5th Spring Plasma School

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Msc Plasma Physics

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Al-Karkh University of Science

Baghdad , Iraq

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(Plasma formation and diagnoses in lab.)

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Interaction of Injected Dust Particles with Plasma

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At the end of the lecture student would be expected to:-

1. Understand the definition of dusty plasma.

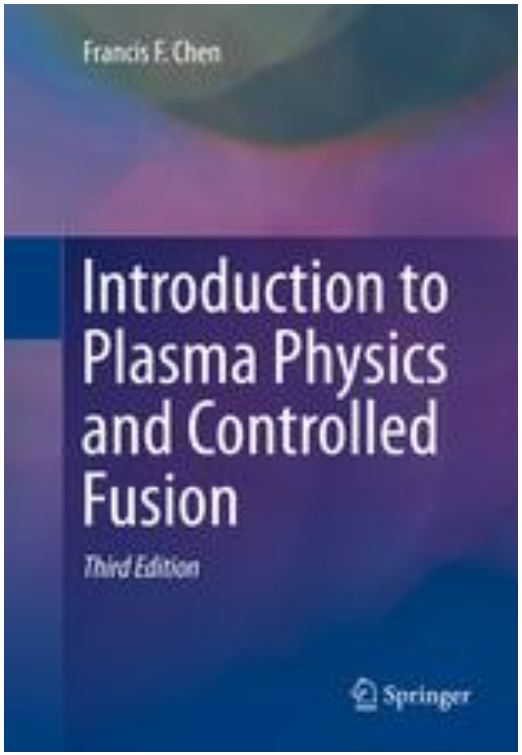
2. Recognize the design and construction of AC dusty plasma system.

3. Plasma Diagnostic Techniques
   - optical emission spectroscopy (OES)
   - Langmuir probes.

4. Influence of zinc dust particle on the discharge characterization in two discharge column regions
(plasma bulk and plasma sheath) in alternating current system

Plasma :

Is quasi neutral gas of charged and neutral particles which exhibit collective behavior .



More than 99% of the visible matter in the universe is in the plasma state .

Chen, Francis F.

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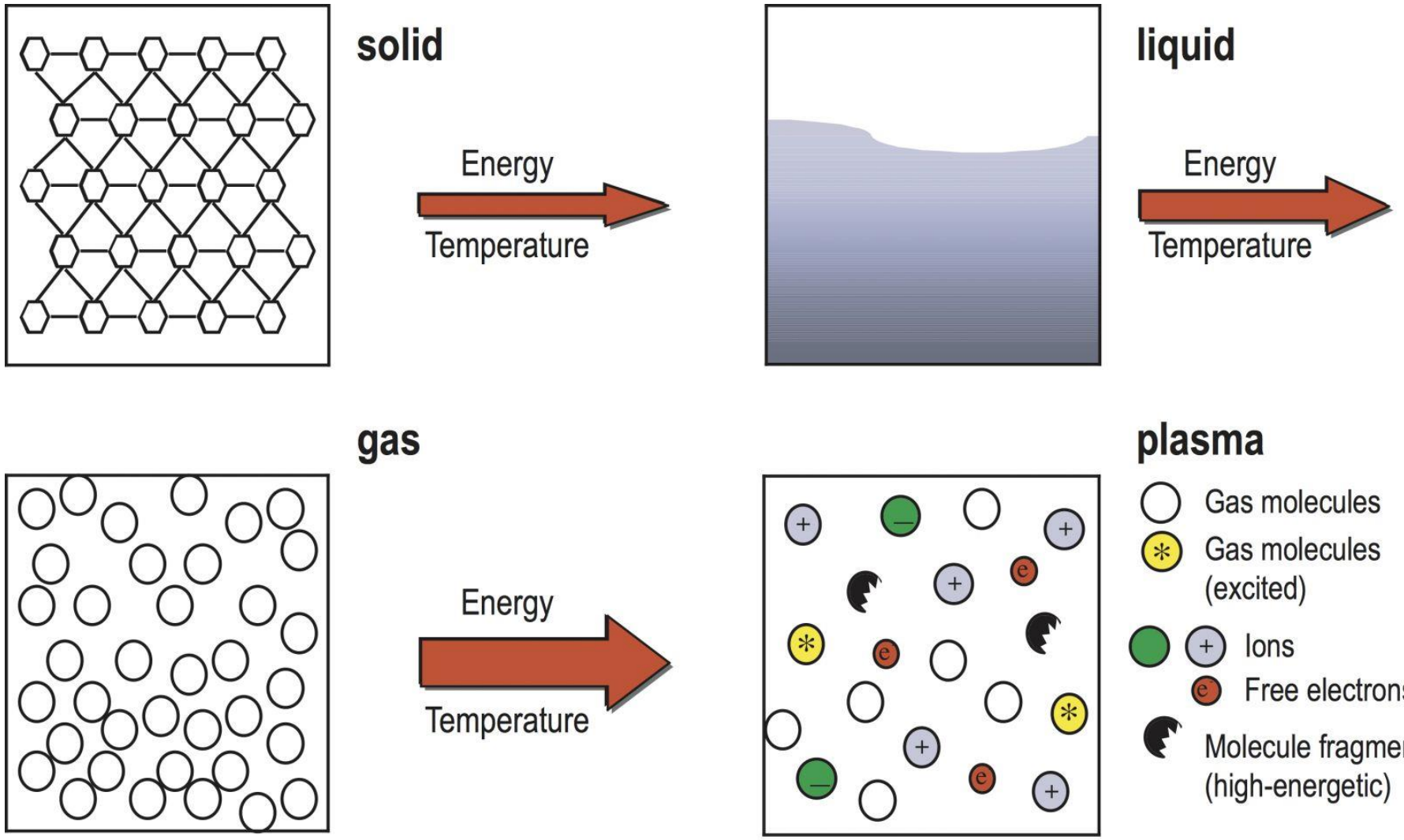
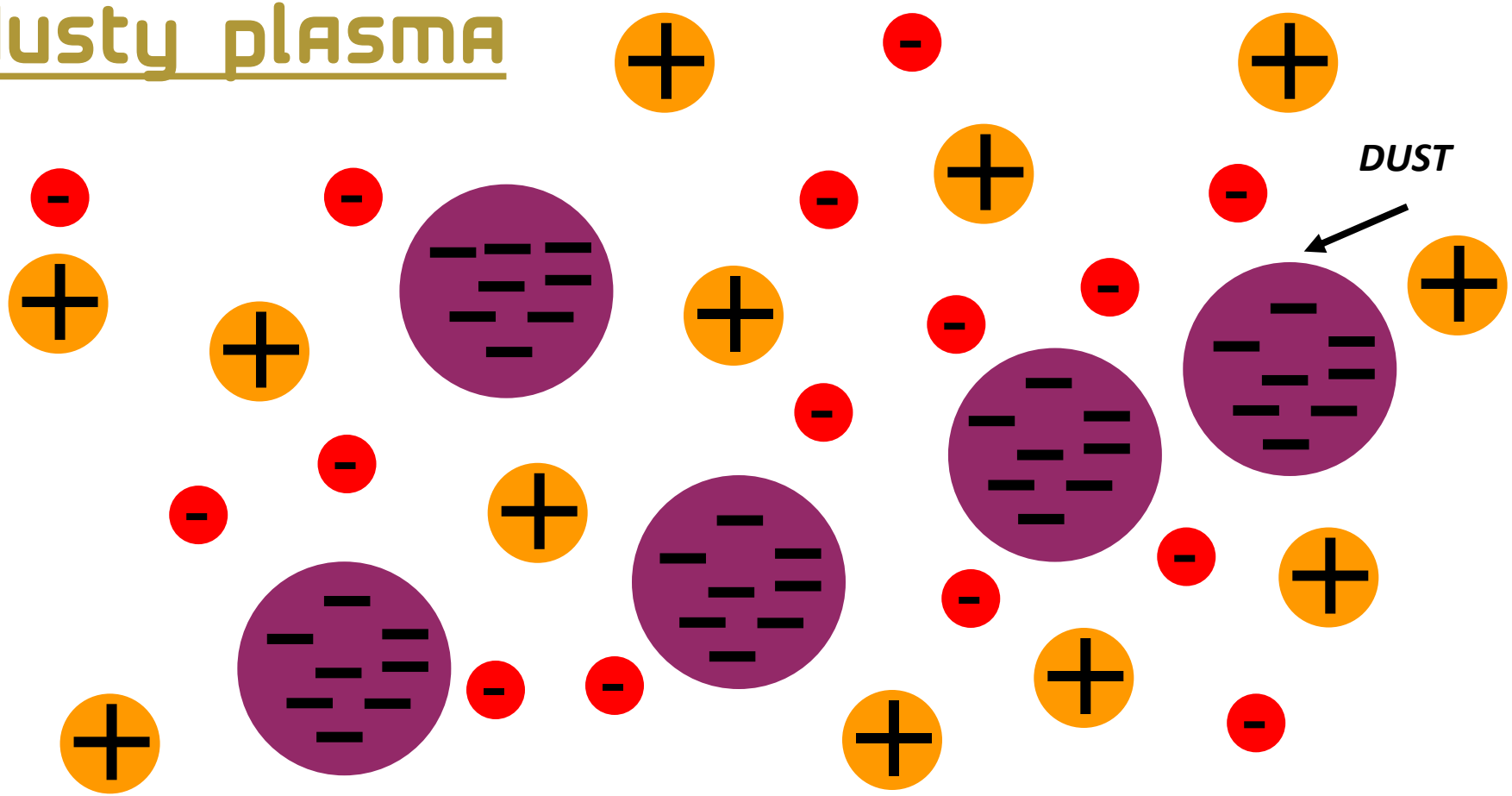
Introduction to Plasma Physics and Controlled Fusion


solid
Energy
Temperature
liquid
Energy
Temperature
gas
Energy
Temperature
plasma
Gas molecules
Gas molecules (excited)
Ions
Free electrons
Molecule fragment (high-energetic)

