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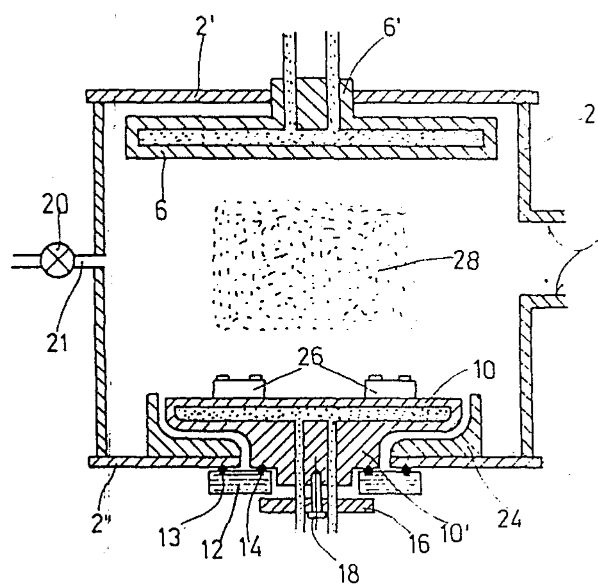
## (54) Adjustment to desired value (trimming) on thin film resistors by ion sputtering.

(57) A technique for adjusting to the desired value, thin film integrated resistors is made known. This method consists in exposing a resistor, whose thickness is greater than that necessary for the desired resistance, to ionic sputtering of the resistive material until a the resistor thickness is such as to correspond to the desired electric resistance.

Ion-sputter etching is realised iether by means of a plasma or by means of an ion-gun.

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# ADJUSTMENT TO DESIRED VALUE (TRIMMING) OF THIN FILM RESISTORS BY ION SPUTTERING

## Description

This invention regards a technological procedure for trimming (adgusting to desired value) of thin film integrated resistors by means of ion-sputter etching.

The techniques most used at present for the trimming of thin film resistors are the following:

1) Eletro- erosion
2) Sand blasting
3) Laser erosion
4) Anodic oxidation

With the exception of anodic oxidation (which consists in the oxidation of the resistor surface and reducing in this way the useful conductive cross-section) all the above techniques are based on change the initial geometry (length and width) of the said resistor, a situation which is unacceptable for microwave circuits.

Anodic oxidation which does not present this inconvenience is however only applicable to tantalum resistors which are more difficult to realise and futhermore are little used in microwave circuits technology.

The present invention tends to avoid these inconveniencens by proposing a technology based on a controlled and uniform thinning of the resistive film by means of ion sputtering.

This sputtering is obtained by bombarding the surface, on which has been deposited the resistive film, with an homogeneous flux of particles (generally gaseous ions) which as a result of the sputtering phenomenon (cathodic spraying or cathodic pulverisation) volatilize part of the resistive surface film with an etch rate (that is, quantity of material removed per unit time per surface area) which depends on the particles used, on their energy and on the angle with which they mpinge on the surface.

Due to the characteristics of the sputtering phenomenon,a first advantage is that the thinning can be carried out with extreme care, eventually even slowing down the etch rate once near the predetermined value. In general for slowing down the etch rate one can control the quantity and energy of the ionic flux.

Another advantage of ion- sputtering is due to its uniformity and controlability, the possibility of trimming one or many resistors without a "dynamic" control of the operation, that is without the need to measure directty and continuously the resistance variations of the resistors subjected to trimming.

This represents a great advantage in all those cases in which the circuit configuration renders impossible a direct reading of the resister value and for which one must rely on near -by resistors or a reference "monitor". A futher advantage is the possibility of trimming simultaneously many resistors on the same substrate and also many substrates together, in all those cases, in which the deviation from the projected value is essentially due to a uniform deviation of the value of surface resistivity of the resistive film.

With regards to the operating time necessary for trimming with the technique of this invention we can say that even at the very simple level with which we are operating at the moment, the times taken (owing to the extreme rapidity of the vacuum chamber) are comparble the those necessary for an anodic oxidation precess.

In addition to this; the procedure according to the present invention lends itself to an automation which can drastically reduce the realisation times. For exaple by using a loading lock and by using an ion beam together with an X-Y mobile support table it could the possible, even for large numbers of circuits, a high precision trimming individual resistors.

Trimming by ion sputtering can be realised by means of either d.c. or r.f. plasma sputtering systems ( cathodic pulverisation with plasma) in which the circuit to be trimmed is exposed (masked or not) to ion bombardament (generally gaseous) which costitute the discharge atmosphere of the system, this atmosphere may or may not be reactive for the time and with the power necessary. Otherwise sputtering can be achieved by means of an ion beam. In this case the circuit to be trimmed is exposed to the bombardment of an ion beam (neutrallised or not) for the time and with the power necessary.

