

[54] MULTI-STATION VACUUM APPARATUS

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[51] Int. Cl. C23c 13/12

[58] Field of Search 118/5, 48-49.1, 118/620, 9; 219/422, 437, 271-276; 200/11, 18

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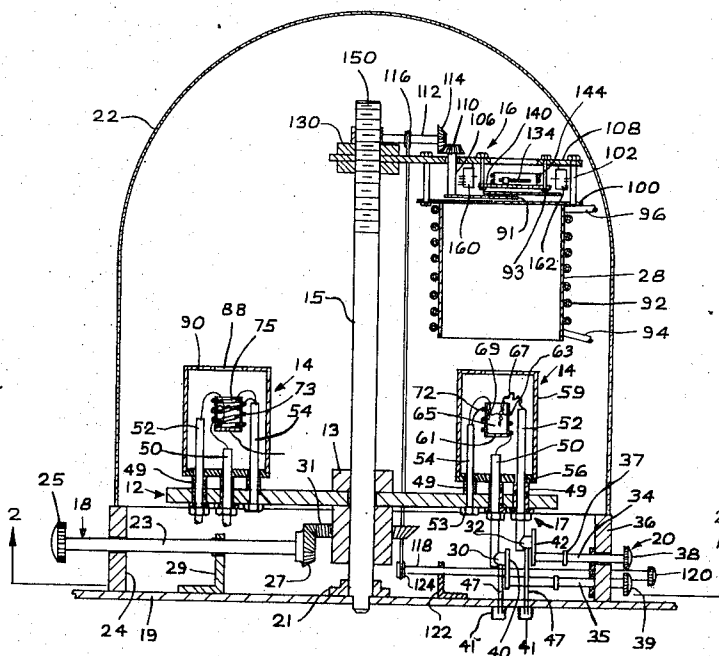
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[57] ABSTRACT

A high-current vacuum system suitable for on-vacuum deposition of multiple layers onto a substrate. A vacuum chamber encloses a stationary substrate holder disposed above a plurality of vapor sources utilizing diverse heating elements. The vapor sources are arranged on a rotatable support for sequential movement to a deposition station for the vaporization and deposit of low and high temperature metals and dielectrics. Manipulators for making and breaking electrical contact to the station and for rotation of the support are positioned without the chamber and are externally operated to change sources without breaking vacuum. A liquid nitrogen cooled cold cam is situated between the station and the substrate support to funnel the vapor stream toward the stationary substrate target.

