

United States Patent

[11] 3,594,679

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2,564,706 8/1951 Mochel 338/308
 1,962,438 6/1934 Flanzer et al. 29/610 X
 3,261,082 7/1966 Maissel et al. 29/620
 3,284,878 11/1966 Best 29/620

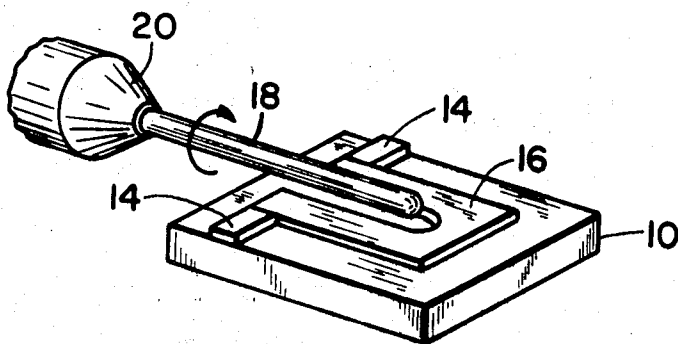
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[54] **METHOD OF MAKING LOW NOISE FILM
 RESISTORS AND ARTICLE**
5 Claims, 4 Drawing Figs.

[52] U.S. Cl. **338/195,**
 29/620, 174/25
 [51] Int. Cl. **H01c 9/00**
 [50] Field of Search 29/610,
 619, 620, 621; 338/195

[56] **References Cited**
UNITED STATES PATENTS
 3,512,254 5/1970 Jenkins 338/195

ABSTRACT: A method of forming a low current noise, thin film resistor having a thin electroconductive or resistive film applied to a dielectric substrate with a portion of the film thereafter being removed so as to increase the length to width ratio thereof. The method includes the step of rubbing, smoothing, or polishing the edges of the remaining film surrounding the area where said portion was removed with a rubberlike member whereby resistor current noise is significantly decreased.



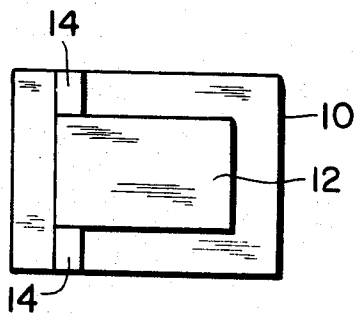


Fig. 1

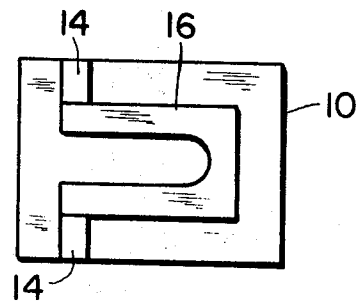


Fig. 2

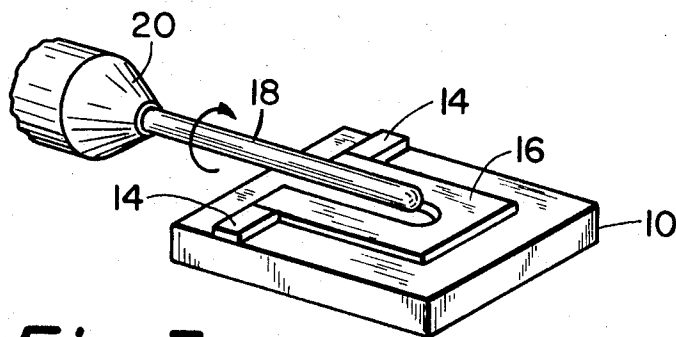


Fig. 3

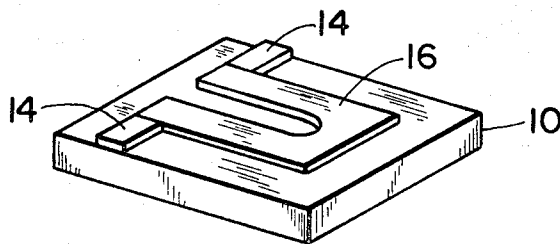


Fig. 4

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METHOD OF MAKING LOW NOISE FILM RESISTORS AND ARTICLE

BACKGROUND OF THE INVENTION

Electrically conductive films of metal oxide are quite well known and have come into extensive use in connection with forming resistors within microcircuits, resistor modules, and the like. There are many inherent difficulties in the deposition and patterning of thin film resistors resulting in out of tolerance resistance values. Consequently, such resistors are formed with films having resistance values less than ultimately desired, which films are thereafter adjusted or tailored by increasing the resistance thereof to the desired value. The resistance of thin film resistors may be increased by decreasing the film thickness or by increasing the length to width ratio thereof.

The most common way of increasing the resistance is by increasing the length to width ratio. Some prior art methods of tailoring the resistance included forming a photographic mask over the film and thereafter removing a portion of the film around the mask. Another method is that described in U.S. Pat. No. 3,284,878 issued to Gary R. Best wherein a resist is applied over the film and thereafter a portion of both the resist and the film are removed by sandblasting. Other methods include direct sandblasting of the film or removal thereof by passing high current through localized areas thereof.

