Sept. 9, 1969 G. D. ADAMS 3,466,424

EVAPORANT SOURCE FOR VAPOR DEPOSITION

Filed Aug. 31, 1967 2 Sheets-Sheet 1

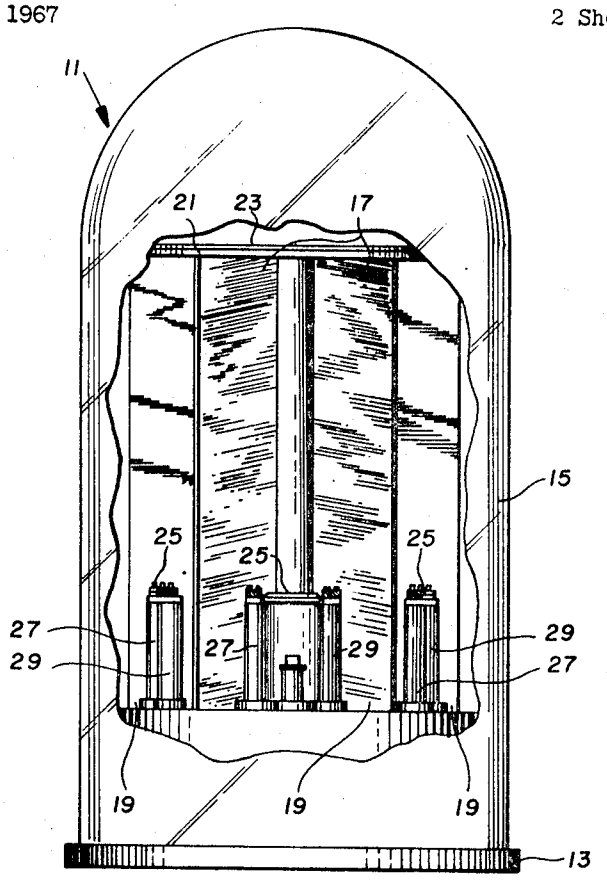


FIG. 1

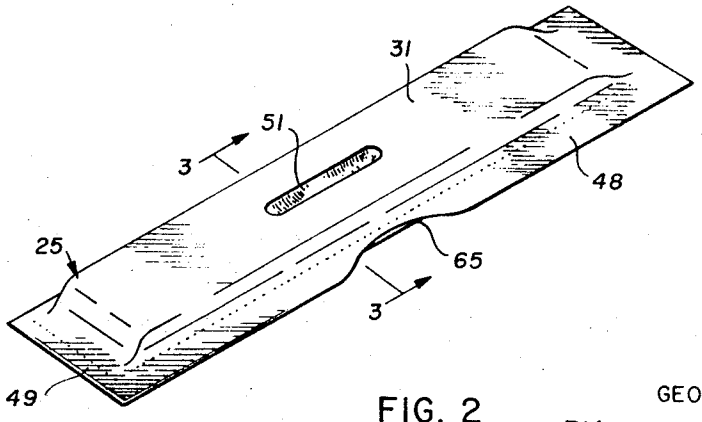


FIG. 2

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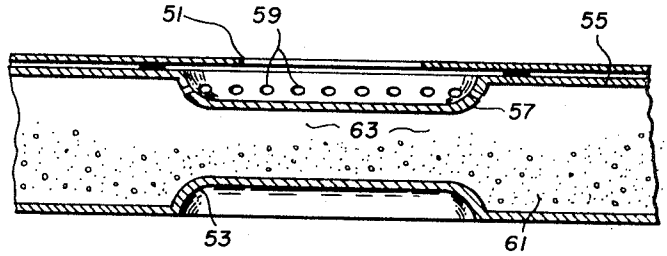