7 Claims, 8 Drawing Figures



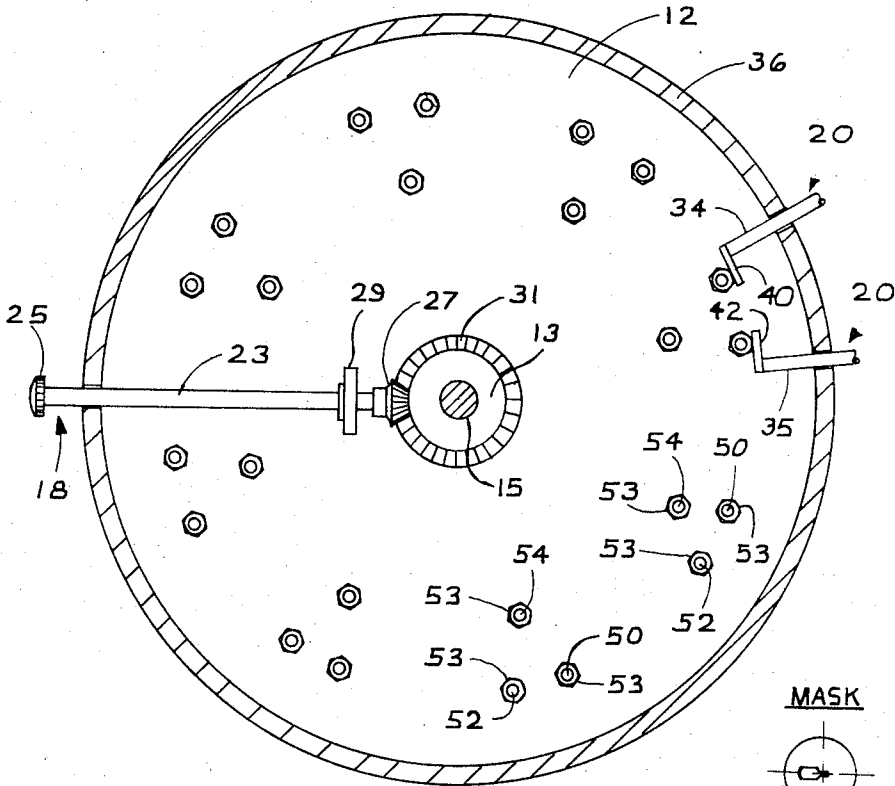


FIG. 2

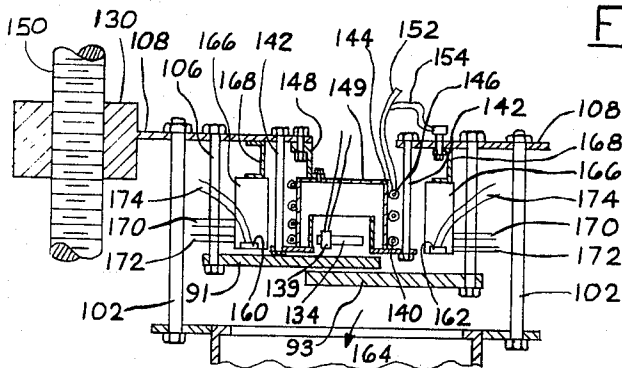
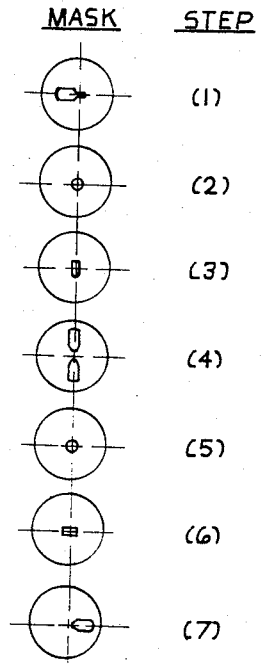


FIG. 6

FIG. 8



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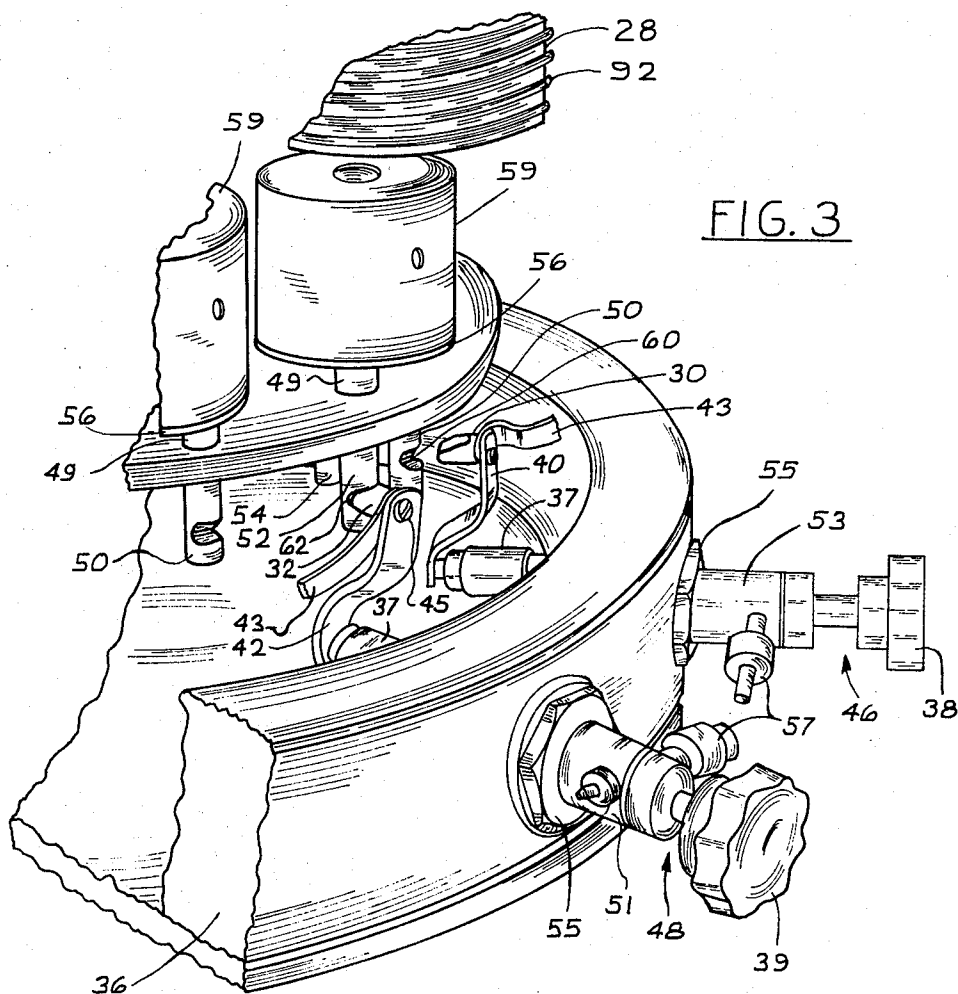


