

[54] CATHODE ATOMIZATION
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Germany[73] Assignee: **Siemens Aktiengesellschaft**, Berlin
and Munich, Germany[22] Filed: **May 20, 1970**[21] Appl. No.: **39,121****Related U.S. Application Data**[63] Continuation-in-part of Ser. No. 614,156, Feb. 6,
1967, abandoned.

[52] U.S. Cl.204/298

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[58] Field of Search.....204/298, 192

[56]

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[57]

ABSTRACT

A cathode structure for use in a cathode sputtering apparatus for production of a homogeneous multi-component layer on a substrate. For example, the multi-component layer is a magnetostriction free ferromagnetic Ni-Fe layer. The cathode is composed of individual components of the multi-component layer and each of the individual component surfaces is selectively varied to control the amount of that component sputtered during formation of the multi-component layer.

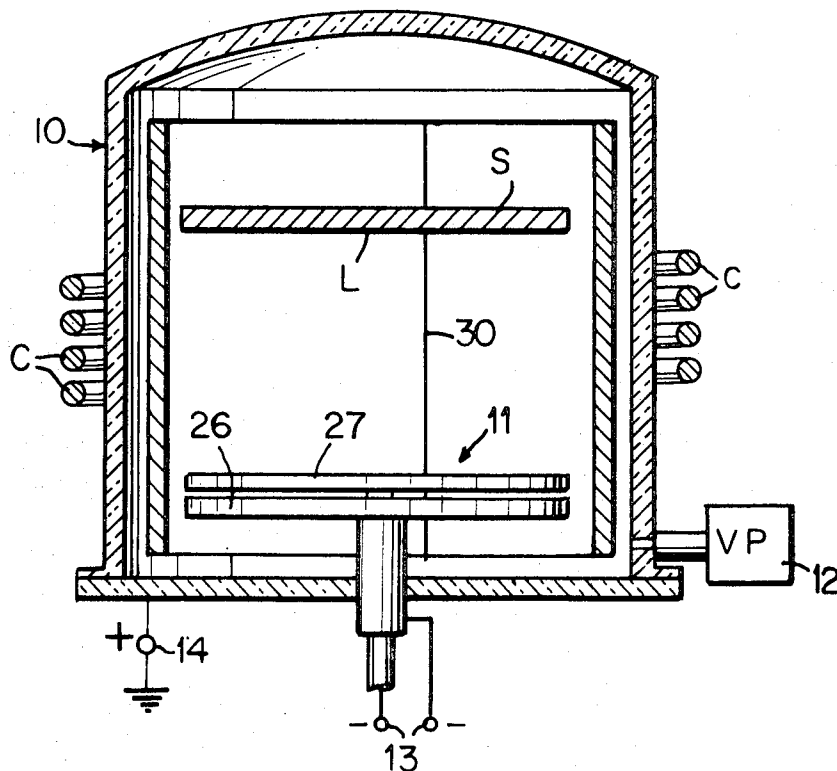
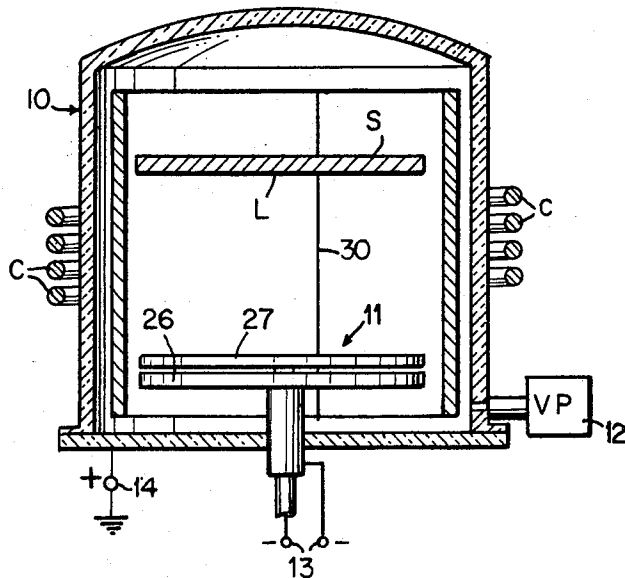
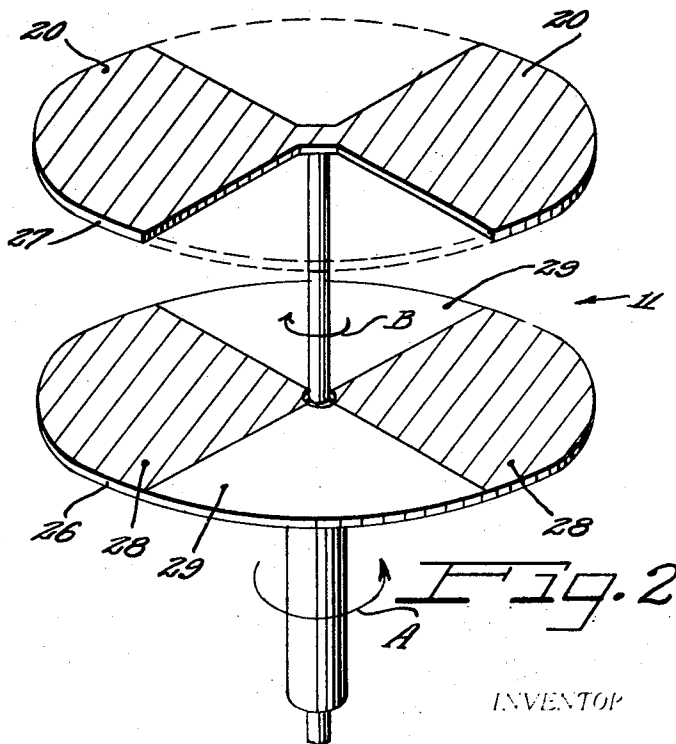
5 Claims, 2 Drawing Figures

