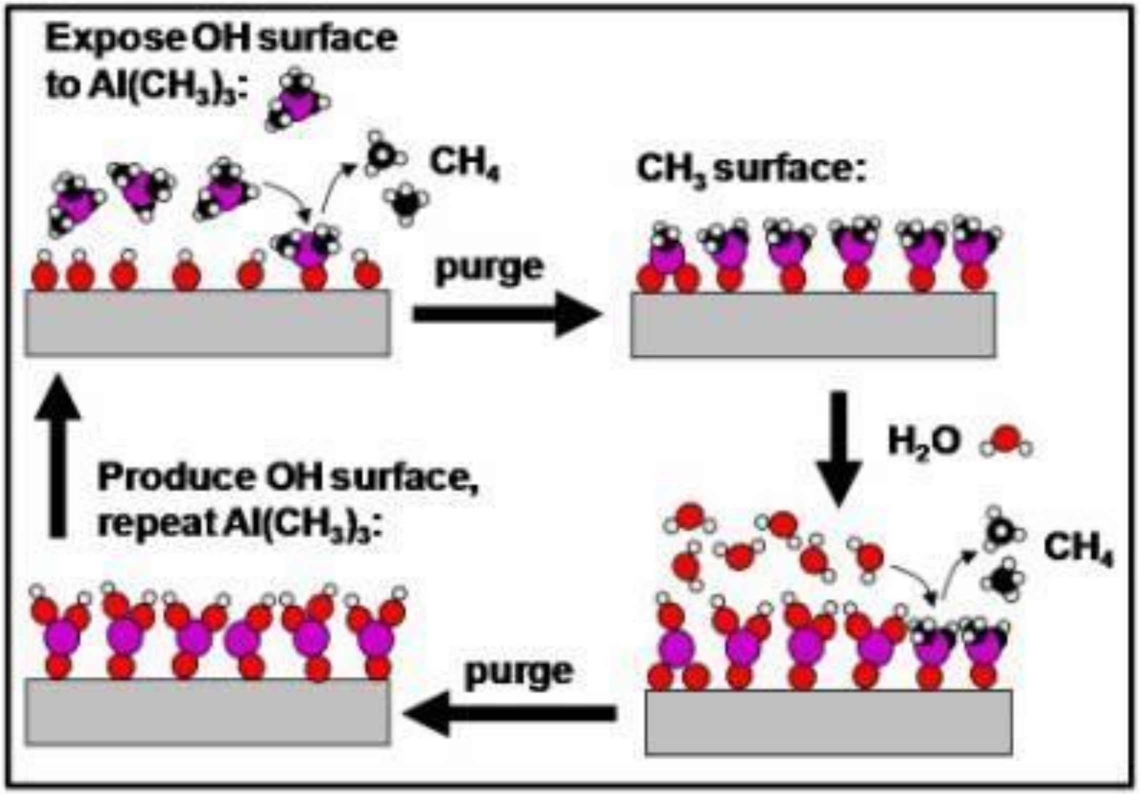




Molecular Beam Epitaxy (MBE)

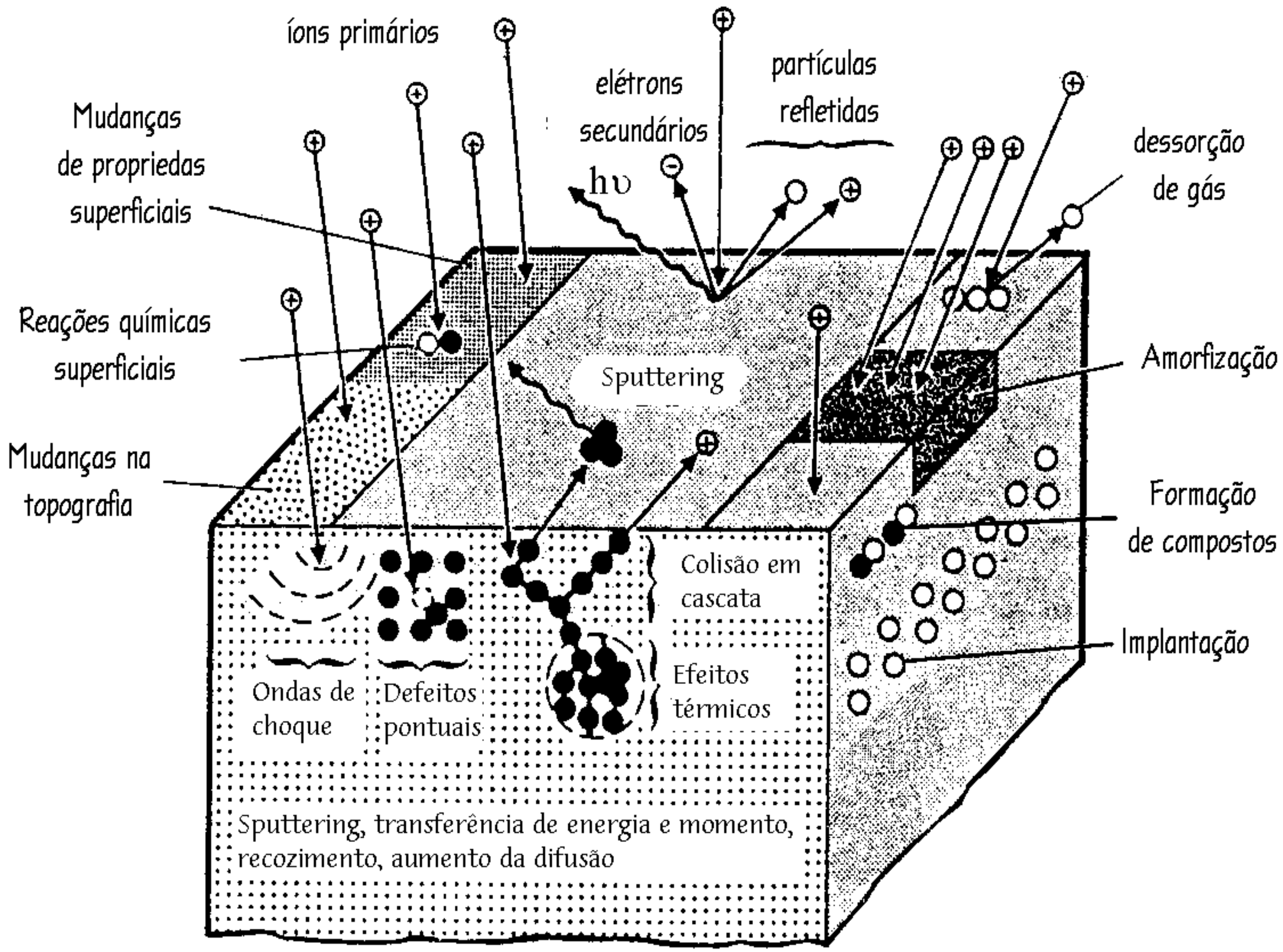


Atomic Layer Deposition (ALD)



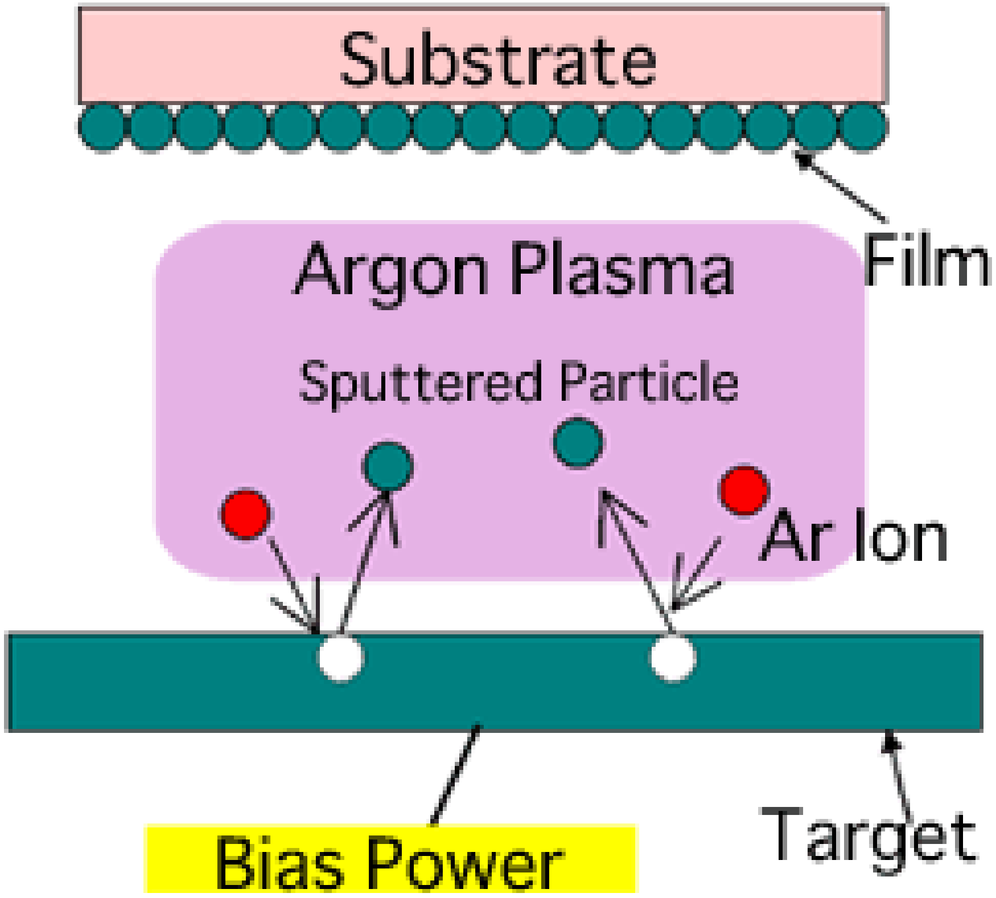
Atomic Layer Deposition is a binary set of self-limiting surface deposition reactions. One "ALD Cycle" produces one molecular monolayer of Al_2O_3 or other material of interest.