FIG. 3

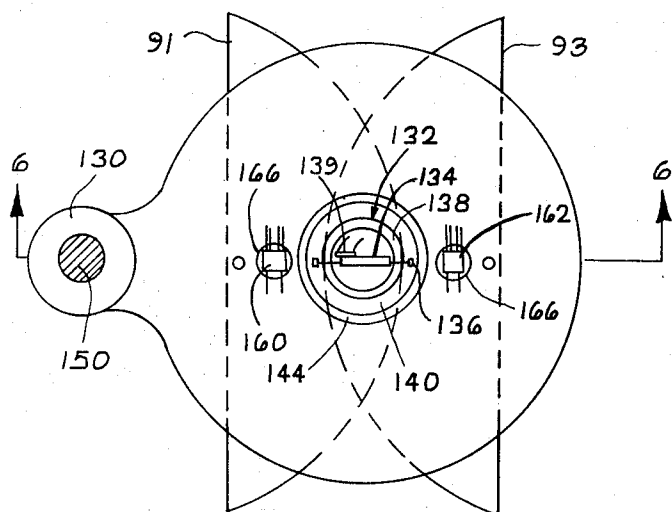


FIG. 5

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MULTI-STATION VACUUM APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to a vacuum system for multi-layer deposition and more particularly to an apparatus for continuously and sequentially depositing a plurality of diverse layers onto a substrate without breaking vacuum.

2. Description of the Prior Art:

Thin film multi-layered structures are becoming common place in the fields of optics and microwave acoustics, i.e., where wavelengths of the order of microns are used. These thin film structures can be utilized either as narrow band pass or band elimination filters depending on the combination of $\frac{1}{2}$ and $\frac{1}{4}$ wavelength thick layers that are used. In the manufacture of ultrasonic multi-layered filters for operation at frequencies of several hundred megahertz, forty or more metal and dielectric layers in the region of 100 angstroms to 10 microns thick are consecutively deposited to form a stack. When the acoustic impedances of the layers are properly controlled, such stacks form bandstop or band-pass filters that operate in a manner similar to those used in thin film monochromatic or narrow-band optical filters. Furthermore, the layers must deposit in a manner to form very good bonding and the physical properties such as grain compaction and orientation must be carefully controlled.

The available vacuum systems are not capable of efficiently or effectively forming such multi-layered deposits.

The deposition of such thin films in such critically controlled thicknesses requires that the source be turned ON and turned OFF quickly. Many of the dielectrics and metals have high melting points which require high electric power and therefore, equipment that can safely and effectively accommodate the necessary power level. Moreover, available multi-source vacuum systems are very wasteful, in that the vapor clouds deposit throughout the apparatus involving a loss in material and cleanup time and risk of contamination between layers. Though contamination is lessened by operating in continuous vacuum, such systems do not have the capability of accurately starting and stopping the film depositions over short time periods as well as the capability of carefully controlling the rate and amount of deposition with the required precision.

OBJECTS AND SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide a multi-source vacuum deposition apparatus having provision for in vacuum exchange of sources.

Another object of the invention is to provide for efficient and effective deposition of diverse layers of films onto a substrate within a single vacuum chamber.

Yet another object of the invention is to accurately control the rate, thickness and character of diverse metal and dielectric layers sequentially deposited in vacuum.

A still further object of the invention is to minimize contamination and spread of vapor in the vacuum deposition of plural layers onto a substrate.

These and other objects and many attendant advantages of the invention will become apparent as the description proceeds.

The multi-source vacuum deposition system in accordance with the invention comprises a vacuum chamber containing a rotatable support on which is mounted a plurality of deposition vapor sources, and a substrate holder mounted above said sources. Means extending without said chamber are provided for rotating said support to dispose each of said sources below said substrate holder. The system may further include a vapor funnel means disposed between the substrate holder and the vapor sources.

In accordance with the invention a substrate is coated with a plurality of thin layers by positioning the substrate within the chamber over an energizable station and disposing a plurality of vapor sources with the chamber. The chamber is evacuated

to low vacuum and maintained at low vacuum throughout operation. A first source of vaporizable material is positioned at the station and the station is energized to create vapor. The vapor is transported through a vapor funnel having cool walls to the substrate. The station is deenergized and a second source is positioned at said station and the station energized and vapor transported to the substrate.