dusty plasma



- absorbs electrons and ions
- becomes negatively charged

- **Dust in Plasma (low density dust)**

(dust particles are considered as a collection of isolated screened grains)

$$r_d << \lambda_D < a$$

- **Dusty plasma (high density dust)**

(in which charged dust particles participate in the collective behavior)

$$r_d << a < \lambda_D$$

(r_d) dust grain radius

(a) average integrin distance

(λ_D) plasma Debye radius

Milestones in dusty plasma research

1980

1998

Milestones in dusty plasma research

1980

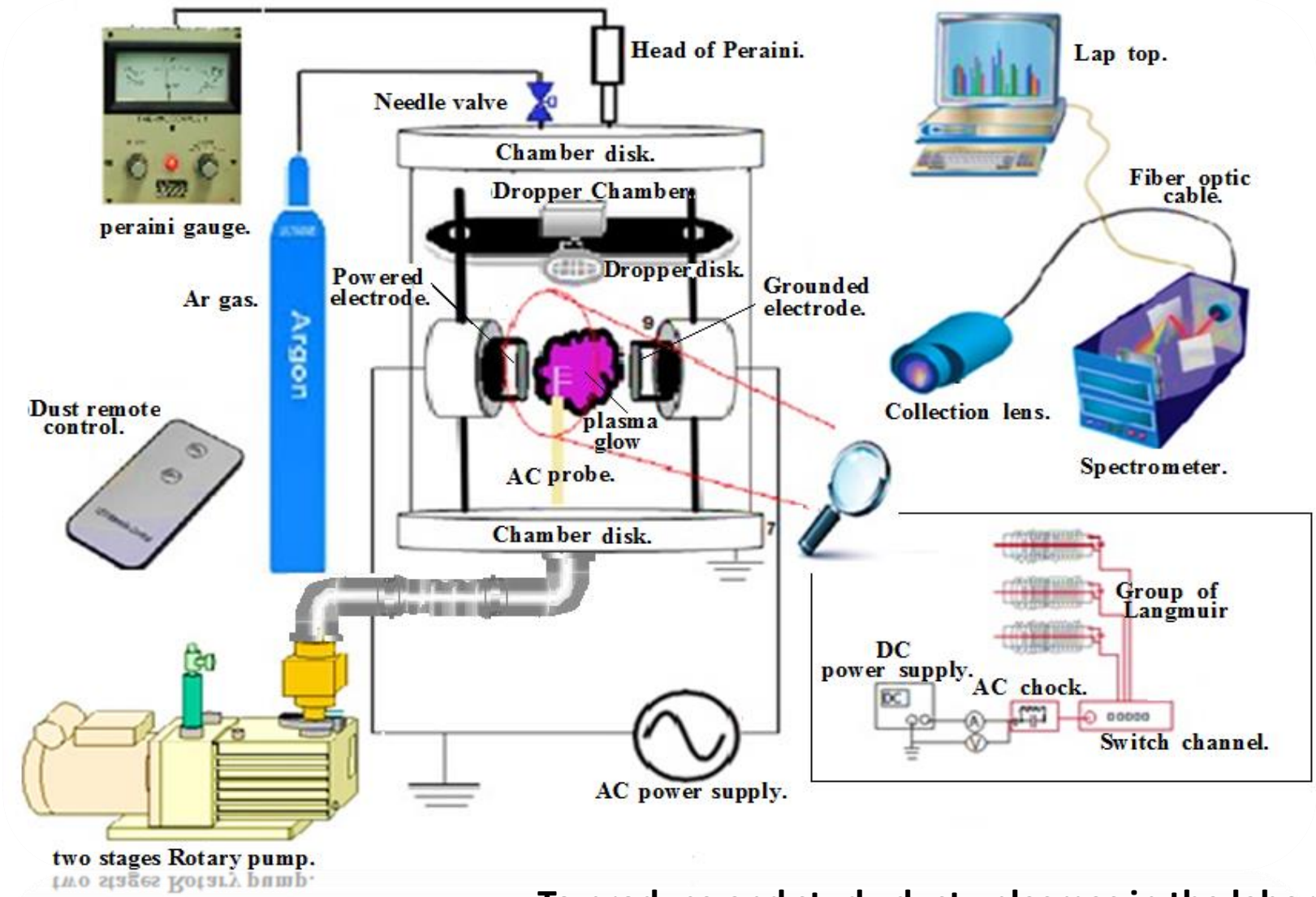
- The discovery of the spokes in Saturn's B ring.
- Realization of the dust contamination problem in the semiconductor processing industry

1998

- The discovery of the dust problem in Fusion reactors.

Dusty Plasma System

Dusty plasma devices (DPDs)

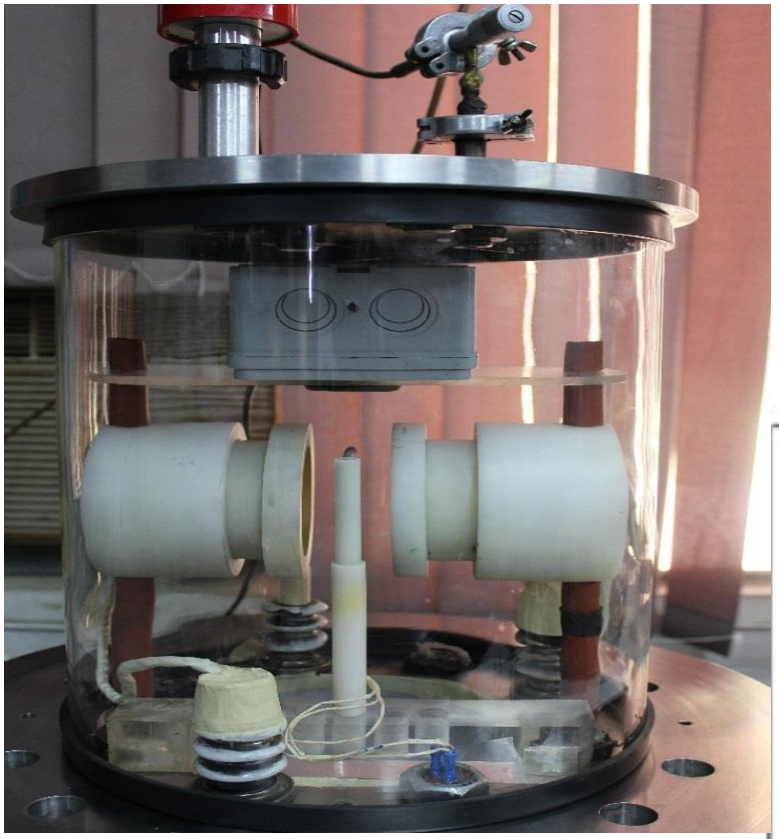


To produce and study dusty plasmas in the laboratory

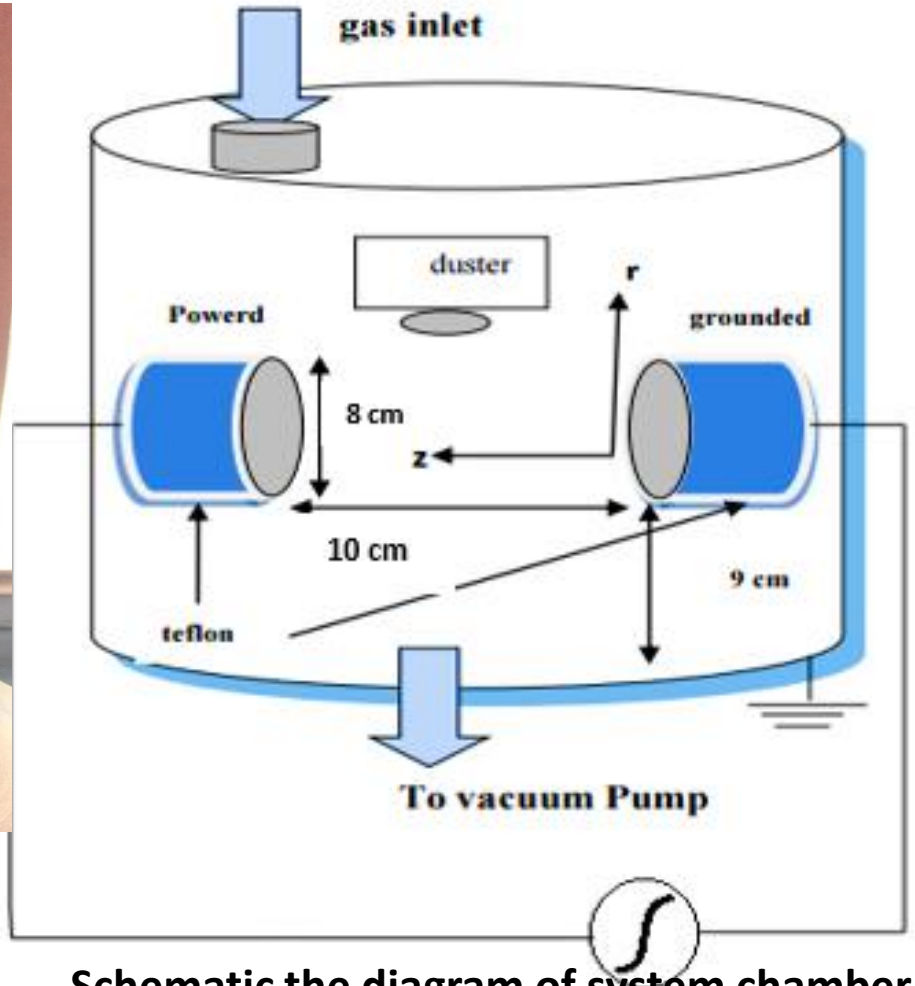
Basic Parameters of Ac dusty plasma system.

