METHOD OF PRODUCING THIN TUNGSTEN-SILICON RESISTOR FILMS

Filed June 28, 1968 3 Sheets-Sheet 1

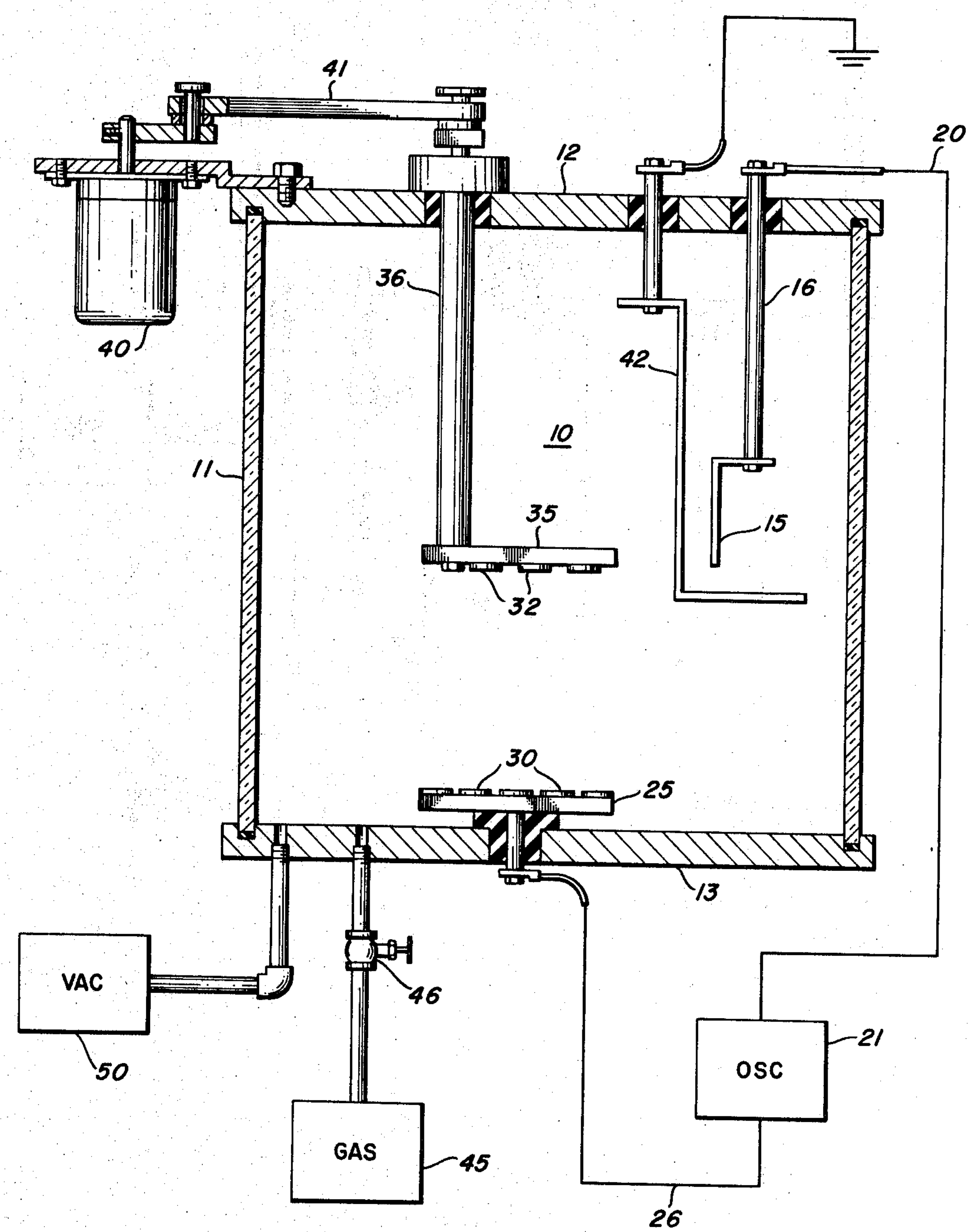


FIG. 1