FIG. 4

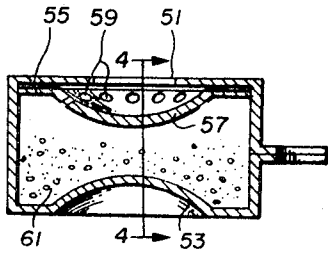


FIG. 3

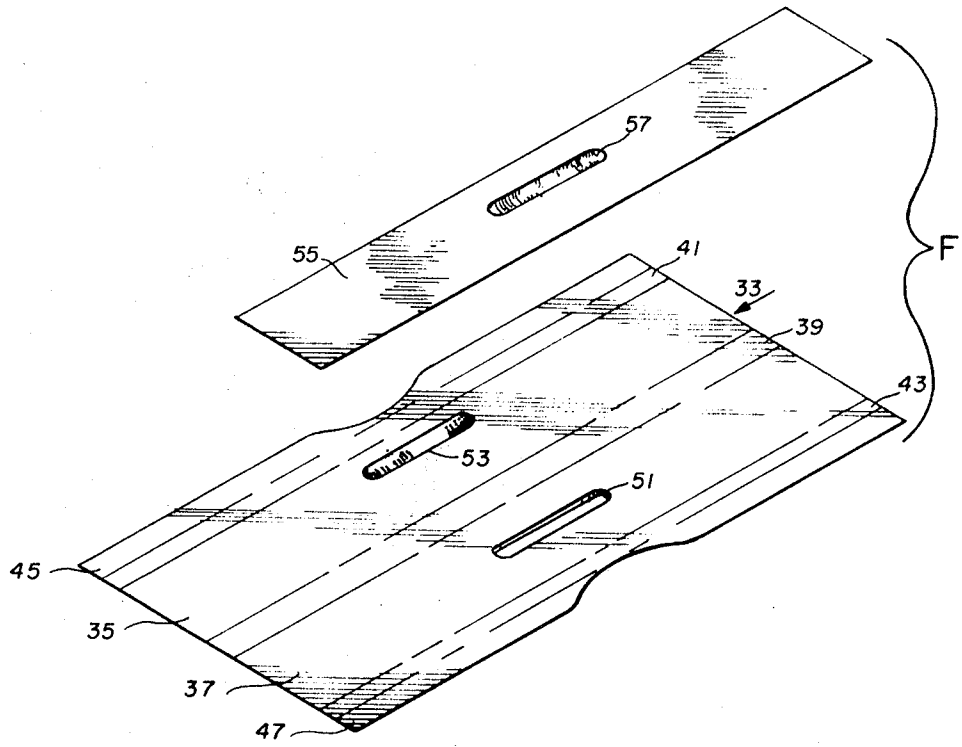


FIG. 5

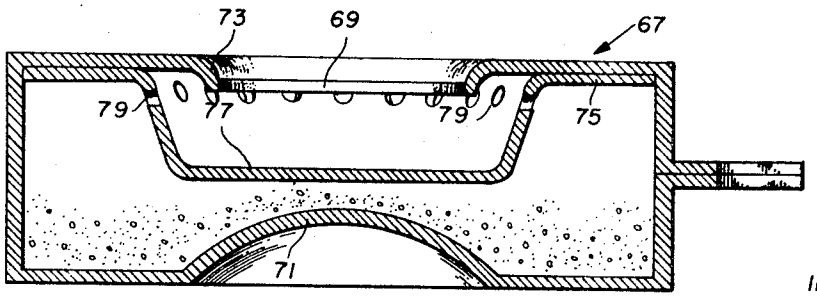


FIG. 6

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EVAPORANT SOURCE FOR VAPOR DEPOSITION

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U.S. Cl. 219—275 7 Claims

ABSTRACT OF THE DISCLOSURE

A spatterproof evaporant source for use in vacuum depositing of thin solid films upon a substrate. A metallic cartridge for containing evaporable material has a vapor exit opening formed in the central region of the upper side of the cartridge. An inwardly depressed dimple is formed in a metallic strip beneath the vapor exit opening and the dimple has small perforations in an area offset from vertical alignment with the vapor exit opening. Vapors pass through the perforations and are initially deflected by the portion of the upper side of the cartridge around the vapor exit opening and subsequently re-evaporated or deflected upward through the vapor exit opening to the substrate. Any gross particle spattering through the perforations will be trapped in the dimple cavity or else reflected through the vapor exit opening at such a low trajectory that it will not reach the substrate to damage the film being deposited.