Sputtering

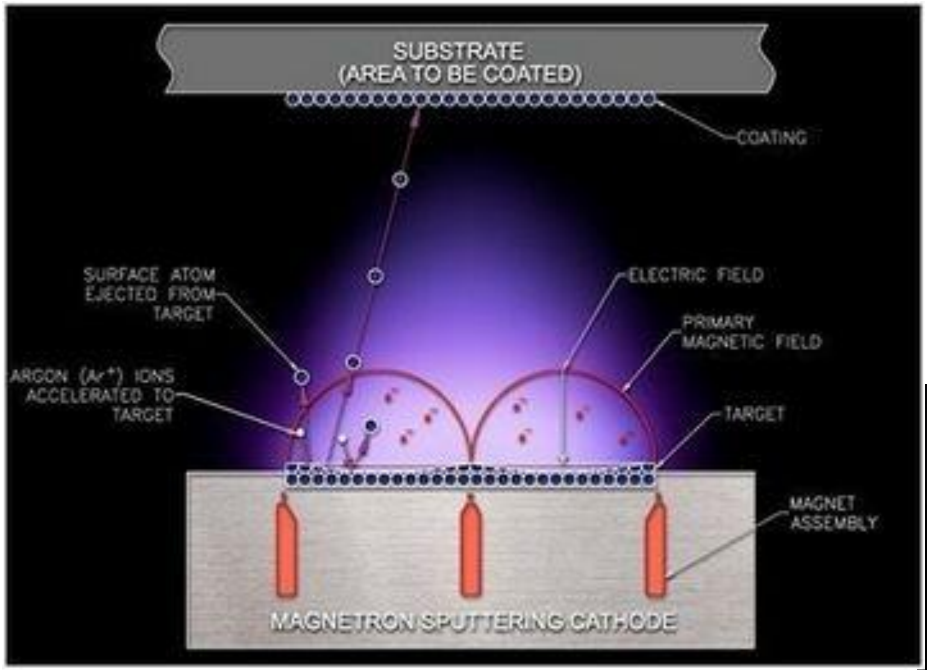


íons primários
Mudanças de propriedas superficiais
elétrons secundários
partículas refletidas
hυ
dessorção de gás
Reações químicas superficiais
Sputtering
Amorfização
Mudanças na topografia
Formação de compostos
Colisão em cascata
Efeitos térmicos
Implantação
Ondas de choque
Defeitos pontuais
Sputtering, transferência de energia e momento, recozimento, aumento da difusão

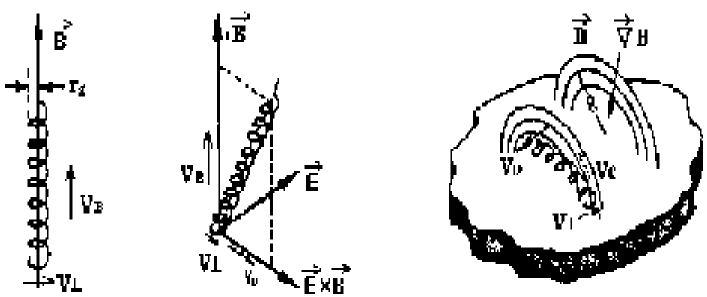
Sputtering deposition



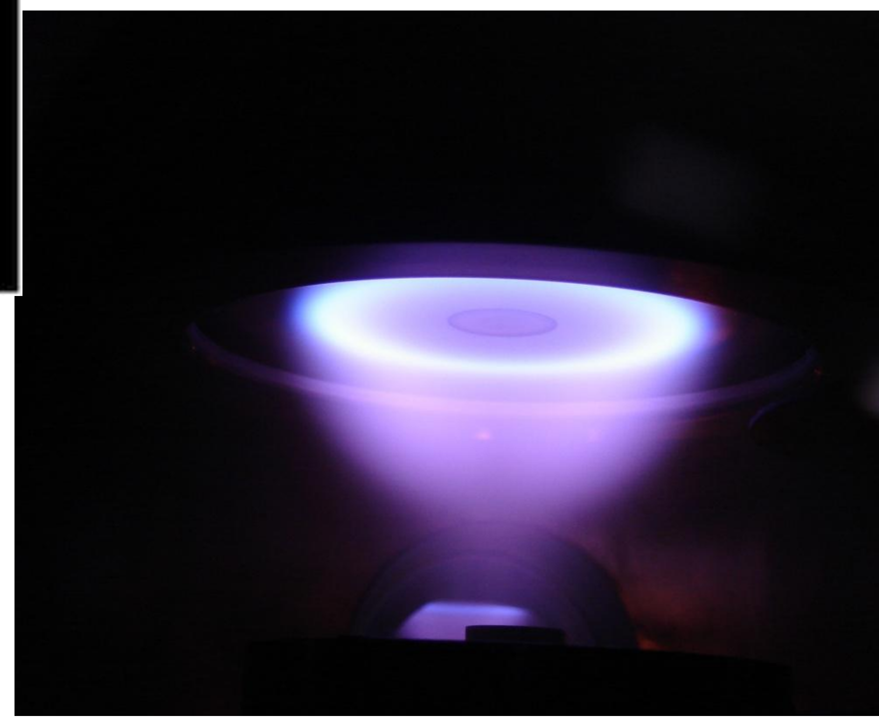
Magnetron Sputtering



$$\frac{d\vec{v}}{dt} = -\frac{e}{m}(\vec{E} + \vec{v} \times \vec{B})$$

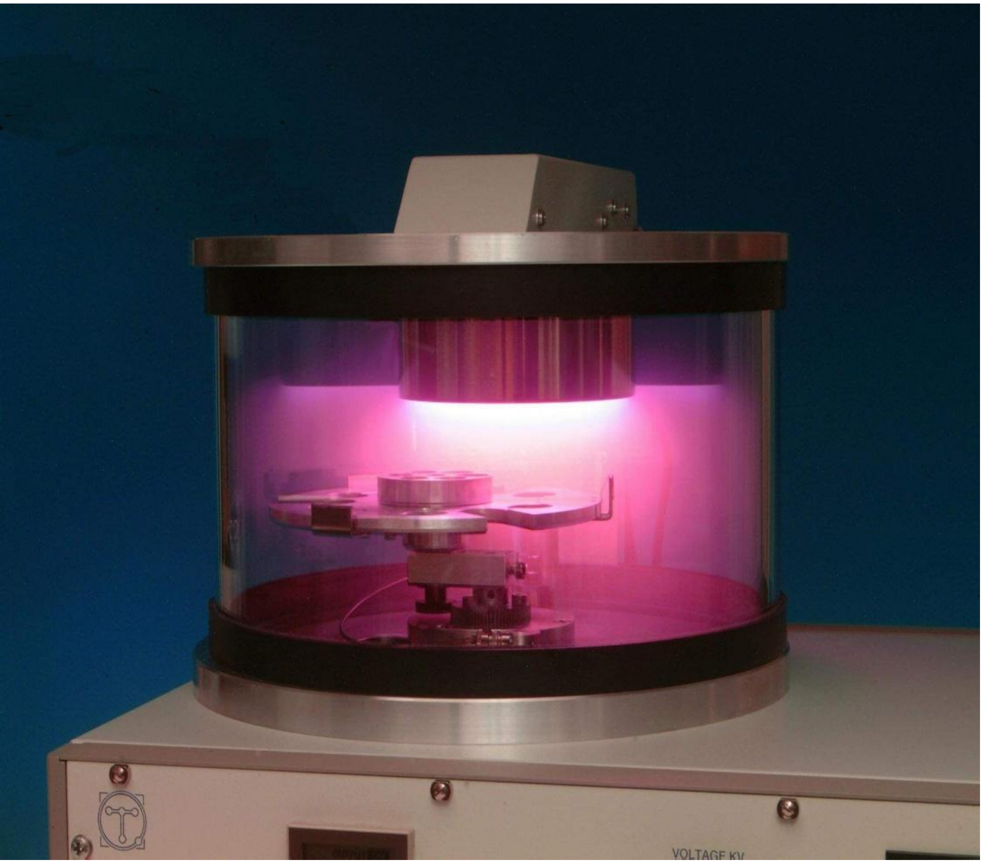


(a) (b) (c)

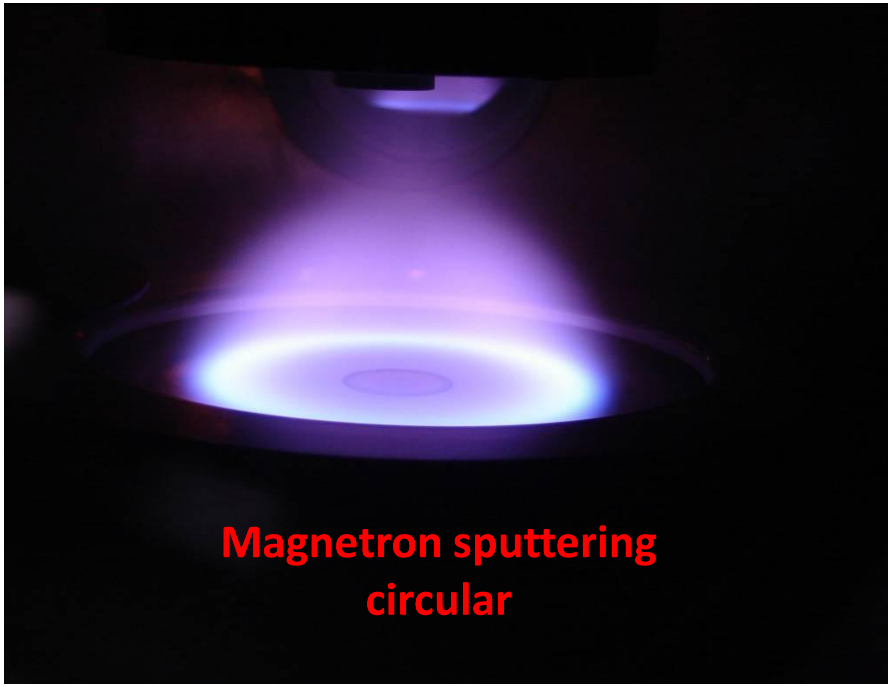


2. Plasma na Engenharia

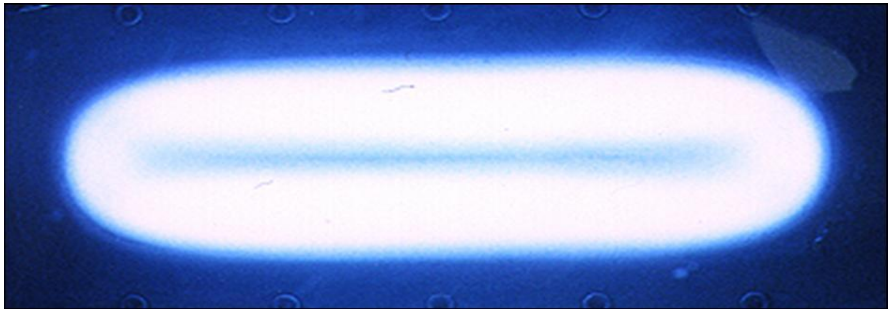
Magnetron Sputtering (operação e geometria)



