

[54] **TRIODE DEVICE FOR SPUTTERING MATERIAL BY MEANS OF A LOW VOLTAGE DISCHARGE**

[75] Inventor: **Otto Sager**, Balzers Furstentum, Liechtenstein

[73] Assignee: **Balzers Patent-und Beteiligungs AG**, Liechtenstein

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

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Primary Examiner—John H. Mack

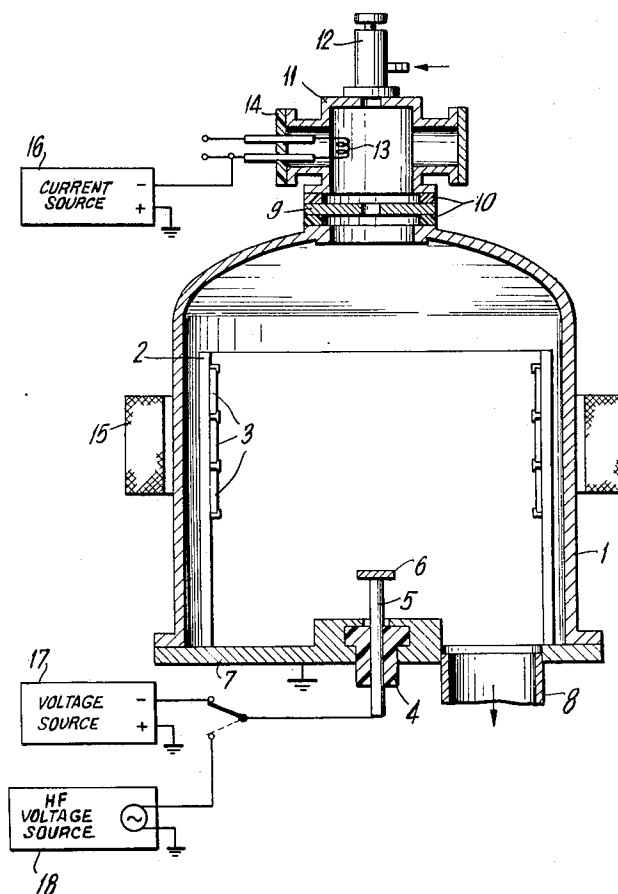
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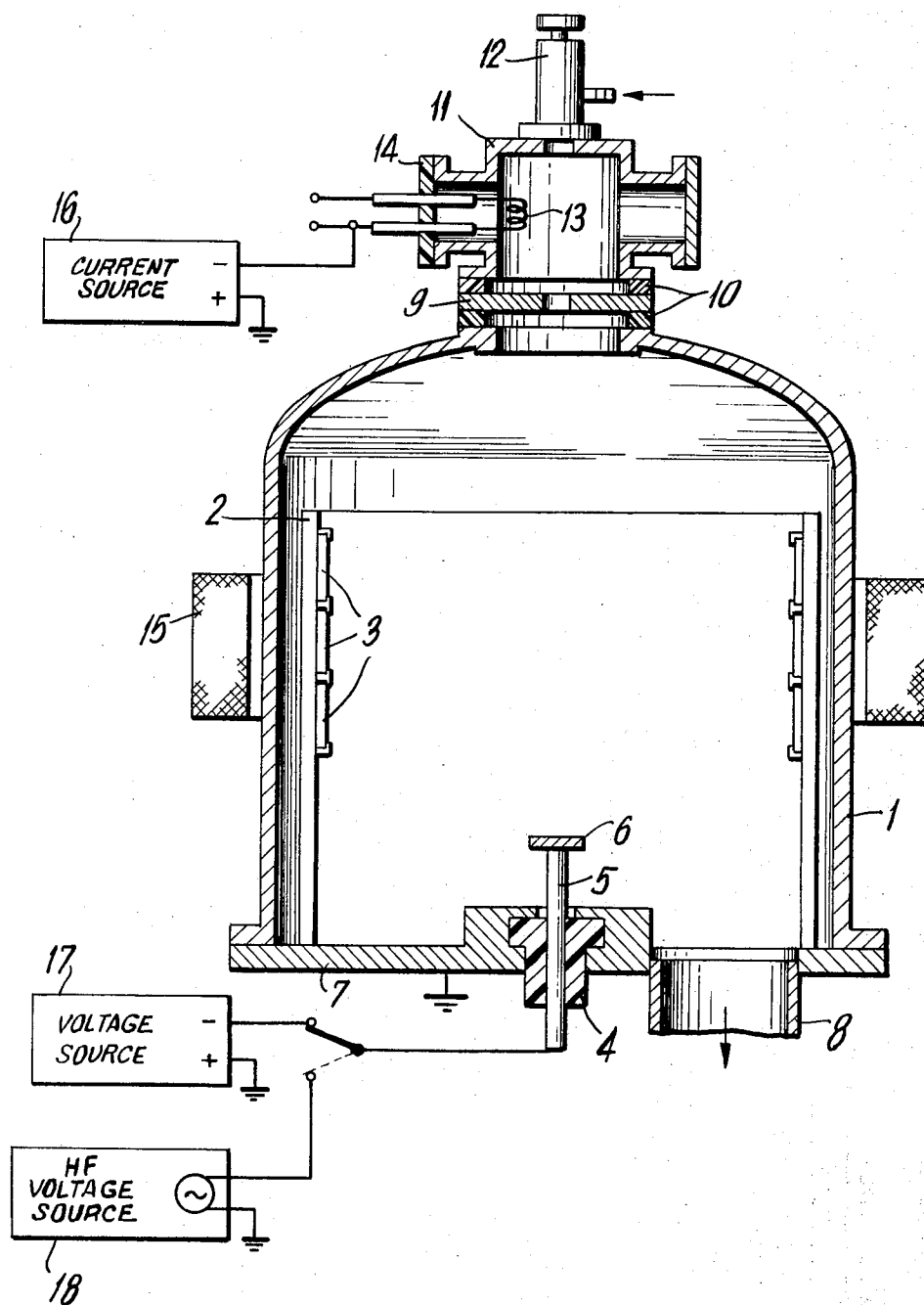
Attorney, Agent, or Firm—McGlew and Tuttle