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates generally to vacuum deposition of thin solid films on substrates and more particularly to evaporant sources for use in vacuum deposition operations.

The art of vacuum coating is very important in the field of microelectronics since many of the critical electronic components are formed by the vacuum deposition process wherein extremely thin films of dielectric and conductive materials are deposited in the desired arrangement on a substrate. A continuing problem encountered in the vacuum deposition process has been that known in the art as spattering of the evaporation source material. This spattering occurs when the solid evaporant material explodes during heating because of occluded gases. Relatively large solid particles of evaporant leave the evaporant source at high velocities and strike the thin film being deposited on the substrate with sufficient energy to pierce the film and leave pin holes therein. This type of film damage has been particularly bothersome in the formation of dielectric films in thin-film capacitors. These explosions will also empty the source of evaporant material before the evaporation begins unless a means is provided to trap the material in the source.

Efforts to solve the spattering problem have been directed toward designing the evaporant sources or containers so that the detrimental microscopic particles will be separated from the vapor before striking the substrate. This is done by directing the vapor toward the substrate while rebounding the harmful particles in the vapor off of a reflecting surface in a direction that misses the substrate, this being possible since the vapor is reflected from a smooth surface at random directions, having no relation to the angle of incidence, while the microscopic particles are reflected specularly, meaning that the angle of reflection of the particles will approximate the angle of incidence.

Although certain of the evaporant sources recently introduced have proved somewhat successful in alleviating the spattering problem, all of these sources are unduly complex in design, involving several components such as a separate and distinct reflecting hood and reflecting box in addition to the crucible or cartridge that contains the evaporant. Such elaborate sources are rather difficult and expensive to fabricate and require an excessive amount of power for operation.

Summary of the invention

Briefly described, the invention comprises an evaporant source that is very simple and may be made from two strips of metal foil. The source comprises a cartridge evaporant container having a vapor exit port in the upper side thereof. Beneath the upper side of the cartridge is a metallic strip having a depressed or dimpled area positioned in opposed relationship to the vapor exit port with the dimpled area being directed inwardly of the cartridge. The dimpled area is larger than the area occupied by the vapor exit port and small perforations are provided in the peripheral zone of the dimpled area which perforations are offset from vertical alignment with the vapor exit port. Vapor rises from the cartridge through the perforations in the dimpled portion and is reflected off of the inner surface of the upper side of the cartridge around the vapor exit port and is subsequently reflected or re-evaporated off of the dimpled surface and out through the vapor exit port toward the substrate. Since harmful microscopic particles cannot escape from the cartridge in a vertical direction, most of them will be trapped in the cartridge. The particles that do escape through the perforations must strike the portion of the cartridge that covers the perforations in the dimpled area and bounce off this surface at an angle approximating the angle of incidence. Thus, most of these particles will be trapped in the dimple cavity and will never reach the substrate. If occasional ones of the particles do escape through the vapor exit port their trajectories will likely be at such a low angle that they will miss the substrate.

Accordingly, it is a general object of the present invention to provide an improved spatterproof evaporant source.

A more specific object of the invention is to provide a spatterproof evaporant source that is very simple and inexpensive to make and which is durable and reusable and susceptible of operating on low power supply.

Another object of the invention is to provide an evaporant source that separates high velocity miscroscopic particles from the vapor being evaporated from the source by using an extremely simple yet highly effective baffle arrangement.

These and other objects and advantages of the invention will become apparent upon reference to the following specification, attendant claims and drawings:

Brief description of the drawing

FIGURE 1 is an elevational view, partially broken away, of a vacuum evaporation chamber containing a plurality of spatterproof evaporant sources.

