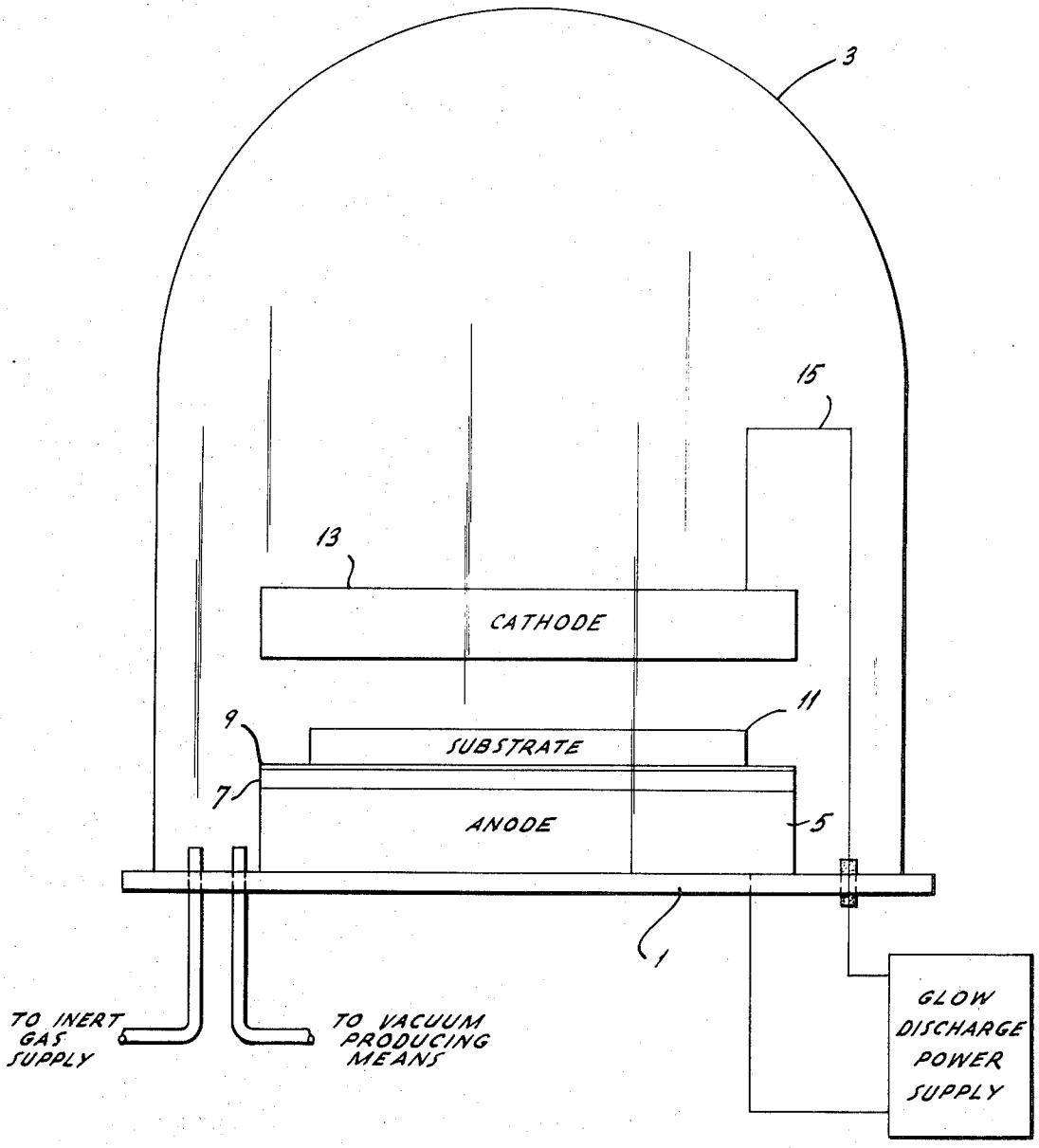
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CATHODIC SPUTTERING METHOD

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CATHODIC SPUTTERING METHOD

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ABSTRACT OF THE DISCLOSURE

A cathodic sputtering method for depositing a thin film of cathode material on a substrate comprising the steps of positioning the substrate adjacent an anode surface coated with a material having properties similar to those of the substrate, and sputtering the substrate and the coating on the anode surface. Because of the anode coating, the anode "looks" to the cathode much like the substrate and therefore a thin film having uniform electrical resistance is produced over the entire surface of the substrate.

This is a division of application Ser. No. 568,321, filed July 27, 1966, now abandoned.

The present invention relates to a method of producing cathodic sputtered films and more particularly to a method of controlling the composition of the film through control of the composition of the anode surface in the cathodic sputtering apparatus.