Fig. 1



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CATHODE ATOMIZATION APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation-in-part application of my co-pending U.S. Ser. No. 614,156 filed Feb. 6, 1967 (now abandoned).

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to cathodic sputtering apparatus and more particularly to cathode structures for use in such apparatus.

2. Description of the Prior Art

Heretofore known cathodic atomization devices utilized a plurality of cathodes, each composed of a particular component to be produced onto the substrate and each cathode having its own energy source. Such devices are cumbersome in requiring the plurality of cathodes and are uneconomical to operate since energy must be selectively applied to each cathode. In certain of such known devices, the substrate being coated is selectively movable relative to the fixed cathodes to aid in distribution of the components being produced onto the substrate. However, these types of devices fail to provide a means for easily varying the amount of the component that is produced onto the substrate or a means of producing a homogeneous layer of the several components onto the substrate.

SUMMARY OF THE INVENTION

The invention provides cathode structures for use in cathodic atomization apparatus composed of a plurality of components juxtapositioned to each other and each having a pre-selected surface area exposed for vaporization so that when energy is applied to the cathode, the amount of the individual component that is sputtered is controlled by its exposed surface area and the energy applied so that a homogeneous layer of the plurality of components is produced on a substrate. In one embodiment, a lower disk is formed of one or more adjoining segregated portions, each of which portions is composed of a given layer-forming component and another similarly sized upper disk is formed of one or more pre-selectively spaced portions, each composed of another layer-forming component, with open spaces between some of such spaced portions. These disks are rotatably affixed one above the other so that pre-selected surface areas of the portions on the lower disk are masked or screened by pre-selected areas of the portions on the upper disk so that when energy is applied to such a cathode structure, sputtering or the like of the various layer-forming components occurs in proportion to their respective exposed surface areas and a homogeneous multi-component layer is produced on a substrate. Since the disk areas are changeable during application of energy thereto, various homogeneous multi-component tiers or seams are easily produced as a layer on the substrate.

