Chapter 3. Applications of Thin Film, Thin Films Deposition Processes and Characterization Techniques

Part B: Thin Film Deposition Processes

1. Introduction

Thin Film Deposition technology can well be regarded as the major key to the creation of devices such as computers, since microelectronic solid-state devices are all based on material structures created by the deposition techniques. Excellent stability and accuracy together with a level of reliability (which is not economically feasible with other technologies) of the electronic components and devices is the hallmark of thin film technology.

Equipment manufacturers have made successful efforts to meet the requirements for improved and more economical deposition systems and for in situ process monitors and controls for measuring film parameters.

The improved understanding of the physics and chemistry of films, surfaces, interfaces, and microstructures made possible by the remarkable advances in analytical instrumentation during the past twenty years. A better fundamental understanding of materials leads to expanded applications and new designs of devices that incorporate these materials.

A good example of the crucial importance of deposition technology is the fabrication of semiconductor devices, an industry that is totally dependent on the formation of thin solid films of a variety of materials by deposition from the gas, vapor, liquid, or solid phase.

Films' can be mathematically defined as homogenous solid material between two planes and extended in two directions but restricted along third direction perpendicular to XY plane. Their magnitude vary from 50-100Å (ultra-thin), 100 - 1000Å (thin) and >1000Å (thick films). When a substrate is absent a solid film is called as a foil. Thin films are deposited onto bulk substrate to achieve properties unattainable or not easily attainable in the substrates alone.

The property of thin film generally varies from the values of the physical parameters of the materials in bulk form as given below.

*Thin Films may be:

*Not fully dense, *under stress, *Quasi-two dimensional,

*Different defect structures from the bulk material,

*Strongly influenced by surface and interface effects.

These unique properties can be due to their small thickness of few atomic layers up to micrometer value. This will change the optical, magnetic, electrical, thermal, mechanical and chemical properties. Table1 divides thin film properties into five basic categories and gives example of typical applications within each category. The properties of the thin films can also be affected by the high surface to volume ratio of the film. In many cases the growth and preparation of thin film are affected by the properties of the underlying substrate material.

Table 1: Properties and applications of thin films.

Thin Film Property Category	**Typical Applications**
Optical	Reflective/ antireflective coatings Interference filters Decoration (color, luster) Optical memory discs (CDs, DVDs) Optical Waveguides
Magnetic	Memory discs (Hard discs and tapes)
Electrical	Insulation Conduction Semiconductor devices Piezoelectric drivers
Thermal	Barrier layers Heat sinks
Chemical	Barrier to diffusion or alloying Protection against oxidation or corrosion Gas/liquid sensors
Mechanical	Tribological (wear-resistant) coatings Hardness Adhesion Micromechanics

2. Classification of Thin-Film Deposition Techniques:

A solid material is said to be in thin film form when it is grown as a thin layer on a solid substrate by controlled condensation of the individual atomic, molecular, or ionic species either by physical process or ultra-chemical reactions. There are many dozens of deposition techniques for material formation. Since, the concern here is with thin-film deposition methods for forming layers in the thickness range of a few nanometers to about ten micrometers, the task of classifying the techniques is made simpler by limiting the number of techniques to be considered.

* Most engineering materials (usually called bulk materials) have fixed properties like electrical resistivity, optical opacity, etc.

- ❖ Bulk materials have fixed properties and hence their applications are limited.
- ❖ When the thickness is reduced, beyond certain limits these properties show a drastic change
- ❖ This is called size effect and this adds flexibility in designing devices for a particular application

*Thin film possesses attractive properties and therefore can have versatile applications.

- ❖ Devices with thin films occupy less space
- ❖ Their fabrication requires less material, hence inexpensive.

The number of thin film materials, their deposition processing and fabrication techniques are used to produce the devices.

It is possible to classify these techniques in two ways.

* Physical Vapor Deposition (PVD)
* Chemical Vapor Deposition (CVD)

Physical method covers the deposition techniques which depend on the evaporation or discharge of the material from a source, i.e. evaporation or sputtering, whereas chemical methods depend on physical properties and solid films are formed on the substrate by chemical reaction of vapor phase chemicals that contain the required constituents. Structure-property relationships are the key features of electronic devices and basis of thin film technologies. Underlying the performance and economics of thin film components are the manufacturing techniques on a specific chemical reaction. Thus chemical reactions may depend on thermal effects, as in vapor phase deposition and thermal growth. However, in all these cases a definite chemical reaction is required to obtain the absolute film.

*** Physical Vapor Deposition**

a. Evaporation:

- conventional vacuum evaporation (thermal)
- electron-beam evaporation
- pulsed laser evaporation
- molecular-beam epitaxy

b. Sputtering:

- DC sputtering
- radio frequency (RF) sputtering
- magnetron sputtering
- reactive sputtering

*** Chemical Vapor Deposition**

- atmospheric-pressure CVD (APCVD)
- low-pressure CVD (LPCVD)
- metal-organic CVD (MOCVD)
- plasma-enhanced CVD (PECVD)
- atomic layer deposition (ALD)
- laser-induced CVD (LCVD)

*** Wet Chemical Techniques**

- Chemical Bath Deposition (CBD)
- Spray pyrolysis
- Electroplating
- Sol-gel spin-on techniques

*** Deposition process:**
Source
Transport
Condensation on substrate

- The nature of the film deposited depends on process parameters like substrate, deposition temperature, gaseous environment, rate of deposition etc.

- Favorable conditions are created to transfer the material from the source (*target*) to the destination (*substrate*).