Electrode Material	Zinc
Type of Dust Particle	Zinc
Operation Mode	Ac mode
Background Gases	Argon
Electrode Diameter	8 cm
Distance between Electrodes	10 cm
Electrode Thickness	2 mm
Dust Particle Diameter	~125 µm , ~212 µm
Dust Weight	0.1 g
Frequency	50 Hz
Applied voltage	600 volt
Applied current	80 mA

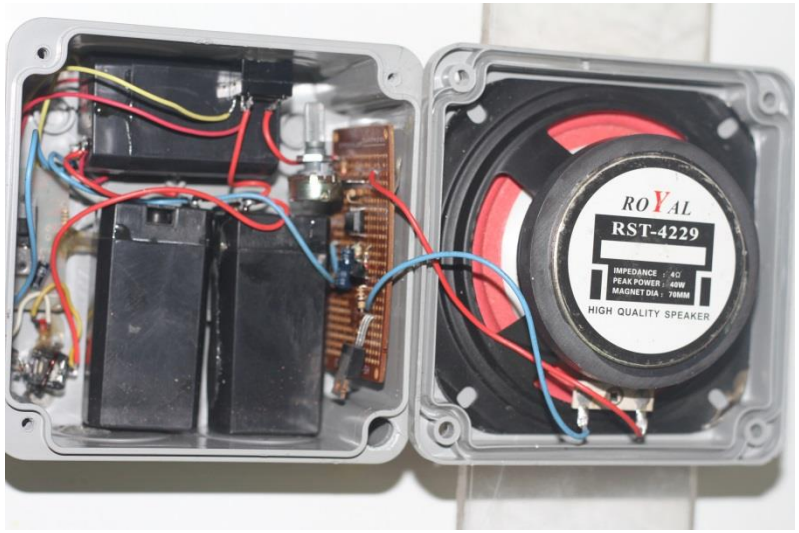
Main parts of the ac dusty plasma systems



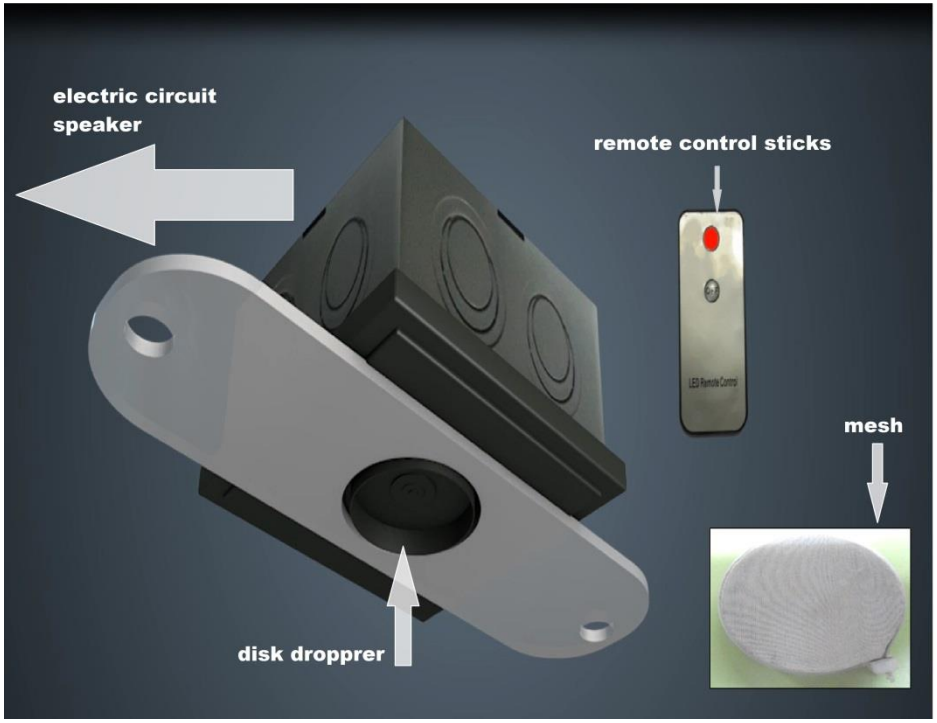
Power Supply

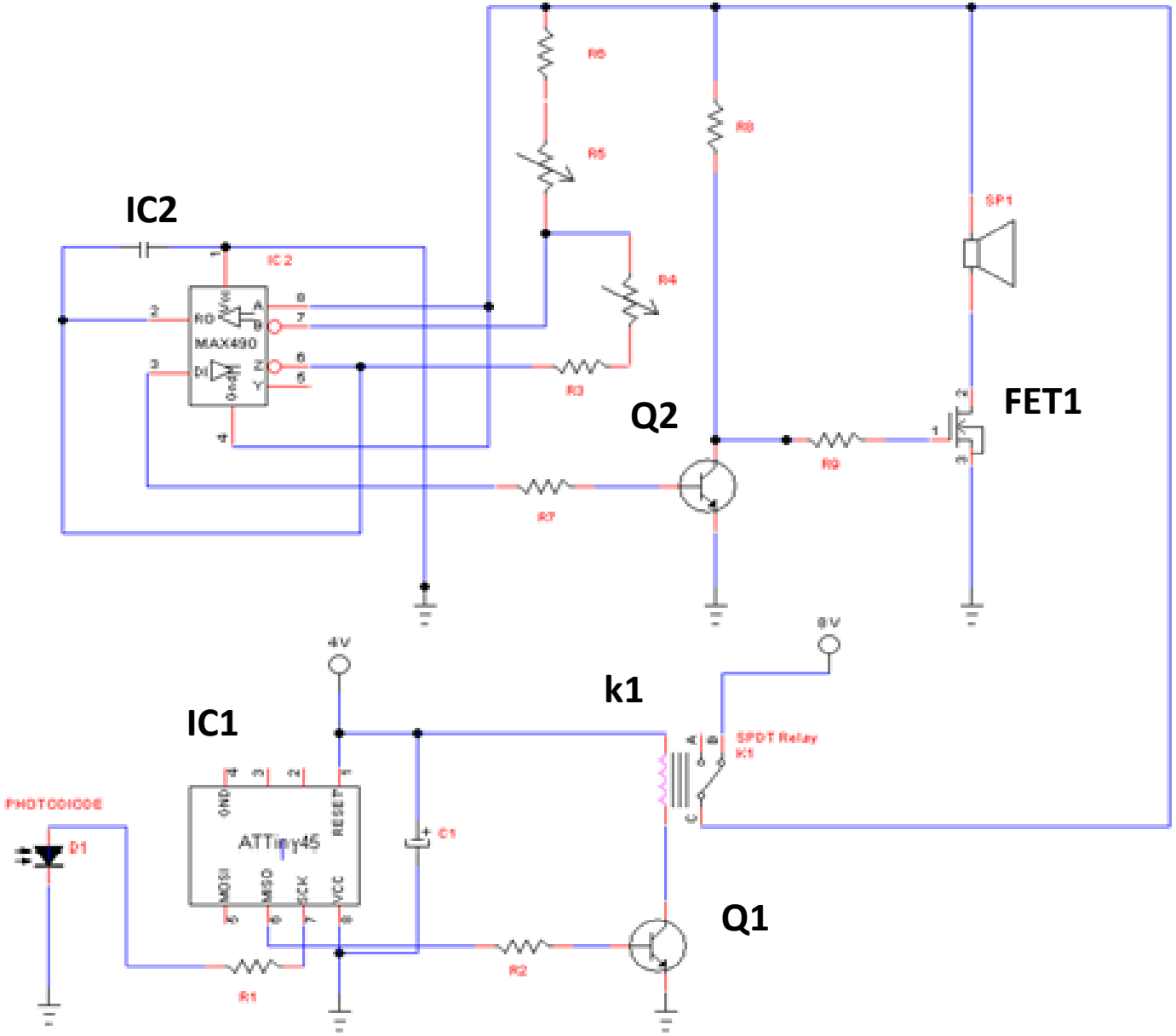


Schematic the diagram of system chamber with electric circuit.