Reator contendo sistema magnetron sputtering

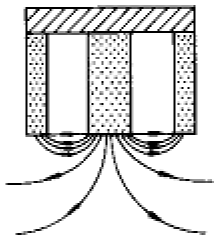


Magnetron sputtering circular

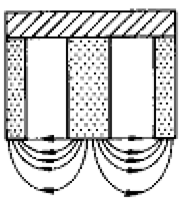


Magnetron sputtering retangular

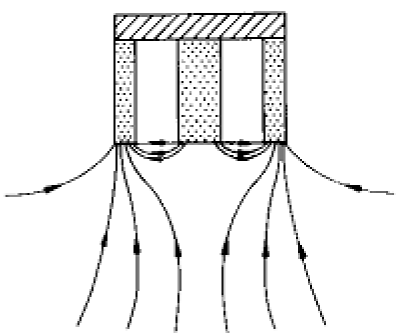
Unbalanced Magnetron



TYPE I

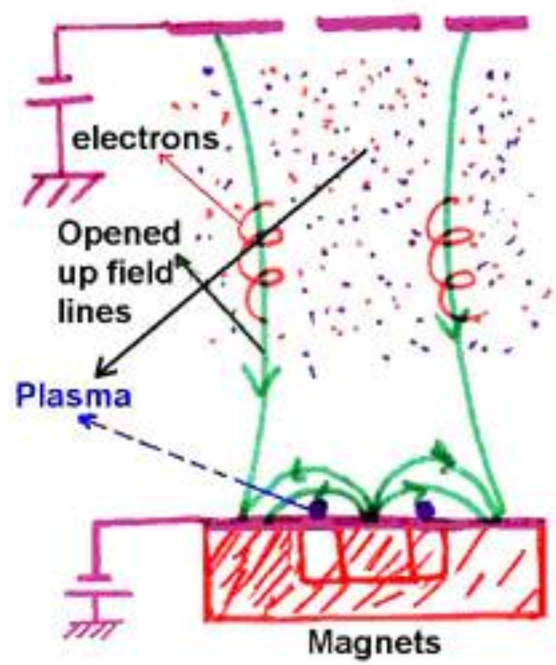


INTERMEDIATE

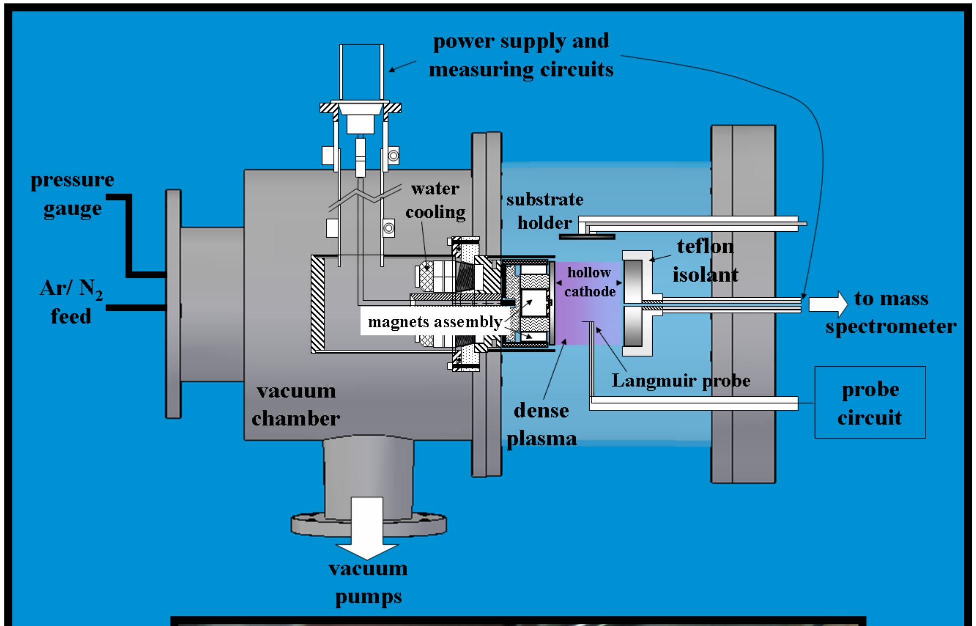


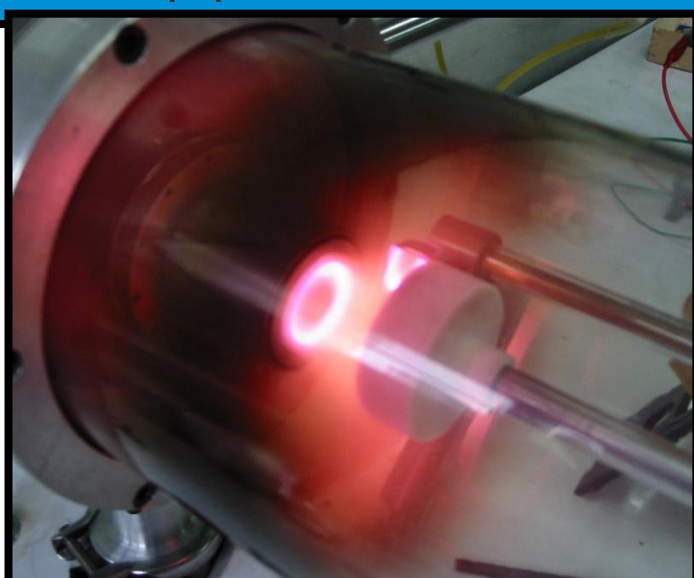
TYPE II

$$K = \frac{\Phi_E}{\Phi_C} = \frac{\int \overrightarrow{B_z} \cdot d\,\overrightarrow{A_E}}{\int \overrightarrow{B_z} \cdot d\,\overrightarrow{A_c}}$$