* **In PVD process**, this transfer takes place by a physical means such as evaporation or impact.
* **In CVD process** films are deposited through a chemical reaction.

Major deposition schemes
* **Physical vapor deposition (PVD)**
Evaporation
    High temperature
Sputtering
    DC sputtering/ RF Sputtering

* **Chemical vapor deposition (CVD)**
    Source contains the material
    High quality films

* **Others**
Electroplating (for very high thickness films, fast process, less control on thickness)
Spin-cast
epitaxial

A brief description of the principles, salient features and applications for some of the important thin-film deposition processes are given below.

*** Physical Vapor Deposition (PVD):**

PVD refers to the process where solid material to be deposited is physically converted to vapor Phase. The vapor phase is transported across a region of reduced pressure from the source to the substrate, at which film growth proceeds. Structural improvement of the film requires migration of arriving species on the growth surface and there is a need to balance arrival rate with this surface mobility, allowing time for atoms to reach equilibrium sites.

Physical evaporation is one of the oldest methods of depositing metal films. Aluminum, gold and other metals are heated to the point of vaporization, and then evaporate to form to a thin film covering the surface of the substrate. All film deposition takes place under vacuum or very carefully controlled atmosphere.

The degrees of vacuum and units are shown below:

rough vacuum	1 bar to 1 mbar
high vacuum	10^{-3} to 10^{-6} mbar
very high vacuum	10^{-6} to 10^{-9} mbar
ultra-high vacuum	$< 10^{-9}$ mbar = vacuum in space

* ***1 atm = 760 mm = 760 torr = 760 mm Hg = 1000 mbar= 14.7 p.s.i***

* ***1 torr = 1.33 mbar***

a. Evaporation:

In the process of evaporation, heat is enter into the source material (often called the charge, which may be an elemental metal, an alloy, a mixture or a compound) to create a plume of vapor which travels in straight line paths to the substrate. The atoms, molecules, and clusters of molecules condense from the vapor phase to form a solid film, upon arrival at the substrate. The heat of condensation is absorbed by the substrate. On a microscopic scale the localized heating from this process can be huge. In the development of metal coating techniques for thin cross-section plastic parts, it is common, to melt substrates during the initial deposition runs. Monitoring of source-to-substrate distances and deposition rates will allow coating of temperature sensitive substrates without melting. There are several methods by which heat can be delivered to the charge to cause vaporization: induction heating, electric resistance heating, and electron beam heating. Deposition of thin films by laser ablation and cathodic arc could be grouped in this section with thermal processes. The laser source is located outside the evaporation system and the beam penetrates through a window and is focused on to the evaporate material, which is generally fine powder form.

- **Thermal evaporation:**

Thermal evaporation is a common method of thin-film deposition. The source material is evaporated in a vacuum. The vacuum allows vapor particles to travel directly to the target object (substrate), where they condense back to a solid state. Thermal evaporation is used in micro-fabrication to make electrical contacts. In thermal evaporation resistive coil or boat is used that contains charge in solid bar or powder form. A large DC current passed through resistive coil/boat to acquire high melting points of respective metals, where metal get evaporated and attain to substrate in high vacuum conditions. The low melting points materials can be deposited by this technique specially. A type of resistive/boat heaters is as shown in figure 1. Evaporation takes place in a vacuum, i.e. vapors other than the source material are almost entirely removed before the process begins. The thermal evaporation chamber is pumped by diffusion pump to create high vacuum. The material that is to be deposited is placed in heater or the crucible that is heated by giving DC power supply. As the crucible or heater gets heated the charge gives off vapor that reaches to substrate and sticks on the surface. In high vacuum (with a long mean free path), evaporated particles can travel directly to the deposition target without colliding with the background gas. Hot objects in the evaporation chamber, such as heating filaments, produce unwanted vapors that limit the quality of the vacuum. The schematic of thermal evaporation system is shown in figure 2.

*** The issues with conventional evaporation are:**

1. Purity of the deposited film depends on the quality of the vacuum, and on the purity of the source material.

2. At a given vacuum pressure the film purity will be higher at higher deposition rates as this minimizes the relative rate of gaseous impurity inclusion.

3. The thickness of the film will vary due to the geometry of the evaporation chamber. Collisions with residual gases aggravate non-uniformity of thickness.

4. Wire filaments for evaporation cannot deposit thick films, because the size of the filament limits the amount of material that can be deposited.

5. In order to deposit a material, the evaporation system must be able to melt it. This makes refractory materials such as tungsten hard to deposit by methods that do not use electron-beam heating.