INVENTOR.
DONALD S. BEYER
BY
Drummond & Cahill
ATTORNEYS

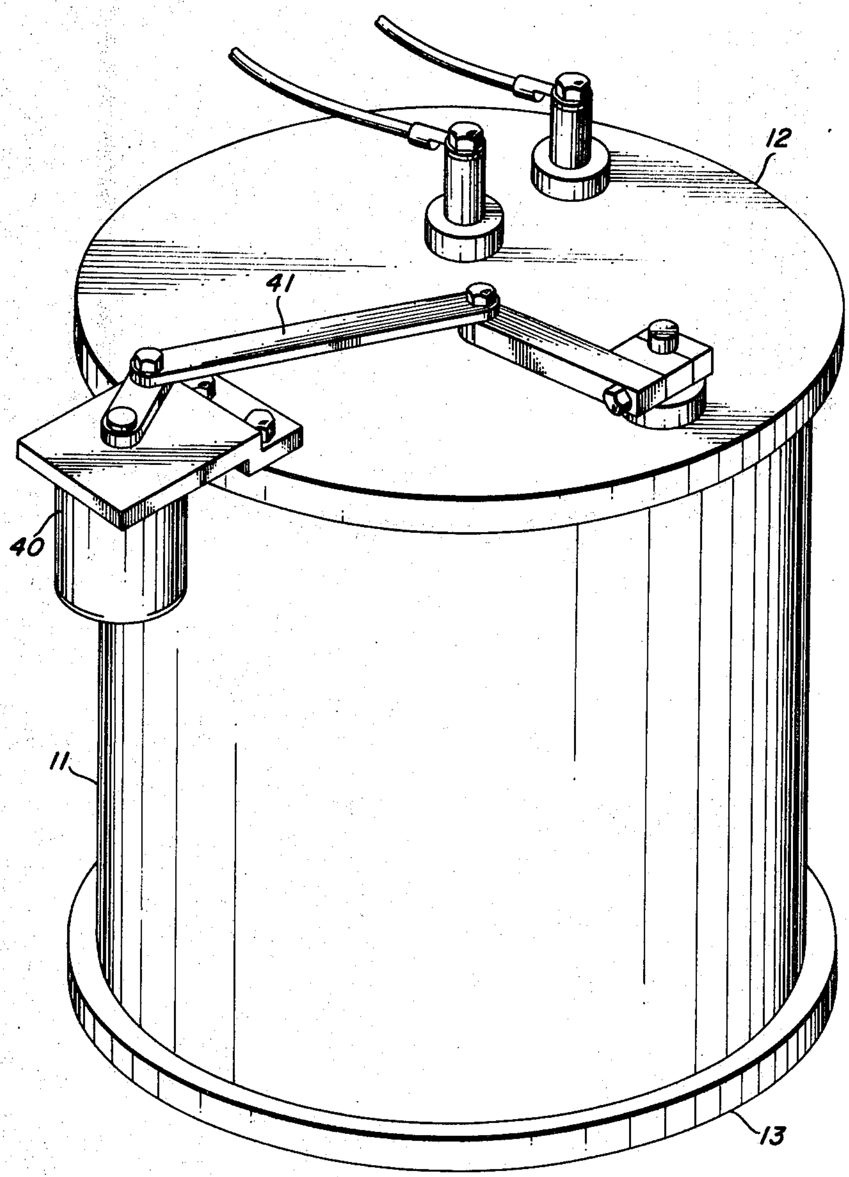
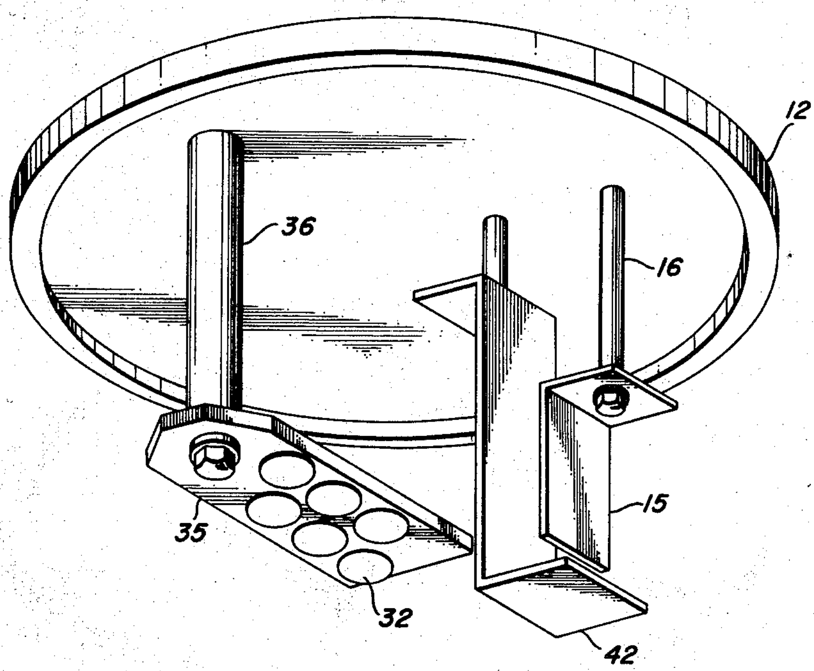