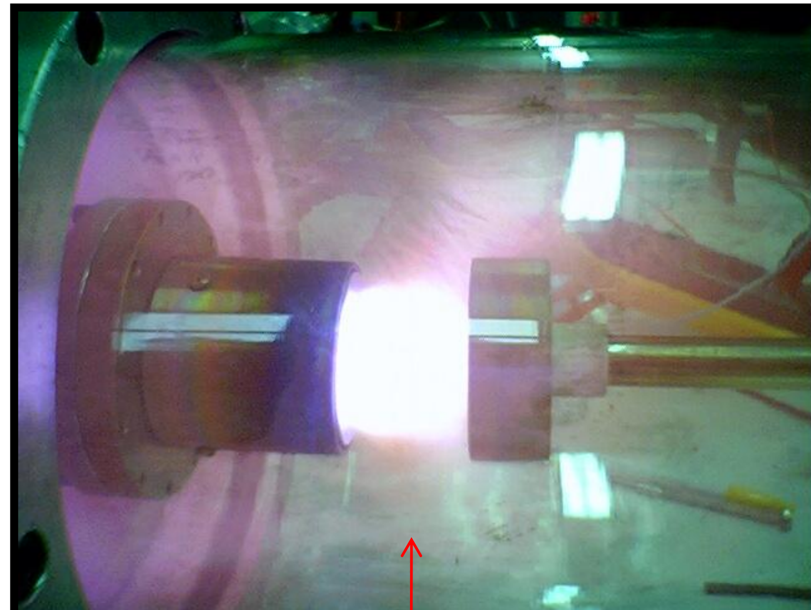


Hollow cathode magnetron sputtering



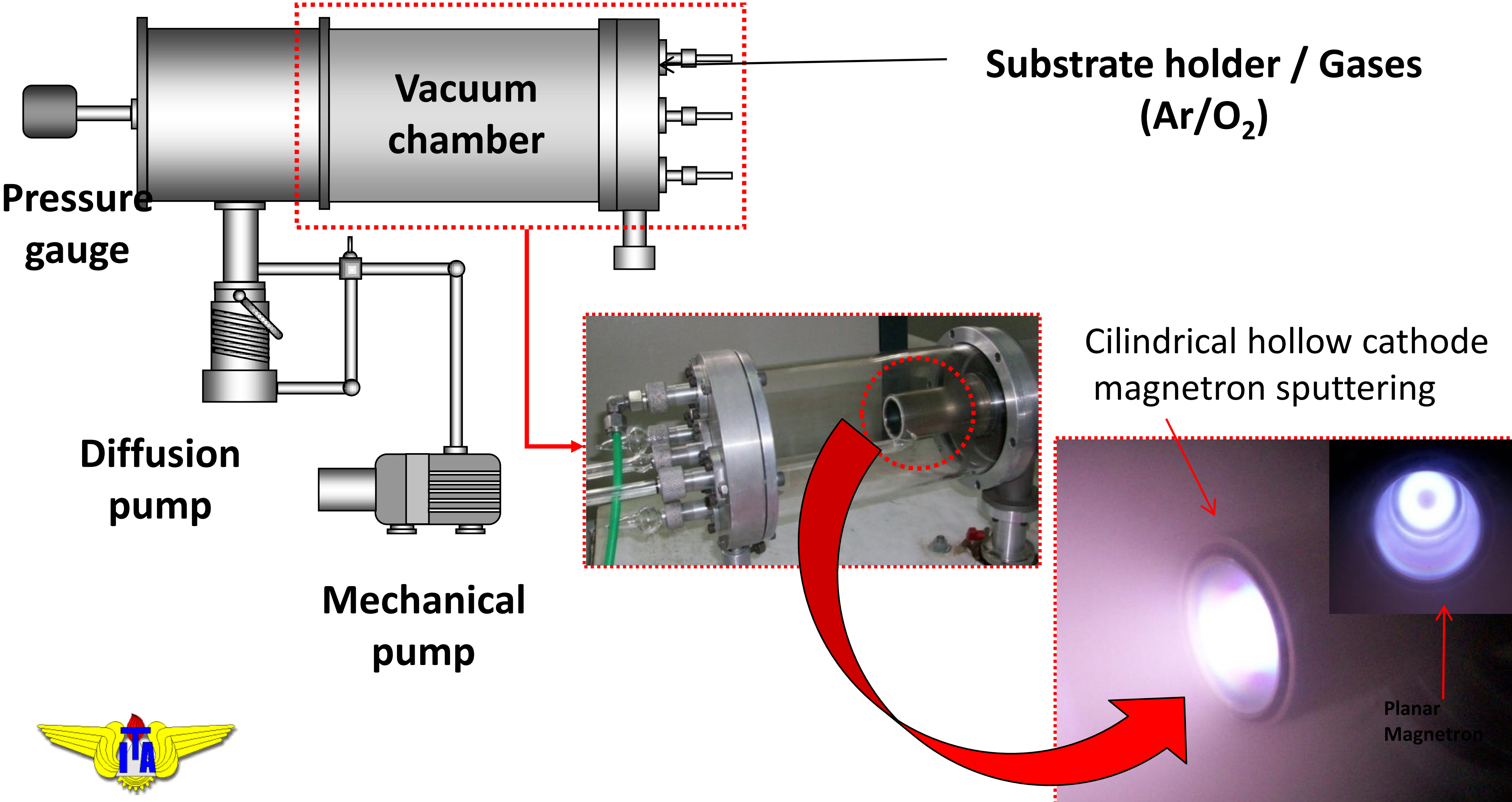


High density plasma



Planar hollow cathode magnetron sputtering

Hollow cathode magnetron sputtering



Hollow cathode magnetron sputtering

TiO_2 deposition

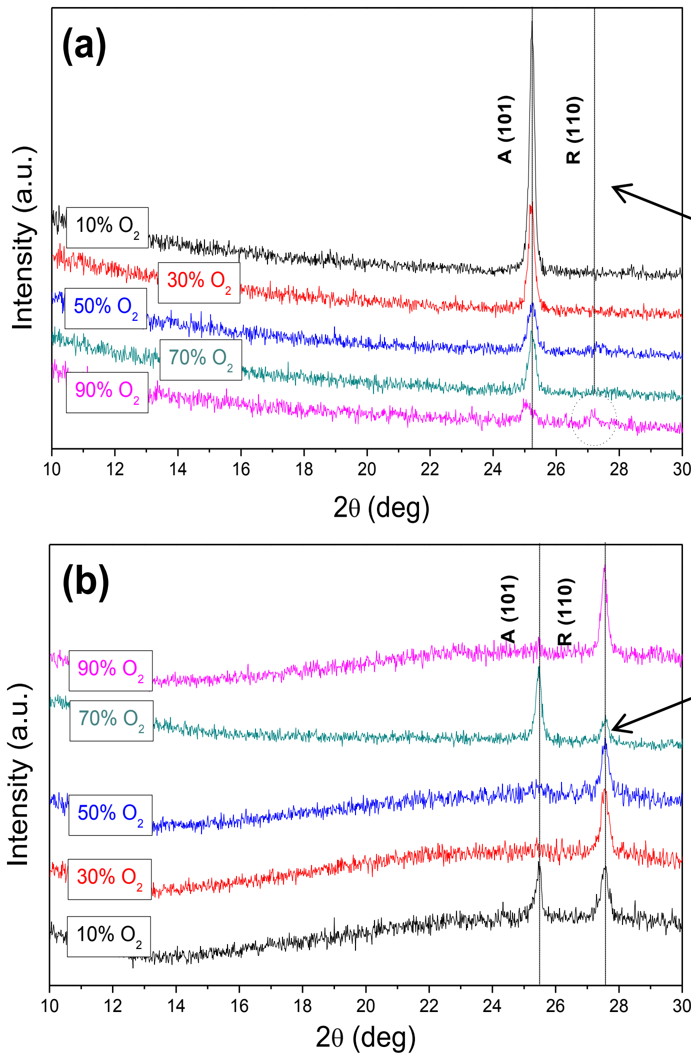


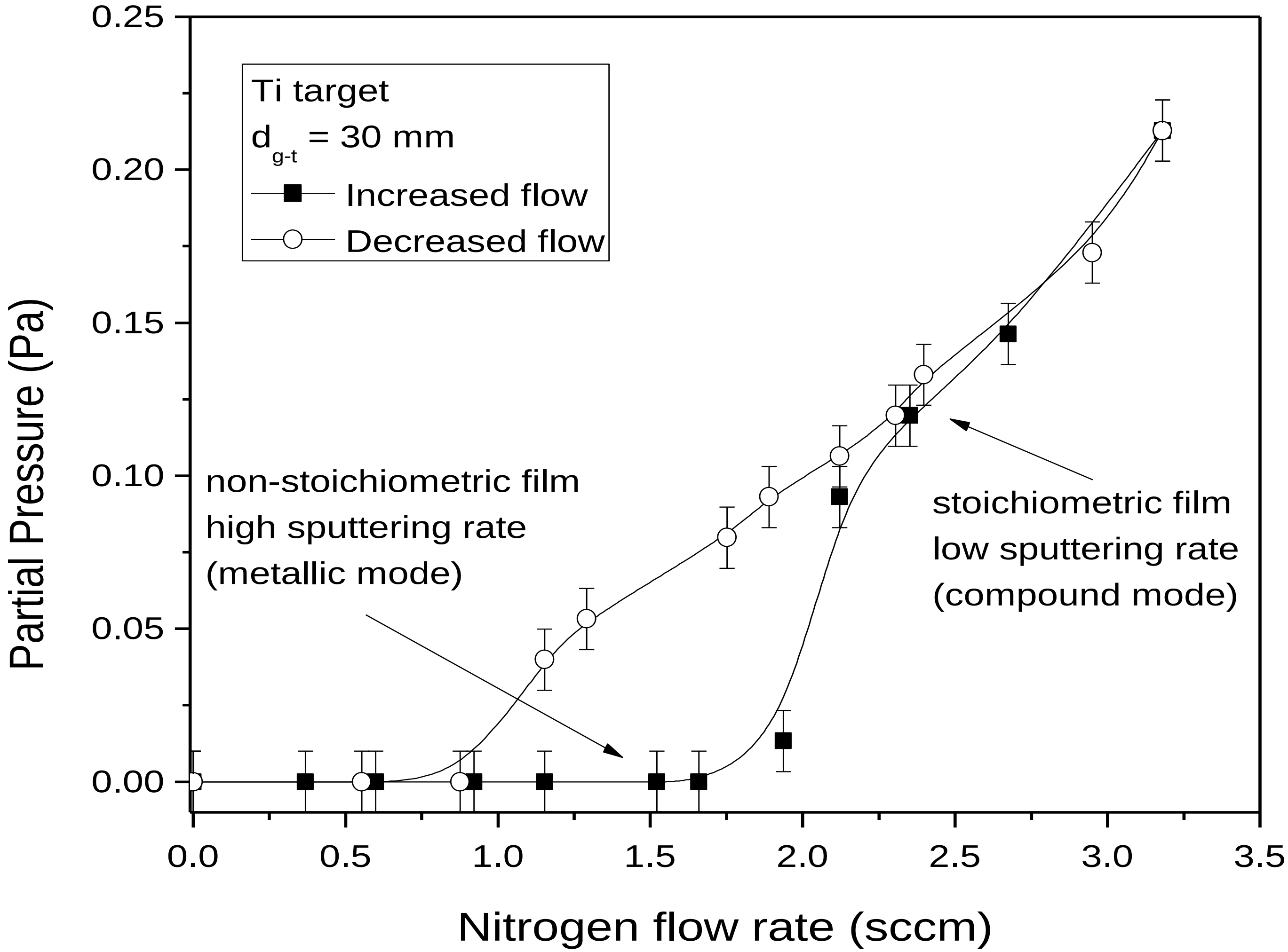
Fig. XRD patterns at various oxygen concentrations to the films deposited by (a) CMS and (b) HCMS systems.

HCMS discharge contributed to the substrate temperature around to 400ºC! For CMS, approximately 200ºC!

Formation of rutile phase in HCMS system

Hollow cathode
Magnetron sputtering (HCMS)

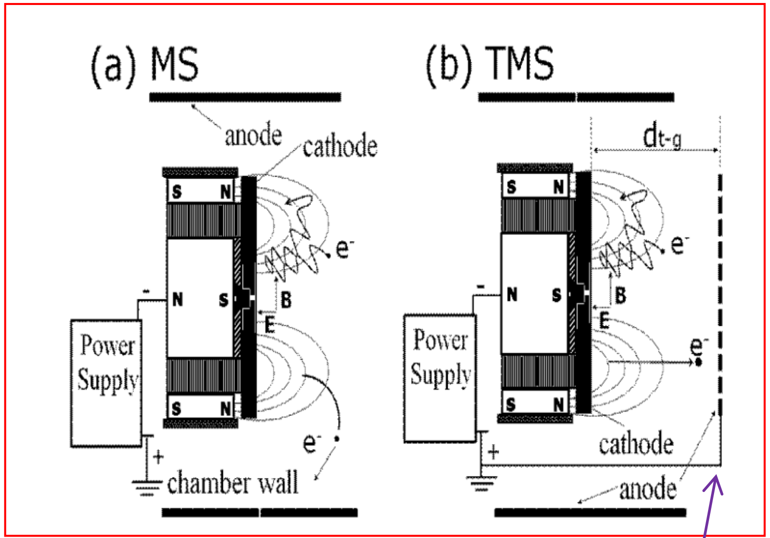
Hysteresis



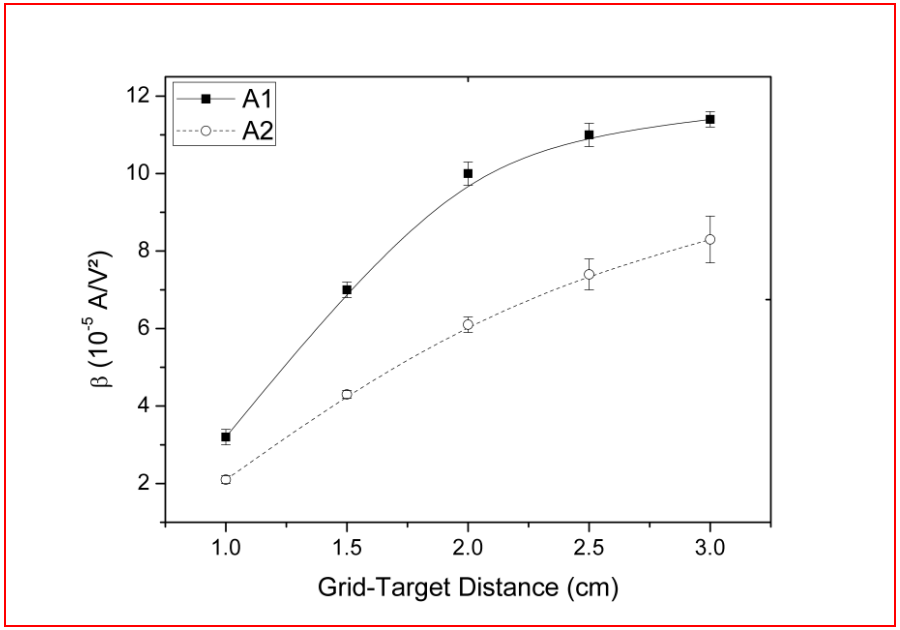
Ti target
d g-t = 30 mm
Increased flow
Decreased flow
non-stoichiometric film
high sputtering rate
(metallic mode)
stoichiometric film
low sputtering rate
(compound mode)
Partial Pressure (Pa)
Nitrogen flow rate (sccm)
0.00
0.05
0.10
0.15
0.20
0.25
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5

Triode Magnetron Sputtering

L. C. Fontana, J. R. L. Muzart, Surf. Coat. Technol., 107 (1998) 24.



Electrostatic confinement provided by the movable anode (grid)



Dependence of magnetron efficiency with grid-target distance

Triode Magnetron Sputtering

More stable discharges in reactive deposition.

