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Chapter 1 : Thin-film optics - Wikipedia

A thin film is a layer of material ranging from fractions of a nanometer to several micrometers in thickness. The controlled synthesis of materials as thin films (a process referred to as deposition) is a fundamental step in many applications.

Traditional electron-beam and thermal evaporation are the most widely employed methods for producing thin films because of their simplicity and relatively low cost of implementation. Here, a coating material is heated either resistively for metals or through electron beam bombardment for dielectrics within a high vacuum chamber until it vaporizes. This vapor then streams away from the source and recondenses on all surfaces that are in a line of sight with the source. This method of evaporation is a relatively low energy process, and, as a result, the dielectric films it produces are porous, of relatively low density, and exhibit a columnar structure. Typically, the substrate is heated to several hundred degrees Celsius during coating to mitigate this effect, but it is by no means eliminated. The problem with these porous films is that they can subsequently absorb moisture, which changes the refractive index of the layer s. This, in turn, means that coating performance parameters such as center wavelength can shift in use with changes in ambient temperature and humidity. Low density also limits mechanical durability to some extent, although these films can typically meet most of the MIL-SPEC durability and environmental requirements. Furthermore, the requirement to heat the components during processing can limit substrate material choice, and also introduce stress in the substrate due to thermal cycling Evaporative coating processes are difficult to automate entirely, and typically need monitoring by an operator. However, the high deposition rates keep coating run times relatively short, and thus production costs low. As a result, this method is particularly favored when cost is a significant consideration, and performance and durability specifications are relatively loose. The other big advantage of evaporative methods is that they are suitable for use with an extremely wide range of coating materials, from fluorides used in the deep ultraviolet, to oxides for visible wavelengths, through semiconductor and sulfide materials often employed in the infrared. Works with coating materials from the deep UV through the infrared Primary disadvantages: IAD is a variant of the electron-beam evaporation process which adds a high energy ion beam that is directed at the part to be coated. These ions act almost like an atomic sized hammer, producing a higher film density than can be achieved with purely by evaporation alone. The ion beam can also be used to pre-clean or etch the surface of the substrate, which can improve film adhesion. The result of higher coating density is improved mechanical durability, greater environmental stability and lower scatter than films produced using just electron beam evaporation. The amount of ion assist can be smoothly varied from zero up to its maximum level for each layer individually, which also gives the process tremendous flexibility. In particular, it enables the intrinsic stress of a coating to be modified during deposition, in some cases changing the overall film stress from tensile to compressive. This can help to maintain substrate surface figure, especially when depositing thick infrared coatings. It also extends the wavelength range over which the process can be used. For example, while IAD is not compatible with some of the commonly used materials in the infrared, it can be used solely on the outermost layer to yield an overall coating with superior durability. IBS coatings are produced in a vacuum chamber. In IBS, a high energy ion beam is directed at a target, typically composed of a metal or oxide. The ions transfer their momentum to the target material, causing atoms or molecules to sputter off. These high energy atoms then deposit onto the parts to be coated. Oxygen is typically present at low pressure in the coating chamber as a reactant to either create oxides when using metal targets, or to re-oxidize any free atoms dissociated by the sputtering process when using oxide targets. The high energy of the ion beam sputtering process results in extremely uniform, high density, completely amorphous films with excellent adhesion to the substrate. This translates into high environmental stability and mechanical durability. Furthermore, the surface roughness of the deposited layers is very low, even into the sub-angstrom level, which can yield visible and infrared with a combined scatter and absorption of less than 1 ppm. While deposition rates are low compared with other coating techniques, control and reproducibility is high, making it possible to hit performance targets with greater precision than evaporative techniques. This makes IBS particularly well suited for producing steep edge filters, very broad band mirrors, and multi-wavelength mirrors and AR coatings. In addition, the process can also be highly automated, meaning that it does not require operator supervision. The biggest drawback of IBS is that it only works with a limited range of materials, typically metal oxides. Covering the full spectrum of your photonics needs.

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Chapter 2 : Thin-Film Coatings: A Buyers' Guide | Photonics Handbook

thin film coatings custom engineered for your application Our broad variety of technologies allow us to create custom-engineered coating solutions for the most demanding of applications. As a result, Materion is the go-to supplier of precision optical filters and thin film coatings.