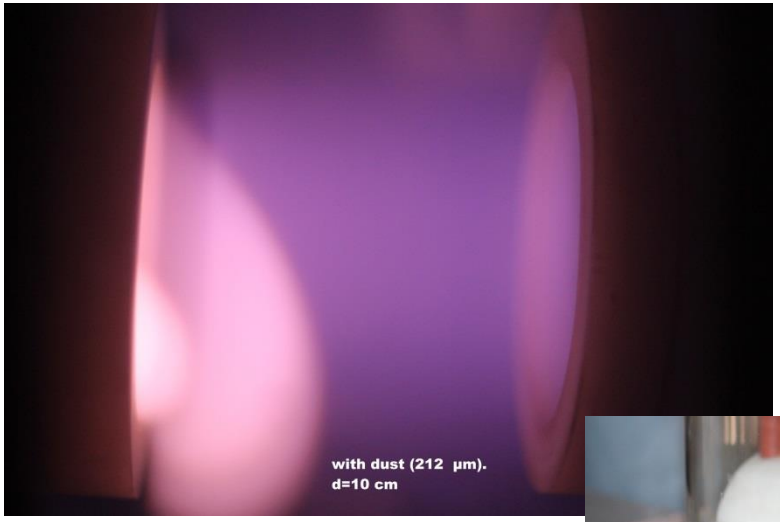


Dust Dropper Device

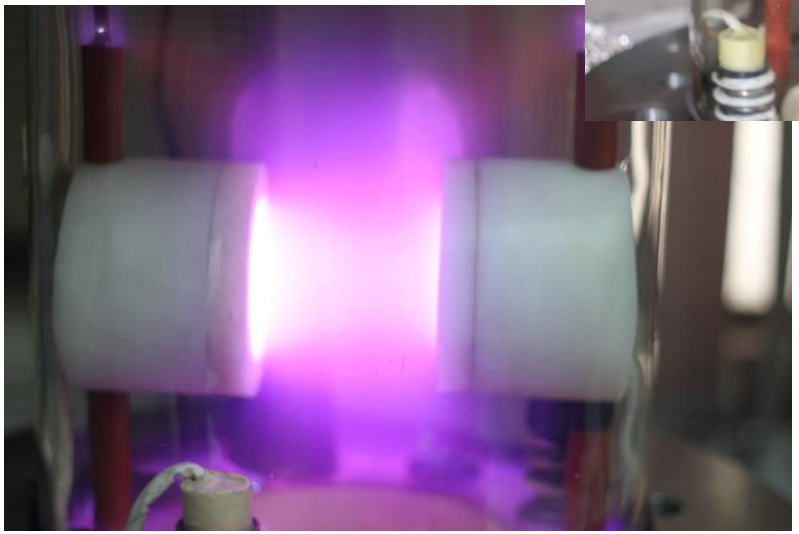


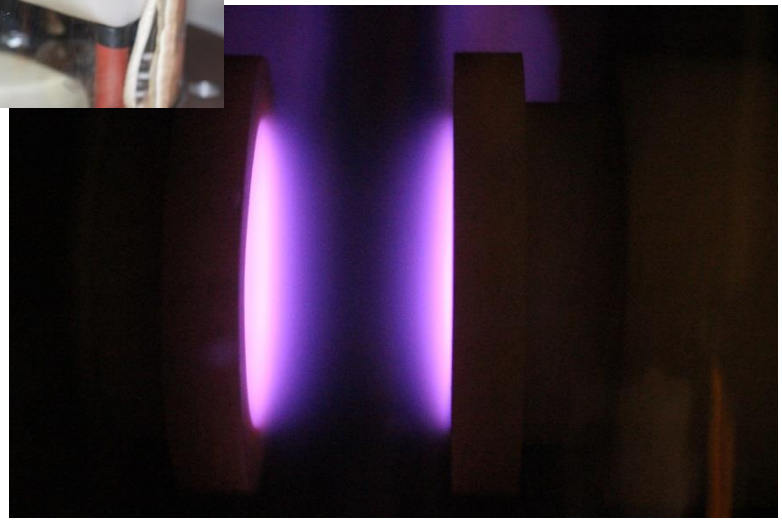


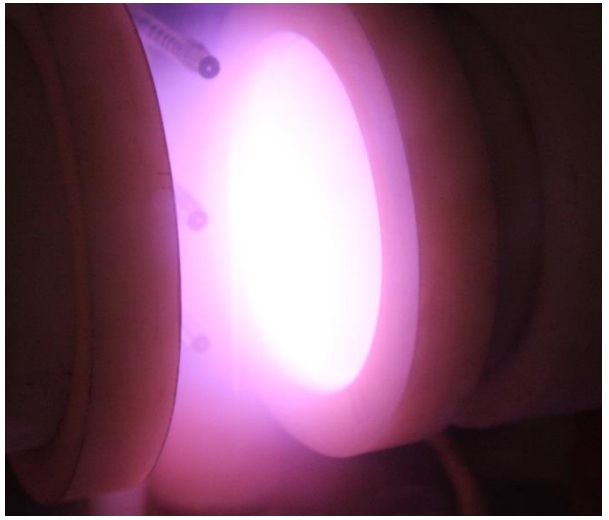
Schematic diagram of designed electric circuit of Dust Dropper device.

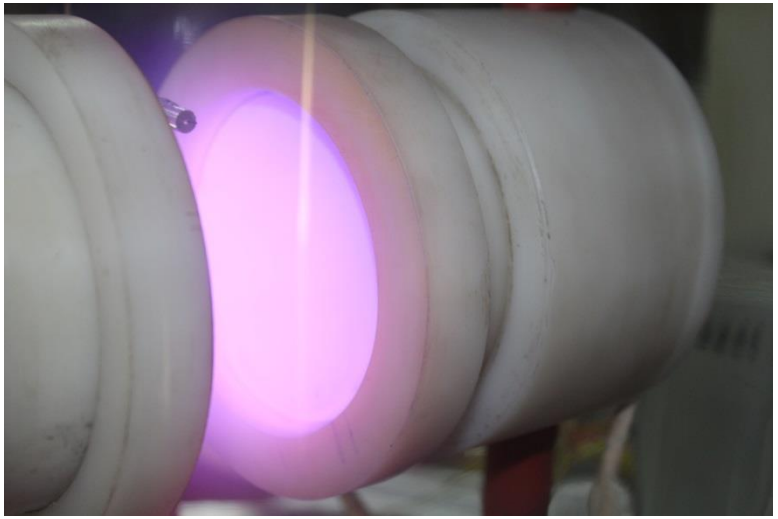

with dust (212 μm).
d=10 cm

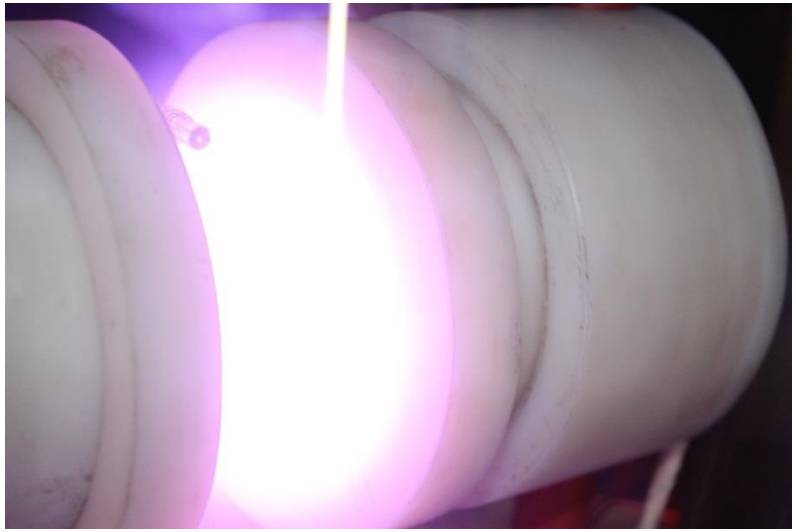

without dust at d=10 cm











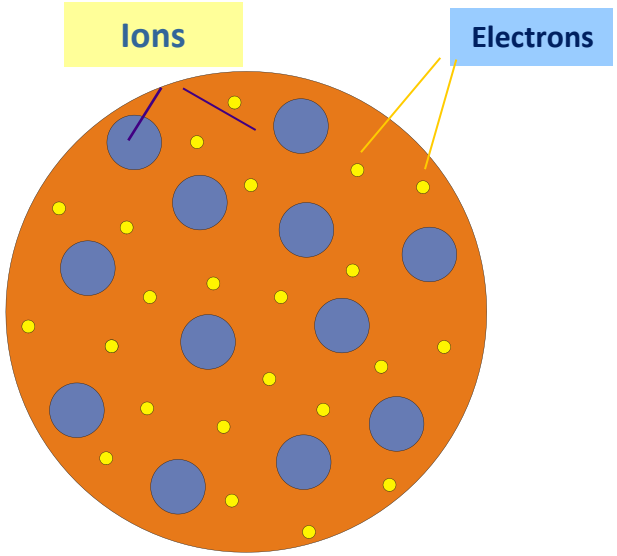
Plasma Diagnostics

Optical Spectroscopy

Langmuir Probe

Optical Spectroscopy ➢

Optical emission spectroscopy (OES), which measures the **light emitted from a plasma as a function of wavelength, time, and location**, is one common remote diagnostic, in OES, visible light is usually collected by a lens and focused onto the slit of a spectrometer.



Plasma

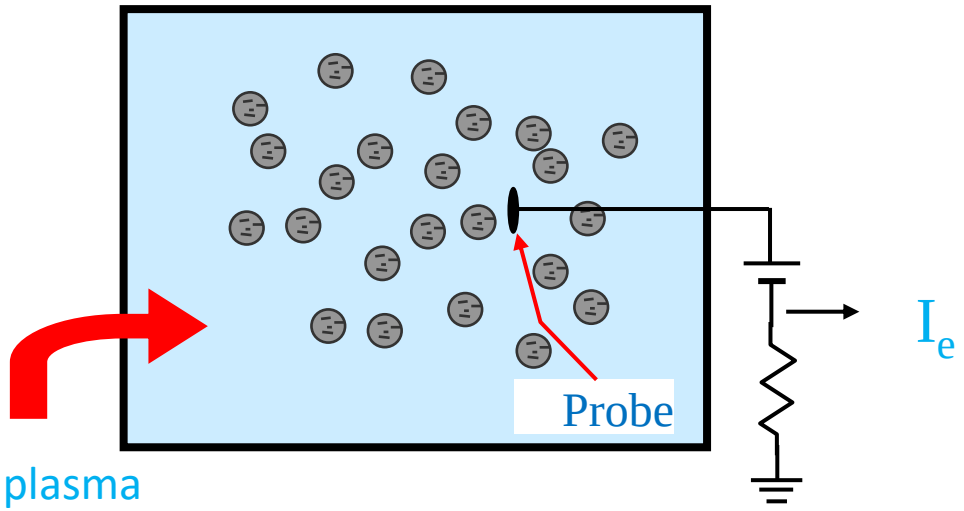
THORLABS compact spectrometer

type: CCS200/M,
Range {λ} 200-1000nm,
resolution Δλ < 2nm,
Slit: 20µm
(made in Germany).

Figure (2.11) A) the used spectrometer: 1. USB port2. Fiber input3. Status LED 4. Trigger Input B)Lens C)Optical fiber.