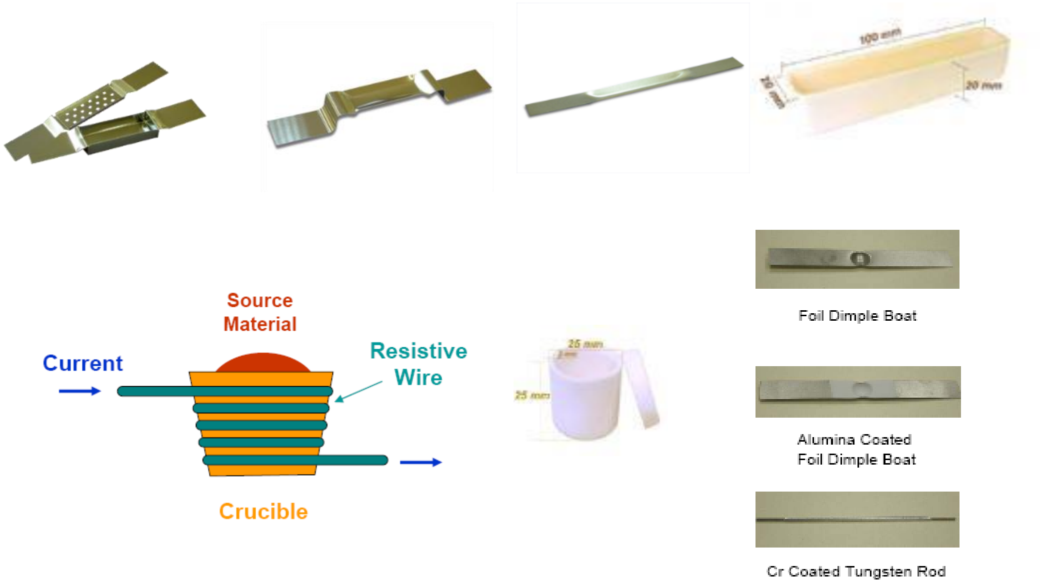
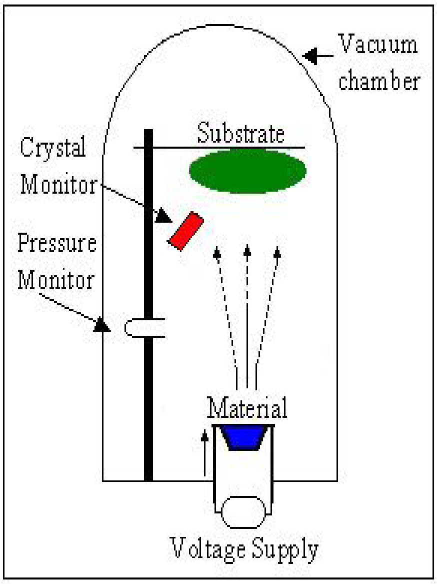


Figure 1: Resistive boats/heaters used in thermal evaporation.



Procedure

* Metal to be deposited is placed in an inert crucible.
* Chamber is evacuated to a pressure of 10^{-6} – 10^{-7} Torr.
* Crucible is heated using a tungsten filament or an electron beam to flash-evaporate the metal from the crucible and condense onto the cold substrate.

* the evaporation rate is a function of the vapor pressure of the metal

Figure 2: Schematic of thermal evaporation

Types of (Boat/Crucible)

Refractory Metal		
Temperature for 10 m torr	melting point (C^0)	material
3230	3380	(W) Tungsten
3060	3000	Tantalum (Ta)
2530	2620	Molybdenum (Mo)
Refractory Ceramics		
Temperature for 10 m torr	melting point (C^0)	material
2600	3799	Graphitic Carbon (C)
1900	2030	Alumina (Al_2O_3)
1600	2500	Boron Nitride

Advantages of vacuum evaporation:

1. High-purity films can be deposited from high-purity source material.
2. Source of material to be vaporized may be a solid in any form and purity.
3. The line-of-sight trajectory and "limited-area sources" allow the use of masks to define areas of deposition on the substrate and shutters between the source and substrate to prevent deposition when not desired.
4. Deposition rate monitoring and control are relatively easy.
5. It is the least expensive of the PVD processes.

Disadvantages of vacuum evaporation:

1. Many compounds and alloy compositions can only be deposited with difficulty.
2. Line-of-sight and limited-area sources result in poor surface coverage on complex surfaces unless there is proper fixturing and movement.
3. Few processing variables are available for film property control.
4. Source material use may be low.
5. Large-volume vacuum chambers are generally required to keep an appreciable distance between the hot source and the substrate.

* Vacuum evaporation is used to form optical interference coatings using high and low index of refraction materials, mirror coatings, decorative coatings, permeation barrier films on flexible packaging materials, electrically conducting films and corrosion protective coatings.

- **Molecular Beam Epitaxy:**

MBE is a sophisticated, finely controlled method for growing single-crystal epitaxial films in a high vacuum. The films are formed on single-crystal substrates by slowly evaporating the elemental or molecular constituents of the film from separate Knudsen effusion source cells (deep crucibles in furnaces with cooled shrouds) onto substrates held at a temperature appropriate for chemical reaction, epitaxy, and re-evaporation of excess reactants.

The furnaces produce atomic or molecular beams of relatively small diameter, which are directed at the heated substrate, usually silicon or gallium arsenide. Fast shutters are interposed between the sources and the substrates. By controlling these shutters, one can grow super lattices with precisely controlled uniformity, lattice match, composition, dopant concentrations, thickness, and interfaces down to the level of atomic layers.

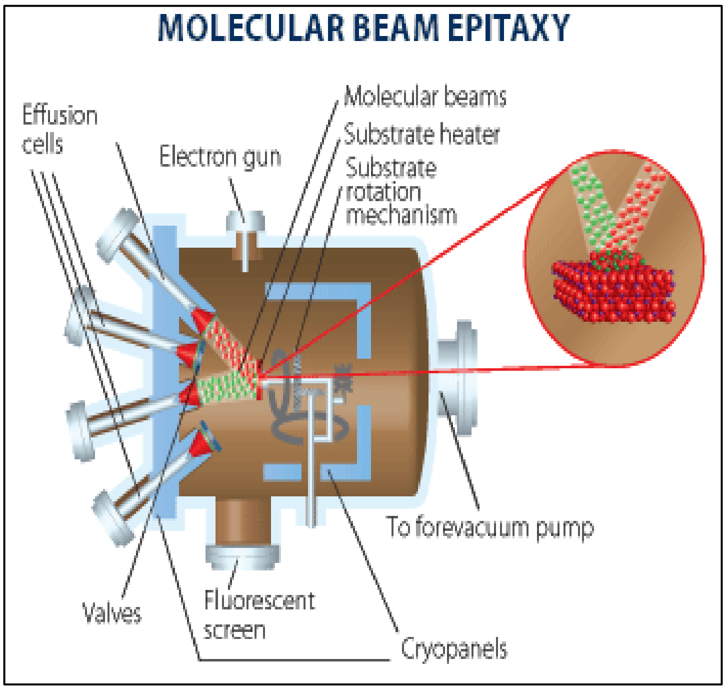


Figure 3: Schematic of Molecular Beam Epitaxy.