Our leading edge capabilities support the design, manufacturing, and verification of AR coatings designed for use at any combination of temperature, wavelength, angle of incidence, polarization, and laser power from 0. All standard AR coatings can be customized for your application. Attenuation Coatings Attenuating Filter Coatings, at the most basic level, are thin film coatings, which reduce the amount of light energy transmission in an optical system. For static applications, a fixed ND neutral density filter provides a constant level of transmission over a wide wavelength band. A more complex variable or gradient filter provides a density change over a custom defined region. The variable function can be defined as linear, circular, or radial and in either in a continuous or step pattern. Band Pass Coatings Band Pass narrow and Band Pass wide coatings are used to create a type of wavelength selection filter operational over a specified wavelength band from the UV to the far IR. A Band Pass Filter allows only the wavelengths in the specified range to pass through the filter, while blocking wavelengths outside of the transmission region with high rejection ratio. A Band Reject Filter blocks a specific wavelength range with high rejection ratio, while transmitting wavelength regions on either side of the rejection region. The custom specified density function can either decrease dark-to-light or increase light-to-dark radially from the center of the substrate. Conductive Coatings Thin film Conductive Coatings can be applied as a uniform plane across a substrate, as bus bars on the sides of a substrate, or as a custom pattern with geometries down to 10um. Various metals can be used depending on the wavelength range of required performance. Dichroic Coatings also known as Color Separation Coatings: Dichroic Filters are sometimes known as color separation filter coatings because their purpose is to separate incoming light into distinct wavelength regions. Commonly used to extract a narrow wavelength band for entertainment or lighting effects, they can also be used as hot mirrors or cold mirrors to separate infrared light from visible light. Dichroic coatings achieve color or wavelength separation with a much higher degree of accuracy than conventional filters. Infrared Coatings Infrared IR Coatings effect light that extends from the edge of visible red nm to the far infrared approximately 50um for Reynard Corporation capabilities. The difference in design is the starting choice of substrate and coating materials used to implement the required function, as reflection and transmission characteristics of individual materials change dramatically at different wavelengths. Reynard Corporation is highly experienced in the design and manufacturing of IR filters and mirrors. Laser Protection Coatings High performance thin film Laser Protection Coatings, are designed to withstand higher energy conditions than classical thin film designs. Improved performance comes from the use of material sets with low absorption and higher melting points as well as through process improvements, such as the use of IAD. Wavelengths smaller than the filter transition point are blocked with a high rejection ratio, while wavelengths longer than the transition point are transmitted. The transition point is application specific and static as defined by the customer. The filters are custom designed for applications that require multiple transmission or rejection bands that are non-contiguous. A filter that transmits the um MWIR band as well as the um LWIR band, while blocking the regions in or around these transmission bands is an example of a multi-band filter. Wavelengths smaller than the filter transition point are transmitted, while wavelengths longer than the transition point are blocked with a high rejection ratio. Trichroic Filter Coatings Trichroic Filters are used to precisely split incoming light into three separate wavelength bands of red, green, and blue, or alternatively to recombine such bands. Applications for Trichroic Filters include multi-sensor camera systems, where the three separated bands are detected by three separate CCD arrays, and projectors, where the Trichroic Filter recombines the red, green, and blue light sources into the presentation image. Visible Coatings VIS Visible Thin Film Coatings in the visible spectrum cover the wavelength range from nm to nm, which correspond to the spectrum detected by the human eye. Thin film designs can be specified as part of our large selection of standard types or customized for application specific requirements.

Chapter 3 : Home - THIN FILM COATINGS

> Thin Film Coatings T hin Film Coatings with Multiple Layers SurfTech Â® was the first to introduce Nano scale Multilayer thin film coatings in for commercial use.