The invention also provides an apparatus for cathode sputtering of a plurality of layer-forming components onto a substrate, with dependent discharge, for example as a high energy frequency annular discharge plasma. The apparatus includes the combination of an enclosed container provided with means maintaining a vacuum and a plasma discharge within the enclosure. A

source of a magnetic high frequency field is provided and directed axially to the container so as to penetrate interior of the container. A unitary cathode structure composed in accordance with one of the embodiments described above and insulated from the container (and its own carrier, if necessary) is positioned within the container in spaced relation from the substrate, and a means for connecting the cathode to a potential for atomizing components thereof to produce a substantial homogeneous multi-component layer on the substrate is provided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic sectional elevational view of a cathode atomization device utilizing an embodiment of a cathode structure in accordance with the principles of the invention; and

FIG. 2 is an exploded perspective view of an embodiment of the cathode structure of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Generally, the invention provides a cathode sputtering process utilizing with a dependent discharge, as for example a high frequency ring-discharge plasma, for the production of a substantially homogeneous layer composed of a plurality of layer-forming components. Such a layer is preferably a magnetostriction free ferromagnetic Ni-Fe layer. The cathode sputtering apparatus includes a prior art enclosed container, such as a slotted anode structure having a cylindrical configuration, with at least one axial slot which surrounds a substrate. The interior of the apparatus is appropriately evacuated of atmosphere, as by a vacuum pump. The anode structure is connected to a positive pole of an energy source and functions as an anode. A source of a magnetic high frequency field is directed axially to the anode structure so as to penetrate the anode structure. The axial slot of the anode structure prevents any short-circuit in such high frequency field and allows such energy field to penetrate into the interior of the cathode atomization apparatus. A single unitary cathode constructed in accordance with the invention is disposed within the container and in spaced relation to the substrate. The cathode insulated from the container and, when necessary, from its carrier. A means connecting the cathode to a source of potential for sputtering the various cathode layer-forming components and producing a substantially homogeneously composed layer is provided in an operational relation to the cathode. The apparatus of the invention is utilized in conjunction with the production of plasma in a sputtering apparatus, as by means of a RF-ring-discharge [for any more detailed discussion of RF-ring discharge see ZIETSHRIFT FUR ANGEWANDTE PHYSIK (Magazine for Applied Physics), H. Gawehn, "Uber ein neues Kathodenzerstaubungsverfahren mit Ringentladungsplasma" (About a New Cathode-Sputtering Method with Ring-Discharge Plasma), (1962) pages 458-462]. This article generally illustrates that a ring discharge is excited by an energy field from a superimposed HF-coil about a cathode sputtering apparatus, after such apparatus has been filled with a noble gas. The highly ionized discharge plasma is diffusely bounded by the periphery of a portion of such

apparatus and forms the ion source. It differs from other prior art ion sources by its comparatively large exit opening, whereby a pressure stage has deliberately not been utilized in favor of high ion currents. Together with its simple adjustability and the applicability of lower gas pressure (up to $< 1 \cdot 10^{-3}$ Torr), the ring discharge thus represents an ideal ion source for cathode sputtering.

In accordance with the principles of the invention, considerably simplified production of conductive layers of alloys of several layer-forming components having different vapor pressures on a substrate is provided. The invention also allows selective variation of the composition of the layer on the substrate during its production.

The invention provides a single cathode structure which is composed of surface areas of layer-forming components desired on the substrate and the extent that such surface areas are exposed to the substrate (collector) is selectively variable.

