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SPUTTERING APPARATUS WITH FINNED ANODE

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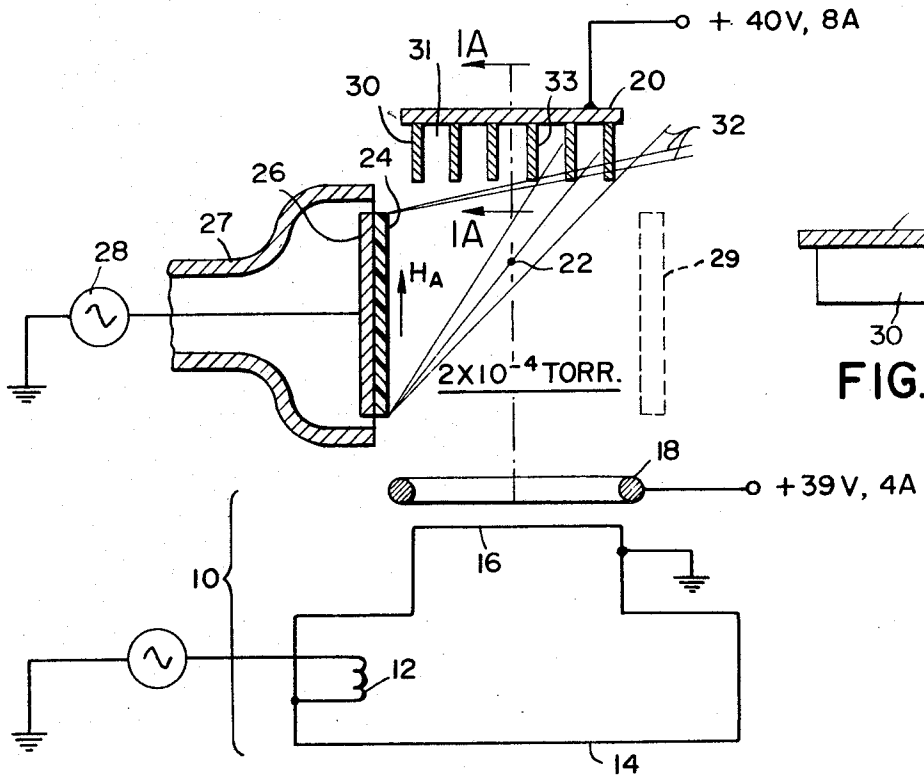


FIG. IA

FIG. 1

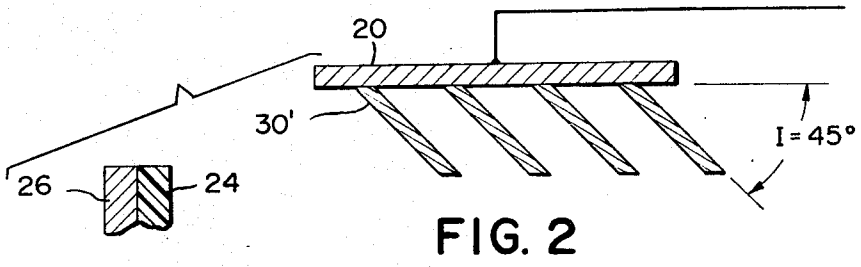


FIG. 2

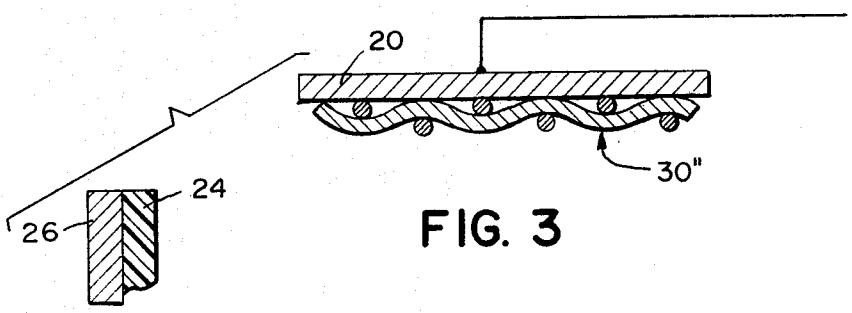


FIG. 3

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SPUTTERING APPARATUS WITH FINNED ANODE

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ABSTRACT OF THE DISCLOSURE

A low energy sputtering apparatus is provided with a finned anode to mask parts of the anode from sputtered target material.

This application relates to sputtering equipment and particularly to low energy sputtering equipment used for sputter coating of insulator materials.

It is already known in the art from the publications of Wehner and co-workers to sputter materials in vacuum by using a separate anode, cathode and target electrodes wherein a plasma is formed by electrons moving from cathode to anode and colliding with residual gas molecules in the vacuum to form positive ions. The target electrode is biased to attract the ions which impinge into the target and "sputter" particles off the target surface. The particles may be intercepted and collected on a substrate to build up as a coating. This prior art also teaches the necessity of applying a high frequency alternating voltage as the target bias when the target is made of insulating material to periodically neutralize a build-up of positive charge on the target surface.

We have discovered that the sputtering of insulators leads to a problem wherein the sputtering is difficult to maintain continuously. The source of this problem is that sputtered insulator material from the target collects on the anode as well as the substrate and as this process goes on, the voltage at the anode rises while anode current drops. In a short time, the plasma extinguishes.

