March 13, 1962 B. I. BERTELSEN 3,024,761

VACUUM EVAPORATION APPARATUS

Filed July 1, 1958

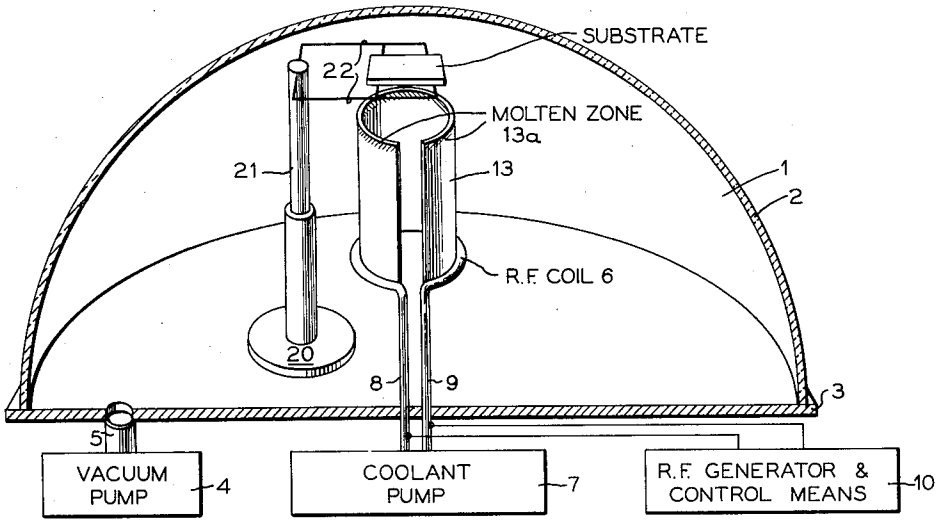



FIG_1

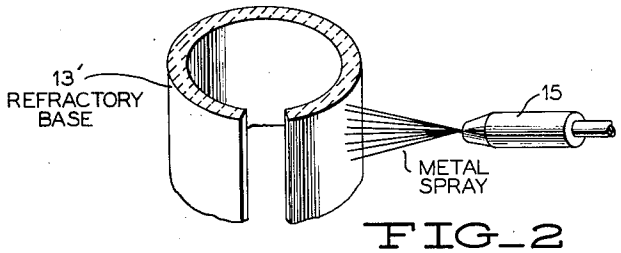



FIG_2

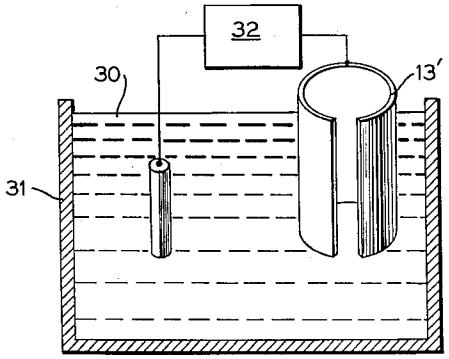



FIG_3

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# VACUUM EVAPORATION APPARATUS

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The invention relates to apparatus for coating various substrates by vacuum evaporation and deposition.

An object of the invention is to provide an improved process and simplified apparatus for obtaining thin films upon a substrate.

Another object is to provide a process and an apparatus whereby the rate of evaporation may be easily controlled to provide deposited films of definite and uniform thickness.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of examples, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

FIG. 1 is the preferred embodiment showing a base cylinder constituted of the material to be evaporated secured to an R-F coil, all enclosed within a vacuum chamber.

FIGS. 2 and 3 show how the refractory base cylinder is subjected, respectively, to spraying and electroplating processes for applying the material on the cylinder, which material is to be evaporated.

The preferred form of the apparatus constituting the invention is seen in FIG. 1. This apparatus is contained within an evacuable chamber **1** formed by means consisting of a bell dome **2**. The latter is movable into and out of sealing engagement with a base plate **3**. The chamber **1** communicates with vacuum pump means **4** through a conduit **5**. The pump means **4** may be any suitable pump means well known in the art. The source for evaporating coating material in the chamber **1** comprises an induction R-F coil **6** communicating with a coolant pump **7** by means of conduits **8** and **9**. The coolant used depends upon the temperature requirement of the R-F coil—for elevated temperatures, liquid sodium or silicones may be used; for lesser temperatures, oil may be used; and, for lower temperatures, water is used. The coil **6** is further connected to an R-F generator and control means **10** by means of leads **11** and **12**, the R-F generator **10** supplying high-frequency current suitable for apparatus of this type. This means **10** further contains regulating control means for controlling the rate of frequency of the current. The coil **6** further supports a sheet **13** of the material which is to be evaporated. The sheet **13** may be configured in the same manner as the supporting R-F coil **6**. In the preferred embodiment shown, the coil and sheet material are cylindrical in shape; this arrangement providing optimum conditions of control. However, at the expense of optimum conditions, the shape may take forms other than cylindrical; for example, rectangular, elliptical, etc. Thus, the current carrier means for supplying heat to the sheet, or base, may have configurations other than circular.