- **Electron Beam Evaporation:**

In electron beam evaporation (EBE) a stream of electrons is accelerated through fields of typically 5–10kV and focused onto the surface of the material for evaporation. The electrons lose their energy very rapidly upon striking the surface and the material melts at the surface and evaporates. That is, the surface is directly heated by impinging electrons, in contrast to conventional heating modes. Direct heating allows the evaporation of materials from water-cooled crucibles. Such water-cooled crucibles are necessary for evaporating reactive and in particular reactive refractory materials to avoid almost completely the reactions with crucible walls. This allows the preparation of high purity films because crucible materials or their reaction products are practically excluded from evaporation. Electron beam guns can be classified into thermionic and plasma electron categories. In the former type the electrons are generated thermionically from heated refractory metal filaments, rods or disks. In the latter type, the electron beams are extracted from plasma confined in a small space.

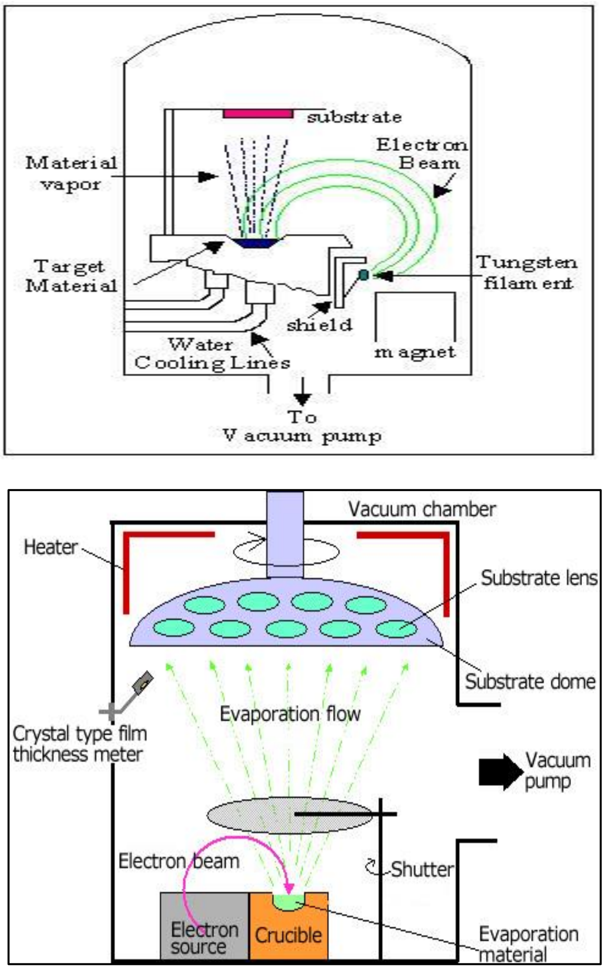


Figure 4: Schematic of electron beam evaporation system.

* High energy focused electron beam to heat the source material at a small area.
* Larger deposition rate.
* Water-cooled container (cavity or hearth): No source-container reaction.
* Sweeping or oscillating the e-beam to heat the source material uniformly.
* Multiple hearth sources: different source materials.

* Focused beam of electrons are used to locally heat the Source.
* Can be used to heat / evaporate even high melting point materials.
* Alloys could be deposited without dissociation of constituent elements.
*Ideally suited for reactive evaporation (Oxides, Nitrides etc.,).

Advantages and disadvantages

1. The deposition rate in this process can be as low as 1 nm per minute to as high as few micrometers per minute
2. The material utilization efficiency is high relative to other methods and the process offers structural and morphological control of films
3. It creates less surface damage from the impringing atom as the film is being formed,
4. The film created has high purity form (due to the high vacuum area) and has less chance for the wafer (substrate) to be heated unintentionally.
5. Electron-beam evaporation allows tight control of the evaporation rate. Thus, an electron-beam system with multiple beams and multiple sources can deposit a chemical compound or composite material of known composition.

* As for the disadvantage, it is more difficult to be controlled incapable of doing surface cleaning, harder to improve the step coverage and could cause x-ray damages by the electron beam evaporation.

A comparison between the method of thermal evaporation and the method of E-beam evaporation

Cost	**Temperature range**	**Evaporation rate**	**Impurities**	**Typical materials for evaporated**	**Material**	**Method**
low	1800 ^{o}C	1of 20 A^{o} / sec	high	Au, Ag, Al, Cr, Sn, Sb, Ge, In, Mg, Ga, CdS, Pbs, Cdse, NaCl ,Kcl, Agcl, Mgf_2, CaF_2	Minerals and materials with a low melting point	**thermal evaporation**
high	3000 ^{o}C	10 of 100 A^{o} / sec	low	All the materials are top plus Ni, Pt, Ir, Rh, Ti, V, Zr, W, Ta, Mo, Al_2O_3, SiO_3, SiO_3, SnO_3, TiO_2, ZrO_2	All metals, insulators and semiconductors	**E-beam evaporation**

- **Laser Induced Evaporation/Laser Ablation/Pulsed Laser Deposition (PLD).**

This technique with many names was first used by Smith and Turner in 1965 to deposit thin films in a vacuum chamber using a pulsed ruby laser. In this technique, material is vaporized and ejected from the surface of a target as it irradiated by a laser beam. Films are formed by condensing the material ablated from the target onto a solid substrate.

