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Article

Deposition Technique of Thin Films: Review

Azhar Mohammed Abd

Salah Al-Din Education Directorate, Ministry of Education, Tikrit, Iraq

E-mail: a3913783@gmail.com

Abstract: The significant recognition and the presence of film procedures in modern applications were highlighted. The film presence procedures have been found and categorised into the major sorts of (i) physical methods, (ii) chemical processes. The most Important technologies within each of these categories were reviewed, including their fundamental principles, prominent characteristics, and the measures for choosing thin film presence innovation were then explained in relations to some specific usages and material elements. Thin film deposition is a crucial factor in their synthesis, as the method used directly affects the quality, structure, and functionality of the resulting film. Various deposition techniques are employed for the synthesis of this film, each with its own principles and advantages.

Keywords: Deposition Techniques, Thin Film, Evaporative Techniques, Spurting, MBE, PLD, ALD.

1. Introduction

These discussions about the operation, suitability, control, and efficiency of deposition devices for the purpose of production usage aim to allow the reader ro obtain some basic perception as well as awareness of the system. Deposition processes can be considered a key the manufactures of many devices, such as computers, since microelectronics relies primarily on the synthesis of materials made using thin films. Electronics engineers are constantly producing high-quality, cost-effective films, which necessitates the rapid development of deposition technology. Therefore, equipment manufacturers worked to meet the requirements through successful efforts of mor advanced and economical deposition techniques and controlling the measurement of film properties constitute an additional major reason for the rapid development of deposition techniques, this was possible thanks to the growing perceiving the chemistry and physics of interactions, films, surfaces as well as microstructures which was enhanced by the notable innovation in analytic items over the last twenty years. One of the most prominent examples that illustrates the essence of the projected deposition procedures is the production of semiconductor devise, this is an industry that rely completely on the production of thin solid films from various materials by deposition from the solid phase, liquid, vapor, or gaseous.

2. Categorization of Deposition Procedures

There are numerous deposition procedures to shape the planned materials. Since the main focus is in relation to creating thickness of the nanometers to approximately ten micrometers, classification processes are simplified by the limited number of techniques to consider. Mainly, thin

films deposition techniques are either only chemical, such as gaseous and liquid chemical processes, or only physical, as methods of evaporation. There are a large number of glow discharge and reactive spattering procedures that integrate both physical and chemical responses. These over lapping processes can be classified as physicochemical methods [1].

3. Physical Deposition Method

We will briefly review the basic principles, prominent characteristics application, and selected references from the literature for the most important application of film deposition and fabrication, to provide a more detailed explanation of the complete field.

4. Review Different Deposition Techniques

4-1 Evaporative techniques

Thermal vanishing of the old procedures applied in thin film deposition, nevertheless it still widely used in laboratories and in the metal and alloy deposition industry, the following basic sequential steps are performed.

1. Steam is produced through boiling of the source resource.
2. The steam generated from the source is transferred substrate surface.
3. The steam condenses, forming a solid layer on the surface of the substrate [1].

4-1-1 Vacuum evaporation

In vacuum evaporation, the net transport of material consists of atoms moving from the source located in the crucible towards the substrate surface when the crucible is heated under high vacuum. The pressure during process occurs is usually so low that the evaporated atoms have a large mean free path, than the extents of the resultant chamber, in a directional fluidity within the surroundings. This fluidity can be affected by the angular discharge of the disappearing species. the rate of evaporation, and the design of the deposition chamber. One method to mitigate the impacts of directional flow is the rotation of the substrate inside the evaporator, which ensures the flow is uniform along an axis perpendicular to the substrate [1]. Vacuum evaporation has advantage [2]

1. Perfectly suited for manufacturing semiconductors devices, especially for the large-scale production of transistors and connectors.
2. It operates in a vacuum environment, which reduces the impact of air particles during the deposition process.
3. It operates efficiently of depostion process can be controlled under high vacuum pressures.

Disadvantage

1. There are some materials that are unsuitable for thermal disappearance owing to their thermal elements.
2. It may be difficult to achieve a uniform thickness over large

4- 1-2 Molecular beam epitaxy (MBE)

MBE is an progressive, precisely control system for the growth of single-crystal epitaxial films under vacuum pressure (10^{-11} torr). The presence of the films was conducted on single crystal substrates using the slow evaporation of the primary or molecular mechanisms of the film obtained Knudsen cells, which are seriously crucibles within the furnaces prepared with chilled lids. These components are directed onto substrates stabilized at a suitable temperature to allow the chemical reaction to take place, with excess unreacted species being re-evaporated. The furnaces work by generating relatively narrow atomic or molecular beams, which are directed with high precision towards the hot substrate [3].

The basic components of the MBE grow chamber are shown in figure (1), which consists of (1) a stainless steel container with a diameter of less than 20 inches for research devices but much larger in the case of production systems,(2) chambers that produce molecular beams, (3) shutters open and

close molecular beams, (4) a substrate holder that can be heated up to several hundred degrees Celsius, (5) a load -looking system that allows chips to be inserted into and removed from the growth chamber without breaking them [4].

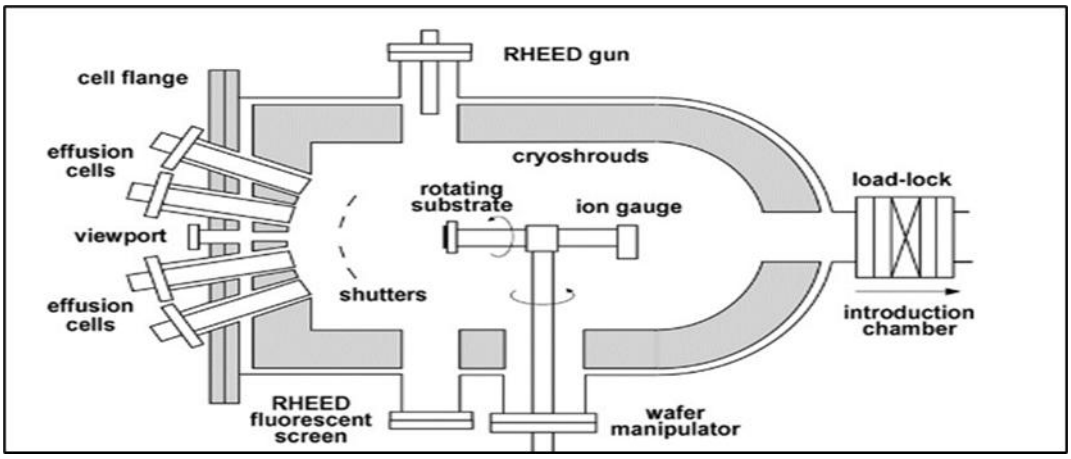

Figure 1. Schematic diagram of the MBE growth chamber [4].