In accordance with an embodiment of such a cathode structure, the composition of the ultimately formed homogeneous multi-component layer is adjusted during its actual formation on the substrate. In this embodiment one or more of the desired layer-forming components are formed into a geometric shape, such as a sector or the like, and such geometric shapes are joined into larger shapes, such as a disk or the like, to define a cathode forming member. Other desired layer-forming components are formed into somewhat similar shapes and joined in a spaced relation to each other to define another cathode-forming member. The two cathode-forming members are rotatably positioned one above the other whereby movement of one relative to the other causes one or more of the aforesaid shapes (or portions thereof) to overlie or mask (cover) at least parts of other shapes so that the substrate is exposed to adjustable surface areas of the component shapes and homogeneous multi-component tiers or seams are formed within the homogeneous multi-component layer.

Referring now to the drawings, FIG. 1 generally illustrates a cathode sputtering apparatus 10 e.g. an insulated glass bell or housing. The housing 10 is provided with a cylindrical anode structure 10a having at least one axial (vertical) slot 30 therein. The housing is provided with a suitable source of vacuum 12, such as a vacuum pump VP for evacuating substantially all atmosphere from the housing and maintaining a suitable sputtering atmosphere therein. A substrate S is disposed within the anode structure 10a and suitably supported in a position by a means (not shown). The container is connected, as at 14 to a positive pole of, for example, a D.C. tension supply so as to function as an anode.

A source of magnetic high frequency field is suitably provided, such as by a coil C, and such magnetic field is directed axially to the anode so as to penetrate the slotted anode and aid the ring discharge.

A cathode structure 11 of the invention is suitably provided within the housing and cylindrical anode structure in a suitably insulated manner. The cathode structure 11 is positioned in working relation from the substrate S whereby the sputtered components easily reach and form a desired layer on the substrate. The

cathode 11 is connected to a negative pole, as at 13, of a source of potential, such as a D.C. tension supply so that when energy is supplied the cathode the components thereof atomize (i.e., vaporizes, ionizes, sputters, etc.) and produces a substantially homogeneous layer L on the substrate S.

An embodiment 11 of the cathode structure is illustrated at FIG. 2 as being formed of two members 26 and 27. The members 26 and 27 are provided with a suitable means (such as concentric shafts, diagrammatically indicated) for relative rotation of one to the other, such as shown by curved arrows A and B and to provide a means of connection whereby a single unitary cathode structure is achieved.

Member 26 is formed of a plurality of geometric shapes 28, 29, such as the illustrated sectors, joined together (as by welding) into a larger geometric shape such as the illustrated disk-like configuration. Each sector 28 and 29 is composed of a desired layer-forming component such as nickel and iron respectively. Member 27 is also formed of a plurality of geometric shapes 20, 20 such as the illustrated sectors, joined together into a larger geometric shape, such as the illustrated segmented disk-like configuration. Member 27 is provided with open areas between sectors 20, 20 so that on assembly with member 26 portions of member 27 mask or screen portions member 26. During the production of a desired layer on a substrate, member 26, for example, can be selectively rotated, as by a mechanical or electrical means (not shown) in the direction of arrow A for a small angle in respect to member 27 to adjust the value of the magnetostriction of the produced ferromagnetic layer on the substrate to exactly zero. This type of adjustment allows changes in the alloy composition of the produced layer as desired.

The cathode structure of the invention advantageously provides considerably smaller permeability of the individual layer-forming components than comparably sized cathodes composed of permalloy sheeting. Accordingly, the distortion of a permanent magnetic field (not shown) being applied for the production of magnetic anisotropy, which otherwise occurs at the substrate (collector) and has a disturbing influence, is kept small.

The embodiment of the cathode structure illustrated at FIG. 2 can be further modified from that described above by selection (or arrangement) of the components of members 26 and 27 so that they are electrically insulated from one another. Then the individual members 26 and 27 can be connected to different potentials independently of one another. Such a modified cathode structure allows production of homogeneous tiers or seams, each having a different composition in a superimposed laminated manner when one or the other member 26, 27 is appropriately connected to an anode for a suitably limited period of time. This type of arrangement allows for production of, for example, several ferromagnetic Ni-Fe seams disposed one above the other in a stack-like manner. The several seams are separated from one another by an electrically conductive nonmagnetic layer, such as copper. Thus, production of such differently composed layers on a substrate is easily achieved without discontinuation (or disconnection) of the plasma.