Absorption characteristics of the material to be evaporated determine the laser wavelength to be used. To obtain the high power density required in many cases, pulsed laser beams are generally employed. Pulse width, repetition rate, and pulse intensity are selected for specific applications.

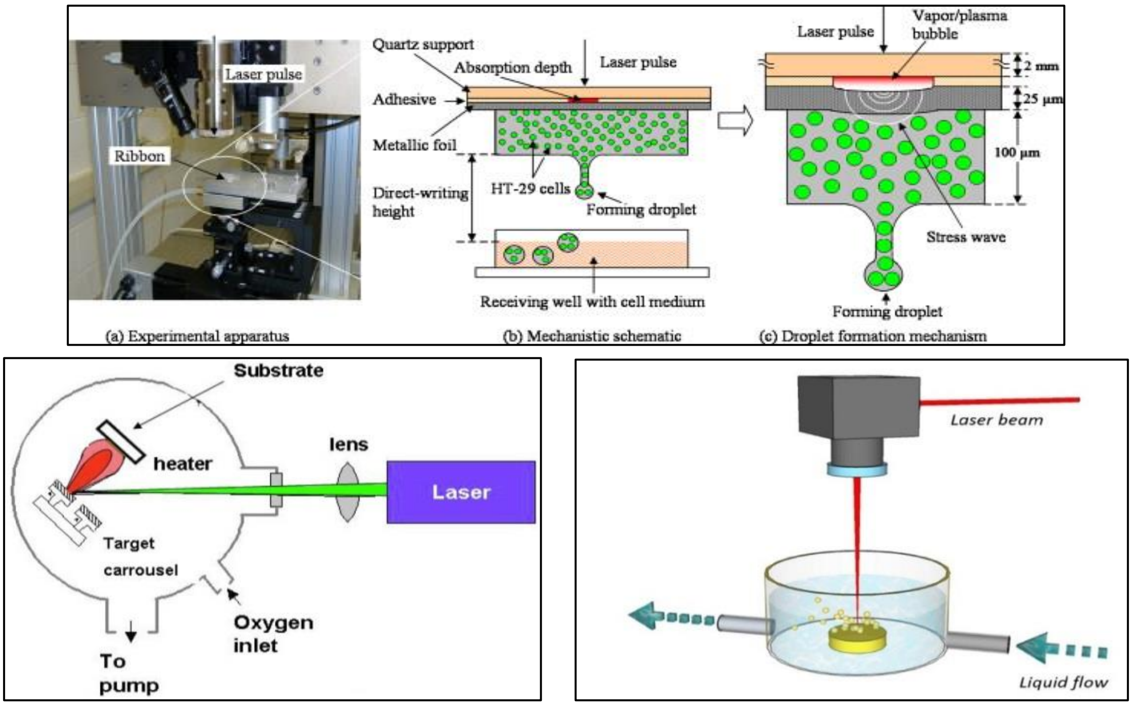


Figure 5: Schematic of Pulsed Laser Deposition

* Uses LASER radiation to erode a target, and deposit the eroded material onto a substrate.

1. The energy of the laser is absorbed by the upper surface of the target resulting in an extreme temperature flash, evaporating a small amount of material.
2. Usually pulsed laser is used.

* Material displaced is deposited onto the substrate without decomposition.
* The method is highly preferred when complex stoichiometries are required.

1. Thin film keeps the same atomic ratio as the target material.

*** Pulsed Laser Ablation deposition (PLD):**
*Used for high quality thin films,

1. e.g., superconducting materials such as $YBa_2Cu_3O_{7-y}$
2. Short-wavelength lasers such as the KrF or XeCl excimer laser in a non-equilibrium process.

* Ease of operation and reproducibility.
* Films do not require post-deposition annealing
* Processing variables

1. laser energy,
2. laser pulse repetition rate,
3. substrate temperature
4. Oxygen background pressure.

b. Sputtering:

The most basic and well-known of these processes is sputtering, the ejection of surface atoms from an electrode surface by momentum transfer from bombarding ions to surface atoms. From this definition, sputtering is clearly an etching process, and is, in fact, used as such for surface cleaning and for pattern delineation. Since sputtering produces a vapor of electrode material, it is also (and more frequently) used as a method of film deposition similar to evaporative deposition. *Sputter deposition* has become a generic name for a variety of processes.

Basic Sputtering Process Idea:

There are many methods used to precipitate materials such as metals, ceramic materials, and plastics on certain surfaces known as the substrate and form thin films. Among these is the sputtering process, which has become one of the most widely used methods of making thin films. Sputtering is a physical vapor deposition technology.

In which the materials are deposited on substrates by expelling, ejaculating, spraying or extracting atoms from the target material and depositing them on the substrate in a vacuum chamber.

The sputtering process is accomplished by preparing the target material or source to be used to obtain from it thin films and installing them in the vacuum chamber, to be ejected with inert gas ions and mostly Argon gas Ar^+. The strong collisions of these ions with the target material work to extract the atoms that move until they reach the sedimentation substrate and begin to condense on their surface in the form of a thin film. As more atoms settle, they begin to bond with each other and form an interconnected atomic layer. One or more layers of these atoms can be obtained depending on the precipitation time to obtain the required thickness as shown in Figure 6.