To minimize the incorporation of impurities that could affect material quality and surface topography, chambers is evacuated to a pressure 10^{-11} torr, achieved using a combination of ions, titanium and closed -loop helium pumps. Cooling panels, particularly those cooled with liquid nitrogen, are widely used around the substrate and the chambers to remove condensable pollutants such as CO_2, CO and H_2O, these cooling panels also provide significant thermal insulation between the chambers (200 ℃, 1100 ℃) which are located very close together (less than a few tens of centimeters) where precise and independent control of the molecular beam flow requires temperature control [4].

Materials that have been extensively studied are the epitaxial layers of (III-V) semiconductors for compounds but insulators, silicon and silicide's, it can be deposited in the form of single-crystal film using this versatile and unique technique. An important additional feature of MBE is relatively very low temperature needed for epitaxy, which ranges from 400C℃ to 800℃ for silicon and from 500℃ to 600℃ for gallium arsenide. Also, the pressure is much lower compared to simple evaporation techniques, and this eliminates the effects of gas collision, which greatly improves the clarity of the films [1]. The MBE technique has certain advantages and disadvantages [3], [5].

1. It provides high accuracy in adjusting film width and its essential structure at the atomic phase.
2. It creates crystalline films of maximum structural eminence.
3. Chiefly appropriate for synthesis semiconductors devices.
4. Reduced risk of contamination as a result of extremely high vacuum medium.

Disadvantage

1. It is highly complex and require advanced technological expertise.
2. Deposition rates are usually lower compared to some other techniques.
3. This can be of scalable eminence for huge scale presence to operate in other procedure.

4-1-3 Electron-beam evaporation

The presumed electron beam and its evaporator often includes a crucible and electron beam gun; this assembly is complemented via a charging device for the evaporating agent. Usually, the electron emitter generation mechanism is combined with the electron beam deflection unit, in addition to the crucible. Electron beam evaporators operate according to different principle, as illustrated in figure (2) [6]. A high-energy electron beam is necessary for vaporizing heat-resistant materials such as most types of ceramics, refractory metals, glass, and carbon. Electron beam heating can be essential in the vaporization of huge quantities of elements and these numerous sources

applied for the purpose of heating electron beams. Some changes may occur when there is solid surfaces of insulating materials as well as charge gathering on the surface of the curvature which may result to the contamination of some particle in the deposition scheme. The high – energy electron beam is generated by thermal emission filament to produce electrons, high voltage (10-20KV) to accelerate the electrons, and direct the processed beam in the position of the surface of the material set to be vaporized using electronic or magnetic fields. The electron gun source may contain multiple cavities to a greater extent than that one substance can be vaporized using the same multi-cavity electron source [7].

The simplest from is electron collision. Heating the cathode in the evaporating medium or crucible causes electrons to flow with accelerating electric potential between the crucible and cathode, directed towards the evaporating medium. With a purpose the electron current intensity at a specific diameter of the evaporating material, a control electrode is used at the cathode potential. if a ring cathode is used, the control electrode is also in the from of a ring that is concentrated around the crucible [6].

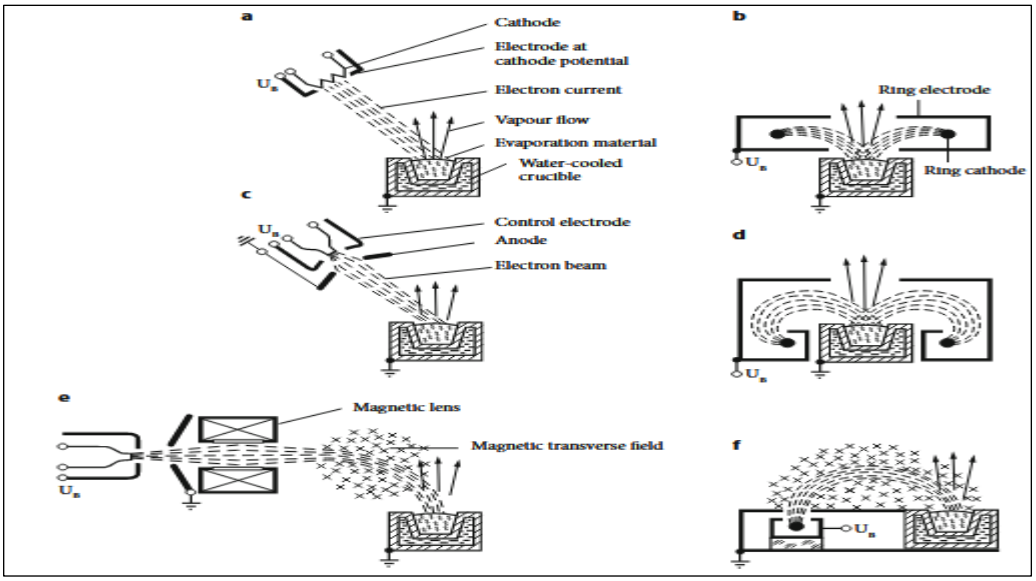

Figure 2. Principles of electron beam evaporators [6].

The bombardment of maximum energy electron creates secondary electrons that can be rebounded by magnetic field towards earth. These electrons cause part of the vaporized materials to ionize, and the resulting ions, or emissions from the excited atoms, will be observed at the proportion of vaporization. The Secondary electrons may lead to be formation of electrostatic release on an electrically insulating substrate. If the stabilizer is grounded, the electrostatic release can differ on the surface of substrate, particularly if the surface is great, which may affect the deposition of the accumulated film. This can be avoided by electro flotation of the substrate stabilizer [7].

4-1-4 Pulse laser deposition (PLD)

The pulse laser deposition is broadly applied in order to deposit used compounds and/or alloys. In laser deposition, a high -energy pulsed ultraviolet laser beam, were exposed to irradiated through a window made of quartz. A quartz contributes to increasing the density of laser energy on the target surface. A thin layer forms on the surface of adjacent samples as a result of the accumulation of atoms removed or evaporated from the surface. Figure (3) illustrates a typical PLD system. The material of target is heated up to reach the projected melting point and similarly it can be melted and as well vaporized within the vacuum to produce photoelectrons from the target, leading to the formation of a plasma column. The vaporization mechanism is expected to be complex, because the process involves both photo plasma and thermal processes, PLD has the advantage [8].