The advent of integrated electronic circuits has generated a need for high quality thin films for use as resistors, conductors, and capacitors. Cathodic sputtering has proved a useful method of forming high quality thin films. Cathodic sputtering is characterized by the removal of cathode material by ionic bombardment of the cathode and the subsequent deposition of the removed cathode material upon a substrate situated adjacent the anode electrode.

It has long been noted that in any cathodic sputtering apparatus only limited areas of a substrate situated on or adjacent the anode electrode could be reliably coated to form thin films. The electrical resistance of the coating at the center of the substrate is generally different than that around the edges of the substrate.

It is theorized that the non-uniformity of electrical resistance across the substrate is due to re-emission of particles from the substrate and anode surfaces. That is, some of the sputtered cathode material and/or ions from the glow discharge bombard the substrate surface and the anode surface adjacent the substrate with sufficient energy to expel particles from these surfaces. The expelled particles are generally deposited on the anode and/or substrate surfaces near the point of their expulsion. However, some of the expelled particles may be deposited on the cathode.

When particles are expelled by cathode material bombardment from a point in the central portion of the substrate, they are generally deposited on an adjacent area of the substrate. Since the entire area adjacent the point is composed of the same material as the material at the point and is also being bombarded by cathode material, it is probable that the particles expelled from points in the central portion of the substrate will be replenished by other substrate particles re-emitted from the substrate area adjacent the points.

However, when particles are expelled from points near the edges of the substrate, many of the particles are not deposited on an adjacent area of the substrate. The particles that are not deposited on the substrate are deposited on the anode surface adjacent the points of their

expulsion. Since the anode and substrate surfaces of prior art cathodic sputtering apparatus are composed of different materials, they have different surface properties. The difference in surface properties causes the quantity and energy of particles re-emitted from the respective surfaces to be different for equal bombardment. Hence, there is no longer the probability that most of the particles re-emitted from points near the edges of the substrate will be replenished by particles re-emitted from the substrate and anode surfaces adjacent the points. Further, since the structure of the film is affected by the energy of each particle being deposited, the structure of the film may be altered near the edges of the substrate. Therefore, the thin films that are formed at the edges of the substrate have a different resistivity than those formed in the central portion of the substrate.

An object of the present invention is to provide a method for forming thin films of uniform electrical resistance.

A further object of the present invention is the elimination of the adverse effects of re-emission from the substrate and anode surfaces during cathodic sputtering.

According to the present invention, thin films are produced by a method comprising the steps of positioning a substrate to be sputtered adjacent an anode surface coated substantially uniformly with a material having properites similar to those of the substrate and sputtering the substrate and the coating on the anode surface. As a result of the coating on the anode surface, the inequality of re-emission between the anode and the substrate is overcome and the non-uniformity of the electrical resistance at the edges of the substrate disappears.

In a preferred embodiment of the present invention, the uniformity of the electrical resistance of the thin film coatings is further improved by making the anode coating smooth and by allowing a thin coating of sputtered cathode material to build-up on the anode coating. The thin coating of sputtered cathode material functions to counterbalance the re-emission of cathode material that has previously been deposited on the substrate.

The above objects and other objects inherent in the present invention will become more apparent when read in conjunction with the following specification and drawing in which:

The sole figure shows an apparatus suitable for practicing the method of the present invention.

Referring to the drawing, there is shown a base plate **1** having a portion thereof covered by a bell jar **3**. An anode electrode **5** is situated on one side of the base plate **1**. On the end of the anode **5** remote from the base plate **1**, the anode **5** is partially covered by a first anode coating **7** and by a second anode coating **9**. A substrate **11**, upon which the thin film is to be formed, is situated on the coating **9**. Spaced from the substrate **11** is a cathode electrode **13** composed of the material to be sputtered, such as a refractory metal. The coatings **7** and **9** may be composed of the same materials as the substrate and cathode, respectively, or of materials having properties similar to those of the substrate and cathode, respectively. Coating **7** is also made as smooth as the surface of the substrate **11**.

The cathode **13** is connected by means of a lead **15** to the negative terminal of a glow discharge power supply **17**. The positive terminal of the power supply is connected to the anode **5** by means of a lead **16**.

Means (not shown) are provided for producing a vacuum in the region enclosed by bell jar **3**. The vacuum is necessary to eliminate reactive gases from the enclosed region and hence prevent contamination of the thin films that are formed. Means (not shown) are provided for supplying an inert gas to the region enclosed by bell jar **3**. Preferably the inert gas is argon, although krypton or helium may be substituted for argon.