Photonics Handbook The vast majority of optics used in precision scientific, industrial, biomedical and military applications incorporate thin-film coatings on their surfaces. This article provides an objective overview of both these topics. REO What are thin-film coatings? The purpose of any optical thin-film coating is to modify the transmittance and reflectance properties of the substrate material to which they are applied. Most coatings can be broadly classified into one of the following categories: These are used to suppress unwanted reflections that normally occur at the interface between two different materials, such as air and glass. Mirror coatings are used to increase the reflectivity of a surface. Beamsplitters transmit a specified percentage of input light and reflect the rest. They are often used at nonzero angles of incidence. Polarizers separate incident light into orthogonally polarized components, typically transmitting one and reflecting the other. These may perform any of the preceding functions, but on a wavelength-selective basis; for example, transmitting one wavelength and highly reflecting a second. Optical coatings are constructed of either thin layers of dielectrics or a relatively thick layer of a metal, as well as combinations of both classes of materials. Metal coatings rely on the bulk reflectance and absorption characteristics of the coating material for their operation. In contrast, dielectric thin-film coatings operate by utilizing optical interference. A simplified schematic of how this works is shown in Figure 1, which depicts a light ray incident upon a material having a single-layer thin film on its surface. Part of the ray energy is reflected at the air-coating interface, and part of it is transmitted and refracted. At the coating-substrate interface, some energy is again reflected and transmitted. The two reflected rays overlap, and, since they are lightwaves, the amplitude of the reflected light is the complex sum of the amplitudes of the two overlapping rays. Schematic illustration of single-layer antireflection coating operation. It is possible to arrange things so that the two reflected rays cancel each other out, meaning there is no reflection at all. This is an antireflection coating. For the two rays to be out of phase, the second reflected ray must traverse an optical path length that is exactly half the wavelength of the light before they recombine. For the amplitudes of the two reflected rays to be identical, the index of refraction of the coating must be exactly the square root of the index of the substrate material. However, these conditions can only be exactly satisfied at one wavelength and one angle of incidence. Furthermore, for many substrates, there may not be any suitable coating material that has exactly the necessary refractive index. So, while single-layer antireflection coatings are widely used, thin films for more demanding applications often consist of multiple layers. More complex, multilayer designs can deliver higher performance and enable operation over a wider range of wavelengths and incident angles, as well as permit the use of the most practical and readily available coating materials. Practical coating trade-offs Utilizing this basic principle of interference, multilayer dielectric coatings can be designed to suppress or enhance reflection at one or more wavelengths, or to preferentially reflect or transmit one polarization. Real-world coatings that accomplish these tasks can sometimes contain tens, or even hundreds, of layers, and are fabricated from numerous available materials. Adding layers to an antireflection coating lowers the reflectance but reduces the coating bandwidth. However, the range of materials available to the coating designer is not infinite, meaning that practical coatings must be constructed using a limited set of refractive indices. Furthermore, these materials cannot be deposited with absolutely perfect control of their thickness and refractive index. It is therefore important for the coating buyer to understand what level of performance specifications can be achieved in practice, and what specifications tend to drive cost, or result in other undesirable outcomes, such as decreased mechanical durability or reduced laser damage resistance. The most common considerations for each of the coating types listed previously are reviewed here. Antireflection coatings Performance in an AR coating is typically specified by either the maximum allowable reflectance at a single wavelength or by the average allowable reflectance over a specified wavelength range. For AR coatings intended for a single wavelength or a single angle of incidence very high performance can be obtained; less than 0. It becomes increasingly difficult to maintain high performance in an AR coating as either spectral bandwidth or angular range is increased. For this reason, it is important for the buyer to make it clear whether the specified performance must be held to its peak value or an average value over the entire operational wavelength or angle range. Otherwise, coating cost may be increased unnecessarily. Therefore, it is critical that the state of the incident polarization be specified. This is done with reference to the reflecting surface. If the polarization vector is perpendicular to this plane, the light is s polarized. Any intermediate state of polarization is expressed as the vector sum of these s and p components. The electric field vector for p polarized light lies in the plane of incidence, while for s polarized light, it is perpendicular to the plane of incidence. The reflectance of a dielectric interface is higher for s polarization than for p polarization at all nonzero angles of incidence. Therefore, if low reflectivity from a tilted component is desired, it is advantageous to design the geometry of the optical system so that the optic encounters p polarized light. It is also important to note the distinction between unpolarized and randomly polarized light. Unpolarized light can be thought of as consisting of equal amounts of s and p polarized components. Random polarization means an unspecified polarized state, the direction or