1. Simple design.
2. The target is available in various forms such as powder, single crystal and sintered pellets.

disadvantage

1. A small area where uniform deposition occurs.
2. The target emits micro-sized particles or globules.

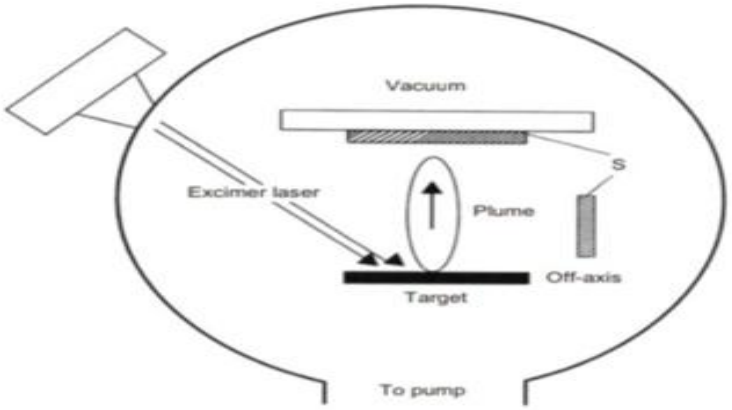

Figure 3. Typical PLD [8].

4-1-5 Arc vapor deposition

The Arc vapor deposition process uses a low-voltage electric Arc and high current to vaporize a cathode electrode or an anode electrode and then evaporated material is deposited onto the substrate. The evaporated material has a high degree of ionization and the substrate is often used to accelerate the ions towards its substrate [7].

4-2 Glow discharge device in thin films

Glow discharge devices can be defined as devices that operate in an inert atmosphere, low-pressure, and gaseous conductors. Glow discharge is one of several forms of gaseous discharge and is often called plasma [9]. The electrode-gas phase phenomenon represents various types of glow discharge (especially radio frequency (RF), discharge a rich source of processes used in thin films deposition and etching [1]. Figure (4) describes the characteristic voltage-current relationship found in many bipolar discharge devices. The process of this expedient on the presence of two main electrodes within a gaseous medium that allows the flow of electric current between them. The cathode has a negative potential, which the anode has a positive potential. In reality, the discharge is caused by the potential difference and therefore the position of the electrodes depends simply on their relative potentials. When a gaseous medium is subjected to high electrical potential between two electrodes, the molecules and atoms of this targeted channel will form the pairs of ions and electrons and later allow the flow of electric current. One of the characteristics of medium failure is that the gas can transform from an assigned poor conductor to a resistance of nearly 10^3 ohms-meters. The possible variation between the confirmed electrodes can be termed as breakdown Vb, which is reliant on the homogeneity and density of the gas. The failure of the gas may lead to the production of the positive ions and highly negatively charged electrons. Following the early failure of the gas and the possible collision of particles within it cause the production of greater electrons and ions. At this stage, the discharge is considered self -sustaining, provided that suitable potential Vn is applied, which is usually less than the breakdown potential Vb [10].

1. Townsend discharge or dark, which carries a current to 10^{-6}
2. Glow discharge can carry an electric current of 10^{-6} to 10^{-1} ampere.
3. Arc discharge can carry an electric current about 10^{-1} ampere and above.

The electrical properties of a gas discharge become clearer when the Townsend discharge

region is adopted as a starting point, which is characterized by very small currents, meaning it is invisible because the density of the atoms realized is commonly few. This shows that it is not self-regulated but it needs an outer force to create the electrons from the real gas. This force may be ultraviolet radiation, x-rays, or cosmic rays [11].

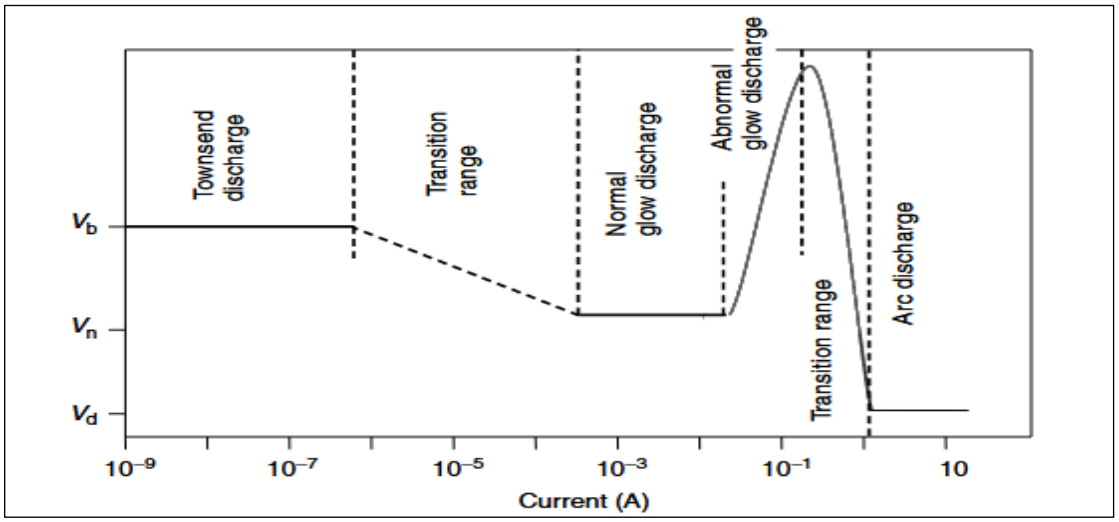

Figure 4. Current-voltage characteristics for a wide range of direct currents [10].

Following the Townsend release then a changing zone occurring from additional energy transfer rate as a result of collisions (due to high gas pressure), this may bring an upsurge in the magnitude of current, but originally, a voltage degrease is needed to maintain the release. Similarly, bright glow release can be seen between the electrodes. Initially, a glow release can increase the current dose not lead the variation in density since the surface of cathode is partially coated by the discharge, therefore, there is no need to increase the voltage. This is considered a type of regular glow expulsion. As the present current increased the glow release will cover the complete surface of the cathode. At this phase, any addition in the release of the current can lead to an increase in density of the current, which dictates floating the discharge voltage. Therefore, plasmas exhibiting this form of increasing voltage -current relationship are called abnormal glow discharges which is most often used in atomic spectroscopy. If the discharge current increases significantly in glow discharge the current density reaches very high values, resulting in significant heating of the cathode due to it continues bombardment by gas ions, resulting in thermal evaporation of the cathode. Under these conditions, the production of a large density of decomposed atoms affects the electric fields, so the voltage-current characteristic become normal, with current increasing in tandem with the decreases in discharge voltage, as is the case for a dc arc. A direct current (Dc) arc typically operates at atmospheric pressure and is known for its high currents and luminous discharge plasma [9].

