PART 2

BASIC PRINCIPLES OF SPUTTER COATING

INTRODUCTION TO THE SPUTTERING PROCESS

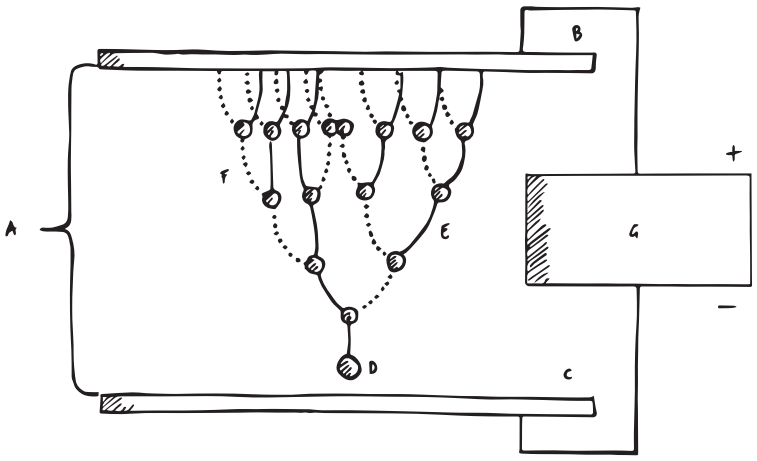
When a metal surface is hit by heavy particles with high speed, decomposition and abrasion of the surface material occurs.

We are talking about “sputtering” when this process occurs by a gaseous glow discharge between a cathode and an anode. In this setup, the surface, which is called the “cathodic target”, is hit by ions generated from an inert gas that has a relatively high atomic weight. The target material is commonly gold or platinum, while the gas is commonly argon.

As a result, a deposition of microscopic target material “particles” will occur in all directions. This material will form a coating on the surface of the sample.

One of the elements that is crucial for understanding the basic principles of sputter coating is understanding the principle of gaseous glow discharge, as it is applied in gas discharge lamps. Electric discharge in a gas appears when it is ionised by applying a voltage that is sufficient to cause electrical conduction in the gas.

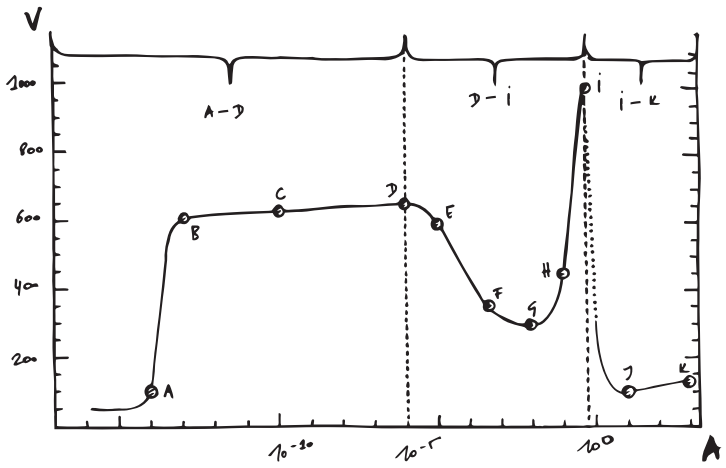
A electric field
B anode
C cathode
D original ionisation event
E ionising electron path
F liberated electron path
G DC voltage source



visualisation of a Townsend Avalanche

This phenomenon, which is typically observed in a gas-filled tube containing electrodes, is known as **Townsend discharge**: when a critical value of electric field strength is reached, a sustained multiplication of electron flow by ion impact occurs.

As the electric field is increased various phases of discharge are encountered:



A random pulses by cosmic radiation
B saturation current
C Townsend avalanche
D self-sustained Townsend discharge
E unstable region: corona discharge
F sub-normal glow discharge
G normal glow discharge
H abnormal glow discharge
i unstable region: glow-arc transition
J electric arc
K electric arc

image: Typical voltage-current characteristics of electrical discharge

The A-D region is called dark discharge; there is some ionisation, but the current is very low and there is no significant amount of radiation produced.

The D-G region exhibits a negative differential resistance

The G-I region is a region of glow discharge; the plasma emits a faint glow that occupies almost all the volume of the tube; most of the light is emitted by excited neutral atoms.