FIGURE 2 is a perspective view of a spatterproof evaporant source such as contained in the vacuum evaporation chamber shown in FIGURE 1.

FIGURE 3 is a cross sectional view taken along line 3—3 of FIGURE 2.

FIGURE 4 is a cross sectional view taken along line 4—4 of FIGURE 3.

FIGURE 5 is an exploded perspective view showing the metallic sheet elements of the evaporant source prior to folding and assembly of the elements.

FIGURE 6 is a cross sectional view of a modified evaporant source.

Description of the preferred embodiments

Referring to FIGURE 1, therein is shown a vacuum chamber **11** comprising a base **13** and a bell jar **15** partially broken away to reveal a portion of the inside of the vacuum chamber **11**. Within the vacuum chamber **11** are a plurality of vertical plates **17** radiating from the center of the chamber to divide the chamber into a series of triangular compartments **19**. The upper ends of the plates **17** are covered by a circular plate **21** that has a series of openings (not shown) aligned with each of the compartments **19**. Supported above the plate **21** is a revolving substrate carrier plate **23** that is designed to support a substrate over either or all of the aforesaid openings in the plate **21** such that the respective substrates are exposed to the respective compartments **19**. Each compartment **19** has an evaporant source **25** at the bottom thereof mounted on electrodes **27** and **29**. In forming an electronic component, such as a thin film capacitor, the sources **25** in the respective compartments **19** may alternatively, from one compartment to the next, contain a dielectric evaporant material and a conductive evaporant material and the substrate carrier plate **23** is adapted to revolve and position the substrate over the compartments for the appropriate vacuum deposition of the dielectric and conductive films.

As is well understood in the art, the evaporable material in sources such as source **25** is resistance heated to a vaporizing temperature through the electrodes **27** and **29** and the material evaporates from the sources **25** and is deposited on the substrate carried by the substrate carrier **23**. Since the details and operation of the vacuum chamber **11** forms no part of the present invention, this apparatus will not be further described.

A novel evaporant source **25** is illustrated in FIGURES 2 through 5, being shown in perspective in FIGURE 2, and comprises a cartridge **31** that is made by folding the blank **33** shown in FIGURE 5 along the broken lines such that the portion **35** constitutes the bottom of the cartridge, and portion **37** forms the top. Portion **39** forms one side, portions **41** and **43** cooperate to form another side, and portions **45** and **47** press together to form a seam **48** (FIGURE 2) that is welded. One end of the cartridge is pressed and welded at **49** as indicated in FIGURE 2. The other end is left unwelded for filling the cartridge with evaporable material.

In the center of the top of the cartridge **31** is a vapor exit port **51** and in the bottom of the cartridge directly opposite the exit port **51** is a dimple **53**, the purpose of which will be explained hereinafter. Coextensive with the top of the cartridge **31**, disposed on the inside of the cartridge and contiguous with the top of the cartridge is a metallic strip **55** that is welded to the top of the cartridge. The strip **55** is provided with a dimple cavity **57** that is vertically aligned with the vapor exit port **51** in the top of the cartridge with the dimple cavity **57** being larger in dimension than the vapor exit port **51**. The dimple cavity **57** is provided with a series of perforations **59** extending around the peripheral zone of the dimple **57** and thus offset from vertical alignment with the vapor exit port **51** and with the axes of the openings **59** disposed diagonally with respect to the cartridge **31** and converging generally in the space above the cartridge. The cartridge **31** is adapted to contain an evaporant material **61** such as sicilon monoxide.

