MEE4099 Capstone Project

Review 1 tentative presentation: first draft

Project Title:

Magnetic Mirror Effect in Magnetron Plasma: Modeling of Plasma Parameters

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Internal Guide:

Professor Sitaram Dash

1. Introduction

1.1 Plasma

Non equilibrium state with long range dynamics

1. Number density, n

   Number of particles per unit volume.

   Mass density $\varrho := mn$

   m is the mass of particles of the species.

2. Ionization, α

   $\alpha := \frac{n_{charged}}{n_{charged} + n_{neutral}}$

   $\alpha = 1$: all the particles are charged

   $\alpha = 0$: all the particles are neutral

3. Temperature, T

   describes the average kinetic energy of the particles in the plasma

4. Mean free path, λ_{mfp}

   influenced by the temperature

   $\lambda_{mfp} := v_{th}\tau$

   v_{th}: thermal velocity of the particles

   τ: timescale of collisions.

5. Plasma beta parameter

   $\beta := \frac{8\pi nT}{B^2}$

   ratio of the thermal and magnetic energies of the plasma

   random thermal motions compete with the Lorentz force.

6. Debye Length, λ_D

Competing

Coulumb interactions	Random thermal speed
between charged particles	based on temperature

Debye sphere: imaginary sphere around a charged particle where oppositely charged particles are attracted
screen the charge of the central particle to the outer plasma
electrostatic influence of a particle is limited to the Debye sphere surrounding it

Quasi-neutral behavior:
electrostatically neutral on scales $> \lambda_D$.
Debye length, λ_D: radius of the Debye sphere.
Other parameters: Larmor radius, frequencies of waves, etc.

1.2 Laboratory Plasma

Properties of laboratory plasma

- High ionization fraction
- Sub atmospheric pressure required to sustain ionization
- Temperature range : 1000 - 30000 K

Surface engineering techniques that use plasma

1. Plasma Immersion Ion Implantation (PIII)
2. Plasma Enhanced Chemical Vapor Deposition (CVD)
3. Magnetron Sputtering (PVD)
4. Air Plasma Spray (Spray technique)
5. Plasma Transferred Arc (Hardfacing technique)

1.3 Physical Vapor Deposition

Thin film coatings are grown on the surface of a specimen
Random walker particles get trapped in strained pockets
Produce nucleation site

1. Sputtering techniques
   Cold techniques
   high energy beam removes material from a target
   removed material is coated on the substrate.

2. Evaporation techniques

   Hot techniques

   heating the material to to a high temperature

   particles in the vapor are coated on the substrate

   Semiconductors like Si/Ge, insulators like oxides and metals like Tungsten often coated

1.4 Magnetron sputtering

Sputtered ions form a magnetically confined plasma

Plasma controlled by magnetic fields

Transports ions to the surface of the substrate forming the coating.

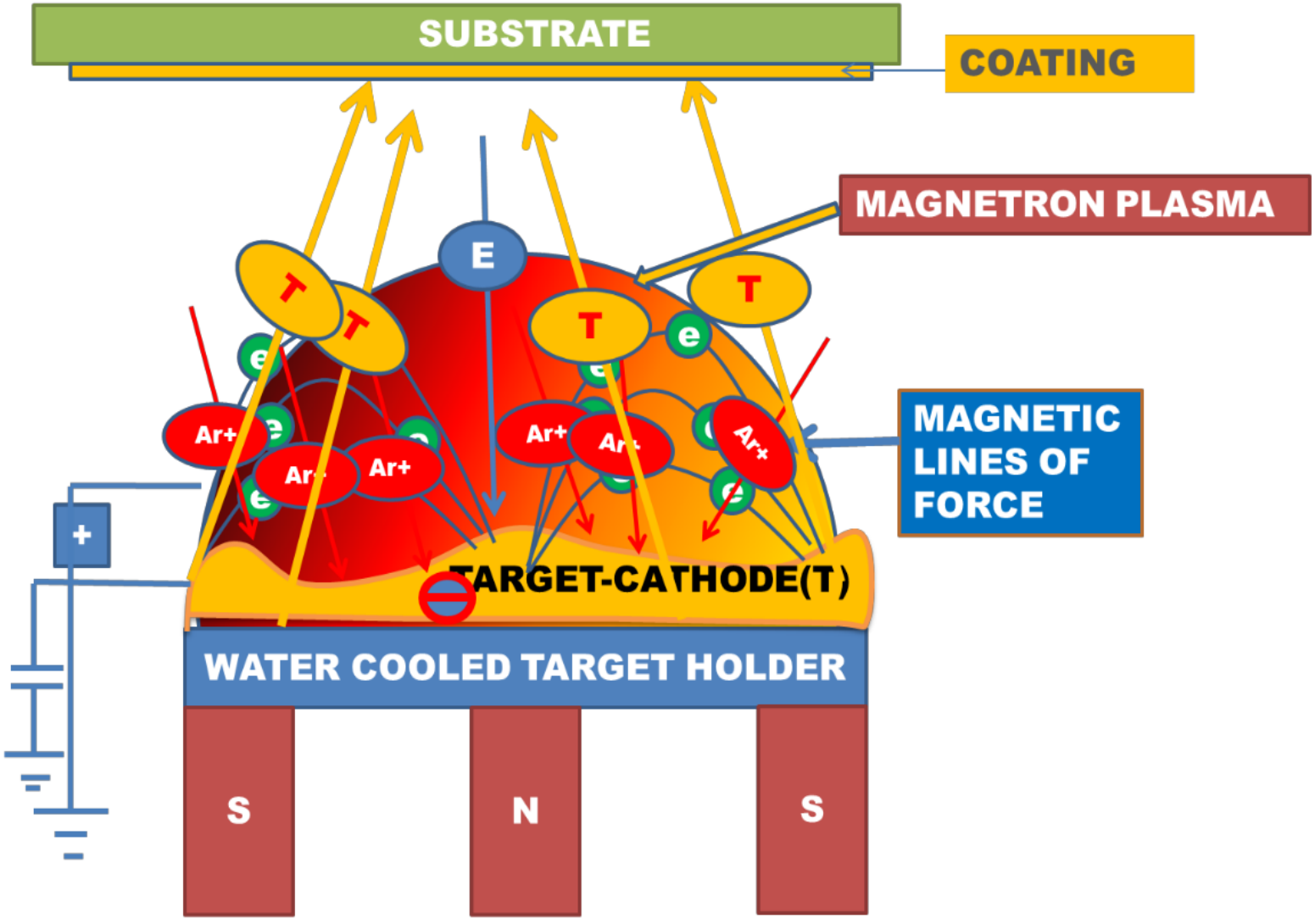

Figure 1: Magnetron Sputtering system. credit: [1]

1.5 Magnetic Mirror

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