The invention will now become better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front sectional view of one embodiment of a vacuum system according to the invention;

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is a partial enlarged perspective view of the contact closure mechanism;

FIG. 4 is a cross-sectional view of a standard coil heater-crucible evaporator assembly;

FIG. 5 is an enlarged view of the substrate holder assembly taken along the line 5—5 of FIG. 1;

FIG. 6 is a cross-sectional view taken along the line 6—6 of FIG. 5;

FIG. 7 is a schematic illustration of a design of a narrow band multi-layer microwave acoustical transmission filter; and

FIG. 8 is a view of a series of masks to be used in fabricating the filter of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 2 the multi-source vacuum deposition system comprises generally a vacuum chamber 10, a rotatable support 12, a plurality of vapor sources 14 mounted on the support and a substrate holder assembly 16 supported above a vapor station 17.

Chamber 10 may also include according to the invention, a vapor funnel 28 axially supported over vapor station 17 between substrate holder assembly 16 and sources 14 and at least one shutter 91 positioned between the substrate holder 16 and the vapor funnel 28. External to chamber 10, the system further includes control means 18 for rotating the support 12 and externally operated energizing means 20 for activating one of the sources 14 when positioned over the vapor station 17.

The chamber 10 is enclosed by a removable cover member 22 which is supported on a base housing 24. The cover is preferably arcuate in shape and is formed of a high strength transparent material such as quartz. The base housing 24 is usually round and in the case of the present invention has a depth sufficient to receive the controls and connecting linkages for operating and manipulating the various equipment contained within the chamber 10.

Referring now, more particularly, to FIG. 2, eight vapor sources 14 are arranged spaced around the rotatable support 12. Support 12 is in the form of a flat turntable to which is attached a central bearing collar 13. The collar 13 is rotatably mounted on a stationary shaft 15. A bracket 21 secures the shaft 15 to the bottom plate 19 of the housing 24 forming a stand for the shaft 15.

The external control means 18 includes a rod 23 attached outside the housing 24 to a turn knob 25 and extending into housing 24 through a vacuum sealed feed-through. A vertical bevel gear 27 is attached to the inner end of the rod 23. The rod 23 is supported along its middle portion by means of an L-shaped bracket 29 attached to the bottom wall 19 of the housing having an aperture provided in the vertical arm of the bracket. The bevel gear 27 engages a horizontal annular bevel gear 31 secured to bearing collar 13. Positioning of the particular source unit 14 over the vapor station 17 is effected by turning knob 25 which rotates turntable 12 to position the source over station 12 and under funnel 28 and substrate support 16.

Each vapor source is associated with a set of outer electrical input posts 50 and 52 disposed a fixed distance from each other and extending downwardly from turntable 12. The leading posts 50 of each source and the trailing posts 52 of the sources are respectively positioned on substantially the same radial distance from the shaft 15. In the present embodiment all the input posts 50 and 52 are disposed the same radial distance from the shaft 15. An inner ground post 54 is also provided to each source 14.

The posts 50 and 52 extend upwardly through the turntable 12 into the vapor source 14 and are secured to the turntable by means of a nut 53. The posts 50 and 52 are electrically insulated from turntable 12 and source 14 by means of ceramic insulators 49 which extend through the post receiving apertures in the turntable 12 and extend past the upper and lower edges of the apertures. In contrast, the inner ground contact post 54 extends upwardly into source 14 but terminates just below turntable 12 and is in electrical contact therewith. The post 54 is also secured to turntable 12 by means of nuts 53.

Each input post 50 and 52 contains a wedge-shaped contact groove 60 and 62, respectively, which outwardly face toward housing wall 36. A circle through the center of the posts 50 and 52 would be tangent to each line formed by the intersection of the faces forming wedges 60 and 62. Each set of adjacent posts 50 and 52 for each source 14 are in a fixed relation to the housing wall 36 and are adapted to be rotated sequentially to the vapor station 17 and to be energized at that location.

Referring now to FIGS. 1 to 3 station 17 is disposed directly below vapor funnel 28 and substrate holder 16 and includes a plurality of translatable electrical contact heads 30 and 32 supported upstandingly on flexible copper plates 40 and 42. The lower end of each plate 40 and 42 is connected to a shaft 34 and 35 which extends through the side wall 36 of the base housing 24 below rotatable support 12. Control knobs 38 and 39 are connected to the outer ends of shafts 34 and 35. The portion of the shafts extending through wall 36 is sealed and each shaft contains totally insulated section 37 to isolate the housing and the control knob from the high current source. High current is introduced by means of high current feed-throughs 41 which are in the form of female insulator plug members connected to a conductive stud 47 extending through insulated feed-throughs provided in the wall 14 of the housing 34. The studs are each connected to a connector strap 43 which is attached to the upper end of plates 40 and 42 by inserting the strap 43 between the plate and wedge-shaped contact head 30 and 32 and securing them together with a screw 45. More details of the contact assembly will be discussed in reference to FIG. 3.