When the evaporant source **25** is resistance heated to operating temperature by electric power supplied to electrodes **27** and **29**, the material **61** begins to vaporize and the vapor rises through the openings **59**. Since there is no direct line between the interior of the cartridge **31** and the vapor exit port **51** through which the vapor can pass, the vapor must pass through the openings **59** and rebound on the interior surface of the top of the cartridge around

the vapor exit port **51** and subsequently rebound from the bottom of the dimple cavity **57** and out through the vapor exit port **51** onto the substrate. Moreover, any high velocity microscopic particles that would be detrimental to the thin film being deposited on the substrate must pass through the openings **59** and, therefore, most of such particles will not escape from the cartridge **31**. The particles that do escape will bounce off the surface of the top of the cartridge **31** around the vapor exit port **51** and, since these particles will bounce off the surface at an angle approximating the angle of incidence, most of these particles will become trapped in the dimple cavity **57**. Any microscopic particles that do bounce off of the dimple cavity **57** and through the vapor exit port **51** will likely be directed in a trajectory so low as to miss the substrate.

The purpose of the dimple **53** in the bottom of the cartridge **31** is to reduce the amount of evaporable material disposed directly underneath the dimple cavity **57** so that the exit port region of the cartridge will be maintained somewhat hotter than the rest of the cartridge. Also, the seam **48** of the cartridge is necked down slightly at **65** to create a hot spot in the area of the dimple cavity **57** and the vapor exit port **51** so as to prevent clogging of the openings **59** during the vapor deposition operation.

FIGURE 6 illustrates a cross section of an evaporant source that provides an even more complete trapping of high velocity microscopic particles than that shown in FIGURES 2 through 5. In FIGURE 6 a cartridge **67** has a vapor exit port **69** and a dimple **71** in the bottom of the cartridge **67** in vertical alignment with the vapor exit port **69**. The top of the cartridge **67** has a downwardly directed rim **73** around the vapor exit port **69**. A baffle strip **75** is welded to the top of the cartridge **67** and has a depression or cavity **77** the bottom of which is generally flat. The cavity **77** has a series of perforations **79** located around the cavity **77** near the top thereof with the axes of these openings directed toward the rim **73**. With the configuration of the vapor exit port and dimple cavity shown in FIGURE 6, it would be virtually impossible for any high velocity particles to pass through an opening **79** and subsequently emerge through the vapor exit port **69** before dissipating all of its energy. The vapor, however, which is reflected at random off of the reflecting surfaces will pass through the openings **79** and reflect off of the rim **73** and the surface of the cavity **77** and be passed or reevaporated through the vapor exit port **69** onto the substrate.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore, to be understood that within the scope of the appended claims the invention may be practiced other than as specifically described herein.

I claim:

1. An evaporant source for the vapor deposition of thin solid films upon a substrate comprising:

(a) a cartridge having an interior space for containing evaporable material;

(b) said cartridge having a vapor exit opening formed in the upper side thereof;

(c) a strip substantially coextensive with and underlying said upper side of said cartridge;

(d) the area of said strip underlying said opening and the portion of said upper side defining said opening being depressed inwardly of said cartridge to form a cavity in the region of said cartridge beneath said opening;

(e) said depressed area of said strip having a series of regularly spaced perforations therethrough extending around the peripheral zone of said depression with said perforations being offset from vertical alignment with said opening;

(f) said strip being bonded to said upper side of said cartridge in the area of said strip around said depression.

2. The invention as defined in claim **1** wherein said

perforations are disposed in said depression above the bottom of said depression.

3. The invention as defined in claim 2 wherein said depression is of concave cross section.

4. The invention as defined in claim 1 wherein said evaporant source is necked down in the region of said exit opening.

5. The invention as defined in claim 1 wherein said cartridge comprises a depression in the side of said cartridge opposite said vapor exit opening, said depression being directed inwardly of said cartridge toward said opening whereby the quantity of evaporable material that may be disposed directly beneath said opening is reduced.

6. The invention as defined in claim 2 wherein a rim extends at least partially around said vapor exit opening, said rim being directed inwardly of said cartridge.

7. The invention as defined in claim 6 wherein the central axes of said perforations coincide with lines intersecting a portion of said rim.

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