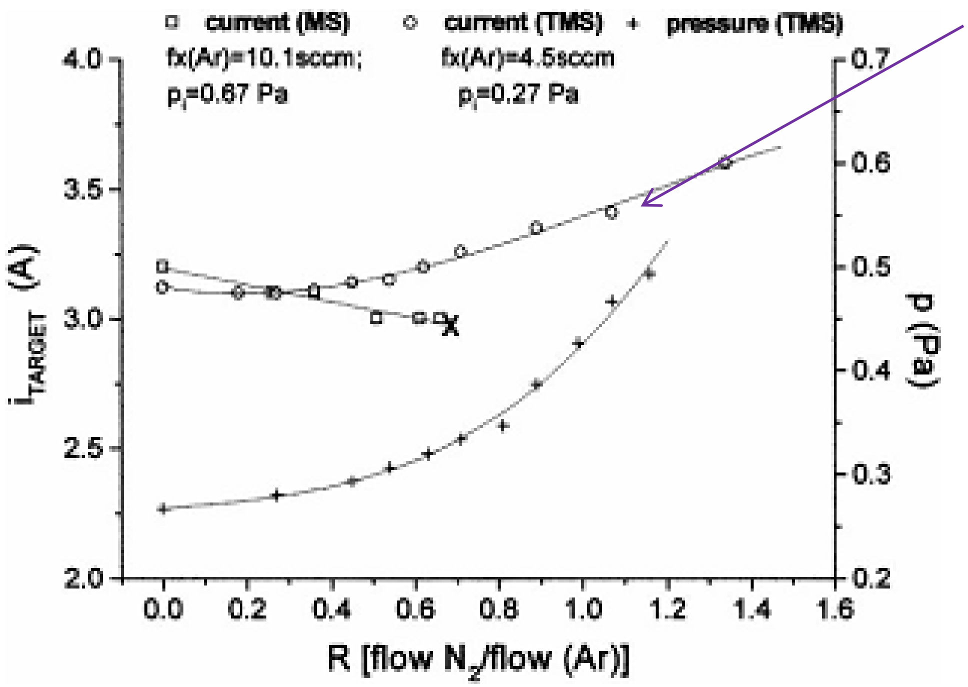
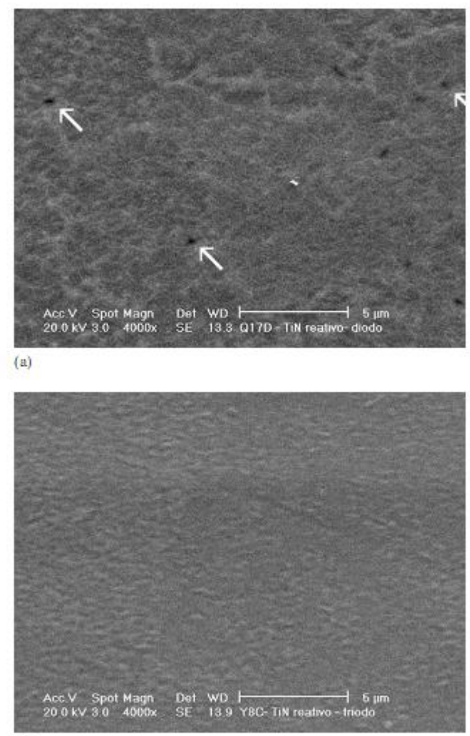


Fig. 2. Evolution of the current at the target and pressure as a function of the parameter R (=N_2 flow/Ar flow. The voltage at the target is fixed at a value of − 580 V. The discharge collapses at point X of the conventional system. MS = magnetron sputtering; TMS = triode magnetron sputtering.



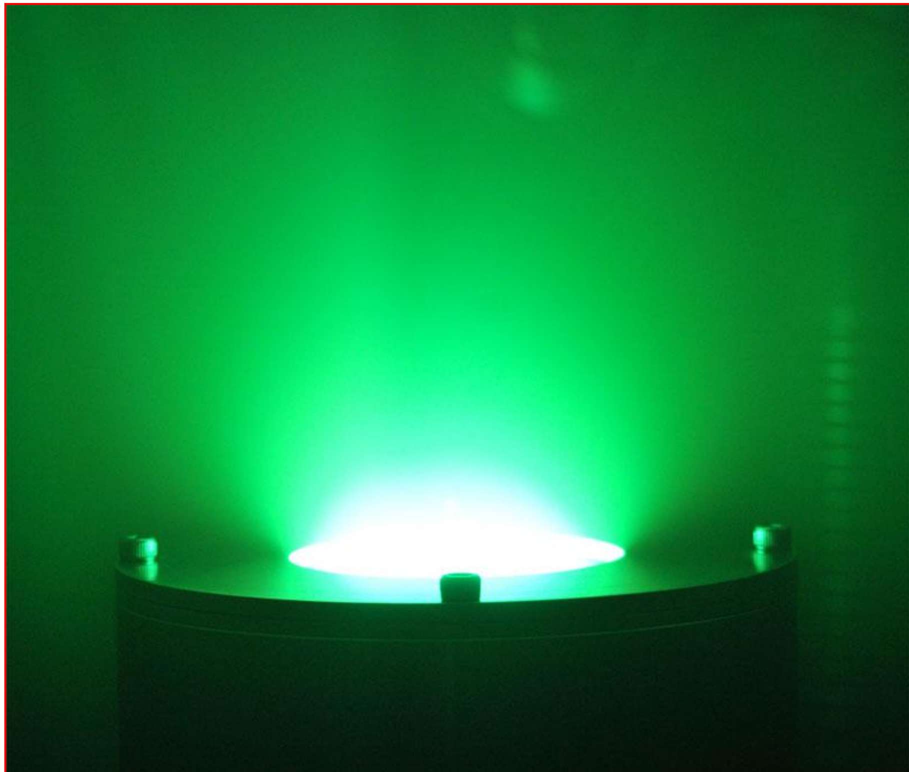
(a)

(b)

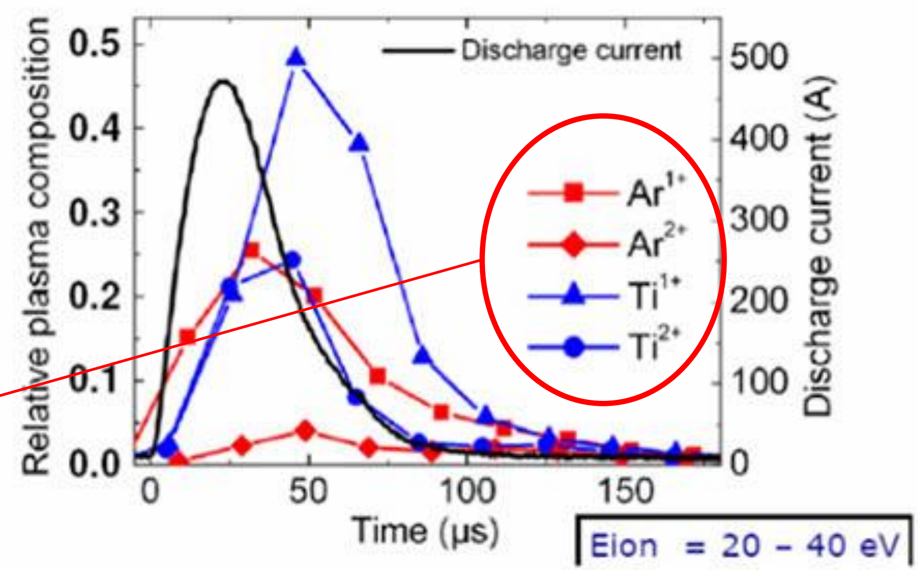
Fig. 8. Scanning electron surface micrographs of films deposited at a bias voltage of − 100 V applied to the substrate. Conventional (a) and triode (b) magnetron sputtering.

L. C. Fontana, J. R. L. Muzart, Surf. Coat. Technol.,114 (1999) 7.

High Power Impulse Magnetron Sputtering (HiPIMS)