The mode of operation of the apparatus of the drawing and the advantages of the method of the present invention are set forth below.

After the reactive gases are removed from the enclosed region, an inert gas is supplied to the region by the inert gas supply (not shown). The cathode **13** and the anode **5** are then connected across the glow discharge power supply **17**. The potential difference between cathode **13** and anode **5** produces a discharge or plasma between the electrodes that ionizes the inert gas. The positive gas ions produced as a result of ionizing the inert gas bombard the cathode **13** causing it to "sputter."

The sputtered particles bombard the anode and the substrate to be coated. Since the particles sputtered from the cathode strike the substrate at high velocities, many of the sputtered particles "stick" to the substrate. However, some sputtered particles reaching the substrate cause re-emission of particles of the cathode material previously deposited on the substrate and particles of the substrate. Most of the re-emitted particles from the central portion of the substrate are replenished by other particles re-emitted from the adjacent area of the substrate. However, many of the particles re-emitted from the substrate near its edges have a component of motion that deposits them on the adjacent anode surface rather than on an adjacent area of the substrate surface. As explained above, if the substrate and the anode surfaces are not of the same material, the number of particles re-emitted from the substrate and anode surfaces is different for an equal amount of cathode material bombardment. This causes a non-uniform coating to be formed on the substrate. Furthermore, since the particles re-emitted from the anode surface have different properties than those of the substrate material, the anode particles that are deposited on the substrate by prior art methods alter the substrate's electrical chaarcteristics.

In the apparatus shown in the drawing, the coating **7** and the coating **9**, to a lesser degree, correct the inequality of re-emission between the anode and substrate surfaces. Due to the coatings **7** and **9** having the same or similar properties as the substrate **11** and the cathode material, respectively, the amount of energy required to re-emit particles from the surfaces of the anode and substrate is approximately equal. Making the coating **7** as smooth as the substrate surface also helps equalize the energy required to re-emit particles from both surfaces. Therefore, the number of particles re-emitted from the anode surface adjacent the edges of the substrate and deposited on the edges of the substrate will approximately equal the number of re-emitted substrate particles deposited on the anode and the coating on substrate **11** will be uniform throughout the entire substrate.

Although the anode coating **9** will inherently build-up and cover the anode coating **7**, sputtered cathode particles have sufficient energy to affect the underlying coating **7**.

As previously stated, the anode coating **7** is composed of a material having the same or similar properties as those of the substrate **11**. Atomic mass, binding energy, and crystal orientation are samples of the properties of the two materials that should be similar. For example, if microcircuits having a silicon dioxide substrate are to be sputtered, a glass coated anode may be used.

Selection of the anode surface coating **7** can also be used to alter the mean resistivity of the deposited thin

films. For example, various doping agents might be introduced into the thin film to be formed by using an appropriate anode coating **7**. The bombardment of the anode by the sputtered cathode material will result in emission of the doping agents and the deposition thereof on the substrate surface.

While the method of the present invention has been described with reference to apparatus including components of certain types and configurations, it will be apparent to one skilled in the art that various modifications and departures in this apparatus can be made without departing from the scope of the present invention as set forth in the appended claims. For example the positive ions used to bombard the cathode could be generated by ion guns, electron beams, or radio frequency excited plasmas. Furthermore, coating **9** does not have to be formed prior to the sputtering operation. The coating will be formed the first time that the apparatus is used. Although the first thin film formed without the coating **9** first being applied is slightly inferior compared to subsequent films formed, it is still very much superior to thin films formed by prior art methods.

I claim:

1. A method of sputtering comprising the steps of:
positioning a substrate to be sputtered, composed of a composition selected from the group consisting of glass and silicon dioxide, adjacent an anode surface coated substantially uniformly with a material also selected from the group consisting of glass and silicon dioxide, and
sputtering said substrate and said coating on said anode surface.

2. The method of claim **1** wherein said composition is silicon dioxide and said material is glass.

3. The method of claim **1**, wherein said material is the same as said composition.

4. The method of claim **1**, wherein said material is glass.

5. The method of claim **1** wherein said material is silicon dioxide.

6. The method of cathodically sputtering a substance onto a substrate, comprising the steps of:
positioning a substrate to be sputtered, composed of a composition selected from the group consisting of glass and silicon dioxide, on an anode surface having thereon a first layer of a material also selected from the group consisting of glass and silicon dioxide and coated substantially uniformly with said material, and a second layer composed of said substance and overlying said first layer, and
sputtering said substrate and said second layer.

7. The method of claim **6**, wherein said material is the same as said composition.

8. The method of claim **6**, wherein said composition is silicon dioxide and said material is glass.

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