ellipticity of which are either unknown or changing with time. This represents something of a worst-case scenario, since it forces the coating designer to assume that specified performance must be met even under the least favorable circumstances. Ambient, incoherent light is unpolarized, for example, while laser light emerging from a single-mode fiber optic is typically randomly polarized. The response of dielectric coatings shifts to shorter wavelengths as angle of incidence increases. This can become a consideration when applying AR coatings on highly curved substrates. This means that, even when working with a single wavelength, the coating must have broad bandwidth so that it still performs well at the nominal wavelength even when its response is shifted. Furthermore, actually applying films on such steep surfaces may require special tooling to maintain uniformity. Thus, the specifier of coatings for use under such conditions should be aware that there may be a significant trade-off in terms of the complexity and cost of that film versus the reflectance. Antireflection coatings that work at two or more discrete wavelengths are common in laser applications. Furthermore, specifying high performance at only one of the wavelengths and relaxing specifications at the other s will also generally keep the cost down. When used at higher angles of incidence, a significant difference exists in the reflectance of an antireflection coating between s and p polarizations. Producing multiwavelength AR coatings that operate in both the ultraviolet and the visible, or in the visible and the infrared, can also be challenging because of the limited number of materials that simultaneously transmit in these regions. Specifically, only a limited number of coating materials can be used below nm, so going shorter than this wavelength constrains design and drives up cost. Laser damage threshold is an important consideration in many applications. Designing a coating to maximize damage threshold may limit the choice of coating materials, designs and processes, which in turn may make it more difficult to achieve a given performance target, such as absolute reflectance at a single wavelength or coating bandwidth. High reflectors For mirror coatings, probably the most important choice facing the consumer is whether to use a metal or metal-dielectric hybrid coating, versus an all-dielectric design. The primary advantage of metal coatings is very broad spectral bandwidth. These levels of performance would be virtually impossible to achieve with all-dielectric coatings. In addition, the difference in reflectance between the s and p polarizations is usually substantially smaller for metal coatings than for all-dielectrics. Reflectance of a typical narrowband high-reflection coating, in this case centered at nm. However, the peak reflectance of metal films does not equal that which can be obtained with dielectric coatings. Even gold, which offers The small amount of absorption in metal films that limits their reflectance also contributes to another significant limitation: Metal films are also less physically durable than all-dielectric coatings. Specifically, they have less resistance to abrasion, humidity, thermal cycling and salt exposure than dielectrics. Silver in particular must always be covered with another material to prevent oxidization, which significantly lowers its reflectance. Thus, the surface roughness of the underlying substrate must be specified, and the consumer should expect that specifying a very smooth surface will drive up cost because it necessitates the use of specialized polishing techniques. As with AR coatings, there is a trade-off in high reflectors between bandwidth and peak performance, although the effect is not as pronounced. Moreover, HR coatings typically contain numerous layers, so demanding very broadband performance can result in coatings that have increased scatter and absorption, as well as significant internal stress; the latter can require special measures to maintain a high level of surface figure accuracy. Beamsplitters and partial reflectors Nonpolarizing beamsplitters come in two basic forms: Cube beamsplitters typically consist of two right-angle prisms mated at their hypotenuses. The beamsplitter coating is applied at this interface, while the input and output faces typically receive antireflection coatings. Plate beamsplitters are typically constructed on a plano substrate: Another common type of partial reflector is a laser output coupler. These are generally on a curved substrate with a relatively long radius and work at normal incidence. One feature of cube beamsplitters is that their performance tends to be less sensitive to input polarization than plate designs. The other major advantage of cube beamsplitters is that secondary reflections from the input and output faces overlap the main beam, whereas in plate beamsplitters they are offset. One drawback of cube beamsplitters is that they are bulkier and heavier than plates, which can be a concern especially for larger aperture sizes. The other problem is that in most cube beamsplitters, the prisms are attached with adhesive or by optical contact. In either case, this can compromise performance by introducing wavefront errors. Furthermore, absorption in the adhesive can cause scatter and significantly reduce laser damage threshold. Some leading manufacturers have developed methods for preparing the prism surfaces so that an actual chemical bond is formed when the components are assembled. Tests at REO show that this yields a component that has the same mechanical strength and ruggedness as a monolithic cube, yet which avoids the absorption, scatter and damage limitations of adhesive bonding. Polarizing coatings maximize the difference in reflectance between s and p polarizations to achieve high extinction ratios. Several factors can drive complexity, and hence cost, in beamsplitters. For example, as angle of incidence increases, the growing difference in reflectivity for s and p polarizations makes it progressively more difficult to deliver a partial reflector that performs equally well for both polarization states. You may also like