The sheet **13** is secured to the coil **6** by welding, soldering, brazing, or by any other suitable process whereby intimate electrical contact is achieved. In operation, the high-frequency current applied to the coil **6** is thereby applied to the sheet **13** and causes maximum concentrated heating to occur on a peripheral band edge **13*a*** (molten zone) of the sheet **13**. This is developed by virtue of the "skin effect" and the cooling at the bottom edge of the sheet **13**. By virtue of this arrangement, the amount of metal to be evaporated and the rate of evaporation can be accurately controlled. This by regulating the degree of coolness of the coil and the frequency of the R-F generator. The cooling of the coil is, of course, determined by the nature and temperature of the coolant circulating through the coil **6**, the coolant pump **7** temperature regulating, not shown, well known in the art. The temperature of the peripheral band edge **13*a*** of the sheet **13** can be accurately determined by knowing the depth, or length, and thickness of the sheet **13**. Heat transfer to the coil is thus predetermined on the basis of these parameters. Higher temperatures narrow the hot band, this being controlled by increasing the frequency of the R-F current applied.



Another embodiment is shown in FIG. 2. Here the base referenced as **13'** is comprised of a refractory base material upon which the metal to be evaporated is applied by any suitable application process; for example, spraying. As seen in FIG. 2, the base **13'** is coated by a conventional spraying apparatus of which spraying nozzle **15** forms a part thereof. The sprayed base is then secured to the R-F coil **6** in the manner explained. Another method by which the metal to be evaporated may be applied is by means of a brush.

In FIG. 3, there is shown schematically how the refractory base **13** may be coated with the metal to be evaporated by an electroplating process. In this process, the base **13'** is partially immersed in an electrolyte **30** contained in a plating tank **31** to which an electrical current suitable for electroplating is applied from a source **32** to pass through the electrolyte and base **13'**; the electrolyte containing the metal in solution. The depth to which the base **13'** is immersed is dependent upon the amount of metal to be plated to the base. Other forms of chemical deposition may be employed for applying the material to the refractory base **13'**.

The refractory base **13'** may be constituted of metals capable of withstanding elevated temperatures and which are electrically conductive and are not affected by the evaporation process; such metals being, for example, tungsten, tantalum, molybdenum, hafnium, niobium, rhenium, and platinum.

The metals that may be applied to the refractory base may be any metal which is capable of being vaporized; for example, iron, cobalt, nickel, the noble metals, alloys, and others.

Any suitable means for supporting the substrate above and near the evaporating source material may be employed; as seen in FIG. 1, a support is used which comprises a base **20** having an unadjustable shaft **21** and an adjustable platform **22** for supporting the substrate in any position with respect to the peripheral edge **13*a*** of the base **13**.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In apparatus for providing thin films upon a substrate by evaporation and deposition in a vacuum, the combination comprising a single open loop configured electrical current carrier contained in the vacuum; a source of R-F current including means for supplying R-F current to said carrier to cause the latter to effect evaporation; and a slotted curved sheet of evaporable material, having substantially the same configuration as the carrier, the open loop of said carrier and the slot of said sheet being in substantial alignment to prevent electrical short-

ing, said sheet supported by and having electrical contact with said carrier whereby the more remote edge of said sheet is subjected to maximum heating to cause evaporation along the remote edge of said sheet upon the flow of R-F current through said sheet.

2. Apparatus, as in claim 1, in which means are provided to circulate a coolant through said R-F current carrier.

3. Apparatus, as in claim 1, in which said current carrier has a circular configuration, and the sheet supported thereby having substantially a cylindrical configuration.

4. In apparatus for providing thin films on substrates by evaporation and deposition in a vacuum, the combination comprising a single open loop configured electrical current carrier contained in the vacuum, a source of R-F current including means for applying R-F current to said carrier, a slotted figured sheet of refractory evaporable metal bearing a layer of metal, and means for securing said sheet to establish electrical contact with said layer whereby the remote band edge of said sheet is subjected to maximum heating to cause vaporization of said layer upon the application of the R-F current, the open loop of said carrier and the slot of said sheet being aligned to prevent electrical shorting.



5. Apparatus, as in claim 4, further having means for supporting the substrates in proximity to the remote edge of said sheet.

6. Apparatus, as in claim 4, in which said current carrier comprises a hollow coil and said sheet being substantially similarly configured along its cross section.

7. Apparatus, as in claim 6, further including means for circulating a coolant through said coil.


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