FIG. 2

INVENTOR
DONALD S. BEYER
BY
Drummond & Cahill
ATTORNEYS

FIG. 4



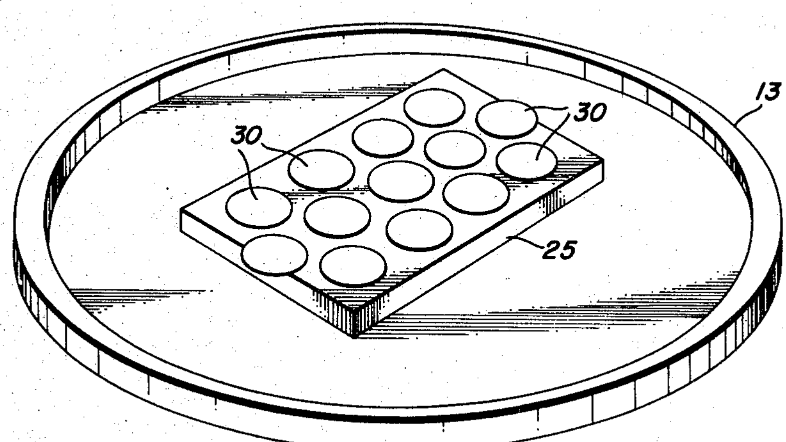


FIG. 3

INVENTOR.
DONALD S. BEYER
BY
Drummond & Cahill
ATTORNEYS

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METHOD OF PRODUCING THIN TUNGSTEN-SILICON RESISTOR FILMS

Donald S. Beyer, Scottsdale, Ariz., assignor to Dickson Electronics Corporation, a corporation of Arizona

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U.S. Cl. 204—192 6 Claims

ABSTRACT OF THE DISCLOSURE

The production of thin films on a substrate is effected by sputtering the film on the substrate; sputtering is achieved by subjecting a tungsten-silicon target to ionic bombardment. The ionizing bombardment is achieved in an argon atmosphere by impressing a RF potential between the target and an aluminum electrode; a grounded aluminum shield shrouds the aluminum electrode.

The present invention pertains to methods of producing thin films, and more particularly, to a method of producing a thin film resistor of the type suitable for use in integrated or miniaturized circuits.

Present methods and techniques for the production of thin film resistors frequently utilize sputtering systems for co-sputtering silicon and tungsten onto a silicon substrate. The resulting composition forming the film is a combination of silicon dioxide, tungsten and oxygen, known in the trade as Ceremet. The production of such thin film resistors leaves much to be desired in that the finished product usually varies from the desired resistance value to the extent requiring subsequent alteration. Alteration of these composite film resistor resistances is usually accomplished by trimming the film with an abrasive blasting compound or by such techniques as diamond abrading or laser beam trimming. The reproducibility of such composite films also suffers since the combination of trace oxygen with the sputtering materials is not consistent, resulting in variations in film resistance and concomitant variations in temperature co-efficient of resistance of the resistor.

It is therefore an object of the present invention to provide a method of producing a thin film resistor by sputtering techniques.

It is a further object of the present invention to provide a method of producing a thin film of silicon and tungsten free of oxygen.

It is another object of the present invention to provide a method for producing a thin film, the physical parameters of which may inexpensively and accurately be controlled by simply controlling power per unit time during the sputtering thereof.

It is still another object of the present invention to provide a method of producing a thin composite film of silicon and tungsten having a very hard and durable surface.

These and other advantages of the present invention will become apparent to those skilled in the art as the description thereof proceeds.

Briefly, in accordance with the embodiment chosen for illustration, the present method co-sputters silicon and tungsten by applying a RF potential between a target of tungsten partialy shrouded by silicon and an aluminum electrode. A grounded aluminum shield shrouds the aluminum electrode from the target and from a substrate positioned in the vicinity of the target; the substrate is continuously moved to insure that the entire surface thereof is uniformly subjected to the silicon and tungsten particles dislodged from the target by the ionic bombardment. The present invention may more readily be described by reference to the accompanying drawings, in which:

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FIG. 1 is a cross-sectional view, partially schematic, illustrating apparatus suitable for practicing the method of the present invention.

FIG. 2 is a top perspective view of the type of apparatus as shown in FIG. 1.

FIG. 3 is an illustration of a tungsten-silicon target for use in the present method.

FIG. 4 is a perspective view of a portion of the apparatus of FIG. 1 showing an oscillating platform supporting the substrate, the aluminum electrode, and the aluminum shield.