The secondary electrons emitted during the atomization process are essential for maintaining the discharge by ionizing the gas phase. The negative potential on the surface of the cathode causes electrons to accelerates through the dark region of the cathodes towards negative glow region.

4-2-1 Sputtering

Sputtering is the erosion of material surfaces by the impact of particles. Atom-level atomization is the emission of some atoms or molecules from material surface, initiated by the bombardment of a single particle. Sputtering is a widespread phenomenon when energetic molecules interact with materials, its effects have numerous applications, so the term is used in different senses by different communities. Those who use spraying as a means of etching, cleaning or polishing materials may use spraying synonymously with ion beam bombardment, while the research and engineering community used atomization instead of evaporation in film deposition synonymously with spray

deposition this term historically emerged early in this century to describe the initial event that was thought to be similar to what happens when a stone falls onto the surface of water[12].

Sputtering begins with the initial collision between the atoms on surface of target and incident ions. The momentum generated by the incident ions is transferred, leading to a series of collision that result in similar the vaporization of the atoms close to the surface. the magnetron is one of the most commonly used configurations, as the strong electric and magnetic field confines the plasma close to the target [13].

Figure (5) illustrates the processes occurring at the surface, in the surface area, and the area near the surface that are exposed to bombarded. Bombarding particles can actually penetration into the surface region, while the impact of collisions occurs in the region adjacent to the surface, where the bombarding particles trigger a series collision. Part of the momentum of the bombarding particles is transferred to atoms of surface, which can then be ejected from the surface. The reflection of some bombarding particles produces neutral particles with high energy, and some become embedded within the surface. The deliberate incorporation of krypton into the surface is called kryptonation, and the resulting materials are called kryptonates [7].

When sputtering is carried out in vacuum or a low-pressure environment, the atoms that possess high energy bombard the growing film, which affects its formation. Particles with high energy can leave the target carrying energy ranging from a few volts to several hundred volts, determined by power of the occasion ion, the relative masses of the bombardment ions and target material. High energy bombardment may lead to material sputtering to redisperse, resulting in a significant reduce in the sputtering yield of the presumed target. At the spattering procedure, the efficiently keeps the target cool, were cooling the target reduces the radiant heat in the sputtering system. The reduced radiant heat is one factors that allows heat sensitive surfaces to placed close to the spurting target, and cooling also contributes to enhanced diffusion to the target, which leads to variation in the composition of elements in the surface area when using alloy spray targets [7].

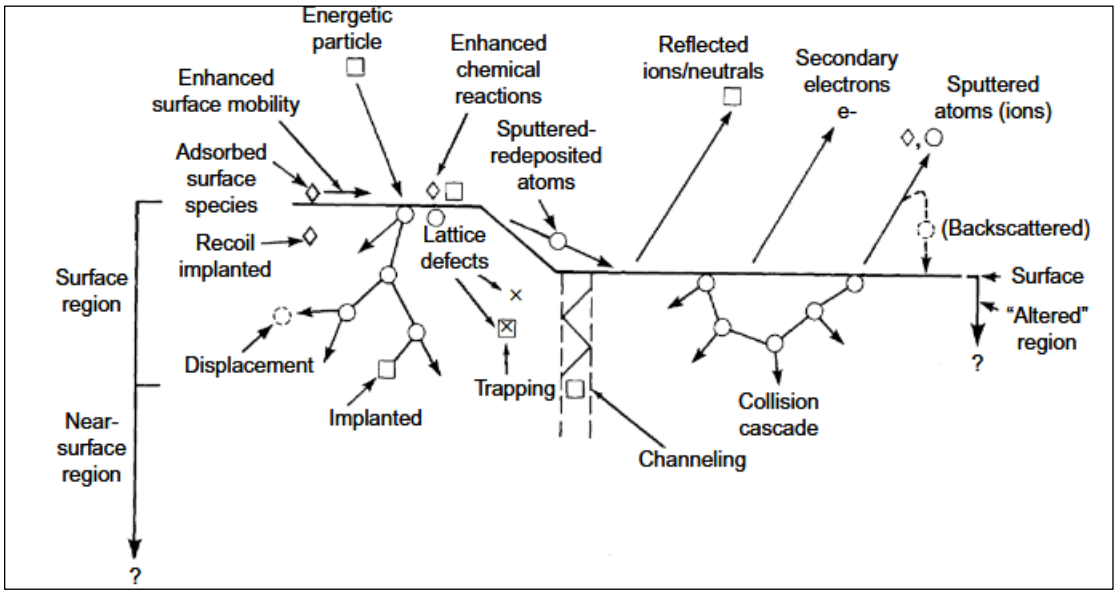

Figure 5. Illustrates the processes that occur on the surface when it is bombarded with atomic particles [7].

4-2-2 Reactive sputtering

Thin film of compounds is deposited onto metal target substrates in the reactive sputtering process in the presence of a reactive gas shown in figure (6). Typically, reactive gases are characterized by their low atomic masses (O=16, N= 14 amu) and are therefore inefficient in

sputtering, so it is appropriate to aid the sputtering process, a heavier inert gas such as argon (40 amu) is used, process of adding argon with the reactive gas contributes to activation the reactive gas via penning ionize/excitation [7]. The most common compounds that have been reactively atomized (the reactive gases used) are listed in brief [14].

1. Oxides (O)- Ta_2O_5, SnO_3, In_2O_3, SiO_2, AL_2O_3
2. Nitrides (N, NH_3)- Si_3N_4, TiN, AIN, TaN.
3. Carbides (CH_4, C_2H_2, C_3H_8)- TiC, WC, sic.
4. Sulfides (H_2S)-CdS; CuS; ZnS.
5. Oxynitrides and Oxycarbides of AL, Ta, Ti and Si.