[57] **ABSTRACT**

A device for sputtering coating material by means of a low voltage arc discharge comprises a hot cathode disposed in a cathode chamber into which gas to be ionized is introduced, and a sputtering chamber which can be evacuated and in which the anode, the material to be sputtered, and the supporting structures for the workpieces to be coated are arranged. The cathode chamber and the sputtering chamber are electrically insulated from each other and mutually separated by a partition wall which comprises a central aperture through which the two chambers communicate. The anode may be an insulated electrode or, preferably, is formed directly by a bottom portion of the sputtering chamber. The material to be sputtered (the target) is preferably arranged in the axis of the arc discharge. In order to avoid erosion of the sputtering chamber walls and of the supporting structures or also contamination of the workpieces by disruptive discharges from the arc, the electric connection is provided such that, during operation, the cathode and the cathode chamber have a negative potential in respect to the walls and the equipment of the sputtering chamber.

8 Claims, 1 Drawing Figure





TRIODE DEVICE FOR SPUTTERING MATERIAL BY MEANS OF A LOW VOLTAGE DISCHARGE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates, in general, to vacuum treating of workpiece surfaces and, in particular, to a new and useful device for sputtering coating material by means of a low voltage arc discharge, which includes a triode arrangement comprising an anode provided in a sputtering chamber, a hot cathode located in a separate ionization chamber, the two chambers communicating through an aperture provided in a common, electrically insulated partition wall, and a target to be sputtered which is positioned preferably in the axis of the gaseous discharge.

2. Description of the Prior Art

Known types of sputtering devices comprise a sputtering chamber in which a low pressure can be created and in which the arc discharge, bunched by an axial magnetic field, extends between a hot cathode disposed in a separate chamber and an anode which is located in the sputtering chamber and has a positive potential in respect to the walls of the same. Supporting structures for the target to be sputtered as well as for the pieces or substrates to be coated by the pulverized material are also disposed in the sputtering chamber.

A service-proved device of this type (Swiss Pat. No. 456,249) is characterized in that the material to be sputtered is placed on a support which is surrounded by an annular anode.

The known types of triode arrangements show a drawback inasmuch as during operation, there is a constant danger of electric breakdowns between the anode and the walls of the sputtering chamber or the equipment (for example supporting structures for the workpieces) located therein. Even in the absence of breakdowns, the inner surfaces of the sputtering chamber walls and the equipment surfaces are, because of the potential difference between the same and the plasma, in a certain extent exposed to sputtering by the impact of incident ions escaping from the arc. This not only causes damage by an undesirable erosion of the surfaces but above all entails a contamination of the applied coatings. Besides, in one of the modes of operation with the known device in which it was intended to deposit electrically non-conducting materials, i.e., insulators, the application of a high-frequency voltage to the structure supporting the substance to be sputtered resulted in a strong coupling between the high-frequency current and the direct current circuit of the arc discharge with the risk of overloading the latter.