Referring now to the drawings, a chamber **10**, formed, for example, of a Pyrex cylinder **11** and metal end plates **12** and **13**, supports an aluminum electrode **15**. The electrode **15** is attached to arm **16** which is electrically insulated from the plate **12** and connected by means of a suitable conductor **20** to one side of an oscillator **21**. A tungsten table **25** is electrically connected through the plate **13** to the other side of the oscillator **21** by conductor **26**. A predetermined plurality of silicon wafers **30** are uniformly positioned on the table **25** so that the relative exposed area of tungsten and silicon represent the desired proportion of silicon and tungsten to be sputtered onto the substrate. A plurality of targets **32** are mounted by any convenient means to the underside of an oscillating platform **35**. The platform **35** is supported by a shaft **36** extending through the plate **12** and is driven by a conventional electrical motor **40** through a reciprocating arm **41**.

A shield **42** constructed of aluminum is positioned to shroud the electrode **15** from both the target and the substrate wafers **32**; further, the shield **42** is supported from the plate **12** and is electrically connected to ground. A source **45** of inert gas, such as argon, communicates through valve **46** to the interior of the chamber **10**. Similarly, a vacuum pump **50** communicates with the interior of the chamber **10** so that the pressure therein may be lowered.

The method of the present invention may be implemented by apparatus such as that just described by introducing an inert gas, such as argon, into the chamber **10** and reducing the pressure therein by the vacuum pump **50** to a pressure in the range of 0.1 to 3 microns mercury. The electrical motor **40** is energized by connecting it to any conventional electrical power source (not shown) and the oscillating platform thereby caused to "sweep" back and forth immediately over the tungsten-silicon target formed by tungsten table **25** and silicon wafers **30**. The oscillator **21** is energized to apply RF potential between the aluminum electrode **15** and the tungsten-silicon target. The ionic bombardment of the target by argon ions dislodges silicon and tungsten which subsequently travels to the substrates **32**. The aluminum acts as a "getter" and combines with trace oxygen (either atomic or molecular) remaining in the chamber **10**. This gettering action permits the deposition of substantially pure silicon unlike the silicon dioxide deposited by prior art methods. The oscillator **21** supplies electrical energy to the system by a balanced line (i.e., the RF potential is applied directly between the electrode and target and is double-ended with neither side being grounded). The aluminum shield **42** acts as an effective shroud to prevent contamination of the target with aluminum. The resulting film produced by this method is very hard and can be controlled by simply controlling the power per unit time delivered by the oscillator **21**. The elimination of the requirement to substantially trim the resistor greatly reduces the cost of the production of such composite film resistors. The potential used may be set in accordance with the other parameters and has been found to be generally in the neighborhood of 200 volts; the frequency of the RF potential may also vary but characteristically is in the range permitted for industrial uses (27+ megacycles).

It is possible using the method of the present invention to deposit a layer of pure silicon on a silicon substrate having a thermally grown layer of silicon dioxide thereon. The structure thus formed may be used as a building block for the production of capacitors and the like. It will therefore be apparent to those skilled in the art that many modifications may be made in the method of the present invention without departing from the spirit and scope thereof. It is therefore intended that the present invention be limited only by the scope of the claims appended hereto.

I claim:

1. A method of producing a composite thin film resistor comprising the steps of: placing a tungsten target in a chamber; covering a predetermined proportion of said tungsten target with silicon to form a tungsten-silicon target; placing a silicon substrate in said chamber, placing an aluminum electrode in said chamber; placing an aluminum shield in said chamber positioned to shroud said aluminum electrode from said silicon substrate and said tungsten-silicon target; introducing an inert gas into said chamber; reducing the pressure in said chamber to the range of 0.1 to 3 microns mercury; and applying a RF potential between said aluminum electrode and said tungsten-silicon target for a predetermined time to ionically bombard said target and sputter tungsten-silicon onto said substrate.

2. The method set forth in claim **1** wherein said inert gas is argon.

3. The method set forth in claim **1** wherein said substrate is silicon with a silicon dioxide layer thereon.

4. The method of claim **1** wherein said silicon substrate is continuously moved relative to said target.

5. The method set forth in claim **4** wherein said inert gas is argon.

6. The method set forth in claim **5** wherein said RF potential is applied by balanced line and wherein said shield is grounded.

References Cited

UNITED STATES PATENTS

3,450,581	6/1969	Shortes	204—192
3,477,935	11/1969	Hall	204—192
3,481,854	12/1969	Lane	204—192

ROBERT K. MIHALEK, Primary Examiner

U.S. Cl. X.R.

75—176; 204—298