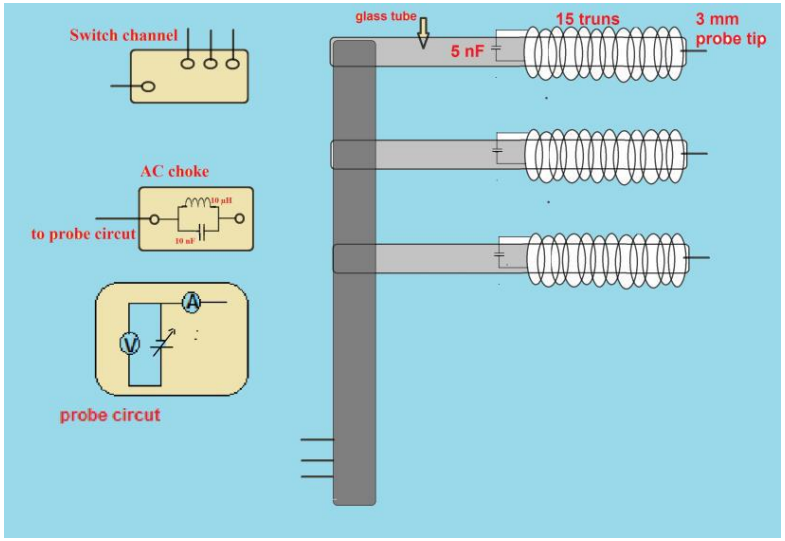
Langmuir Probe

An electrostatic probe is merely a small metallic electrode (usually a wire) inserted into a plasma. The probe is attached to a power supply capable of biasing it at various voltages positive and negative relative to the plasma, and current collected by the probe then provides information about the conditions in the plasmas .

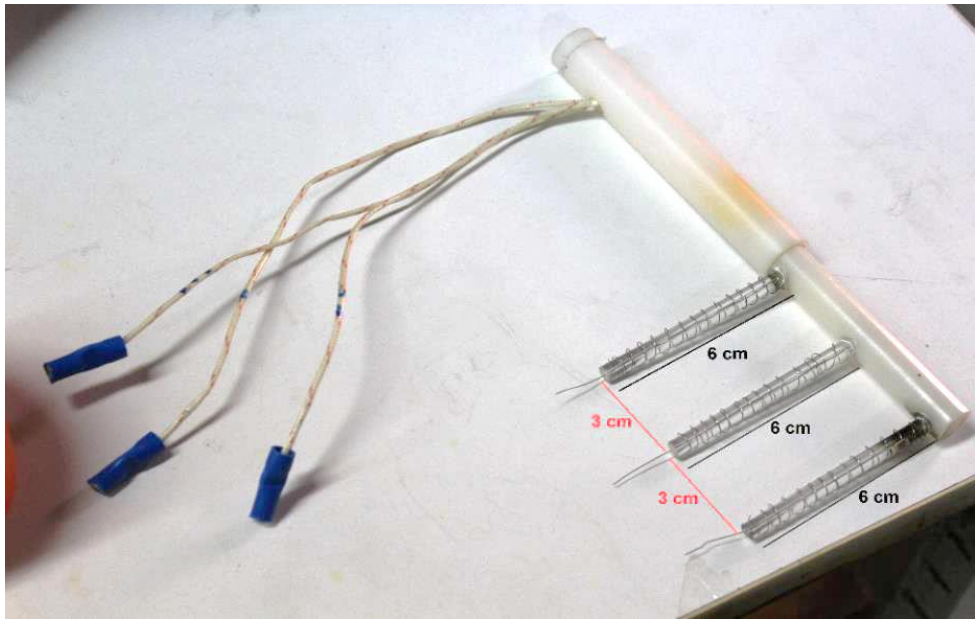


Three cylindrical Langmuir probes

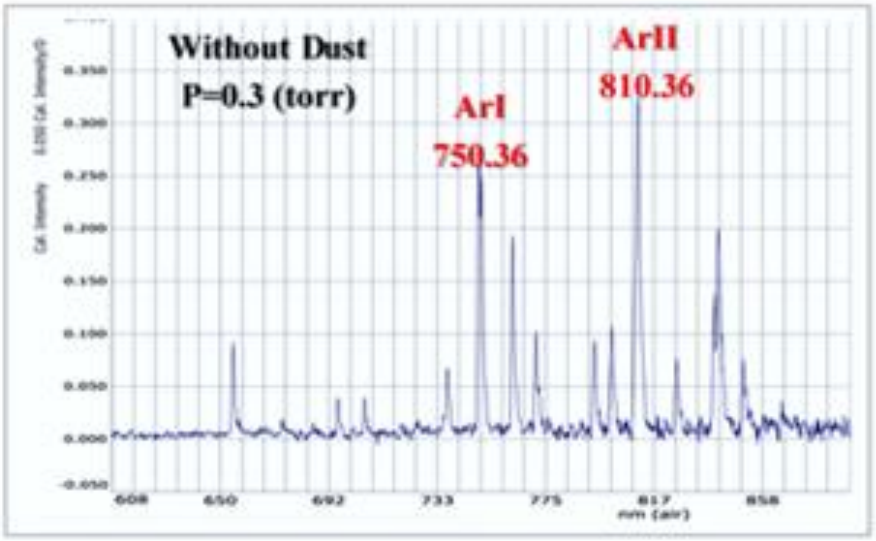
tungsten wire
Diameter = 0.15mm
The length of tip is 3mm.

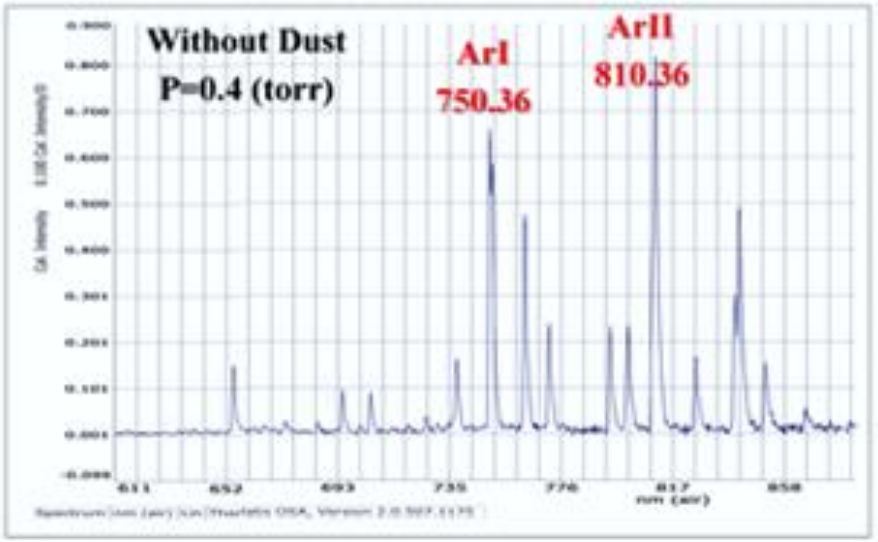


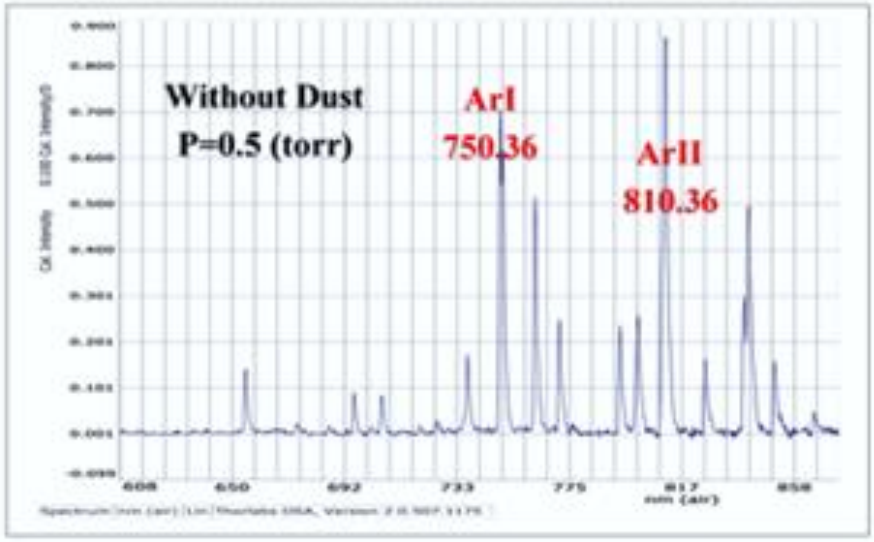
The 15 turns winding which represent an external floating electrode is connected to the probe via a 5nF ceramic capacitor



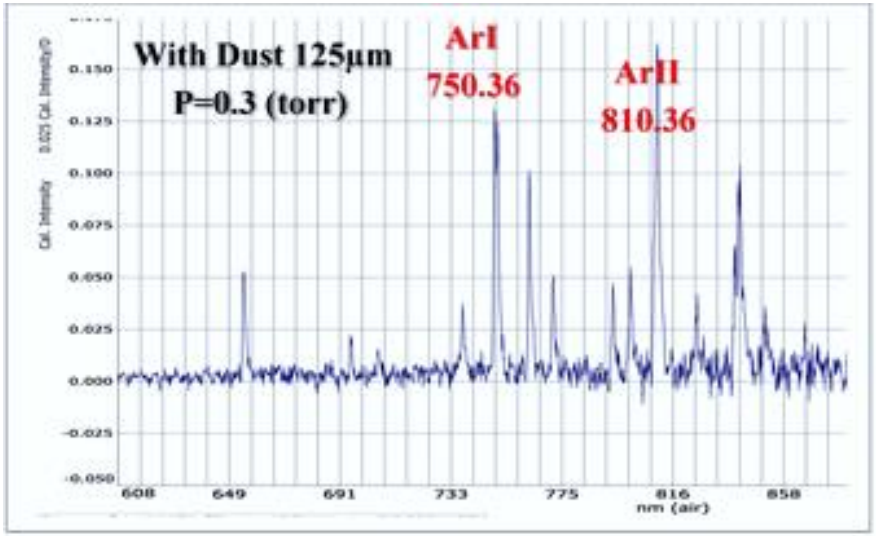
Typical spectrum recorded for argon gas without dust at different gas pressure.