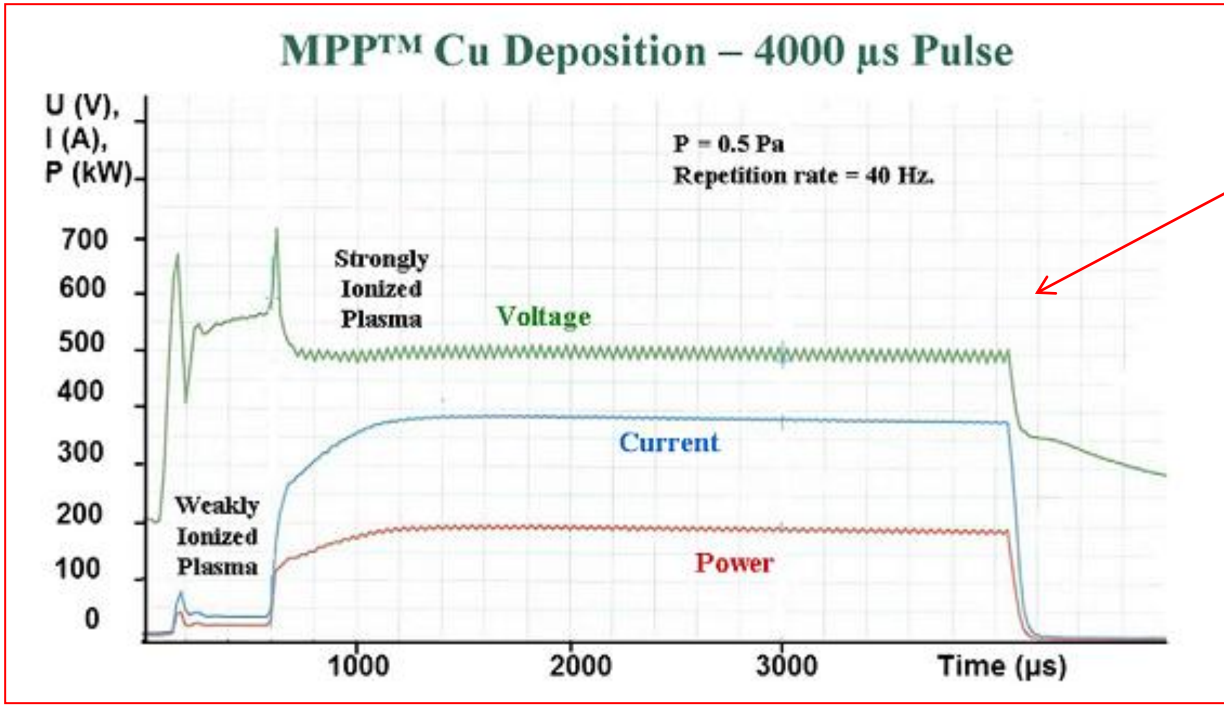


- New power supplies
- High plasma density
- Self-sputtering



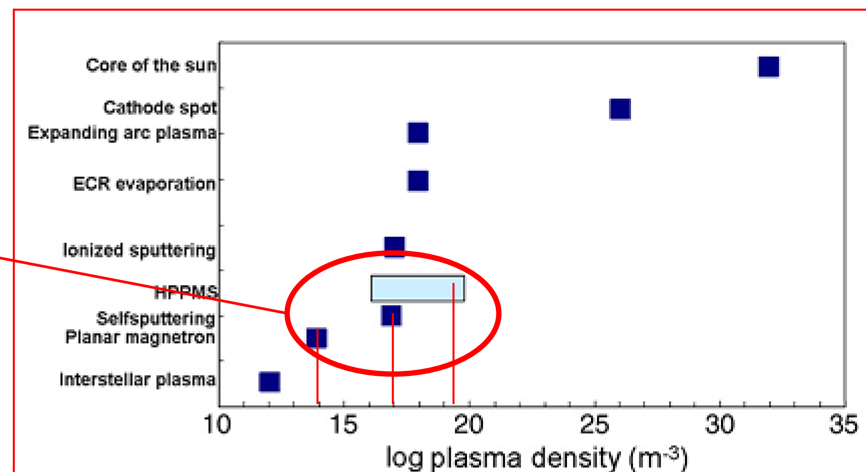
High ionization degree

HiPIMS



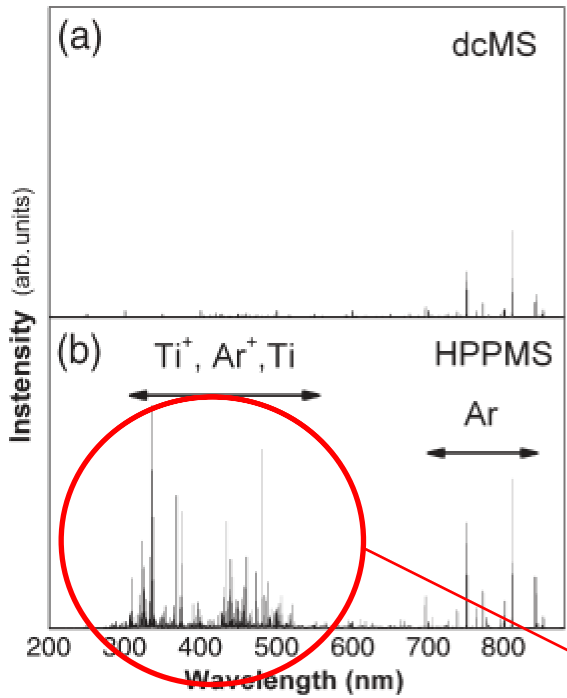
Temporal evolution

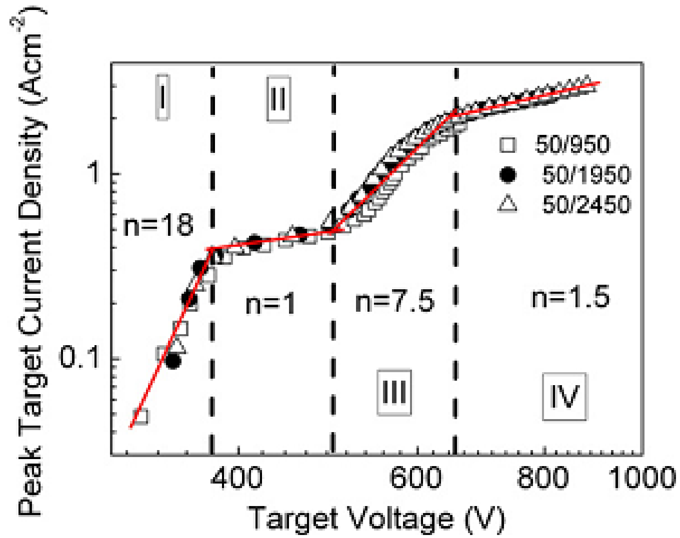
Increase of almost 6 orders of magnitude compared to planar magnetron



K. Sarakinos et al, Surface & Coatings Technology 204 (2010) 1661–1684

HiPIMS





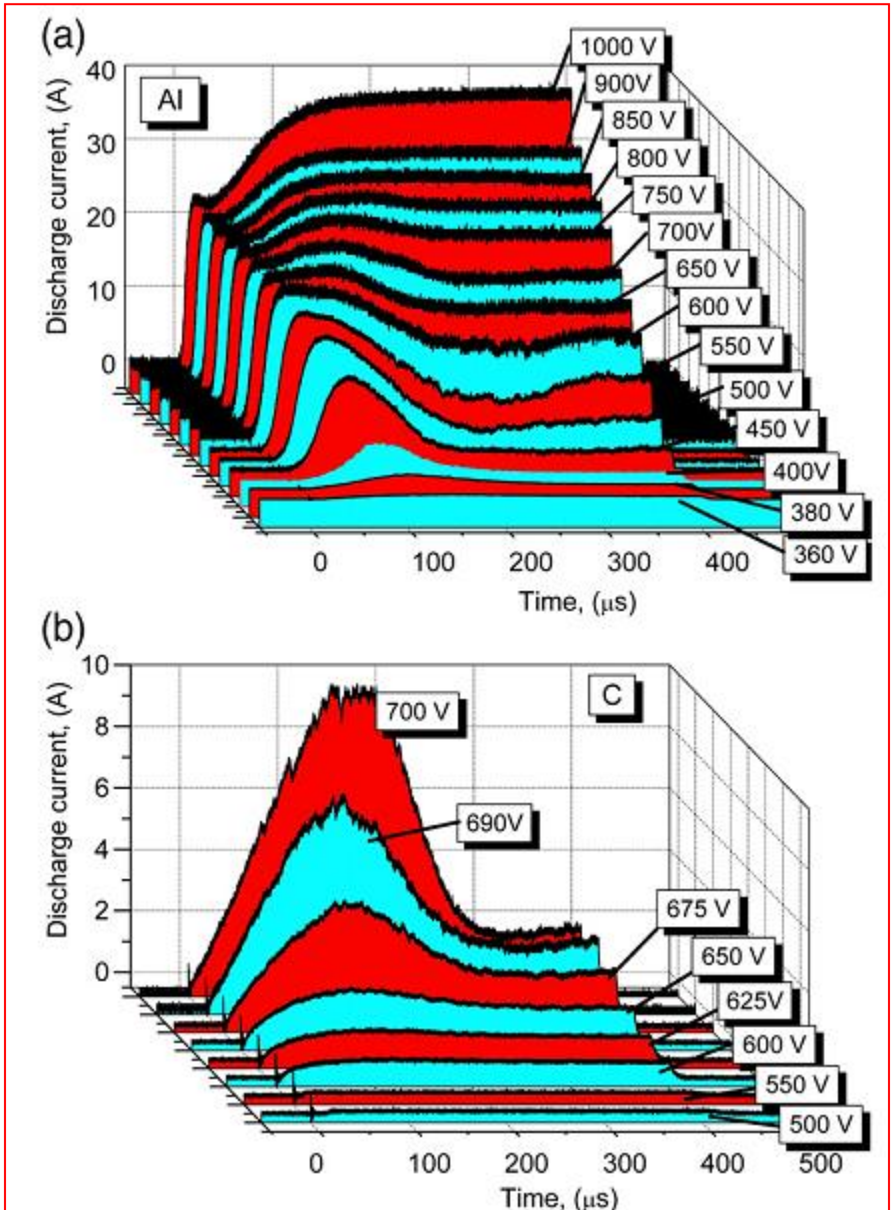
$$I = kV^n$$

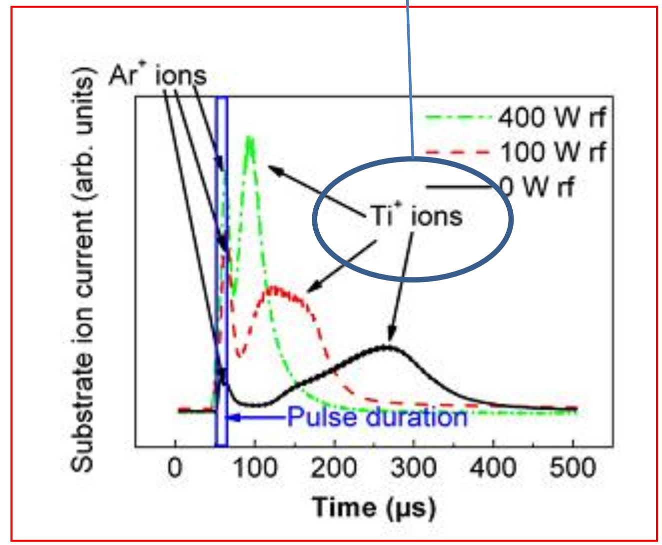
Ionization of sputtered species

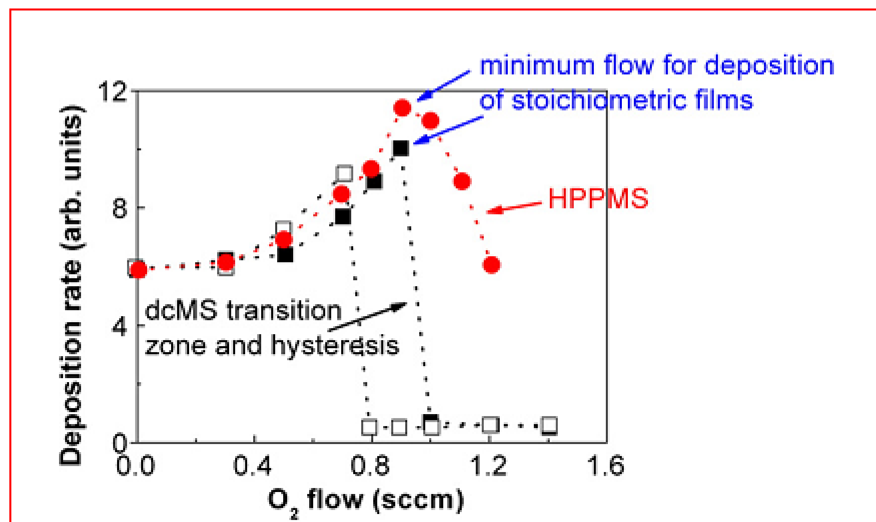
K. Sarakinos et al, Surface & Coatings Technology
204 (2010) 1661–1684