Referring more particularly to FIG. 3, axial motion feed-through manipulators 46 and 48 for the contacts are shown. Each manipulator is adapted to cause the contact heads 30 and 32 to move inwardly or outwardly and to close or open and make contact with the opposed wedge recess contacts 60 and 62 provided on the power input posts 50 and 52 extending downwardly from rotatable platform 12. The shafts 34 and 35 are slidably received in bearing housings 51 and 53 which are attached to the vacuum chamber housing wall 36 by means of nuts 55. A set screw 57 is mounted on each bearing housing 55 for securing the shafts 34 and 35 to maintain contact heads 32 or 30 in either closed or open position.

Each source 14 includes a circular base plate 56 separated from turntable 12 by means of electrical insulators 49. The input posts 50 and 52 are provided to power the inner and outer heating coils associated with the vapor source crucibles. Since the level of power input to the different types of coils are usually in different ranges it is desirable for purposes of convenience and safety to consistently utilize the same post to power the same coil. Therefore, in a counterclockwise direction of rotation, the leading post 50 of each source will always power the outer coil heater and in turn will be powered by righthand manipulator 46. The trailing post 52 will power the inner coils and will in turn always be powered by means of lefthand manipulator 48.

The coils are each powered by a high current, 300 amp 50 volt source which can be set at a selected level by means of a variac-controlled heavy duty transformer, not shown. The power is fed to the apparatus through the standard high current feed-throughs 41.

In FIG. 3 the righthand set of contacts 30 and 60 are shown open while the lefthand set of contacts 32 and 62 are shown almost closed. The wedge-shaped contact heads 32 and 30 are manipulated from the outside by axial motion of the feed-through manipulators 46 and 48. When the chamber 10 is evacuated, the suction provided by the inner vacuum on the manipulator shafts further causes the contacts to be pushed together and maintained in contact. Breaking of the contact is provided by a reverse axial motion of the manipulator shaft. The mating surfaces of the wedge-shaped grooves 60 and 62 on the stainless steel posts 50 and 52 into which the wedge-shaped heads 32 and 30 fit are ground smooth and fit suitably have an angle of slant of about 25 percent.

The fabrication of acoustical and optical filters requires that materials of diverse vaporization temperatures and conductivities be deposited. Furthermore, these materials will not always be deposited in the same order.

The multiple electrical inputs to each source 14 provide great flexibility in the types of materials that may be consecutively evaporated from the eight separate sources as well as permitting sensitive control of the rate of evaporation. For example, three different types of evaporation units may be provided.

Referring now to the righthand vapor station 14 shown in FIG. 1 the station consists of the base plate 56 enclosed by a cylindrical cover 59. A standard refractory crucible 61 such as one made out of alumina is surrounded by a filamentary heating coil 63 and is housed within the cover 59. The input lead to filament 63 is connected to post 50 as discussed. A double twisted wick wire 67 such as one formed of 15 mil diameter tungsten wire is introduced into the molten material 65 contained within the crucible 61. One end of this wick wire is connected to electric contact post 52 the other end as discussed is introduced into the melt deeply enough to make electrical contact with the molten material at all levels. The ground contact from the wick is provided by a second tungsten wire 69 also immersed into the melt 65 near the wall of the crucible 61 and is connected to ground post 54. The ground wire 72 from the heater coil 63 is also connected to ground post 54. Inside the melt the wires are disposed parallel to each other to near the bottom of the crucible. However, it is not necessary that they touch since electric contact is made through the molten charge 65. Of course, this type of crucible should only be utilized with conductive charges such as gold.

Capillary action causes the molten gold to wet the wick. The wick temperature is kept high enough to produce gold evaporation from its small area rather than from the entire top surface of the crucible. This permits very accurate and sudden control of the evaporating rate and quick ON-OFF manipulation. For a rate of evaporation of 1 micron in 20 minutes at the substrate, this requires 35 amp through the wick circuit. A current of 150 amps is required through the heater circuit to produce this melt and the crucible can be maintained at melting temperature at current of about 80 amps, typically.

To evaporate non-conductive dielectrics that remain poor conductors in the molten state, another arrangement can be utilized. This arrangement is shown in the lefthand side of FIG. 1 and comprises a standard alumina crucible 71 surrounded again by an external heating filament 73 connected on its input side to post 50 and on its output side to ground post 54. Inside crucible 71 a second heating filament 75 is incorporated connected on its input side to post 52 and on its output side to ground post 54. The inner heating coil can be made of standard 15 mil tungsten wire.

