

[54] **WORKPIECE SUPPORT FOR GLOW DISCHARGE APPARATUS**

2,762,945 9/1956 Berghaus et al. 315/185
3,141,989 7/1964 Jones et al. 313/210

[75] Inventors: **Claude K. Jones**, Marblehead; **Stuart W. Martin**, Salem, both of Mass.

Primary Examiner—Palmer C. Demeo

[73] Assignee: **General Electric Company**, Schenectady, N.Y.

Attorney—William C. Crutcher and James W. Mitchell

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[51] Int. Cl. **H01j 1/88**

[58] Field of Search **313/185, 210, 281, 313/282**

[56] **References Cited**

UNITED STATES PATENTS

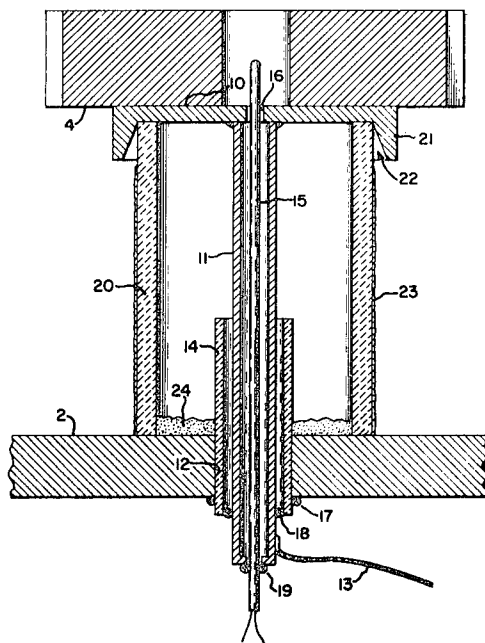
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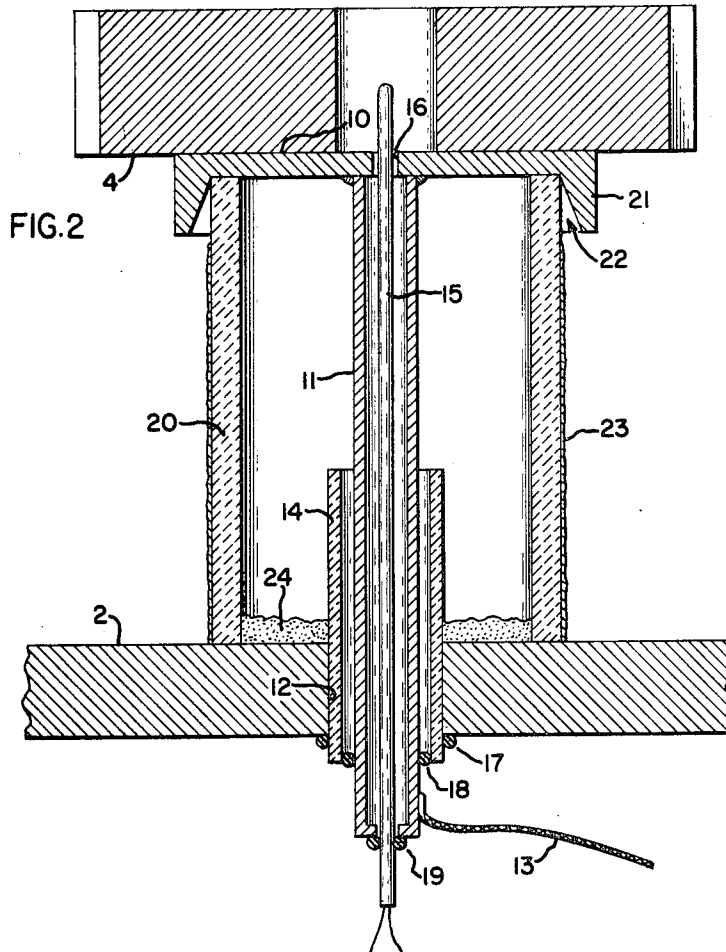
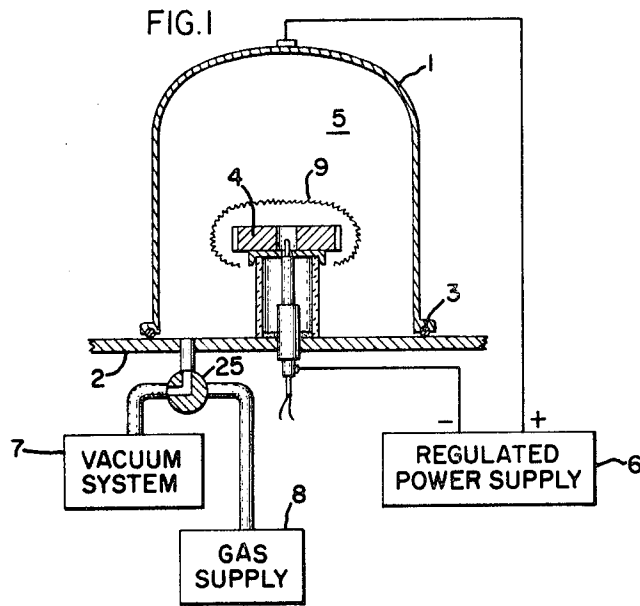
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ABSTRACT