HiPIMS

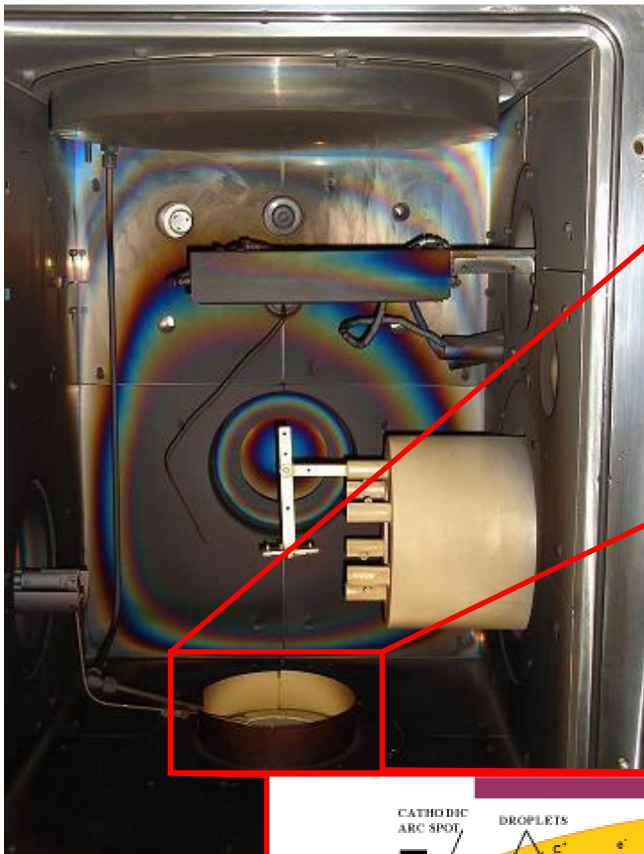
Deposition of ionic species:
higher energy transfer to the film