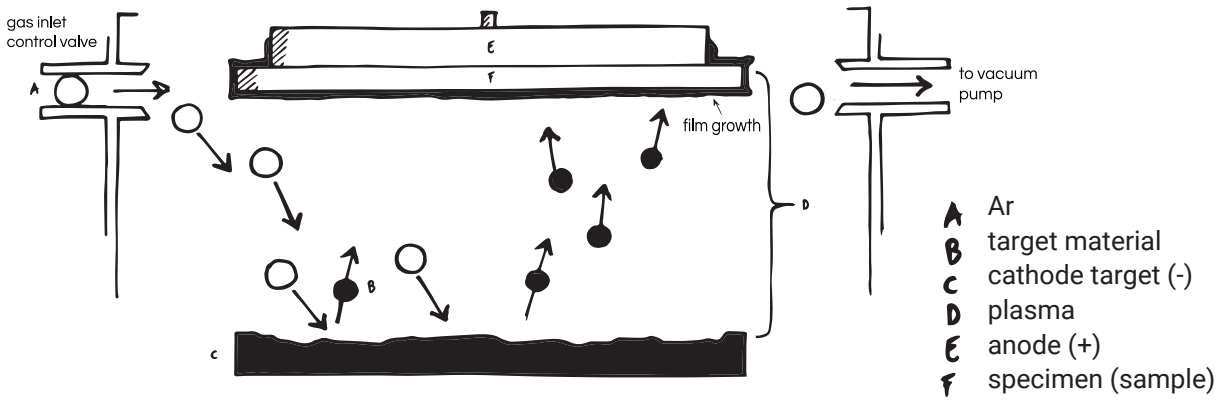
The I-K region is a region of arc discharge; the plasma is concentrated in a narrow channel along the centre of the tube; a great amount of radiation is produced.

The voltage required to initiate and sustain a glow discharge is dependent on the pressure and type of gas. Once the condition for a sustained discharge is met, the tube exhibits the characteristic glow discharge. It has been established that free ions and electrons are attracted to opposite electrodes producing a discharge.

Under conditions of glow discharge in an argon filled tube, an ion bombardment of the cathode target material by the relatively high atomic weight argon ions will occur. This will result in the decomposition of the cathode material and is termed plasma sputtering, with the subsequent deposition of the sputtered material forming a coating of the original cathode material on the surface of the sample and sputter chamber.

HOW DOES A SPUTTER COATER WORK, AND WHICH PARAMETERS INFLUENCE THE PROCESS?

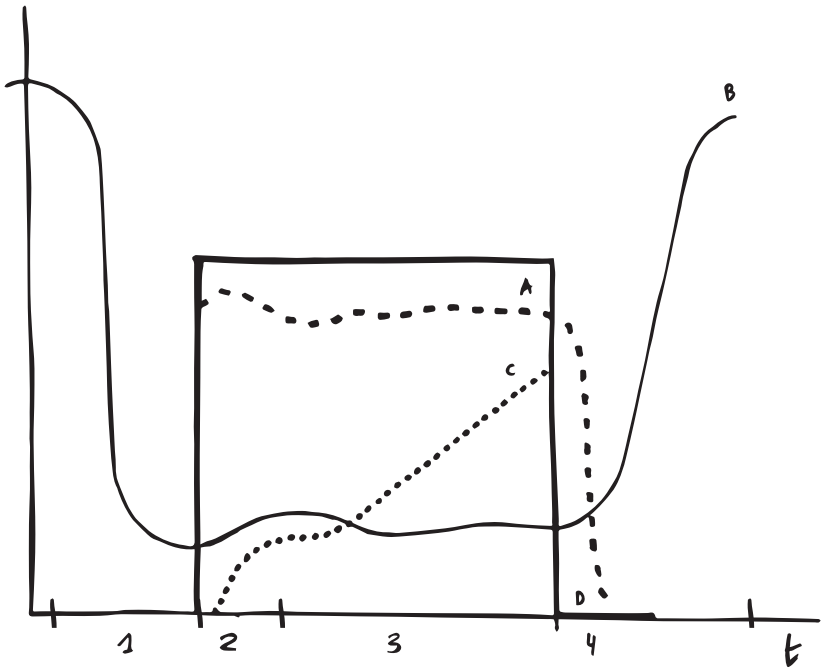
We just learned that under conditions of glow discharge, an ion bombardment of the cathode by (argon) ions will occur. This will result in the decomposition of the cathode material, with the subsequent formation of a coating of the cathode material on all surfaces.
What would a basic setup of a sputter coater system look like? The sputtering process takes place in a closed glass cylinder, the “sputtering or plasma chamber”, which houses an anode and a cathode. Furthermore, there is an opening towards a vacuum pump, and an opening for injection of the inert process gas.



The negative cathode (C) will be the target material to be sputtered (typically gold or platinum), while the specimen (F) to be coated (the substrate) will be on the anode (E).

The desired operating pressure is obtained by a vacuum pump, while an inert gas, such as argon, is admitted to the chamber by a control valve.