Since some changes and modifications to the above described embodiments of the invention may be made without departing from the spirit and scope thereof it is intended that all matters contained in the above description shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. An apparatus for cathode sputtering comprising, an insulating housing means, a cylindrical anode structure enclosed within said housing means, means for applying a positive potential to said anode structure, means for maintaining a suitable ionization atmosphere within said housing means, means for providing a magnetic high frequency field directed axially to said anode structure so as to penetrate said anode structure, said anode structure being slotted, a cathode structure positioned within said anode structure in working relation to a substrate and insulated from said housing means and anode structure, said cathode structure consisting essentially of a first geometrically shaped member composed of a layer-forming component and having a given surface area exposed to a substrate and a second geometrically shaped member composed of another layer-forming component, said second member being affixed in a relatively rotatable manner onto the exposed surface area of said first member, and means for connecting said cathode structure to a source of negative potential for effecting sputtering of said layer-forming components to produce a substantially homogeneous layer on a substrate.

2. An apparatus as defined in claim 1 wherein the second member is electrically insulated from the first member.

3. An apparatus for cathode sputtering adapted for producing a layer on a substrate comprising, an enclosed housing means, a cylindrical anode structure positioned within said housing means, means for applying a positive potential to said anode structure, means for maintaining a suitable ionization atmosphere within said housing means, means for providing a magnetic high frequency field directed axially to said anode structure so as to penetrate said anode structure, said anode structure being slotted, a cathode structure positioned within said anode structure along a peripheral boundary of said anode structure spaced from a substrate, said cathode structure being insulated from said housing means and anode structure and consisting essentially of a first disk-shaped member having a given diameter with at least one segregated portion thereof composed of a first layer-forming material, said first member having a surface area thereof exposed to a sub-

strate, and a second sector-shaped member affixed in a relatively rotatable manner onto the first member so as to be movable relative to the exposed surface area of said first member, said second member having at least one portion thereof composed of a second layer-forming material, and means for connecting said cathode structure to a source of negative potential for sputtering said first and second layer-forming materials to produce a substantially homogeneous layer composed of said layer-forming materials on a substrate.

4. An apparatus as defined in claim 3 wherein the first member is provided with a plurality of segregated portions composed of a first layer-forming material, each of such portions separated from other first layer-forming material portions by other portions composed of a second layer-forming material, and the second member is provided with a plurality of segregated portions composed of at least one of said first and second layer-forming materials, each of such second member portions separated from other second member portions by open space whereby said second member portions mask at least one of said first member portions.

5. An apparatus for cathode sputtering adapted for producing a layer of a given composition on a substrate comprising, an enclosed housing means, a cylindrical anode structure positioned within said housing means, means for applying a positive potential to said anode structure, means for maintaining a suitable ionization atmosphere within said housing means, means for providing a magnetic high frequency field directed axially to said anode structure so as to penetrate said anode structure, said anode structure being slotted, a cathode structure positioned within said anode structure along a peripheral boundary of said anode structure and in a spaced relation to a substrate, said cathode structure being insulated from said housing means and anode structure and consisting essentially of a first geometrically shaped member having a given diameter with at least one segregated portion thereof composed of a given material, said first member having a surface area exposed to a substrate, and a second geometrically shaped member affixed onto said first member so as to be relatively rotatable in relation to the exposed surface of said first member so as to mask some of said exposed surface area of said first member, said second member having at least one portion thereof composed of a material different from said given material, and means for connecting said cathode structure to a source of negative potential for sputtering said portions to produce a substantially homogeneous layer of said materials on a substrate.

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