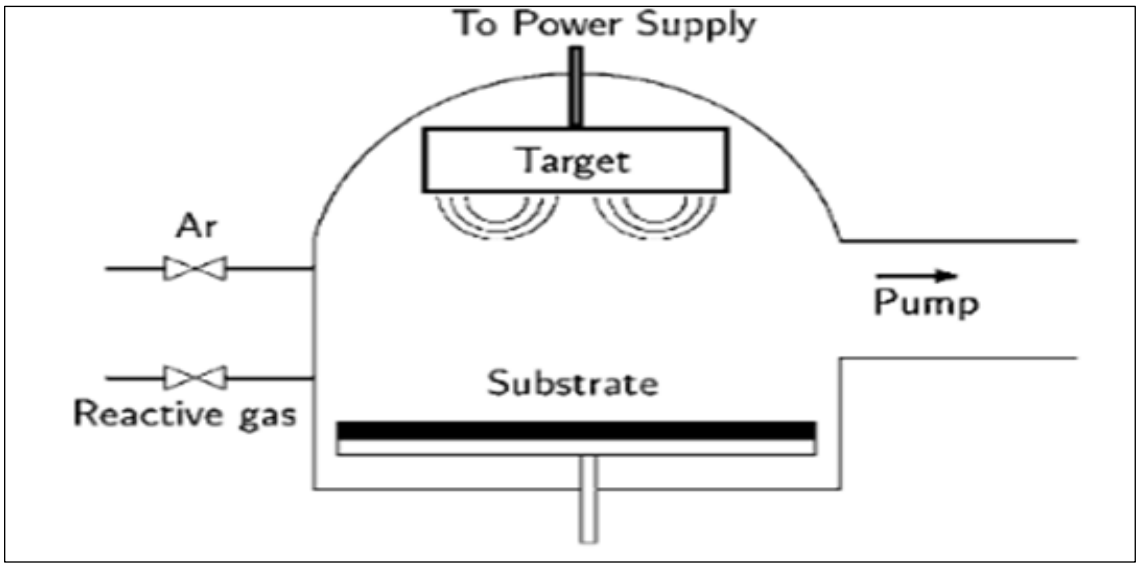

Figure 6. Reactive sputtering system [15].

4-2-3 ion plating

Ion plating is a spattering procedure that applies progressive presence of a substrate to deposit a film through active particles. The construct and usage of ion plating were first recognised and published in one of the technical reviews in 1964, it was used to enhance adhesion and surface coating and to thicken PVD films. Later this procedure was introduced to enhance chemical responses in the reactive deposition of thin films. Later, it was shown that continuous bombardment could be used when atoms are deposited from a chemical vapor material [7], the material in the ion plating, is evaporated in a manner similar to what occurs in the evaporation process. However, it is transmitted via a gaseous glow discharge and then onto the substrate, as a result, a proportion of the vaporized atoms undergo ionization (figure 7). The glow discharge occurs as result of applying reverse bias to the substrate (-2, -5 Kv) and introducing gas most often argon, at a pressure of 5 to 200 m tor inside the deposition chamber [16].

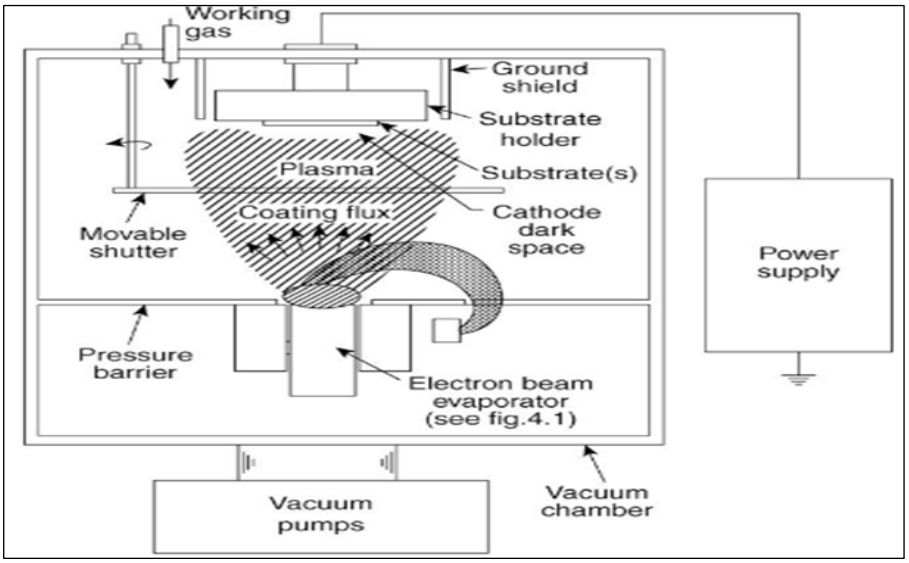

Figure 7. Shows the ion plating process [16].

The substrate is bombarded prior to deposition through high energy gas ions ejected from the surface material. This process results in continuous substrate cleaning (any surface purification from impurities through sputtering, this helps improve adhesion and reduce the percentage of impurities). Bombardment during deposition can be applied to get reliable adhesion, assist in chemical response, reduce residual stress and thicken deposition material. It modifies the nucleation behavior of the deposition material, such as nucleation density interfacial surface formation, and film properties. The active particles used in bombardment usually inert gas ions, reaction gas (reactive ion coating), or in some cases, condensing agent ions [16].

Ionic plating is also called ion-assisted deposition, ionization-assisted deposition, ion-vapor deposition, ionized physical deposition, and energetic condensation [7].

4-2-4 Magnetron sputtering

Magnetron sputtering deposition technology was developed to complement other vacuum plating techniques such as electron beam evaporation and thermal evaporation, but these methods have shown certain drawbacks, particularly with heat-resistant metals and alloys, due differences in the pressures and high melting points of the alloy, and in addition, the compounds can decompose from their chemical components at low vapor pressures. Magnetrons sputtering process has many advantages, including [17].

1. High deposition rates.
2. Easy sputtering of any compound, alloy or metal.
3. Extremely pure films.
4. Excellent film adhesion.
5. The ability to deposit on heat sensitive substrates.
6. Uniform coverage on large scale substrates.