Another shortcoming of the known devices for sputtering insulators by means of an arc discharge while a high-frequency voltage is being applied to the target, is an unintentional coating of the electrodes by the pulverized insulating material. For this reason, it has been impossible to use reactive sputtering methods for depositing dielectric coatings. A further problem has been the back-sputtering of the substrates to be coated or of the walls of the sputtering chamber, caused by drops of the high-frequency voltage.

Thus, up to date, in most cases capacitive high-frequency discharges are used for depositing dielectric coatings. However, even these so-called diode-high-frequency-discharges show some serious drawbacks. The

carrier density in such a discharge is low (10^{10} to 10^{11} per cm^3) even under relatively high pressures (p 10^{-2} torr) so that high voltages are necessary to obtain the desired sputtering rates. Thereby, aside from the constructional problems connected thereto, the stress the substrates undergo owing to the bombardment by secondary electrons is markedly increased. Moreover, the productive capacity of such devices is limited because the useful surface of the substrates is always smaller than the target surface. On the other hand, low voltage arcs attain carrier densities of 10^{12} to 10^{13} particles per cm^3 . This makes it possible, with low target-voltages, to effect a high-rate metal sputtering even in the 10^{-4} torr range. The bombardment of the substrates by secondary electrons may in this case be largely avoided by application of static magnetic fields.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a device for sputtering coating material by means of a low voltage arc discharge, including a cathode chamber in which a hot cathode is disposed and, preferably, the gas to be ionized can be introduced, and a sputtering chamber or vessel which can be evacuated and which comprises the anode, the target or material to be sputtered, and the equipment necessary to support the pieces or substrates to be coated. The two chambers are separated by a common partition wall and are electrically insulated from each other. However, the two chambers are in communication with each other through a central aperture provided in the partition wall. The electrical connecting circuit is arranged so that during operation, the cathode and the cathode chamber have a negative potential in respect to the walls and the supporting structures of the sputtering chamber.

Owing to the utilization of two mutually insulated chambers and to the negative electric potential of the cathode and the cathode chamber in respect to the walls of the sputtering chamber, the plasma column of the arc also is brought to a negative potential in respect to the walls of the sputtering chamber so that sputtering of these walls is not possible. The same applies to the supporting structures of the sputtering chamber which have the same potential as the chamber walls.

It is advantageous to electrically insulate the partition wall provided between the two chambers against the walls of the sputtering chamber, either by providing an electrically insulating layer on the partition surface facing the sputtering chamber or, in case the partition is metallic, by providing a corresponding insulation between the partition and the sputtering chamber.

In the inventive device, the bottom part of the sputtering chamber can itself serve as an anode. However, a separate electrode may also be provided to which the necessary voltage is applied through a bushing insulator mounted in the wall of the sputtering chamber. In this case, it is useful to apply to the anode a negative potential against the wall of the sputtering chamber.

The application of the invention is in no way limited to coating workpieces or substrates but may also be useful for an anodic oxidation treatment in a glow discharge in oxygen. To such a purpose, oxygen is introduced into the device through a valve.

Accordingly, it is an object of the invention to provide a device for sputtering coating material by means of a low voltage arc discharge, including two separate

chambers, namely a cathode chamber in which a hot cathode is disposed, and a sputtering chamber comprising the anode, the target to be sputtered, and the supporting equipment for the objects to be treated and for the target.

Another object of the invention is to provide between the two chambers a common partition wall which is electrically insulated at least from the walls of the sputtering chamber and is provided with a central aperture through which the two chambers communicate.

Still another object of the invention is to provide an electric circuit arrangement ensuring that during operation, the cathode and the cathode chamber have a negative potential in respect to the walls and the supporting structures of the sputtering chamber.

According to a further feature of the invention, a portion of the sputtering chamber walls may directly serve as anode for the arc discharge or a separate anode may be provided which is insulated from the sputtering chamber walls and, during operation, preferably has a negative potential against these walls.