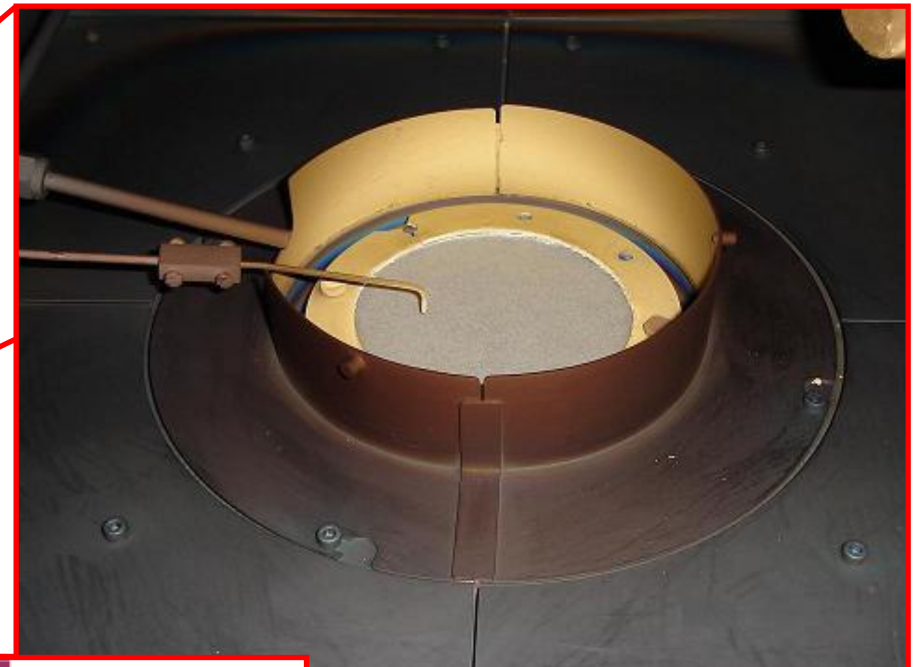


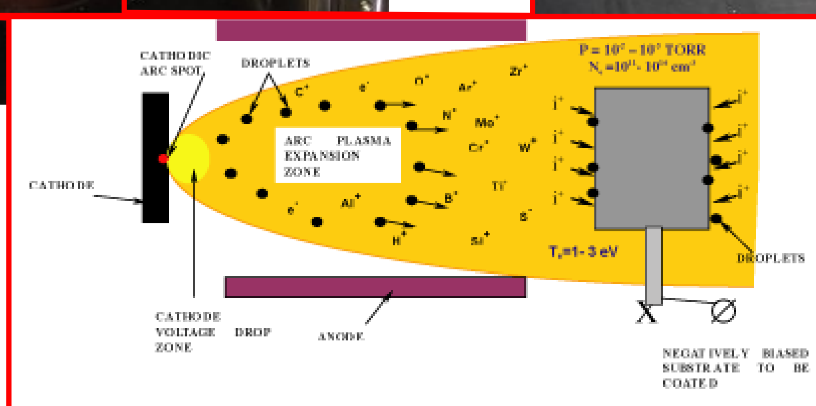




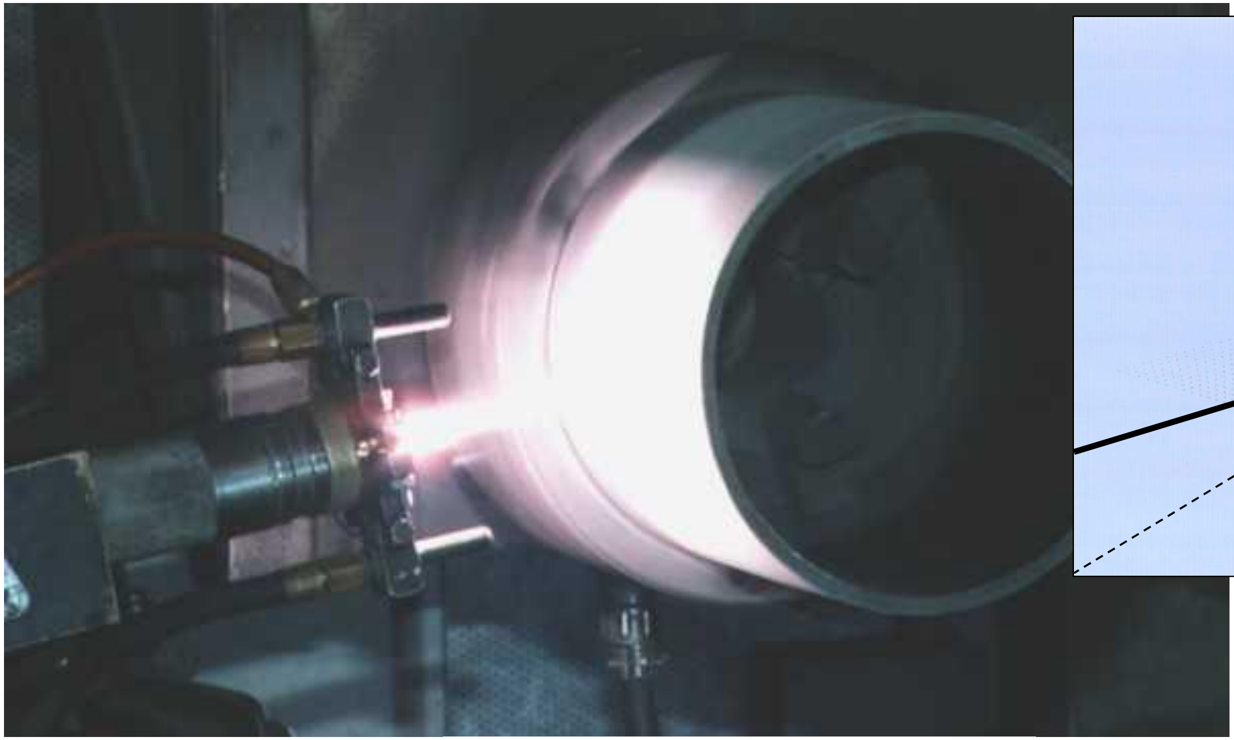
Vacuum arc deposition

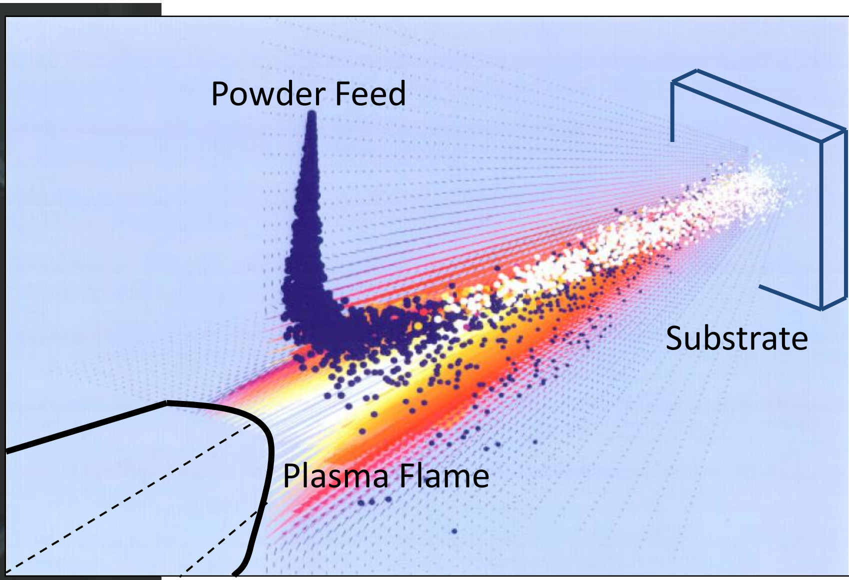


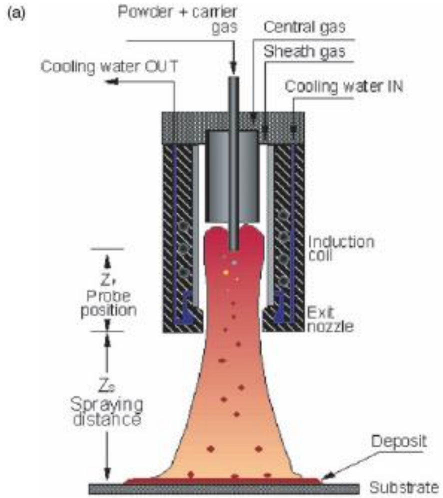




Thermal Plasma Spray

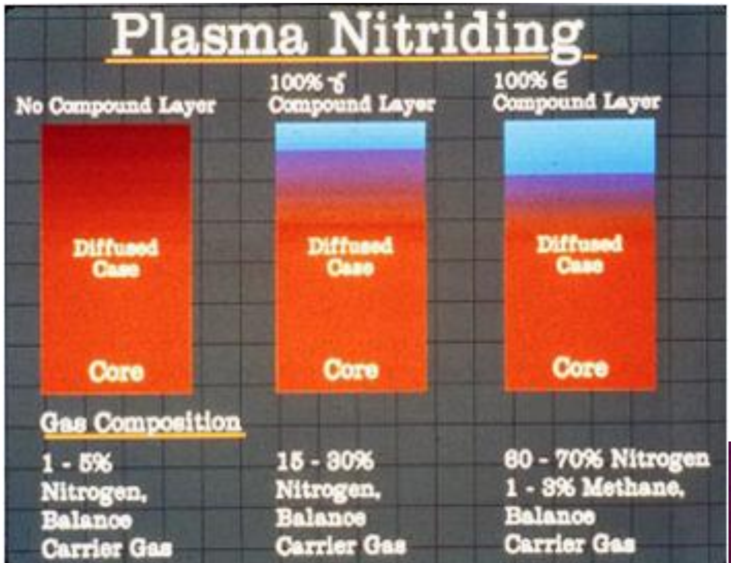


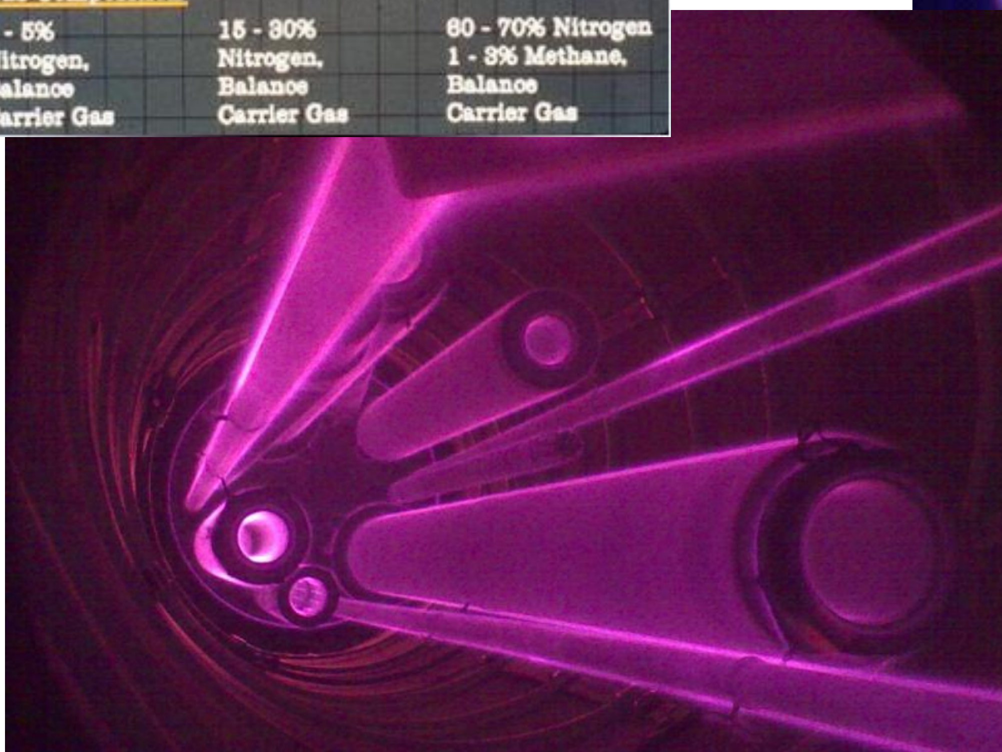


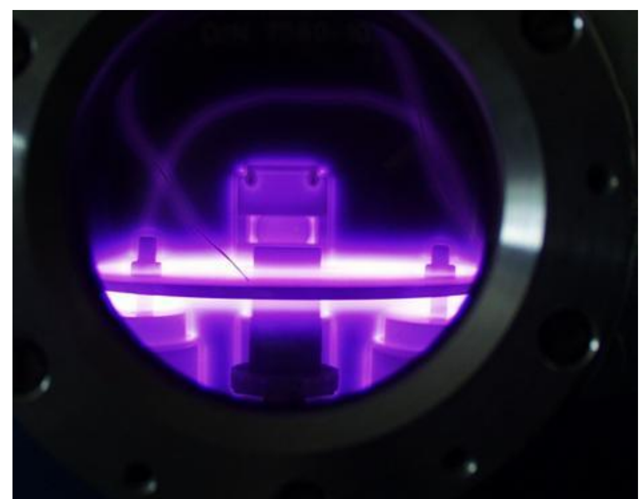


1. Powder melts in Plasma Flame
2. Molten droplets are accelerated towards substrate
3. Droplets solidify on substrate
4. A new layer of molten droplets solidifies

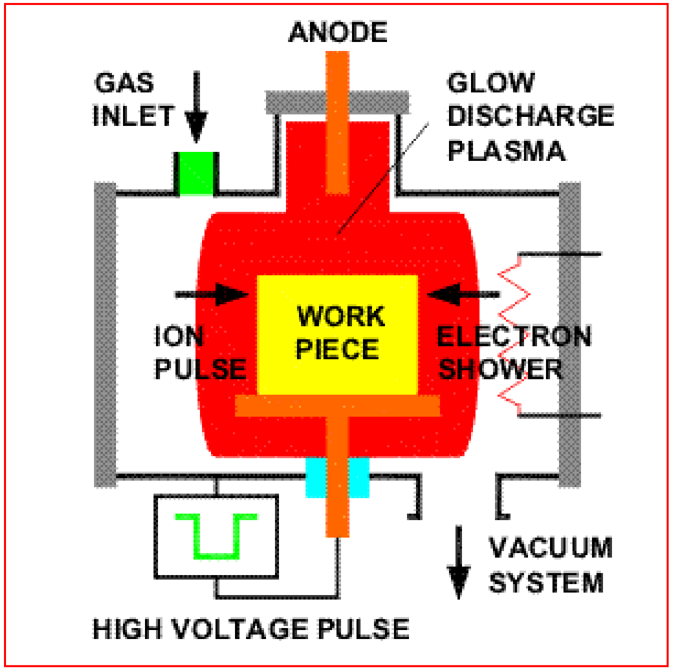
Plasma nitriding

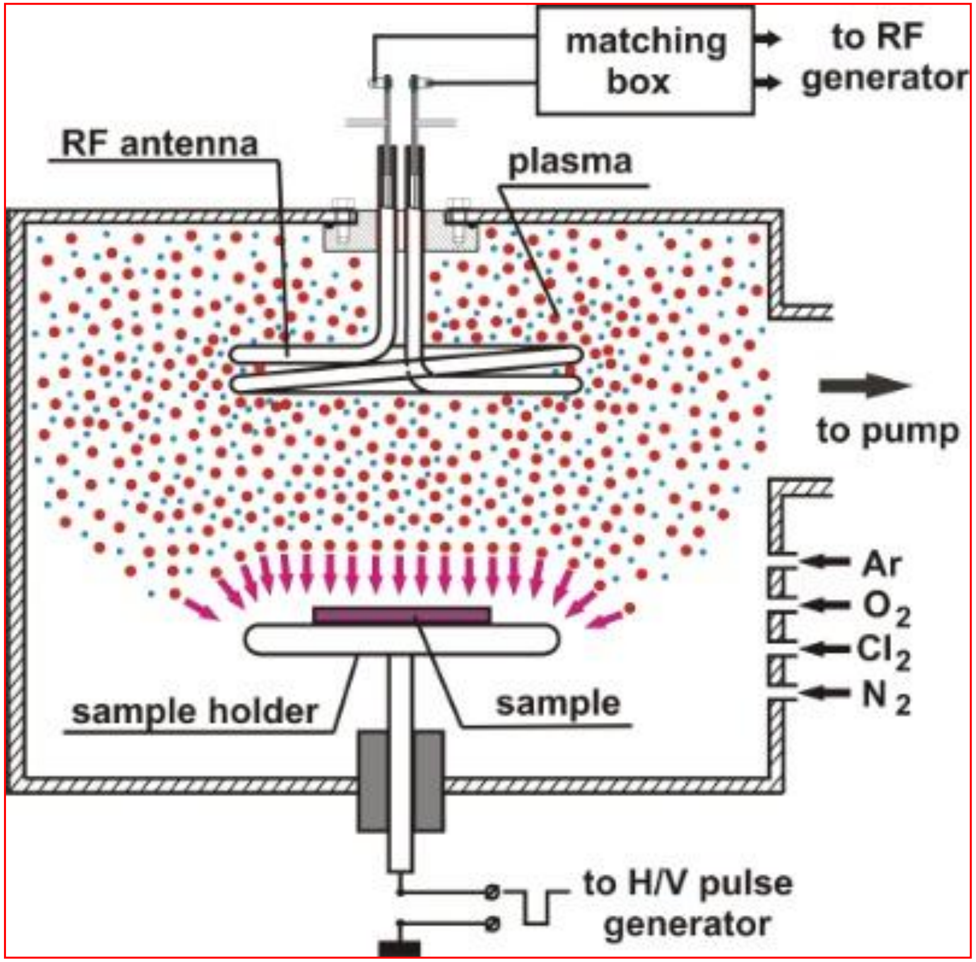






Plasma Immersion Ion Implantation





OBRIGADO

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