In the operation of this evaporator unit the operation is initiated by heating the crucible 71 to a dull red (approximately 750° C) with the external crucible filament 73. When this temperature is reached the inner heating coil 75 is energized to produce an evaporating melt whose final temperature depends

on the dielectric material utilized. Evaporation proceeds from the surface of the melt. With this double heating arrangement careful control of the evaporation rate is possible. In film deposition where the acoustical or optical properties of the film depend, among others, on the density or orientation of the crystallites of the film, it becomes necessary to control the rate of deposition as well as the evaporating temperatures. Dielectrics such as SiO_2 (M.P. 970°C), MgF_2 (M.P. $1,690^\circ\text{C}$) and ZnS (M.P. $1,900^\circ\text{C}$) have been deposited at varying rates with the double coil arrangement according to the invention.

With high-melting point metals a commercially available cone-type filament unit may be utilized. This unit is shown in FIG. 4. This unit comprises a crucible 80 in which is inserted a cone-type filament coil heater 82. The input side of the coil is connected to post 52 and the output side is connected to ground post 54. Secondary post 50 is not utilized with this unit. The heater coil is wetted by the molten charge 84 and evaporating temperature is achieved with the same coil. Metals such as titanium (M.P. $1,800^\circ\text{C}$), aluminum (M.P. 600°C), silver (M.P. 957°C) and tin (M.P. 232°C) have been deposited using a standard cone filament evaporator.

The vapor rises from the heated crucible and leaves the vapor sources 14 through the aperture 88 in the top 90 of the removable cover 59. To prevent excessive metal and dielectric spillage over the exposed surfaces of the apparatus it is preferred to situate vapor funnel 28 over the vapor station 17 below the substrate holder. The vapor funnel is a thin walled cylinder having its surface maintained at low temperature by means of an external coil 92 which receives a flow of refrigerant, preferably at cryogenic temperatures, through inlet 94 and outlet 96. Inlet 94 and outlet 96 pipes extend through sealed feed-throughs to an external source of cryogenic liquid, not shown, such as liquid nitrogen. The vapor funnel 28 cold can arrangement substantially eliminates contamination and prevents the vapor from spreading by containing the vapor cloud within the cold can. The vapor funnel 28 at cryogenic temperatures acts to scavenge excess vapor and to remove impurities from the system. The vapor funnel 28 may suitably be maintained in position by means of an upper flange 100 through which bolts 102 are inserted to suspend the funnel 28 directly below the substrate holder assembly 16.

The deposition apparatus of the invention may further include at least one shutter plate 91 and linkages associating plate 91 with external positioning controls. The shutter 91 may be utilized to shield the substrate after the desired thickness has been deposited or to maintain the substrate covered until the vapor source has reached temperature and is delivering a steady cloud of vapor at constant rate. The linkage may take many forms. In FIG. 1 the shutter plate 91 is fixed to a post 106 which extends through an aperture in upper bracket 108 and is connected to a bevel gear 110. A horizontal shaft 112 rotatably mounted in a bearing attached to shaft 15 carries a pulley 116 and a bevel gear 114 meshing with gear 110.

A control rod 118 extends outside housing 24 where it is connected to a control knob 120 and extends through a guide 122 inside the housing. The rod carries a second pulley 124 and a cable 126 joins pulleys 116 and 124. Rotation of control knob 120 in a first direction will remove shutter plate 91 from shielding the substrate and rotation of the knob 120 in the opposite direction will return the shutter plate 91 to its closed position. The positioning mechanism for shutter plate 93 is not illustrated. The mechanism described with respect to shutter plate 91 or other equivalent arrangements may be utilized to move shutter plate 93 from without chamber 10.

In some of the depositions steps involved in filter manufacturing it becomes necessary to maintain the substrate at an elevated temperature to achieve the desired physical properties in the deposited films. For this purpose, a substrate heating oven and a thermocouple temperature monitor may be incorporated. A substrate holder assembly incorporating these components as well as a thickness monitor sensitive in the desired range is illustrated in FIGS. 5 and 6.

Referring now to FIGS. 5 and 6 the substrate holder assembly is adjustably supported on a threaded section 150 of the shaft 15. The height of the holder assembly may be raised or lowered depending on the size of the particular substrate. The holder assembly is supported by means of an upper annular bracket 108 attached to a threaded support member 130 riding on the threaded section 150 of the shaft 15.

The upper bracket 108 acts as a suspending support for the flange 100 of the funnel 28, as a rotatable support for the shutters 91 and 93 and to support brackets suspending the thickness gages, temperature sensors as well as the substrate holder 132.