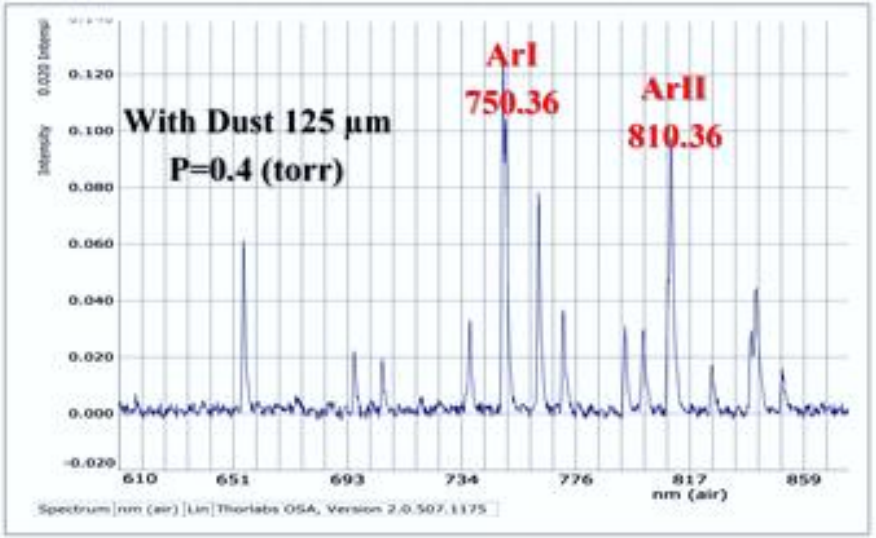


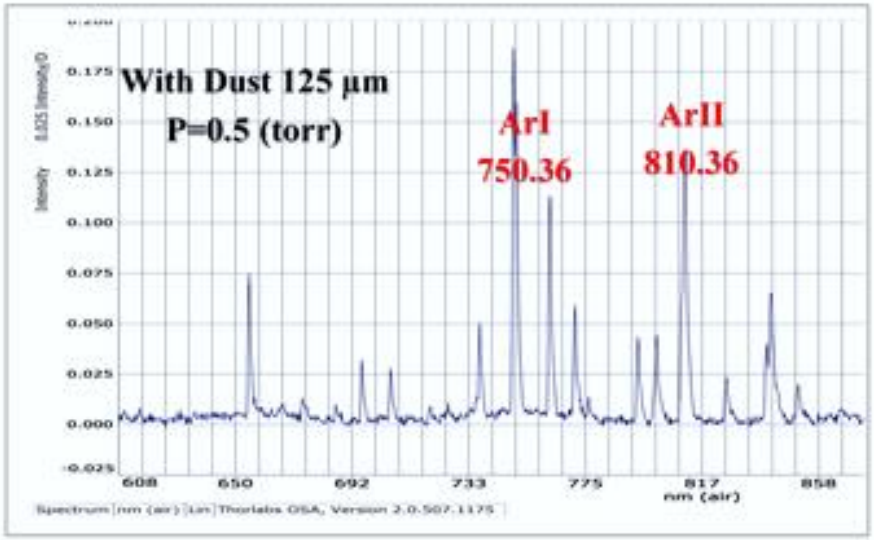




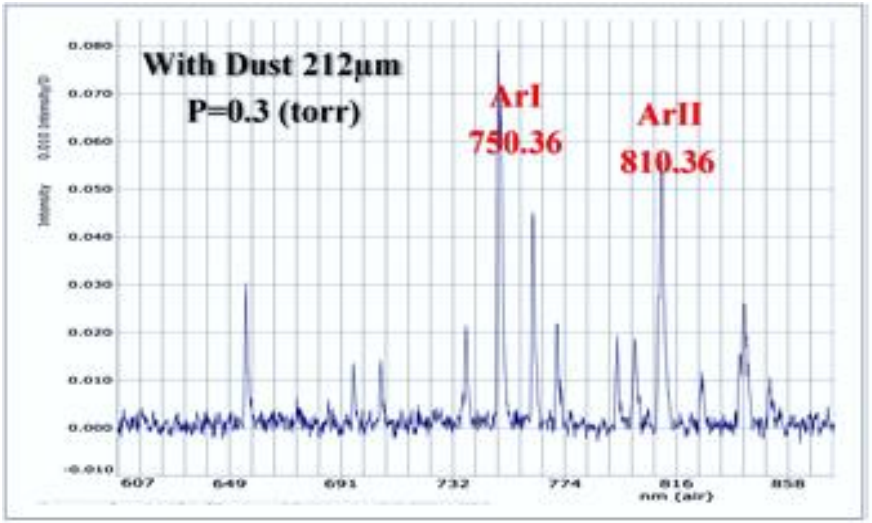
Typical Spectrum record for Argon with present 125 µm Zinc dust size at different Ar /pressure.

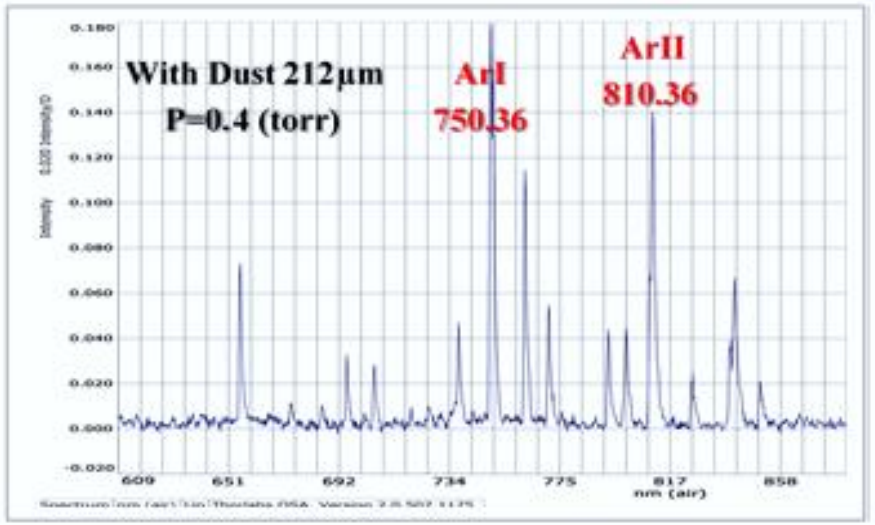


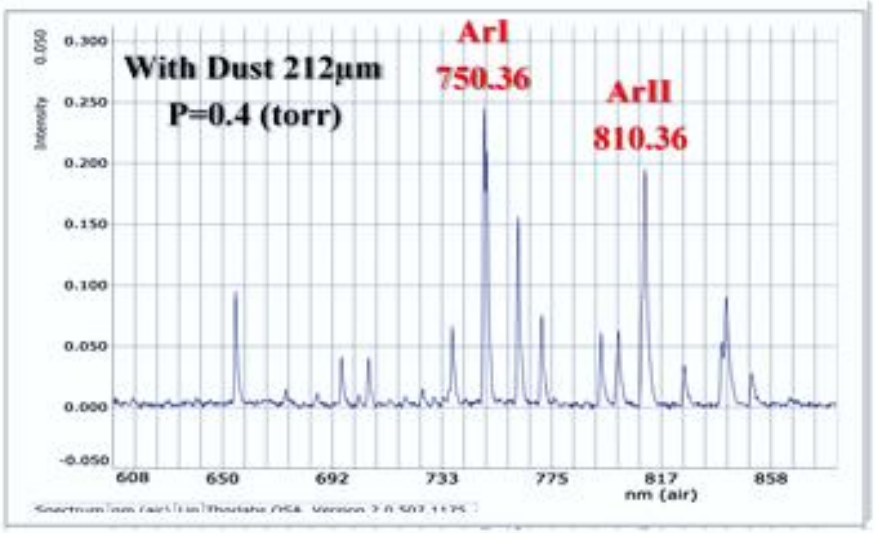




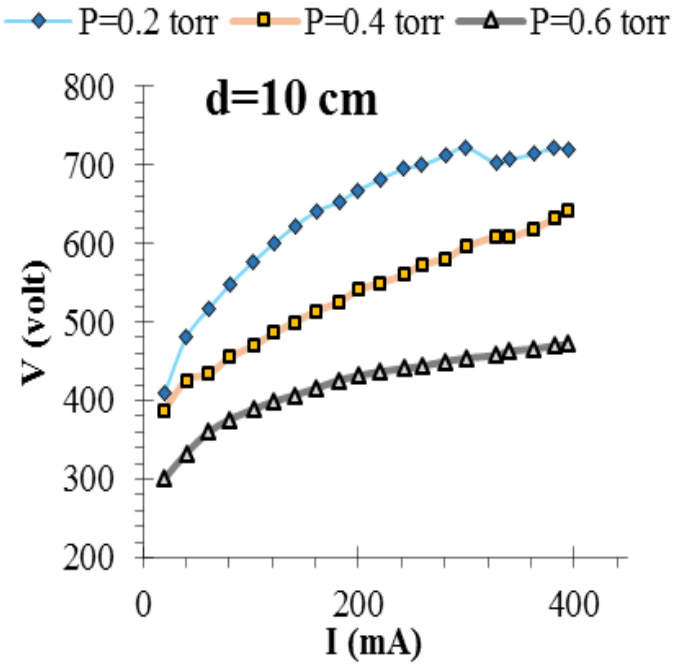
Influence of 212 µm Zinc dust size on typical Spectrum record for Argon at different Ar pressure.