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Chapter 4 : Optical and Non Optical Thin Film Coatings by Materion

Thin film coating and vacuum coating processes use vacuum technology to create a sub-atmospheric pressure environment and an atomic or molecular condensable vapor source to deposit thin films and coatings.

When one adds custom material compositions and form factors, the choices are nearly endless. For the thin film designer, this is a beneficial outcome of the growth and maturity of the optical coatings materials industry. When selecting a coating material, it is paramount that the thin film engineer considers the advantages of the available options for their particular application. Multiple Material Choices When selecting the best material choice for your application, there are a number of factors to consider: In perusing available materials, one finds many routes to the desired film including metals, alloys, inorganic compounds and cermets. There are also less defined items such as intermetallics and interstitial compounds. The producer of metallic materials tends to offer the end-user materials of higher purity and at, or very near, theoretical densities. In addition to these various compositions, there is a large selection of form factors to take into account. Metals and most alloys are melted and subsequently swaged hot or cold to form rod or wire, or the molten material may be dropped through a sieve to form shot. There are also rods, pellets, tablets, granules, slugs, shaped sources, wire, turnings and a few others. Navigating through this supermarket of options can be a daunting task. At its simplest, the choice of the form can be distilled down to ease of degassing, the length of the run and the ability of the material to form a stable pool or surface for evaporation. The less the surface area larger particles, wire or shaped charges , the faster the producer can be ready to coat and the more stable the evaporating surface will remain during a run. When examining the multitude of options available, you need to understand such driving factors as: Exploring Coating Processes Deposition techniques for metals and a great number of metal alloys are quite flexible. Both resistive and electron beam evaporative techniques can be used successfully for most metals. Integration of the use of gas in thin film deposition has allowed coaters to use metal source material to create a reactive process. While carbides are possible, the most common evaporative reactive films are oxide or nitride coatings. Use of metals in a reactive deposition can offer some advantages over direct use of the base compound. The high purity source material is reacted with high purity gasses to yield high quality films. Ion assisted deposition IAD is often used to ensure complete oxidation while some novel environments can be back-filled to assist with proper film properties. Even in this case however the stability of the melt pool or surface can be the most critical challenge over a run. Widely available metals in the market have aided the growth of an industry for large area deposited metal films on a variety of substrates. Such films can successfully be deposited from pellets, shot, wire or a shaped source. Pellets or shot would typically be used in the case where a hearth, crucible or boat is employed; wire may be the choice where a heated pier or molten pocket is implemented. Typical applications for metals in optics are reflector coatings, interference films and adhesion layers. One must consider the application when selecting appropriate materials. Many metal films exhibit excellent performance; however, some of the reflecting materials can be relatively soft or tarnish quickly when in thin film form. Overcoming these limitations may require a protective overcoat layer in the form of a dielectric compound material. Comparatively speaking, the e-beam evaporation process of chemical compound coating often comes down to controlling unwanted side reactions, decomposition products or unstable melts. The Science and technique to overcome individual challenges to these key compounds has resulted in mature commercial market and specialists in different parts of the EM Spectrum. This is especially true for the visible wavelength region where glare reducing antireflective coatings are highly prevalent from a multitude of deposition techniques aligned to different performance characteristics. Creating Materials With Certain Properties Material properties and their synthesis method generally dictate the choice of fabrication and often ultimately impact what form the evaporation material should take. In the case of materials that start as Oxides, final methods chosen are generally a densification of powder process. This process usually takes the form of a classical ceramic bindering, pressing and firing AKA cold press and sinter or hot-press and billet with size reduction. The former can more easily yield material in specific geometries such as pellets or tablets, in addition to granules. The economics of hot-pressing lend themselves more towards fabricating granules. There is concern that cold press and sinter processes often introduce organics and moisture-laden materials into the coating material; a final firing can be coupled to vacuum degassing. Hot-pressing processes typically do not use binders, and the final forms are generally limited to granules. The less thermal history a material has, or the higher surface area or internal granule porosity it exhibits, the more critical the initial burn-in procedure or pre-melting process is to achieving a consistent product. These high vacuum evaporative processes pull oxygen off the source material risking absorption in the growing film. It is for this reason that a partial pressure of oxygen is frequently implemented. This requirement for the use of additional oxygen is often balanced with a material supplied in a slightly reduced or slightly oxygen-deficient state from the manufacturer. With such materials, processes are developed that take into consideration the rate of re-oxidation, the rate of evaporation and substrate factors such its preparation and temperature. Generally speaking, most of the Fluoride materials start from a wet chemical process where the resultant material is then subjected to a prescribed thermal process melting, crystallization, etc , followed by a particle size classification. While pellets and tablets of Fluoride materials are available, the prevailing form is generally granules or pieces. Fluoride materials present some inimitable challenges to the coating process. Fluorine loss in the evaporation process leads to absorption, instability or premature failure of key films. An optically optimum Fluoride thin film can have hygroscopic properties or require such delicate temperature controls that adhesion is difficult to maintain over long runs. Some evaporative Fluoride films exhibit columnar growth patterns which put pressure on the coating tools and Engineers to control. These challenges are typically met with techniques involving controlling the rate of deposition, having the appropriate chamber conditions, optimal material selection and post deposition treatment of the thin films. With the utilization of best practices, Fluoride materials can be used in a multitude of sophisticated, multilayer precision optical designs. Fluoride materials are the subject of both longtime unchanging techniques and continuous improvement and investment as DUV and LWIR application development. As such, they are at the forefront of military, medical, microelectronic and aerospace excellence. Coating Materials Expertise We offer the most comprehensive technical expertise, range of products and unique materials solutions available today. As specialists in the sourcing, reaction chemistry and production of critical thin film coating materials, we aid our customers in selecting the best available option from the myriad choices available.