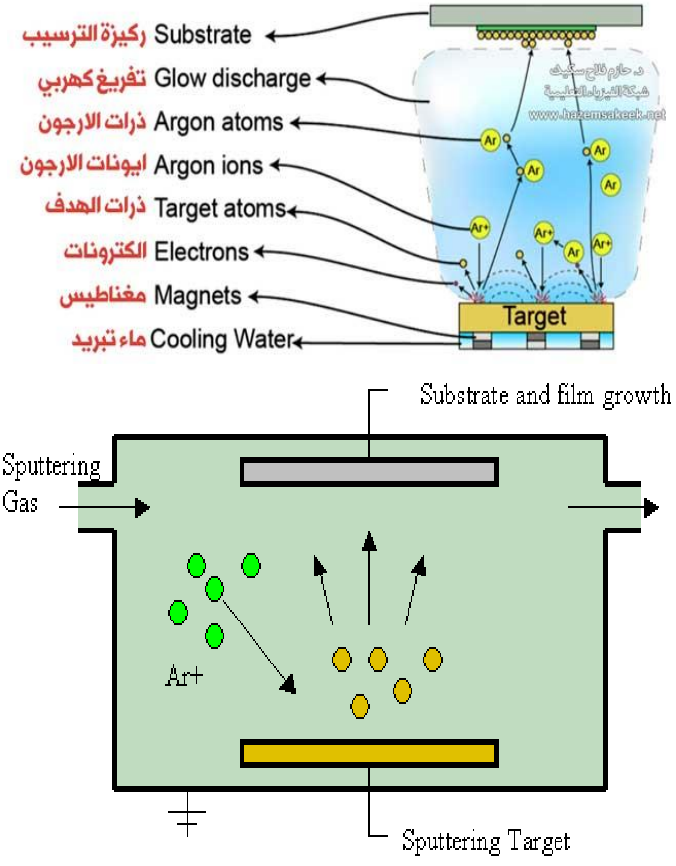
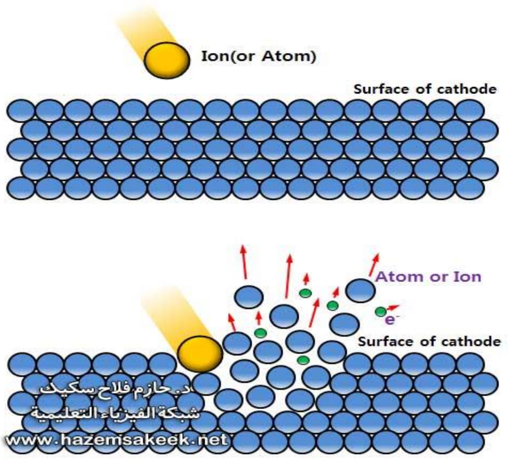


Figure 6: The basic components of the sputtering system.

The ionized argon impacts the target and frees atoms from the target that travel to the sedimentation substrate. Electrons and argon ions form plasma near the target and use a magnetic field to control its spread, which results in higher precipitation efficiency and a thin film of high quality.



From the previous explanation, we see how easy and simple the process is, but the real mechanism is more complicated. Electrically neutral argon atoms are inserted into the vacuum chamber at a pressure of 1 to 10mTorr. A DC voltage difference is applied between the target and the sedimentation substrate that ionizes argon atoms and converts them to plasma, which is a gas that contains ions and electrons at a high temperature.

The plasma is also known as a glow discharge due to its light. Argon ions precipitate toward the target. The collisions caused by the accelerated argon ions with the target extract the target atoms, which in turn move towards the sedimentation substrate and settle on it. The electrons released during the argon ionization process accelerate the shift of the substrate and collide with its turn with more argon atoms, ionize more of them and release more electrons, and the cycle continues as shown in Figure 7.

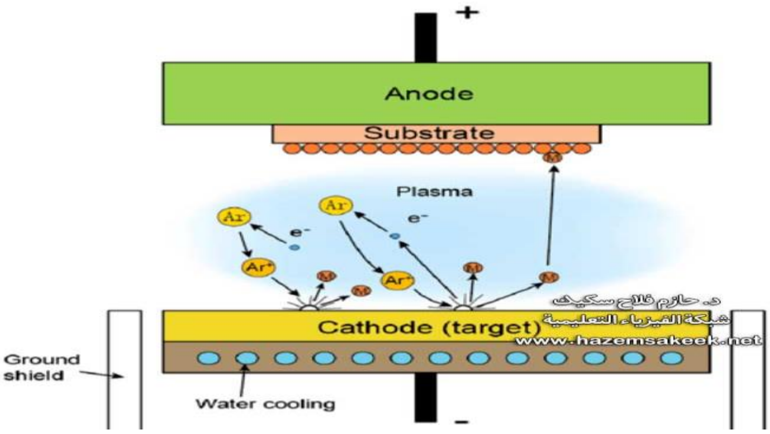


Figure 7: argon atoms ionize using a high potential difference, and the ions precipitate toward the target. After the impact, the target atoms are released and move toward the substrate, where the atoms precipitate as layers and form a thin film.

* Advantages of sputter deposition:

1. Elements, alloys and compounds can be sputtered and deposited.
2. The sputtering target provides a stable, long-lived vaporization source.
3. In some configurations, the sputtering source can be a defined shape such as a line or the surface of a rod or cylinder.
4. In some configurations, reactive deposition can be easily accomplished using reactive gaseous species that are activated in plasma.
5. There is very little radiant heat in the deposition process.
6. The source and substrate can be spaced close together.
7. The sputter deposition chamber can have a small volume.