An insulating support for the workpiece in a glow discharge apparatus. A workpiece table rests on and forms an acute angle with an insulating ceramic tube. A thin poorly conductive layer of sputtered metal deposit on the exterior of the tube, except at the location of the table and tube junction, forms a self-adjusting layer with a continuous potential gradient which suppresses arcing after the glow is established.

5 Claims, 2 Drawing Figures





WORKPIECE SUPPORT FOR GLOW DISCHARGE APPARATUS

BACKGROUND OF THE INVENTION

This invention relates generally to a workpiece support for glow discharge apparatus used to carry out ion nitriding and the like, and more particularly relates to an insulating support which reduces the tendency toward arcing.

A glow discharge is the process of placing a workpiece in an air tight chamber containing a selected gas or mixture of gases at reduced pressure and establishing an electrical potential between the workpiece and the chamber or an auxiliary electrode under conditions which form a glow discharge around the workpiece. Various processes can be carried out in the glow discharge. For example, ion nitriding can be carried out to form a hard nitride layer on the workpiece if the atmosphere in the chamber includes nitrogen. One of the limitations with the glow discharge process is the tendency of the glow discharge to break down into an arc which damages the workpiece. Insulating materials which might be used to support the workpiece and to insulate it from the container are susceptible to damage also from the normal action of the glow.

It has been suggested in U.S. Pat. No. 3,141,989 issued to C. K. Jones and S. W. Martin on July 21, 1964 and assigned to the present assignee, that a workpiece may be supported by a conducting member with insulators at the junction between the conducting member and the workpiece and at the junction between the conducting member and the base, provided that the insulators are protected by a surrounding gap which the glow cannot enter. The conducting member then assumes a potential which "floats" between that of the workpiece and the base and the tendency toward arcing is reduced. Although this type of support is satisfactory for very heavy workpieces, it requires special assembly of the various components and must be separate from the electrode lead which is connected to the work table.

It is well known that the insulating members associated with the electrode itself may also be protected from the action of the glow by judicious selection of dimensions at the junctions between insulating and conducting members so as to form acute angles or narrowed gaps into which the glow cannot penetrate. Exemplary of such constructions are U.S. Pat. Nos. 2,762,945 and 2,929,947, both issued to B. Berghaus and H. Bucek. These constructions employ very complex assemblies as a means of protecting the insulators which are associated with the workpiece electrode lead.

Accordingly, one object of the present invention is to provide a simple and effective insulating workpiece support which reduces tendency toward arcing of a workpiece in a glow discharge apparatus.

Another object of the invention is to provide a simple workpiece support which also serves to shield the electrode and the electrode insulators from the glow discharge.

SUMMARY OF THE INVENTION

Briefly stated, the invention comprises a ceramic tube support which surrounds the insulated workpiece electrode. The electrode is connected to a workpiece table resting on the ceramic tube and forming an acute angle with the top exterior tube surface. A sputtered

metal deposit on the ceramic tube exterior provides a surface with a continuous potential gradient, reducing arcing tendency. The interior of the ceramic tube is provided with means to prevent a glow from taking place in the interior thus protecting the electrode and insulator.

DRAWING

The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of practice, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which:

FIG. 1 is a simplified elevation view, in section, of a glow discharge apparatus, and

FIG. 2 is an enlarged cross sectional view of the workpiece support and electrode assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIG. 1 of the drawing, a metal dome 1 is attached to a metal supporting base 2 by suitable means (not shown) and provided with a gas tight seal 3. Dome 1 and base 2 are of electrically conductive material to permit establishing a glow discharge with a workpiece 4 disposed in a chamber 5, by establishing a suitably controlled electrical potential. The glow current is supplied by a power source 6 and may be A.C. but is preferably D.C. with the workpiece 4 connected to the negative terminal. A three-way valve 25 permits connecting chamber 5 first to a vacuum system 7 and then to a gas charging system 8 to allow chamber 5 first to be evacuated and then to be supplied with a suitable atmosphere for conducting an operation on workpiece 4. Under proper conditions, a glow 9 is established around the workpiece.