Two magnetron deposition systems were used to prepare thin film: one cylindrical type and the other planer type. The magnetron uses strong magnetic field, usually from permanent magnets, to keep secondary electrons spatially confined to the periphery of the target surface, thus concentrating the glow discharge within the region of high magnetic field [18]. Secondary confinement near the target surface significantly prolongs the time electrons spend in the plasma, leading to increased ionization of the bursting gas atoms and trigger the production of a denser plasma. The electric field generated by the cathode potential drop in a magnetron sputtering source, secondary elections are accelerating towards the target surface. The magnetic field arrangements are typically designed so that the field lines are parallel to the target surface, this results in an EXB drift

force acting on secondary electrons , thus restricting their movement to circular drift orbits parallel to the target surface , leading to additional collisional ionizations of volatile gas atoms and plasma currents [19], thus the etching on the surface of cathode is uneven resulting from circular cathode glow, resulting in a short cathode lifespan. Therefore, several enhanced magnetron plans were already developed which include magnetron with mobile magnets or system consisting of multiple magnets to achieve a uniform wear zone and extend the targets life. The working pressure in the magnetron sputtering system is (10^{-3}-10^{-5} torr) and the volatile particles pass through the discharge space without being subjected to collisions, therefore deposition rate R can be calculated by equation [18].

$$R \cong {}^{KW_o}/_{t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Which K=1 with regards to the plane system, $K = {}^{r_c}/_{r_a}$ for a cylindrical scheme in which r_c is the cathode radiuses, r_a seems the anode radius, w_o is the total amount of atomized element, the equation is given.

$$W = {}^{K_1 W_o}/_{pd} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

In which W is the density of the planned atomized film, w_o is the total amount of atom element per unit area of the cathode, d seems to be the distance between the electrodes, and p is the assumed pressure of the vacuum gas.

Several designs for enhanced magnetron spattering schemes were proposed according to the concept of an in balanced magnetron, electrons may disappear from the early magnetic restriction close to the magnetic field the lines play a role in trapping energetic electrons that are trying to escape, and the trapped electrons also cause collisions that lead to ionization, thus producing secondary plasm near the substrate. This resulted in an increased flow of ionized particles within the unbalanced magnetron, leading to increased deposition rates as shown in figure [18]. The common feature in all designs is that the EXB drift effect keeps secondary electrons in closed confined paths so that they can ionize several atoms of the sputtering gas, i.e., they are designed so that the magnetic fields are perpendicular to the strong electric field when the cathode potential [19].

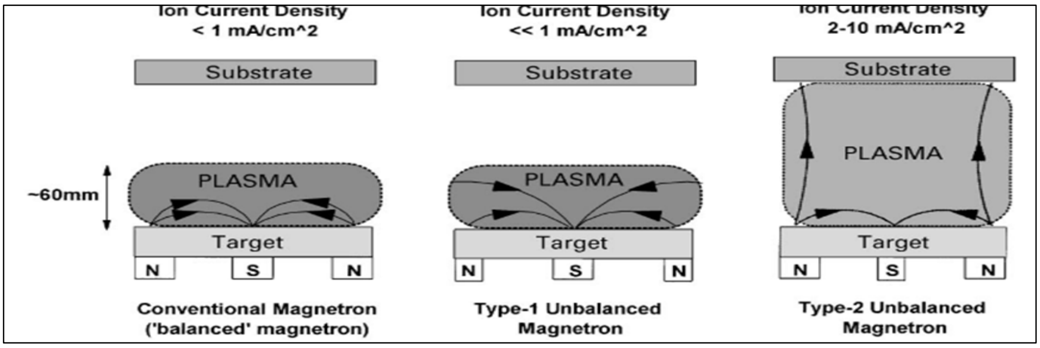

Figure 8. Represents the diagram for plasma confinement in a balanced and unbalanced magnetron [20].

4-2-5 Ion beam deposition

The glow discharge sputtering technique is limited in that the current density and voltage cannot be controlled independently except by changing the working gas pressure with the exception where the voltage can be changed at a constant current and pressure by changing the intensity of the magnetic field [15]. Furthermore, the gas compression within the glow discharge scheme, can be so high that gas molecules can radiate during the thin film production, which cause the molescules to become implanted in the deposited films. While the target can be bombarded by this ion beam in a spattering chamber from the ion beam source. in a glow. A large-scale ion source based on the

Kaufman design was recently developed. This type of source is characterized that ion source contains a plasma chamber, along with a heated filamentary cathode. Multi-aperture gratings are used to accelerate the ions generated within the source, resulting in the formation of wide bombardment zone and a dense beam. The ion beams current depends on the source dimensions, ranging from 10 mA to numerous amperes. The energy of the set ion may be controlled to around (0.5 kv to 2.5 kv), the gas compression of deposition chamber is about (10^{-4} to 10^{-5} torr). This system is typically widely applied for etching in semiconductor devices [11]. The film deposition rate primarily determined by several factors, most importantly: the target material used, the temperature, the type and energy of the colliding ions, the distance and angle between the substrate and ion source as well as the separation distance between the substrate and target [14]. The substrate is positioned appropriately to receive the coating flow as shown in figure [15].

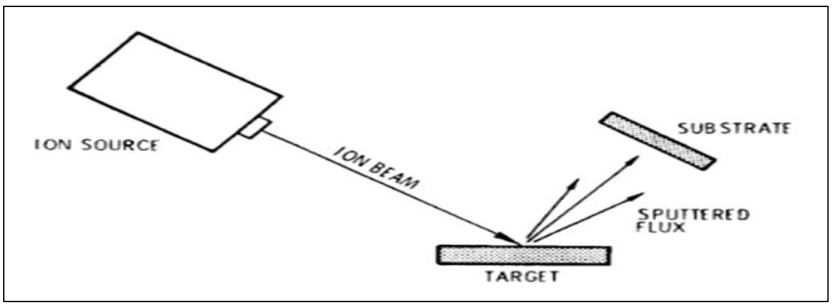

Figure 9. Is diagram representing ion beam sputtering showing the relative positions of the target and substrate [15].

4-2-6 Ion beam sputtering deposition

Ion beam sputtering is commonly used for thin film deposition, while the resulting deposition rates are moderate (from a few $^{Å}/_{min}$ to hundreds $^{Å}/_{min}$) when compared to process such as the magnetron [21]. When designing an IBSD chamber, supplementary details should be observed.

Firstly, the beam is often obtuse so the primary elements will bombard the surrounding parts and chamber covers. These corrosive elements will contaminate the developing film to reduce this; the chamber must be selected suitably.

Second, the pumping swiftness of the space system must be adequately high to evade or diminish background gas particle coating on the target surface. Surface coating can affect sputtering efficiency and also lead to additional harmfulness of the thin films.

Ion deposition consists of ion beam source, a target a carrier and a substrate as shown in figure (10) the most important parameters of the process are (1) ion beam parameters: types of ions and ion energy, (2) geometric parameters: angle of incidence of ion, angle of emission and scattering angle [22].