*Disadvantages of Sputter Deposition

1. Sputtering rates are low compared to those that can be attained in thermal evaporation.
2. In many configurations, the deposition flux distribution is non-uniform, requiring moving fixturing to obtain films of uniform thickness.
3. Sputtering targets are often expensive and material use may be poor.
4. Most of the energy incident on the target becomes heat, which must be removed.
5. In some cases, gaseous contaminants are "activated" in the plasma, making film contamination more of a problem than in vacuum evaporation.
6. In reactive sputter deposition, the gas composition must be carefully controlled to prevent poisoning the sputtering target.

Sputter deposition is widely used to deposit thin film metallization on semiconductor material, coatings on architectural glass, reflective coating on polymers, magnetic films for storage media, transparent electrically conductive films on glass and flexible webs, dry-film lubricants, wear resistant coating on tools and decorative coatings

Comparison: Evaporation & Sputtering

	Evaporation	**Sputtering**
Rate	1000 atomic layer/sec (thickness control is difficult)	1 atomic layer/sec (thickness control possible)
Choice of material	Limited (to those with low melting point)	Almost unlimited
Purity	Better	Possibility of incorporating impurity
Alloy composition	Little or no control	can be tightly controlled
Changes in source material	Easy	Expensive
Decomposition of material	High	Low
Adhesion	Often poor	Very good

***The sputtering further classified into:**

- **DC sputtering:**

In this, d.c. electric field is impressed across two water cooled electrodes. In D.C. sputtering, it is essential that positive ions impringing on the target surface have an opportunity to recombine with electrons to avoid charge accumulation on the surface. With D.C. sputtering system, it is feasible to reverse system polarity, and thereby etch the substrate prior to film deposition. This process, known as back sputtering, is extremely useful for removing thin surface layers such as residual oxides, which can affect the electrical and mechanical properties of the film substrate combination, or prevent adhesion of the film to the substrate.

- **RF sputtering:**

Radio frequency sputtering is generally carried out with 1 to 3 kV peak to peak r.f. potential. Excitation is normally offered at 13.36 MHz, which is intentionally assigned for equipment usage. DC sputtering cannot be used for insulating films because the surface on the target becomes positively charged.

The use of a RF power source with an impedance matching network solves this problem and allows the sputtering of insulating materials. The voltage applied at a frequency of 13.56 MHz; allows for charging and discharging of the insulating target.

- **Magnetron sputtering:**

The application of magnetic field in plasma causes the electrons to spiral around the direction of the magnetic field lines. Magnetron sputtering utilizes magnetic fields to increase deposition rates and allow for low operating pressures and temperatures.

For example, the application of a planar magnetron will cause electrons in the glow discharge to follow a helical path, increasing the rate of collisions and ionization. Therefore, magnetron sputtering grows high quality films at lower operating pressures.

* Magnetron Sputtering Process

Many improvements have been made to this technique to enhance the sedimentation process. Among the most important of these methods is the use of the magnetic field to become the technique of the magnetic system sprinkler magnetic system. The main difference between this method and the traditional method described just earlier is the use of a strong magnetic field near a target. A strong magnetic field causes the movement of electrons in a spiral path along magnetic flux lines near the target rather than being attracted directly to the sedimentation substrate.

One of the advantages of this method is to confine the plasma to the target without causing any damage to the thin film during its precipitation. The electrons move longer distances, and this increases the possibility of ionizing more argon atoms. This leads to the generation of stable plasma with a high density of ions. More ions mean more atoms released from the target, thereby increasing the efficiency of the spattering process. The increased sedimentation rate works to reduce the impurities formed on the thin film and increase the distance between the plasma and the substrate reduces the damage caused by the collision of argon ions and electrons sometimes with the thin film.

Note: The efficiency of the precipitation process is determined by the sputtering yield, which is defined as the number of atoms of the released target for each argon ion at a given kinetic energy.

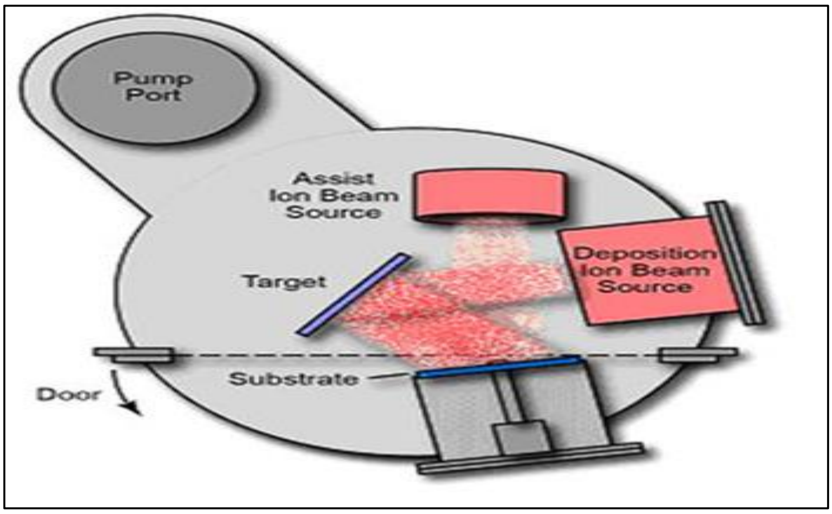
For example, if two atoms of the target material are released with each ion-argon collision, the spatter result is in this case equal to 2.

Note: When working with a conductive material target, it uses a DC power supply. When dealing with a target of an insulating or semi-conductive material, an RF power supply is used.