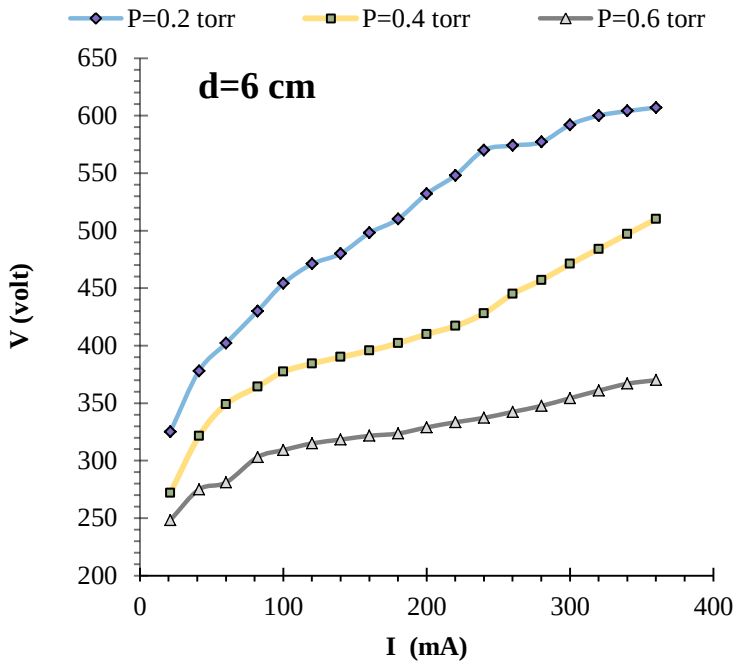






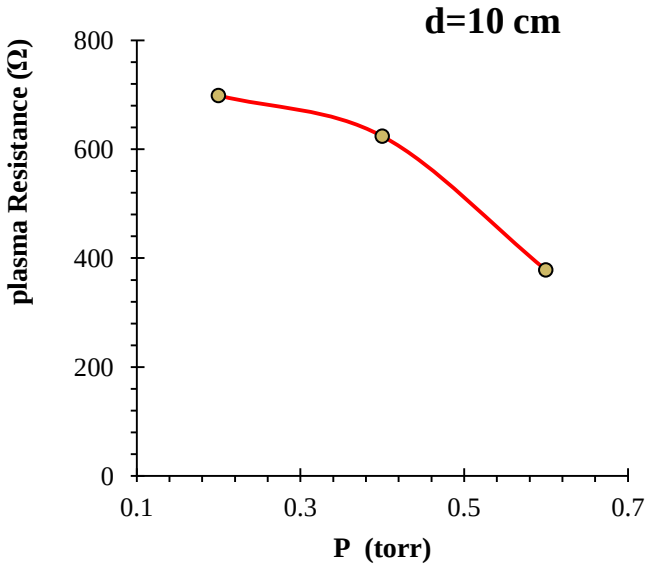
NIST Atomic spectral database

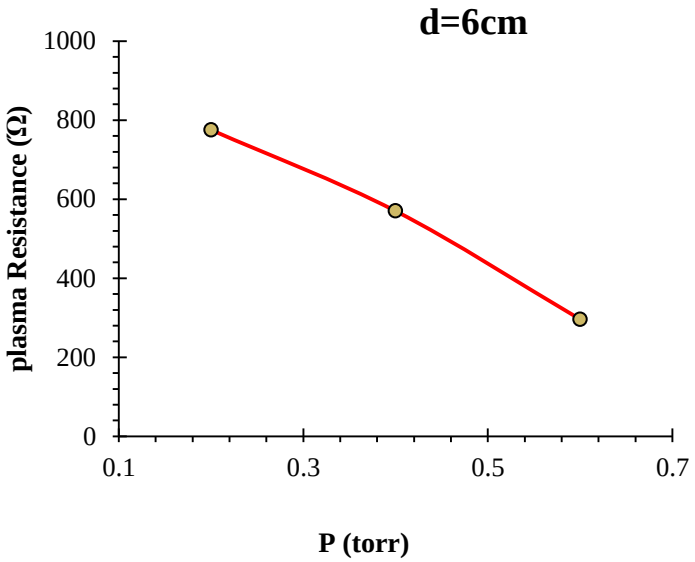




- A linear relationship and the slope of the curves depends strongly on the Ar gas pressure.
- we can expected that the low frequency discharge approximately obey ohms law.

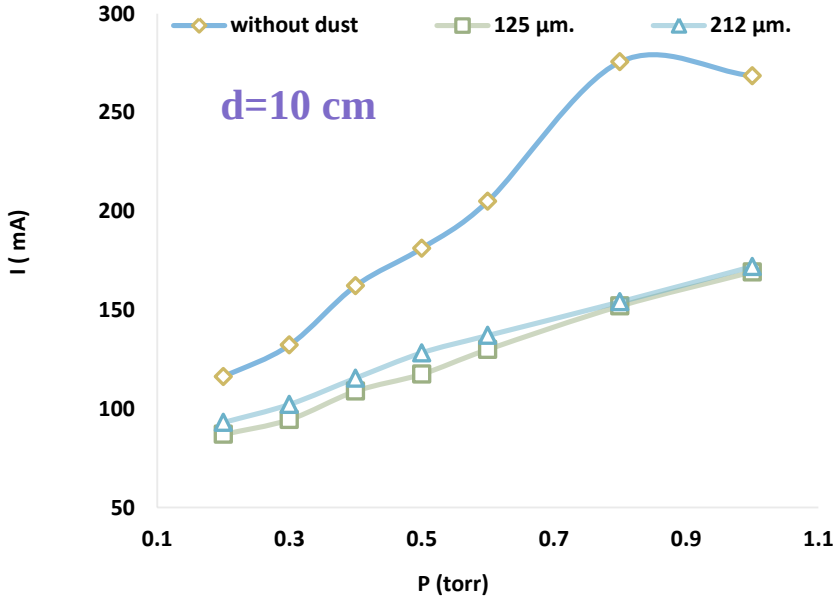
discharge resistance as a function of Argon gas pressure at different electrode gap

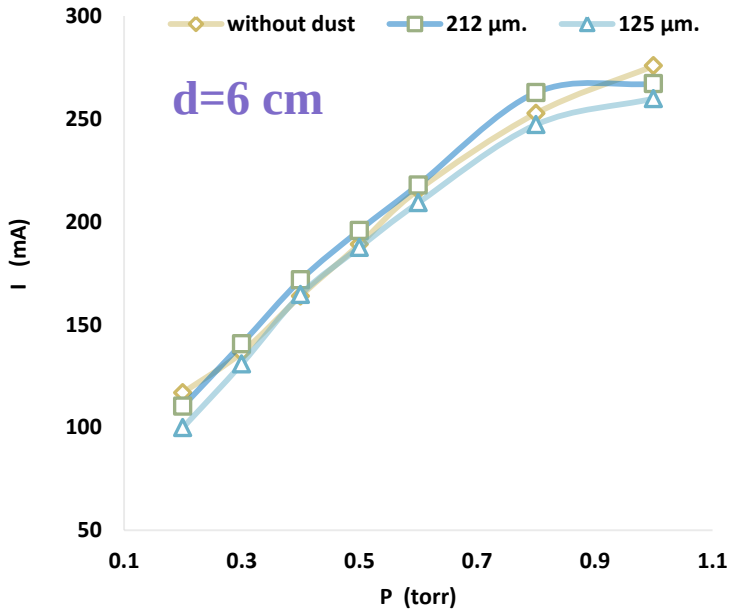


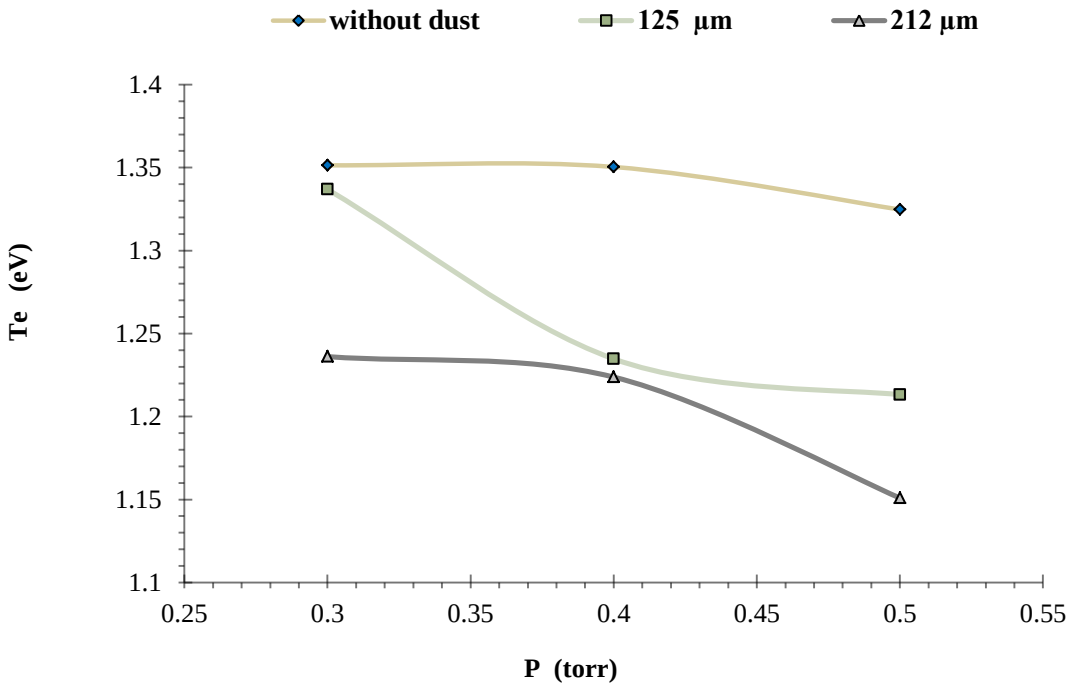


the discharge resistance gradually decreases with increase of Ar pressure. This behavior can be explained by increase of the charged particles due to inelastic collisions as well as the decrease of sheath thickness