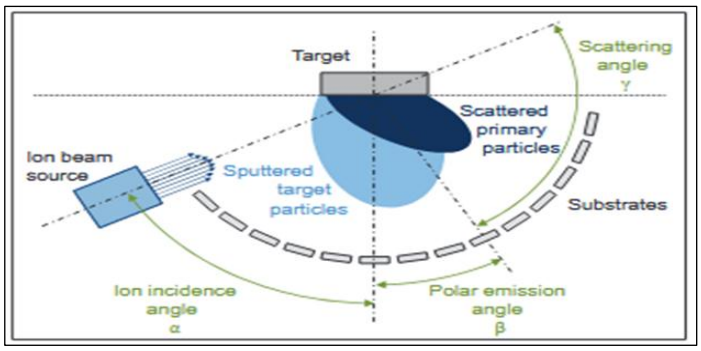

Figure 10. Is a diagram representing ion beam sputtering deposition [22].

Several advantages can be achieved with ion beam sputtering deposition. One is its ability to sputtering new material compounds without the need for costly fabrication of sputtering targets. A second advantage is that the samples are not immersed in a dense plasma, as with various plasma based sputtering system, the absence of plasma reduces the risk levels in sensitive equipment, and consequently no negative ion is formed with ion beam sputtering, in many sputtering scenarios of targets in the presence of the required oxygen, the negative ions may form on the target surface. These ions accelerate towards the target sheath and are directed towards the sample with high energy. These ions become electrically neutral in the plasma and impact the growing film with high energy; this bombardment can cause substantial variations in the general rate of deposition in addition to the chemical composition of the film. A third advantage is the ease of deposition on magnetic material; the magnetization of the target is ion sensitive to ion beam deposition. The target made of a magnetic material tends to alter the magnetic field lines and significantly reduce plasma density. However, current techniques for magnetron sputtering of magnetic material remain generally inadequate [21].

4-2-7 Radio frequency sputtering

Radio frequency is type of sputtering deposition process. This process relies on changing the voltage of the presumed electric current in a vacuum medium with the use of radio frequencies. The cathode may act as another source of film deposition, whereas, the anode can be linked to the other end of the capacitor to be shielded. That ensures the clear transfer of energy from the radio frequency to the plasma release. The target is bombarded with high voltage at frequency of 13.56 MHz inside vacuum chamber, causing generation of high energy ions to eject atoms and form a thin layer covering the substrate [23].

5. Chemical Deposition Methods

5-1 Chemical bath deposition

Thin films can be placed on metallic non-metallic substrate through the immersion of suitable solutions of metal salts without using an electric field. Deposition may take place through consistent chemical reactions of metal ions in solution by the reduction of some agent. Of the methods are more economical and easier than physical method is ideal for preparing thin films that meets all achievable condition. Among chemical techniques, chemical bath deposition is the most commonly used currently, due to the possibility of preparing a large number of conductive and semiconducting thin films using this method. It is also, widely popular due to low cost and simplicity. This method allows for the depositing of thin film on various substrates such as ceramics, glass and metals. It is a simple and has the potential to producing large areas adhesive films with high-quality and uniform thickness [24]. Chemical bath deposition process has many advantages, including.

1. Suitable for low temperature film deposition, which reduces thermal stress on the substrate
2. Deposition is permitted in vertical, horizontal, or other specified substrate position
3. In general, it features lower original equipment setting costs in comparison with other advancements.

Disadvantage

1. The level control over film elements relatively limited compared to some other techniques
2. Suitable for specific material, which limits it rang of uses
3. They may encounter difficulties in achieving a unified coating on difficult surface.
4. They typically feature slower deposition rates compared to some high temperature technologies [25], [26].

5-2 Atomic layer deposition

The atomic layer deposition (ALD) is a form of chemical vapor deposition procedure that depends on stopping gas responses. There are some basic stages that are necessary to e repeated which include four distinct steps. These steps may include exposing the substrate to the initial

chemical in the gas phase and cleaning the deposition chamber where a slow gas or simply is evacuated using a vacuum pump, then exposed to oxidizing or reducing agents in the gaseous phase the final step is to remove the deposition with an inert gas. As shown in figure 11, the initial step is an atomic stage which is the absorption of the gas stage metal precursor of the substrate surface. To attain self-adsorption, chemical adsorption is required, which is characterized by a much higher binding energy to the substratum the surface in comparison with the physical absorption. In the process of chemical adsorption, the raw material molecules and the other substrate surface can be generated simultaneously when will later be removed and plush out in the next stage. The later phase should be to clean and evacuate the deposition chamber which will remove most of the gaseous debris as well as the physically present reactive species on the surface. Following the evacuation and purging processes, the risk of gas stage response and nucleation will be due to the introduction of oxidizing/ reducing chemicals into the chamber is reduced. The substrate surface is also uniformly coated with chemically adsorbed reactive species for the next response stage as indicated in figure 11, the third stage includes introducing as well as oxidizing chemicals to react with the active sites of the precoated surface. This is one of the essential stages in the oxidation process whereby the adsorbed areas will be replaced with new reactive bonds to interface with the precursor molecules for the onward cycle. The final step is to clean/ evacuate reactive oxidants/reducers. After this step, the substrate is ready to begin a new cycle of deposition [27].

The advantage of ALD [28], [29].

1. Digital thickness control at atomic layer
2. Thickness uniformity over large areas
3. Low defect density
4. The ability to deposition at low temperature from room temperature to 400℃
5. Atomically smooth topography

Disadvantage

Its low growth rate, which is typically less than one atomic layer per cycle.