Chapter 5 : Thin Film Coating Materials

The continuous growth of thin film coating technologies is driven by industrial needs, that is, new coating functionalities, improvement of coating quality, production cost-efficiency and environmental aspects.

Deposition[edit] The act of applying a thin film to a surface is thin-film deposition â€” any technique for depositing a thin film of material onto a substrate or onto previously deposited layers. Molecular beam epitaxy , Langmuir-Blodgett method and atomic layer deposition allow a single layer of atoms or molecules to be deposited at a time. It is useful in the manufacture of optics for reflective , anti-reflective coatings or self-cleaning glass , for instance , electronics layers of insulators , semiconductors , and conductors form integrated circuits , packaging i. Similar processes are sometimes used where thickness is not important: Deposition techniques fall into two broad categories, depending on whether the process is primarily chemical or physical. An everyday example is the formation of soot on a cool object when it is placed inside a flame. Since the fluid surrounds the solid object, deposition happens on every surface, with little regard to direction; thin films from chemical deposition techniques tend to be conformal , rather than directional. Chemical deposition is further categorized by the phase of the precursor: Plating relies on liquid precursors, often a solution of water with a salt of the metal to be deposited. Some plating processes are driven entirely by reagents in the solution usually for noble metals , but by far the most commercially important process is electroplating. It was not commonly used in semiconductor processing for many years, but has seen a resurgence with more widespread use of chemical-mechanical polishing techniques. Chemical solution deposition CSD or chemical bath deposition CBD uses a liquid precursor, usually a solution of organometallic powders dissolved in an organic solvent. This is a relatively inexpensive, simple thin-film process that produces stoichiometrically accurate crystalline phases. Langmuir-Blodgett method uses molecules floating on top of an aqueous subphase. The packing density of molecules is controlled, and the packed monolayer is transferred on a solid substrate by controlled withdrawal of the solid substrate from the subphase. This allows creating thin films of various molecules such as nanoparticles, polymers and lipids with controlled particle packing density and layer thickness. The speed at which the solution is spun and the viscosity of the sol determine the ultimate thickness of the deposited film. Repeated depositions can be carried out to increase the thickness of films as desired. Thermal treatment is often carried out in order to crystallize the amorphous spin coated film. Such crystalline films can exhibit certain preferred orientations after crystallization on single crystal substrates. There are two evaporation regimes: Commercial techniques often use very low pressures of precursor gas. Unlike the soot example above, commercial PECVD relies on electromagnetic means electric current, microwave excitation , rather than a chemical-reaction, to produce a plasma. Atomic layer deposition ALD uses gaseous precursor to deposit conformal thin films one layer at a time. The process is split up into two half reactions, run in sequence and repeated for each layer, in order to ensure total layer saturation before beginning the next layer. Therefore, one reactant is deposited first, and then the second reactant is deposited, during which a chemical reaction occurs on the substrate, forming the desired composition. Physical deposition[edit] Physical deposition uses mechanical, electromechanical or thermodynamic means to produce a thin film of solid. An everyday example is the formation of frost. Since most engineering materials are held together by relatively high energies, and chemical reactions are not used to store these energies, commercial physical deposition systems tend to require a low-pressure vapor environment to function properly; most can be classified as physical vapor deposition PVD. The material to be deposited is placed in an energetic , entropic environment, so that particles of material escape its surface. Facing this source is a cooler surface which draws energy from these particles as they arrive, allowing them to form a solid layer. The whole system is kept in a vacuum deposition chamber, to allow the particles