It is the object of the invention to provide an improved sputtering apparatus which substantially solves this problem allowing continuous sputtering of insulators at low anode voltage.

This object is achieved, in general, by a new construction of anode comprising fins on the anode extending inwardly towards the plasma to define troughs therebetween which are open to and substantially facing the electron source and partially masked from the target so that there is no clear line of sight path from the target to these masked areas. Of course, secondary collisions lead to eventual coating of the troughs by the target material and eventual extinguishment of the plasma.

But using this anode we have demonstrated the ability to run in a low energy sputtering of quartz for over an hour, and substantially more, without the onset of drastic voltage rise. This is sufficient for many practical purposes and we have established the feasibility of this concept for tailoring other anodes to other insulator sputtering tasks.

Other objects, features and advantages of the invention will in part be obvious and will in part appear hereinafter.

The invention is now specifically described with reference to the accompanying drawings in which FIG. 1 is a diagram of the apparatus arranged according to a preferred embodiment of the invention and FIGS. 2–3 are drawings of modified anodes for use in the arrangement of FIG. 1.

Referring to FIG. 1 there is shown an electron source assembly **10** including a thermionic filament **12** enclosed by a grounded enclosure **14** having an exit port **16**.

Adjacent to the exit port is an auxiliary anode (or grid) electrode **18**. An anode electrode is provided at **20**. Electrons are emitted at the filament and drawn to anode **20** along an electron path coinciding approximately with the axis **22**. A plasma is produced along the electron path consisting of the electrons and ions produced by collision of the electrons with gas molecules. A sputtering target **24** of insulating material, such as quartz, is mounted on a supporting electrode **26** connected to a radio frequency power source **28**. A grounded Paschen shield **27** is provided for the target electrode. A substrate to be coated with sputtered target material may be located at **29**. Of course, the apparatus may be used without the substrate, for instance for etching the target material, or with the vacuum vessel as a substrate for use as a getter ion pump. All of the electrodes—anode **20**, target **26**, grid **18** and enclosure **14**—are cooled by appropriate cooling means not shown. The anode is biased to about 40 volts by a power supply (not shown), the grid is biased to about 39 volts by a power supply (not shown). The filament **12** is powered by standard industrial house power. All the above apparatus is contained in an hermetically sealed vacuum vessel (not shown) evacuated to about 2×10^{-4} torr as indicated in the drawing. A magnetic field is produced in the direction H_A by a magnet (not shown) to focus the electrons.

All the above described apparatus is prior art with respect to the present invention.

According to a distinct preferred embodiment of the present invention, fins **30** are added to the anode **20**. Typically, in a 6 inch diameter anode **20**, made of ⅛ inch thick steel of copper disk, the fins are steel or copper plates 1 inch wide, 5 inches long, 1/16 inch thick and spaced about ½ inch apart, or with spacing at least equal to or greater than the width of the fins or, in other terms, the spacing being at least equal to or greater than the depth of the troughs **31** formed between fins and opening toward the plasma.

Typically the target **24** is a 6 inch long sheet and typical line of sight paths for material sputtered from the target are indicated by lines **32** with the fins providing very effective masking provided in certain regions of the anode structure, e.g. at **33**. Of course, the masked regions will eventually be coated with sputtered insulator material due to secondary collisions of sputtered material in flight. But this coating of masked areas will occur later and at a slower rate than the directly exposed anode structure.

FIG. 2 shows a second embodiment of the invention wherein the fins **30** on anode **20** are inclined away from the target **24** at an angle I equal to 45 degrees to enhance masking.

FIG. 3 shows a third embodiment of the invention wherein the masking is provided by a wire mesh **30″** spot welded to the anode **20**.

Still other embodiments may be made within the scope of the invention. For instance, where the target **24, 26** is a solid or transparent (helix or cage) cylinder instead of the flat plate structure of FIG. 1 concentric ring fins would be more appropriate than the flat plate fin structure of FIG. 1. Also, the fins could be made of different widths to provide troughs **31** of different depths or the fins might be bent for more effective masking and made non-conductive to minimize disturbance of the electrical field of the apparatus.

As another variation the troughs **31** could be formed of grooves milled out of a block anode structure.

Still other variations within the scope of the invention will occur to those skilled in the art. It is therefore intended that the above disclosure shall be read as illustrative and not in a limiting sense.

What is claimed is:

1. In a sputtering device comprising an anode, an electron source and a sputter-target disposed in a vacuum zone with the electron source producing electrons moving along an electron path from said source to the anode and the target being essentially parallel to and offset from said path and biased to attract, to a face thereof opening toward the electron path, ions formed in a plasma in the region of said path by collison between the electrons and residual gas molecules of said vacuum, said anode extending in cross-section transversely to the electron path, and having a surface facing the electron path, said surface being per se in line-of-sight relation to said sputter target face, the improvement comprising projections on said anode surface extending away from said surface to at least partially block said line-of-sight relation to said target surface.

2. The apparatus of claim 1 wherein the anode has the form of a plate extending transversely to the electron path and the masking is provided by troughs opening towards the plasma.

3. The apparatus of claim 2 wherein the troughs are formed by fins attached to an anode member and extending parallel to said target.

4. The apparatus of claim 2 wherein the troughs are deeper than they are wide.

References Cited

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