The substrate 134 with the face intended to be deposited facing down is supported between clamping screws 136 insertable through the walls 138 of the substrate holder 132. A thermocouple 139 is in mechanical contact with the substrate during a run. The substrate holder may further include masks for depositing particular configurations of metals or dielectrics onto the substrate. For this purpose clips may be provided at the lower end of the holder for holding the masks in place during the run. The holder 132 rests on an annular plate 140 suspended in the control opening of annular bracket 108 by means of bolts 142. The holder 132 is in turn surrounded by a metal can 144 the outer surface of which contains a heating element 146 in the form of a coil of ceramic coated wire. The can 144 rests on annular plate 140 and the top face 149 of the can is attached to a bracket 148 suspended from upper bracket plate 108. The lead wires 152 to the heating element 146 are attached to a clip 154.

A pair of piezoelectric crystals 160 and 162 are disposed on each side of the substrate 134 above separately operable shutter plates 91 and 93 but axially within the opening 164 of the cold can vapor funnel 28. The crystals 160 and 162 are housed in cold cans 166 suspended from bracket 108 by means of angles 168. Water inlets and outlets 170 and 172 and electrical leads 174 are supported by means of various brackets and clamps, not shown, and are connected to external sources of water and electrical monitoring equipment by means of high vacuum feed-throughs, not shown.

Commercially available 5-MHz quartz oscillator wafers may be utilized as the film thickness monitor. Since the vibrating crystals are calibrated for only one type of depositing material at a time, it is necessary to utilize a separate crystal for each material being deposited. Superimposed layers of different metals would render the crystal useless for further monitoring during the run. In accordance with the invention, a plurality of separately controlled shutter plates can be utilized so that one plate may be maintained in position to isolate one crystal during the run while the other plate is fully opened to expose the substrate and the active monitoring crystal. The thickness monitors are carefully precalibrated with a well-known multiple beam interferometer technique. The commercial piezoelectric thickness monitors utilized were of the beat frequency type and the output can also be connected to a frequency counter. A variation of 1 kHz in 5 MHz may be readily detected and identified to the interferometer thickness.

The substrate heater oven surrounds the holding mechanism and in this embodiment takes the form of a stainless steel cylinder having a ceramic insulated heater wire wound on its outer surface. The substrate temperature is monitored by the thermocouple situated at the rim of the surface being evaporated on and in mechanical contact with the substrate. With this arrangement substrate temperatures of up to 900°C can be maintained during deposition of layers. Generally these high substrate temperatures are utilized when depositing dense acoustical or optical layers. One of the reasons for high temperature is the necessity to achieve high compaction in the deposited film.

A generalized operating procedure comprises filling the crucibles in counterclockwise order with the desired vaporizable materials to be consecutively deposited as layers on the substrate. The substrate is placed in the holder mechanism and the thermocouple attached to it. Clean precalibrated

quartz crystals are placed in cold cans of the thickness monitor and the clear cover is then placed over the assembly and onto the base housing. The chamber is then evacuated to low vacuum and the first chamber rotated into position in the vapor station.

The cooling water is flowed into and through the thickness gage cold cans and liquid nitrogen is flowed through the coil surrounding the vapor funnel. The axial feed-through manipulators are operated to close the contacts and power is turned ON to feed power to the first crucible. The shutter isolating the crystal calibrated for the material being deposited is opened and vapor is continuously deposited as a first layer until the thickness gage indicates the desired amount of material has been deposited. The shutter over the thickness crystal that has been utilized is then closed and the opposite shutter is opened to expose a fresh thickness gage. The second crucible is rotated into position in the vapor station and the contacts are again closed and energized to create a flow of vapor that rises through the cold can and onto the substrate.

The chamber is brought to vacuum by means of a standard pumping unit attached to a vacuum feed-through and includes a mechanical roughing pump to bring the system to 10 microns or less and a sublimation pump with a capacity of 3,600 liters per second to evacuate the chamber to 10^{-4} torr and finally two 25 liters per second ion pumps are utilized to bring the system to 10^{-8} torr. Flowing liquid nitrogen through the cold can of the vapor funnel 28 during pumping helps to scavenge residual ions from the system and with the cold can in operation about 30 minutes is required to bring the system to the desired low vacuum. During operation the vacuum outside the cold can may rise temporarily to 2 to 4×10^{-7} torr but recovers within 2 to 3 minutes after deposition is terminated.

Prior to assembling the components into the system, a very careful standard cleaning and degreasing procedure should be followed. After assembling, several dry runs are made with the purpose of further cleaning and degassing. The system is always brought to atmospheric pressure by introducing purified N_2 to partially prevent the absorption of oxygen and other gases by the components. The parts that operate at high temperature within the system are degassed prior to and during the evacuating cycle. Any parts handling is done by using lint-free gloves and the entire system is constantly kept in a clean room (free of organic matter and dust). The system is constantly kept under vacuum and is brought to room pressure only for as long as it takes to introduce substrates and to charge the evaporators. Cleaning of the system is minimal since the use of a cold can as vapor funnel as well as trap, considerably reduces the spreading of metal or dielectric vapors onto the rest of the system.