Another feature of the invention is that, preferably, the cathode chamber is provided with an inlet for the gas to be ionized, the sputtering chamber is provided with a connection means for evacuation, and a valve may be provided through which oxygen is introduced for an anode oxidation treatment.

Still another feature of the invention is that, preferably, the target is arranged in the axis of the arc discharge.

A further object of the invention is to provide a device for the vacuum treatment of workpieces which is simple in design, rugged in construction and economical to manufacture.

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

In the single Drawing, the FIGURE shows schematically a vertical cross-sectional view of a device for sputtering coating material according to the invention.

GENERAL DESCRIPTION OF PREFERRED EMBODIMENT

Referring to the Drawing in particular, the inventive device embodied therein comprises an apparatus for vacuum coating of workpieces by sputtering coating material by means of a low voltage arc discharge, comprising a sputtering vessel or chamber 1 which can be evacuated through a tubular connection 8 and is equipped with supporting structures 2 on which objects or workpieces 3 to be coated are arranged. The target or material to be sputtered 6 is disposed on a conducting support or rod 5 through which the working voltage is applied to the target and which passes through a bushing provided in the base plate 7 of the sputtering chamber.

A cathode chamber 11 is arranged on the top of the sputtering chamber 1 adjacent to a top opening thereof and the two chambers are separated by a partition 9 which is electrically insulated from both sides by insulating rings 10. The partition is provided with a central aperture through which the cathode chamber 11 communicates with the sputtering chamber 1. The cathode chamber 11 serves as ionization chamber into which

the gas to be ionized is introduced, in dosed quantities, through a needle valve or gas injection nozzle 12. A hot cathode 13 is disposed in the cathode chamber 11 and fed with heating current over lead-in wires passing through an insulating flange plate 14.

A coil 15 surrounding the sputtering chamber 1 is provided for producing an axial magnetic field which bunches or concentrates the arc discharge.

In operation, the base plate 7 of the sputtering chamber 1 is on ground potential while the hot cathode 13 disposed in the ionization chamber is connected to the negative pole of a source 16 generating high direct currents and having its positive pole grounded.

There are further provided a voltage source 17 furnishing direct voltage of several thousand volts and an alternating voltage source 18 furnishing, preferably, high-frequency voltage. In accordance with the process provided, the source 17 for direct voltage sputtering or the source 18 for alternating voltage sputtering is applied to the target 6. The arc discharge is maintained between the hot cathode 13 provided in chamber 11 and the base plate 7 of the sputtering chamber. The target, which preferably is positioned in the axis of the arc discharge, is thereby sputtered with great efficiency.

While a specific embodiment of the invention has been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A device for treating workpieces under vacuum conditions by using a low voltage arc discharge, particularly a triode device for sputtering coating material, including a vessel having a cathode housing portion defining a cathode chamber having conductive walls in which a hot cathode is disposed and a sputtering chamber housing portion having conductive walls defining a sputtering chamber which can be evacuated and which includes an anode, a support for the material to be sputtered located in said sputtering chamber opposite to said cathode chamber, means in said sputtering chamber to support a workpiece to be treated, a partition wall dividing said sputtering chamber housing portion from said cathode chamber housing portion area being electrically insulated from each chamber and having a central aperture therethrough, and an electric circuit arrangement being provided which insures that, during operation, said anode has the same potential as said sputtering chamber.

2. A device for treating workpieces under vacuum conditions according to claim 1, wherein said anode is formed by a portion of the wall of said sputtering chamber.

3. A device for treating workpieces under vacuum conditions according to claim 1, wherein said partition wall separating said two chambers is electrically insulated both from said cathode chamber and from said sputtering chamber walls.

4. A device for treating workpieces under vacuum conditions according to claim 1, wherein said partition wall is provided at least on its side facing said sputtering chamber with an electrically insulating surface.

5. A device for treating workpieces under vacuum conditions according to claim 1, wherein said partition wall is made of metal and electrically insulated against both of said chambers.

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6. A device for treating workpieces under vacuum conditions according to claim 1, wherein the walls of said cathode chamber are electrically insulated against the walls of said sputtering chamber, against said partition wall, and against said hot cathode.

7. A device for treating workpieces under vacuum conditions according to claim 1, including an inlet for

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the gas to be ionized connected into said cathode chamber.

8. A device for treating workpieces under vacuum conditions according to claim 1, including a valve connected to said vessel through which oxygen may be introduced for an anode oxidation treatment.

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