The resistor (or resistors) may or may not be subjected to a dynamic measurement, that is carried out similtaneously whit the sputtering operation.

In order to illustrate the practability of this invention, we will briefly describe two applications of the technique, one with plasma sputtering and one with ion-beam sputtering.

Figure 1 represents a system for plasma sputtering by means of a discharge obtained either by d.c. or r.f. power. With 2 is indicated the discharge chamber which is connected to the vacuum system (not indicated) by means of the outlet 4. Through a central hole in the top wall of the vacuum chamber 2' passes by means of a vacuum seal which is not isolated from the main chamber the support 6' of the double walled anode through which passed water for cooling.

Through a central hole in the wall 2" at the bottom of the chamber passed by means of an isolated vacuum seal (i.e. thermal and electrical isolation with respect to the chamber walls) the support 10' of the cathode 10, this also with water cooling circulation passing through it.

The thermal and electrical isolation of the cathode support is ussured by a ring of ceramic material 12 pressed against the external surface of the bottom of the chamber by means of a metallic plate 16 with a central secrew 18 which locks between it, and respectively the chamber wall and a thread of the support 10', two concentric O-ring seals 12 and 14. The plate 16 is connected to a d.c. or r.f. generator for generating a plasma discharge in the chamber.

An earth shield 24 protects the cathode from below and from its sides leaving exposed only the top surface facing the anode.

On the flat surface of the cathode facing the anode are placed the resistors 26 for trimming. After the vacuum in the chamber 2 has reached a predetermined value, the plasma gas is introduced across the valve 20 and pipework 21 together with eventual reactive gasses. The plasma discharge 28 is then initiated and sustained for the necessary time and required intensity.

Figure 2 represents a system for sputtering by means of an jon-beam. In Figure 2 the particulars analogous to those in figure 1 are indicated with the same numbers.

The vacuum chamber 2 is connected to the pumping system (not indicated by means of the outlet 4. Inside chamber 2 is positioned the substrate support 10, which is water cooled and functions as a cold cathode onto which are placed resistors 26 to be adgusted. To the wall 2' is positioned a second chamber 30 which constitutes the mentioned ion-gun 34. The ion-gun consists of a cylindrical container 32 in contact with the chamber 2 by means of the aperture 36. In the container 32 enter the tube 21, which can be closed by means of the valve 20, for introducing the plasma gas in the container 32.

Inside the container close to the cylinder walls is positioned an openn ended cylinder 46 acting as an anode.

The container sorrounded by an electromagnetic winding 38 for containing the plasma 39 away from the container walls. The container also consists of at one end a hot cathode and at the other end, near the opening 36 to the main chamber, an extraction and accelerationg grid and a neutralisation filament 44. The system described above as is well known gives rise to a fast axial flux of positive ions derected onto the resistors to be trimmed producing results similar to ionic sputtering which constitutes the aim of the invention.

The invention can be applied to any productive cycle of integrated thin film resistors and has been fully tested in a small batch production line.

Claims

1. Method for adyusting the value of thin film resistors, which consists in exposing for an adeguate time the thin film, whose thichness is greater than that necessary for realizing the necessary resistor, to an ionic bombardment of a heavy gas with sufficient energy to produce a film thickness to a value corresponding to the desired resistance.

2. Method for adjusting the value of thin film resistors as in claim 1, in which the thin film to be adjusted is positioned onto the cathode of a plasma etching system and subjected to the bombardment of the ions which constitute the discharge atmosphere for the time and power necessary to obtain a reduction of the thin film thick ness such as to convey to the resistor the desired resistance value.

3. Method for adjusting the value of thin film resistors as in claim 1, in which the thin film to be adjusted is exposed to the bombardment of an ion-beam produced by an ion-gun for the time and with the necessary power to reduce the thin film thickness to such a level as to give the resistor the desired resistance value.