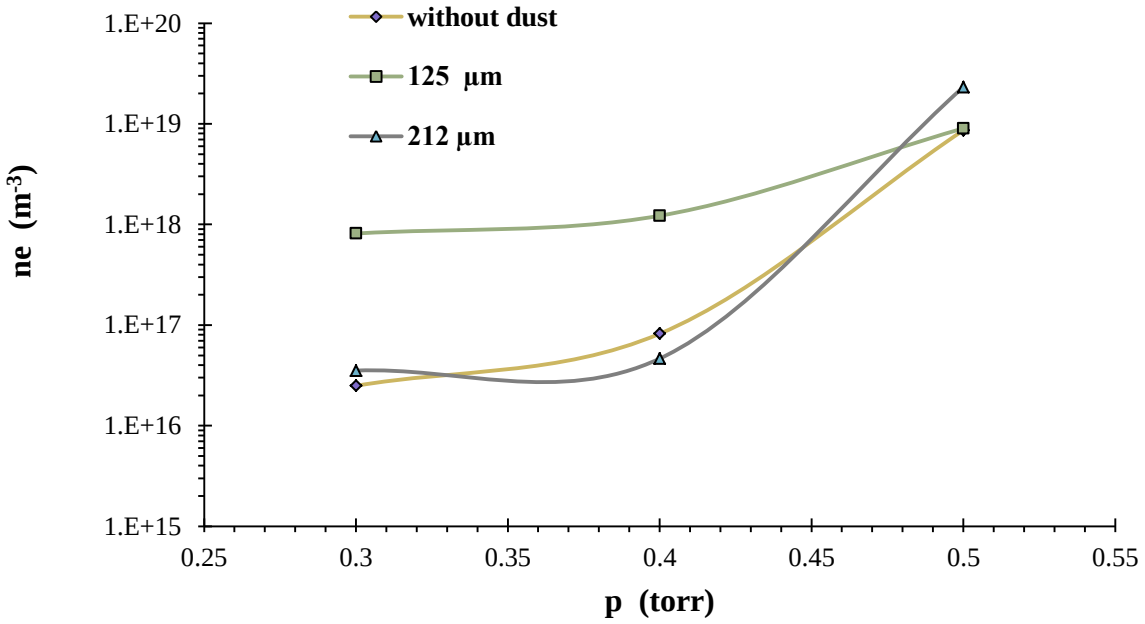
discharge current as a function of Ar pressure with and without two different zinc dust particle size at different electrode distance.



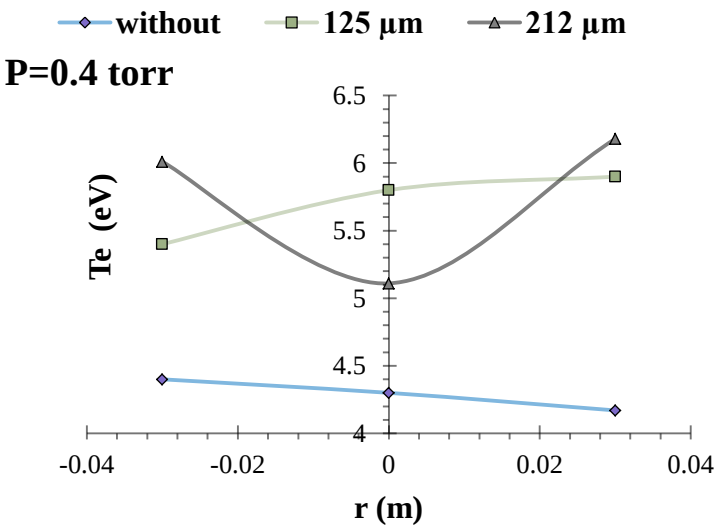


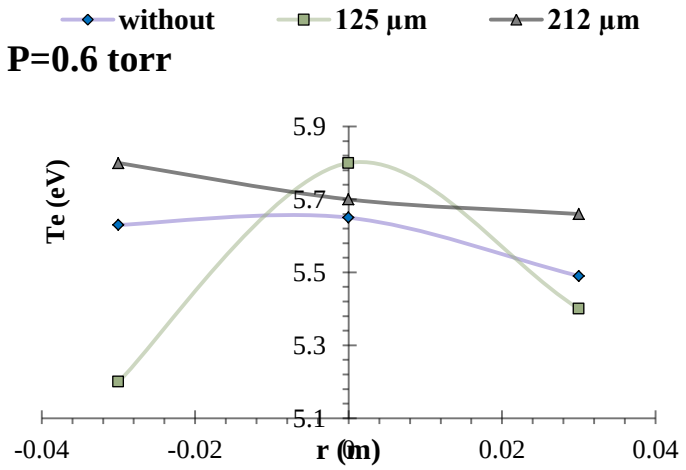


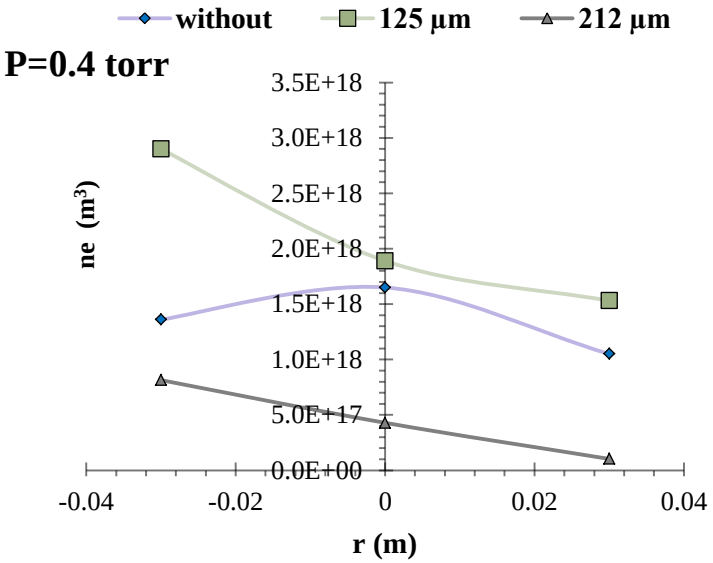
Influence of Zinc dust size on Te , Ne as detected by OES

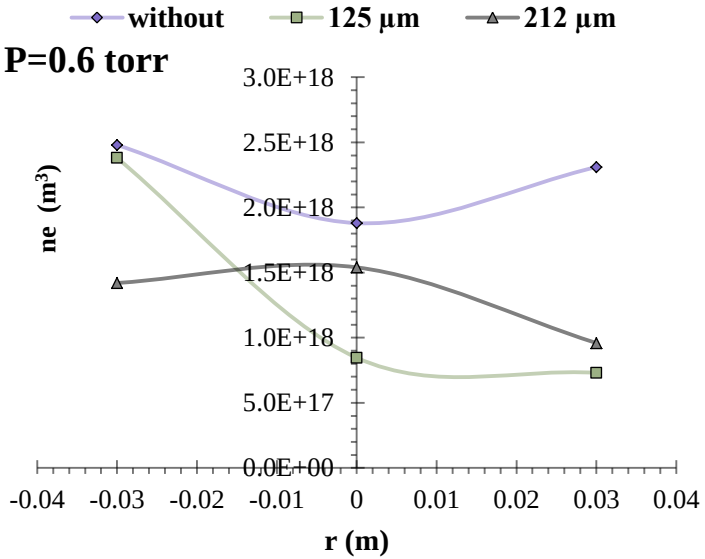


Langmuir Probe Measurements





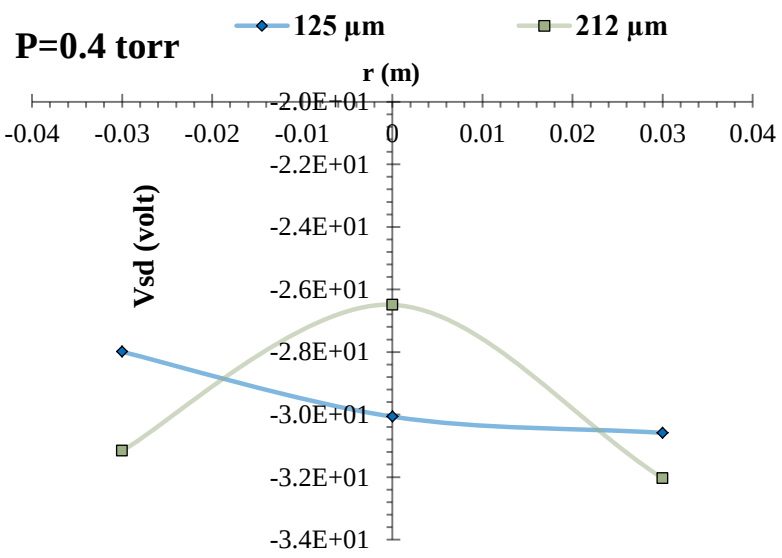


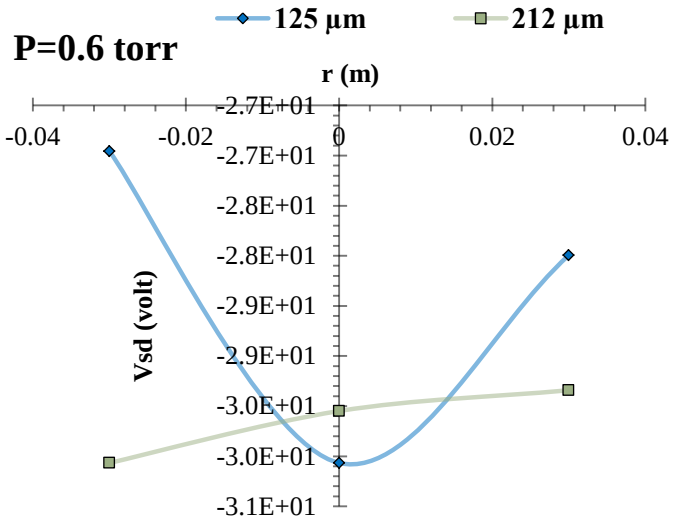


Plasma Sheath Region

dust surface potential (V_{sd})

Radial variation of surface potential of two different dust particle sizes in different Ar pressures.





The floating potential (V_{fd}) of a dust grain

Influence of Ar pressure on the redial profile of floating potential of two different dust particles size.