As an example, the apparatus of the invention was utilized to prepare a microwave acoustic filter consisting of a stack of gold and aluminum film layers terminated with cadmium sulphide input and output transducers. The input transducer generates a compressional acoustic wave that travels through the multi-layer metal stack. This acoustic wave is then converted back to an electromagnetic signal by the output transducer. One possible design for this type of filter is shown schematically in FIG. 7. This filter is designed to exhibit a narrow-band transmission response having minimum insertion loss at a frequency f_0 . The acoustic Q's of evaporated aluminum and gold films have been measured at 575 MHz and were found to be large enough to provide an expected one percent bandwidth with this configuration. The filter was deposited on the end face a 0.685 inch diameter fused quartz substrate. Four large metal pads were provided to electrically connect the filter to a test circuit. The active area of the device was 0.016 inch $\times$ 0.020 inch and the acoustic filter was designed to operate at 1,000 MHz. The steps required in the fabrication of this filter are illustrated in the following Table and the open configuration of the mask for the corresponding step is shown in FIG. 8.

TABLE I

Fabrication Steps

Step	Film	Thickness
1	Ti	300 Å
2	Au	0.76 μ
3	CdS	1.12 μ
10	SiO _x	100 Å
	Ti	300 Å
	Au	0.76 μ
	Al	3.35 μ
	Au	0.76 μ
4	Ti	300 Å
15	Au	2 μ
5	CdS	2.14 μ
6	SiO _x	1000 Å
	Ti	300 Å
	Au	1000 Å
7	Ti	300 Å
20	Au	2 μ

filter

Steps 1, 3, 4, 6, and 7 were carried out in the multi-source system described herein. The CdS depositions were carried out in a separate vacuum system, but in principle, provisions for making this deposition could also have been incorporated in the multi-source system. Step 3 is the critical step in the fabrication of the filter and was accomplished without breaking vacuum. A thin layer of SiO_x was deposited on top of the CdS in order to prevent pinhole shorts across the CdS layers. Next, a thin layer of Ti was deposited to promote adhesion between the SiO_x and the Au. Finally, the multilayer filter section of Au-Al-Au was deposited. In order to deposit the rather large thickness of Al that was required (i.e., 3.35 μ), it was necessary to use five of the eight evaporation stations.

It is to be realized that only preferred embodiments of the invention have been disclosed and that numerous substitutions, alterations and modifications are all permissible without departing from the scope of the invention as defined in the following claims.

What is claimed is:

1. A multi-source vacuum deposition system comprising in combination:

a vacuum chamber containing:

a rotatable support;

a plurality of vapor sources mounted on said support, at least one of said sources comprises a reservoir receptacle for containing a source of vaporizable material; a first electrical heating element for heating the receptacle and an electrical wick heating element extending into the receptacle for vaporizing the body of vaporizable material;

electrical connecting studs connected to said heating elements and extending through said rotatable support and terminating in a first electrical contact;

a second electrical contact, a shaft connected to said second contact, a portion of said shaft extending without said chamber and a portion extending within said chamber adjacent said connecting studs and means connected to said shaft without said chamber for making and breaking connection between said contacts;

substrate holder means disposed above said sources; and means extending without said chamber for rotating said support to dispose each of said sources below said holder means.

2. A system according to claim 1 further including vapor funneling means disposed between said holder and said support comprising a tubular member disposed axially below said holder and means to cool the walls of said tubular member comprising a coolant coil surrounding said tubular member for receiving a flow of liquid coolant.

3. A system according to claim 1 further including heat exchange means associated with said holder for controlling the temperature of the substrate.

9

4. A system according to claim 3 wherein said heat exchange means comprises an electrical heating element surrounding at least a portion of said holder.

5. A system according to claim 4 further including shutter means disposed between said holder and said funnel means, means without said chamber for positioning said shutter and linkage means within said chamber associating said shutter means with said positioning means.

6. A vacuum deposition system comprising:

a base housing;

a removable cover for said housing defining a vacuum chamber, said chamber containing:

stationary substrate holder means;

a rotatable support below said holder;

a plurality of reservoirs for receiving vaporizable material mounted on said support;

10

a first electrical heating element in contact with the exterior of at least one reservoir;

a second wick electrical heating element extending into the interior of at least one reservoir;

a first fixed electrical contact connected to each said heating element;

a second translatable contact disposed adjacent said first contact; and

means extending through said housing into said chamber for moving said second contact into engagement with said first contact.

7. A system according to claim 6 wherein said moving means comprises an axial rod supporting said second contact and bearing means engaging said rod.

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