- **Ion-Beam Sputtering:**

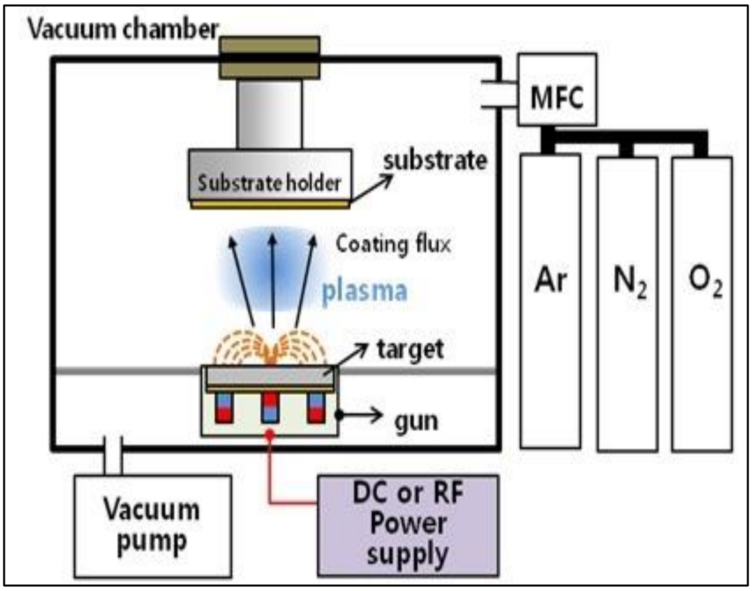
Ion beams, produced in and extracted from glow discharges in a differentially pumped system, are important to scientific investigations of sputtering, and are proving to be useful as practical film deposition systems for special materials on relatively small substrate areas.

There are several advantages of ion-beam sputtering deposition. The target and substrate are situated in a high-vacuum environment rather than in a high pressure glow discharge. Glow discharge artifacts are thereby avoided, and higher-purity films usually result. Reactive sputtering and bias sputtering with a separate ion gun can be used.



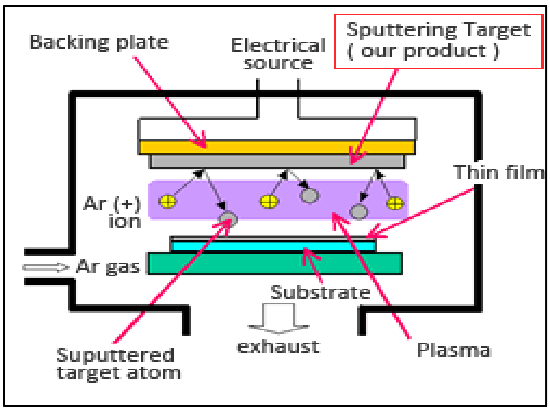
- **Reactive sputtering:**

Reactive sputtering can be used to deposit films of such materials like oxides or nitrides through the use of pure metal targets. In addition to the sputtering gas (argon), a reactive species-oxygen or nitrogen, for example-is introduced into the growth chamber. The sputtered target atoms react with the gas to form the new material. Compounds can be synthesized by reactive sputtering, that is, sputtering elemental or alloy targets in reactive gases; alternatively, they can be deposited directly from compound targets.



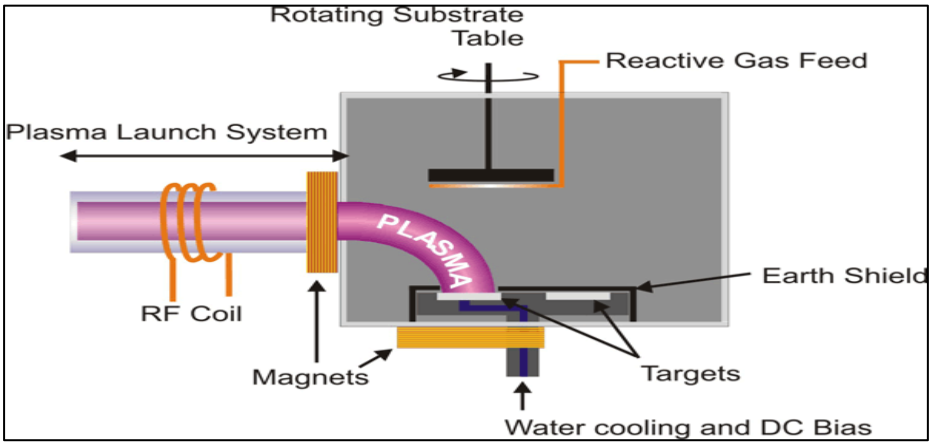
- **Diode Sputtering:**

Diode sputtering uses a plate of the material to be deposited as the cathode (or rf-powered) electrode (target) in a glow discharge. Material can thus be transported from the target to a substrate to form a film. Films of pure metals or alloys can be deposited when using noble gas discharges (typically Argon) with metal targets.



Bias Sputtering:

Bias sputtering or ion-plating is a variant of diode sputtering in which the substrates are ion bombarded during deposition and prior to film deposition to clean them. Ion bombardment during film deposition can produce one or more desirable effects, such as re-sputtering of loosely-bonded film material, low-energy ion implantation, desorption of gases, conformal coverage of contoured surface, or modification of a large number of film properties. The source material need not originate from a sputtering target, but can be an evaporation source, a reactive gas with condensable constituents, or a mixture of reactive gases with condensable constituents and other gases that react with the condensed constituents to form compounds.



Some of the benefits of sputtering include:
1. High uniformity of thickness;
2. Good adhesion of film to substrate;
3. Reproducibility of films;
4. Ability to deposit and maintain the stoichiometry of the target material;
5. Relative simplicity of thickness control.