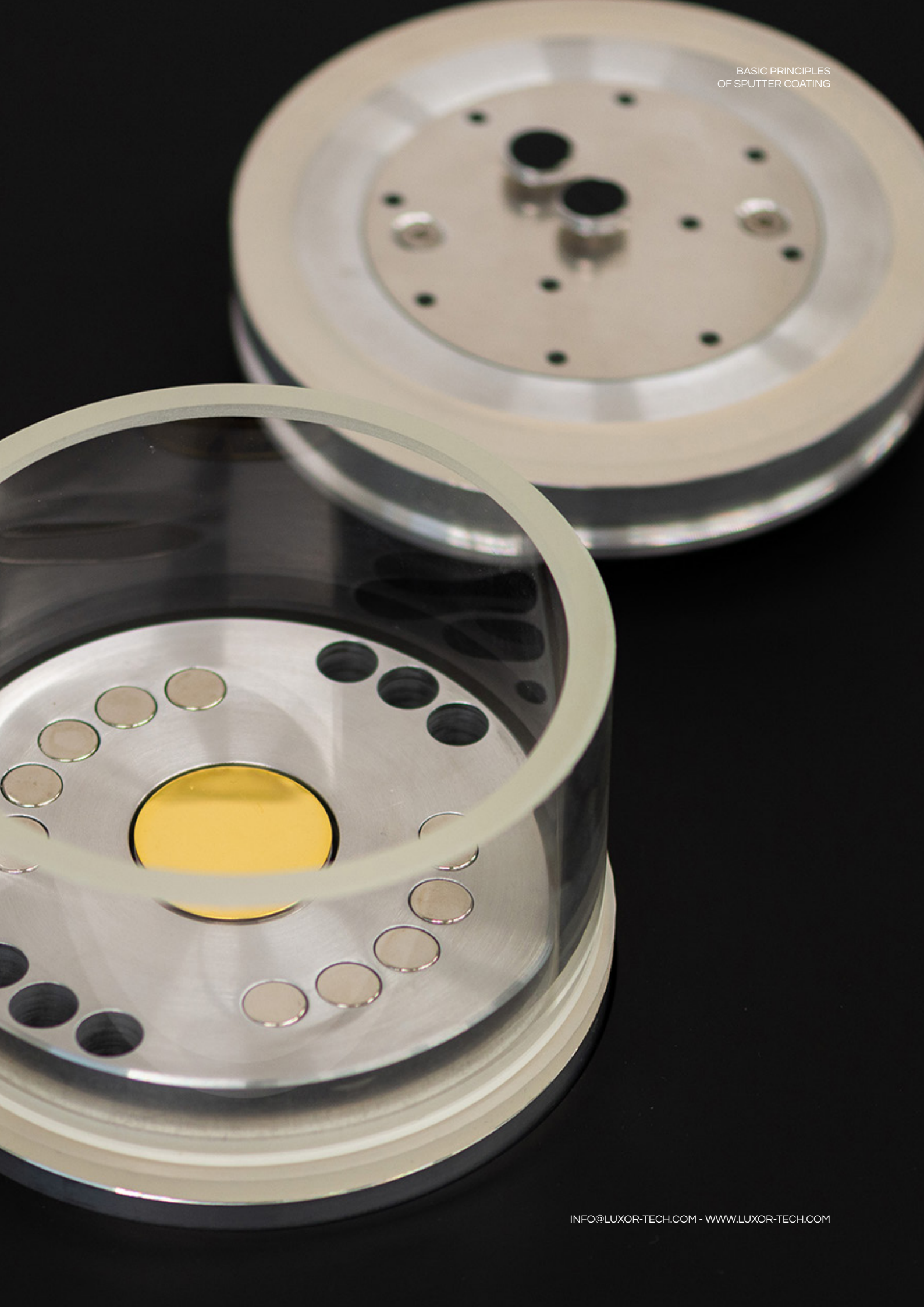
Next is a graphical presentation of a basic sputter coating process using gold as a sputter material and argon as an inert process gas. The graph shows how the current, voltage, pressure and coating thickness are varying during the process.



A current (mA)
B pressure (Pa)
C coating thickness (nm)
D voltage (V)

1. After evacuating the air and filling the chamber with argon, the vacuum pump brings the chamber to the pre-set target vacuum
2. When the vacuum is reached, the high voltage is switched on and the operator regulates the argon flow creating a sputtering current
3. The sputtering process starts with the set argon flow during a pre-set time
4. When the preset time is reached the sputter coating process stops and the chamber is refilled with air

The combination of vacuum, voltage, current, time and distance between target and sample determine the growth rate, homogeneity and fineness of the coating on the sample.



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