to travel as freely as possible. Since particles tend to follow a straight path, films deposited by physical means are commonly directional, rather than conformal. Examples of physical deposition include: A thermal evaporator that uses an electric resistance heater to melt the material and raise its vapor pressure to a useful range. This is done in a high vacuum, both to allow the vapor to reach the substrate without reacting with or scattering against other gas-phase atoms in the chamber, and reduce the incorporation of impurities from the residual gas in the vacuum chamber. Obviously, only materials with a much higher vapor pressure than the heating element can be deposited without contamination of the film. Molecular beam epitaxy is a particularly sophisticated form of thermal evaporation. An electron beam evaporator fires a high-energy beam from an electron gun to boil a small spot of material; since the heating is not uniform, lower vapor pressure materials can be deposited. Typical deposition rates for electron beam evaporation range from 1 to 10 nanometres per second. In molecular beam epitaxy MBE , slow streams of an element can be directed at the substrate, so that material deposits one atomic layer at a time. Compounds such as gallium arsenide are usually deposited by repeatedly applying a layer of one element i. The beam of material can be generated by either physical means that is, by a furnace or by a chemical reaction chemical beam epitaxy. Sputtering relies on a plasma usually a noble gas , such as argon to knock material from a "target" a few atoms at a time. The target can be kept at a relatively low temperature, since the process is not one of evaporation, making this one of the most flexible deposition techniques. It is especially useful for compounds or mixtures, where different components would otherwise tend to evaporate at different rates. It is also widely used in the optical media. It is a fast technique and also it provides a good thickness control. Presently, nitrogen and oxygen gases are also being used in sputtering. Pulsed laser deposition systems work by an ablation process. Pulses of focused laser light vaporize the surface of the target material and convert it to plasma; this plasma usually reverts to a gas before it reaches the substrate. If a reactive gas is introduced during the evaporation process, dissociation , ionization and excitation can occur during interaction with the ion flux and a compound film will be deposited. Electrohydrodynamic deposition electrospray deposition is a relatively new process of thin-film deposition. The liquid to be deposited, either in the form of nanoparticle solution or simply a solution, is fed to a small capillary nozzle usually metallic which is connected to a high voltage. The substrate on which the film has to be deposited is connected to ground. Through the influence of electric field, the liquid coming out of the nozzle takes a conical shape Taylor cone and at the apex of the cone a thin jet emanates which disintegrates into very fine and small positively charged droplets under the influence of Rayleigh charge limit. The droplets keep getting smaller and smaller and ultimately get deposited on the substrate as a uniform thin layer.

Chapter 6 : PVD Coating | Thin Film Coating | Ceramic Coating

Thin Film Coating. RPO's production coaters and spectrophotometers for coating metrology allow us to provide standard and custom coatings, offering greater performance for reflective and transmissive requirements.

Chapter 7 : Thin film - Wikipedia

For the thin film designer, this is a beneficial outcome of the growth and maturity of the optical coatings materials industry. When selecting a coating material, it is paramount that the thin film engineer considers the advantages of the available options for their particular application.

Chapter 8 : Optical Thin Film Coatings

Guernsey Coating Laboratories, Inc., is an optical coating company specializing in quality thin-films covering the wavelength range from ultraviolet to the near infrared. With a complete line of standard coatings as well as custom coating designs, GCL reaches such areas as.

Chapter 9 : Thin Film Coatings | Calico Coatings

Other UV thin film coatings are UV Enhanced Aluminum Metallic coating and UV Protected Aluminum Metallic coating. Visible Coatings (VIS) Visible Thin Film Coatings in the visible spectrum cover the wavelength range from nm to nm, which correspond to the spectrum detected by the human eye.