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Fig. 1

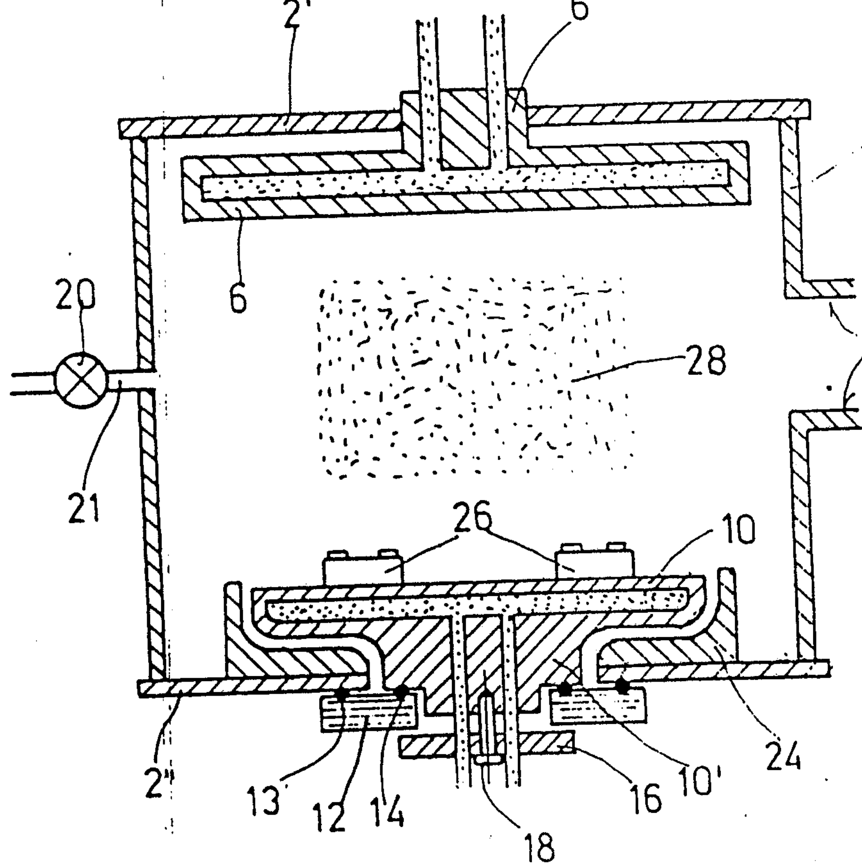
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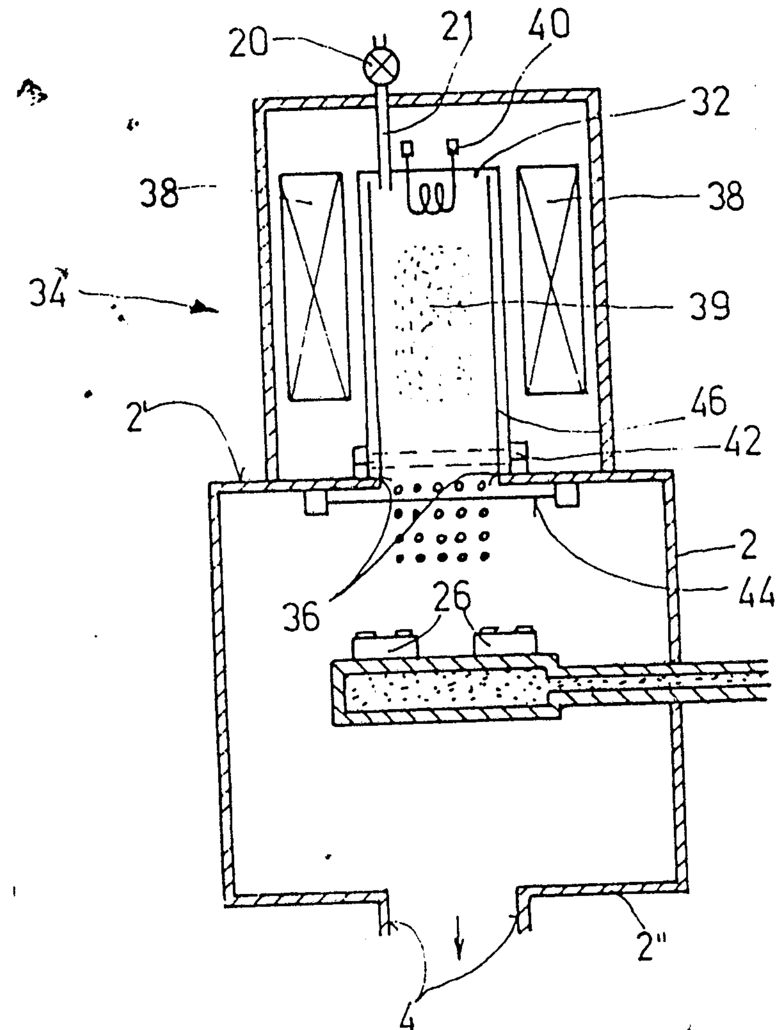
Fig. 2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