Referring now to FIG. 2 of the drawing which illustrates the preferred form of the invention, the workpiece 4 rests on an electrically conductive workpiece table 10 which is electrically connected on its underside to the electrode 11. Electrode 11 extends downwardly through a hole 12 in the base 2 of the apparatus and is connected to the negative power lead 13. Electrode 11 is insulated from base 2 by means of a Pyrex insulating tube 14. A thermocouple sheath 15 passes upward through the inside of electrode 11 and through a hole 16 in the workpiece table. Suitable gas tight seals, indicated only diagrammatically, are shown at 17, 18 and 19 to seal the spaces between the aforescribed members.

In accordance with the present invention, the workpiece table rests on a ceramic tube 20 which surrounds the electrode 11 and its insulator 14. Tube 20 is preferably formed from Alundum (Al_2O_3), which is one of the cheapest and strongest ceramics. Zirconium, beryllium, or various oxide ceramics would also be suitable, but they are more expensive.

The workpiece table 10 has an overhanging circumferential lip 21 which diverges downwardly on its inner edge at an angle of approximately 20° to 30° from the surface of ceramic tube 20. This is a critical feature of the invention since the acute angle is chosen to prevent entry of the glow discharge into the converging gap 22 between lip 21 and tube 20.

Covering the exterior of tube 20 except in the area of gap 22 is a thin sputtered metal deposit or layer formed by a method to be described which preferably has a resistivity on the order of 10^6 to 10^7 ohm-cm.

Lastly, a protective layer of granulated insulating material 24 is disclosed on the floor of the apparatus between electrode insulator 14 and ceramic tube 20 inside the ceramic tube. This may be chosen from the oxides of aluminum, zirconium, berillium etc., but ordinary washed beach sand is entirely satisfactory, since it is fairly coarse, absorbs very little gas, is easy to use and is inexpensive. Granular material is not necessary for layer 24. A ceramic washer would also perform the same function of preventing establishment of a glow between the underside of table 10 and base 2.

The sputtered metal deposit 23 forming a conductive, but high-resistance layer on tube 20 is carefully created during the first few runs starting with a clean tube and building up sputtered metal from the workpiece and workpiece table. Care is exercised in the first few runs to use low glow discharge power so that the layer is established. After this, no further attention is necessary since the thickness of the layer becomes self-adjusting. The gap 22 prevents entrance of the glow or formation of a sputtered metal layer at the top of the tube. Therefore the workpiece table remains insulated from the base.

OPERATION

The operation of the invention is as follows. Inside the ceramic tube 20, the insulating layer 24 of sand prevents the establishment of a glow. Thus the electrode insulator 14 is protected from the damaging effects of glow discharge.

On the outside of tube 20, the resistance of the conductive but high resistance metal layer tends to establish a uniform potential gradient between the workpiece table and the base. This reduces the tendency toward establishment of an arc between the base and the workpiece or workpiece table.

The resistance of layer 23 varies with the thickness of the layer. As more metal is deposited, the resistance is lower and increased heating "boils" the excess metal off so that the layer reaches an equilibrium thickness and resistance. In this manner the layer 23 becomes self-controlling.

Thus there has been described a very simple insulating support which through a self-controlling conductive layer provides uniform potential gradient, and which also surrounds and protects the electrode insulator from glow damage. While other modifications of the invention will become apparent to those skilled in the

art, it is desired to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A workpiece support for glow discharge apparatus comprising:

- a conductive base in said apparatus,
- a ceramic tube disposed on said base,
- a workpiece table supported on said tube and having portions forming a protective gap around the top exterior surface of the tube, said gap being dimensioned to restrict entry of the glow,
- a conductive layer substantially coating the exterior of the tube with the exception of the area protected by said gap, and
- an insulated electrode entering said base, extending through the tube and electrically connected to said workpiece table.

2. The combination according to claim 1, wherein said workpiece table portions comprise a lip extending downwardly around the top exterior surface of said tube and forming an acute angle therewith on the order of 20° to 30° .

3. The combination according to claim 1, wherein said conductive layer comprises a sputtered metal deposit having an overall resistivity on the order of 10^6 to 10^7 ohm-cm.

4. The combination according to claim 1, wherein said base is covered with a layer of insulating material between the inside of said ceramic tube and the outside of said insulated electrode in order to prevent establishment of a glow inside the tube.

5. A workpiece support for glow discharge apparatus comprising:

- a conductive base in said apparatus,
- a cylindrical ceramic tube disposed on said base,
- a circular workpiece table supported on said tube and having a circumferential depending lip extending downwardly around the top edge of said tube and forming an acute angle therewith on the order of 20° to 30° ,
- a sputtered conductive metal layer on the exterior of said ceramic tube with the exception of the surface portion thereof which is surrounded by said lip,
- a second insulating tube extending through said base into the interior of the ceramic tube,
- a layer of insulating material on the base in the space between said tubes, and
- a conductive electrode member extending through said second insulating tube and electrically connected to the underside of said workpiece table.

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