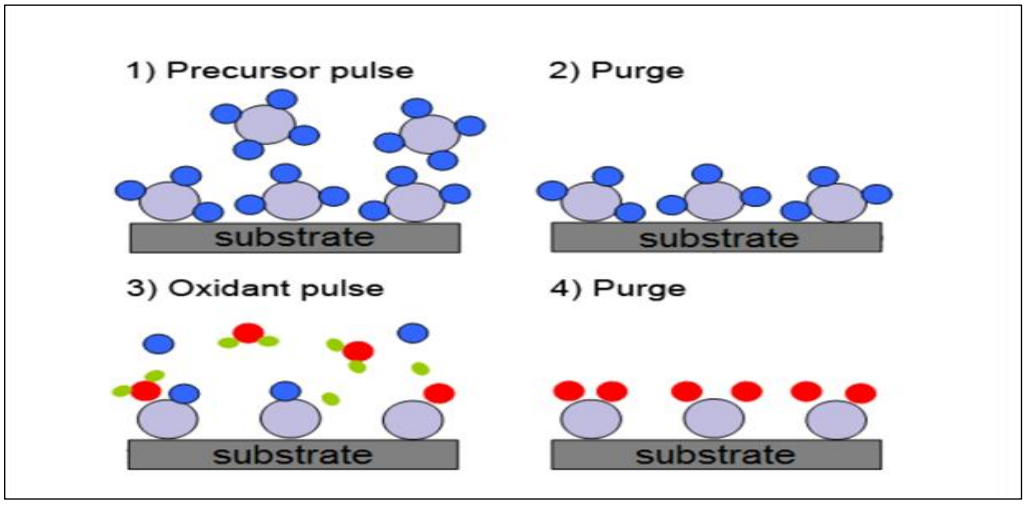

Figure 11. A typical ALD cycle with oxidation reaction [27].

5-3 chemical vapor deposition (CVD)

Chemical vapor deposition is one of the elements involved in the manufacturing procedure where the chemical parts may react in the state of vapor to realize a solid part of the layer. The presence of chemical reaction is vital in this procedure for the development of thin films. Controlling the major parts of the gas stage and the chemical vapor deposition is a serial process that starts with an initial steam stage and it continues through a series of semi-steady sub-processes. This process

ends with the formation of a thin layer with a final microstructure as the figure 12 schematically illustrates the sequence [30].

A. The reactive gases diffuse toward the surface.
B. Adsorption of reactants to surface sites, which is usually following some surface migration.
C. The surface chemical reaction between the reactants, that is usually activated by the surface.
D. The procedure of desorption for reaction through products.
E. The products may diffuse away from real genuine surface.
F. Incorporation of the solid product into the recognised microstructure of film during their growing.

Chemical vapor deposition has been classified by various processes like [1]

1. Atmospheric pressure chemical vapor deposition (APCVD)
2. Low- pressure chemical vapor deposition (LPCVD)
3. Ultrahigh vacuum chemical vapor deposition (UHCVD)
4. Plasms assisted chemical vapor deposition (PACVD)
5. Laser-enhanced chemical vapor deposition (LECVD)

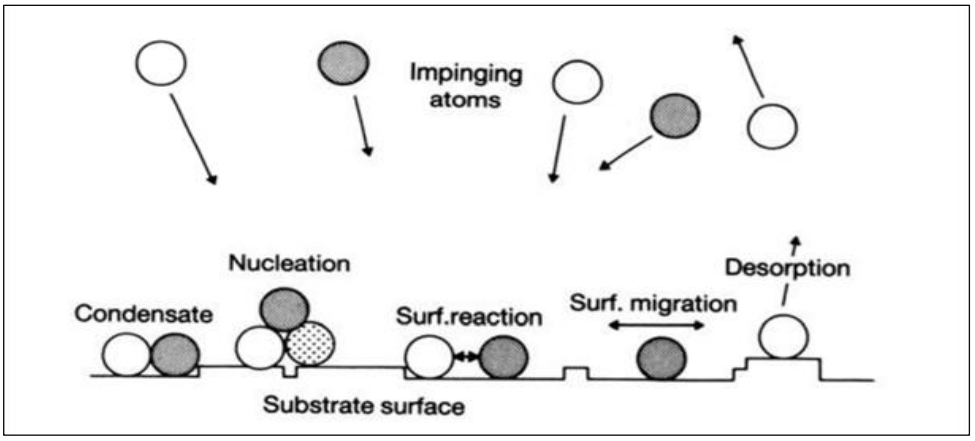

Figure 12. Is a diagram representing of events that occur around surface of substrate [30].

5-4 Sol-gel method

The sol-gel procedure is dependent on the system transitioning from a liquid state, i.e. the colloidal solution "sol" to the solid known as "gel". Sol-gel is a wet chemical combination procedure that can result to thin film and how it is produced though precipitation, gelation and hydrothermal treatment. Their morphology is controlled by relative rates of hydrolysis and condensation [31]. A colloidal solution consists of some hard particles, often with a few hundred nanometers in its diameter, typically inorganic mineral salts, suspended in a liquid stage. Colloidal solution is formed by the acid or base-catalyzed hydrolysis and condensation of a mineral precursor, usually in aqueous or aqueous/alcoholic solution [32]. The subsequent absorbent gel is then chemically sieved and get fired at maximum temperatures to produce highly purified oxide material. The gel can be modified with various additives to produce unique properties in the resulting glass that cannot be achieved by other means. The raw material undergoes a sequence of polymerization and hydrolysis responses to form a colloidal suspension, and then the elements condense into a new stage, where a huge solid molecule is absorbed in a solvent.

The sol-gel process enables the manufacture of material with extremely diverse properties: ultra-fine powders, homogeneous ceramics and glass, ceramic fibers and inorganic film, thin film and aerogels. Scientists have used it to produce some of the worlds lightest material and some of the strongest ceramics [33].

Sol-gel has greater advantage

1. Produces materials (metal and ceramics) at relatively very low temperature.
2. Produces almost a large quantity of commercially feasible materials.
3. Combination of two or more elements concurrently.
4. Coats one or more elements with materials.
5. Produces highly homogenous alloys and compounds.
6. Manufactures ultra-pure materials (99.999%).

5-5 Spray pyrolysis

The reactions in spray pyrolysis technique begin from the vapor phase in high temperatures environment, and the process can be carried out in air for oxides. The spray procedure may involve spraying of a certain solution of the dissolved feedstock on a heated surface to maintain a specific level of temperature and the maximum distance away from the nozzle. The hot part of the substrate can pass through a sort of thermal decomposition and as well form a unified form of crystals of the product [34]. The solvent can evaporate into gaseous substance. The solution two reactants can reoccur and the materials can use the spray pyrolysis procedure must be flexible at the pyrolysis temperature and soluble in the spray solution.

6. Conclusion

In this review, presents many aspects are important and techniques related to the thin film deposition procedure like the concise overview of physical deposition procedure and it has various advantages as well as the disadvantages. Generally, the physical deposition techniques have offered several advantages: process of deposition is slower, long-term deposition, more expensive, and lower process temperature, compared to chemical methods. While, the chemical deposition techniques exhibit several advantages, such as: higher deposition rates, produce quality films, equipment design is simpler and thicker thin films compared to physical method.

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