It has been found that a resistor formed in accordance with such methods has a resistor current noise of high value. As used herein, resistor current noise is defined as unwanted or undesired resistance fluctuations between the resistor terminals while a constant flow of current is passed through the conductive portion of said resistor within a frequency band, the value of the intensity of the disturbance being expressed in decibels.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method for economic and rapid adjustment of resistance of thin film resistors where the current noise value thereof is low without deleteriously affecting the remaining film.

Broadly, in accordance with this invention a method of forming low noise, thin film resistors is provided comprising the steps of applying an electroconductive film having a resistance value less than a predetermined desired value on a dielectric substrate, removing a portion of said film to increase the length to width ratio thereof, and thereafter rubbing, smoothing or polishing the edges of the remaining film surrounding the area where said portion was removed with a rubberlike member.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a plan view of a dielectric substrate with a film resistor applied thereon.

FIG. 2 is a plan view of the substrate and resistor of FIG. 1 after the resistance value of the resistor has been adjusted.

FIG. 3 is a diagrammatic illustration of an apparatus by means of which the cut edges of the resistor film are rubbed and polished.

FIG. 4 is an oblique view of a film resistor formed in accordance with the method of this invention.

DETAILED DESCRIPTION

In FIG. 1 there is shown a dielectric substrate 10 having applied thereon an electroconductive or resistive film 12 which forms the resistance element. Resistor terminals 14 are also applied on said substrate in electrical contact with film 12. For one example of a suitable electroconductive film, its characteristics, and method of application, reference is made to U.S. Pat. No. 2,564,706 issued to John M. Mochel. The electroconductive or resistive films suitable for the purposes of the present invention are hard metallic oxide films such as tin oxide, tin oxide-antimony oxide, other modified tin oxide films or the like. Suitable dielectric substrate materials are glass, glass ceramics, ceramics, and the like.

The resistance of film 12 is adjusted or tailored as illustrated in FIG. 2 by removing a portion thereof whereby the length to width ratio of the film is increased resulting in a resistor element 16 having a predetermined desired resistance. One suitable method for removing a portion of the resistive film is by directing a controlled sandblast stream of abrasive particles to the resistive film whereby the particles will abrade and remove the film in the path of the stream. The flow of sandblast particles and movement of the emitting nozzle may be controlled by a controller which is connected to terminals 14. When an area of electroconductive film 12 has been removed sufficient to adjust the film resistance to a predetermined value, the controller would stop the flow of particles and stop the movement of the sandblast nozzle. Such a controller is not shown and does not form part of this invention and any controlling means responsive to the resistance of the film and capable of regulating the amount of the film which is removed is suitable for the purposes of this invention. A suitable means can be readily selected by one familiar with the art.

The cut edges of the resistive film surrounding the area where the portion of the film was removed is then further treated by rubbing, smoothing or polishing these edges with a rubberlike member 18. It has been found that such rubbing, smoothing, or polishing significantly decreases the current noise of resistor element 16. The exact reason why this decreased current noise is achieved is not known, however, it is believed to be as a result of removing the loose microscopic particles of resistive film which may not have been removed while the resistor was being tailored. Further, it is believed that such rubbing or polishing also smoothes these edges lessening the current noise-creating effect of any irregularities which may be found at the cut edges of the film. Rubberlike member 18 may be formed of natural or synthetic rubbers, such for example as those which may suitably be formed into erasers, or may be any soft resilient or elastic material suitable for polishing or buffing, such as plastics, felt, and the like. As in the case of an eraser, the rubberlike material may contain abrasive particles. Member 18 may be rubbed back and forth along the edges where the film was removed or may be rotated as illustrated in FIG. 3 by means of rotating device 20. Such a device may be an ordinary electric eraser motor or the like.

A typical example of carrying out the present invention is illustrated by the following. An electroconductive film of the type described in the heretofore noted Mochel patent, together with a pair of copper terminals in electrical contact with said film were applied to a hot-pressed alumina substrate. A sharp edge orifice nozzle was employed as a sandblast nozzle and was disposed above the electroconductive film at such a distance that the stream of particles to be emitted from the nozzle would form a very thin controlled stream. The sandblast stream may comprise aluminum oxide powder and dry air at a pressure of about 100 pounds per square inch. The nozzle was moved along the entire path for a distance sufficient to increase the length to width ratio of the electroconductive film to a predetermined desired value. An ordinary draftsman's electric eraser was trimmed to a relatively small diameter and caused to be rubbed along the cut edges of the film within the area where the film was removed while it was being rotated. It was found that the current noise value of such a device was decreased from -10 decibels to -30 decibels.

FIG. 4 illustrates the completed device of the present invention. It should be noted that the present method is suitable with the types of electroconductive or resistive films described herein. When the resistive and electroconductive film is relatively soft, that is one that tends to smear or be readily removed, the present method would be inoperative. As heretofore noted, the present method applies only to relatively hard electroconductive or resistive films such as those illustrated hereinabove.

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Although the present invention has been described with respect to specific details of certain embodiments thereof, it is not intended that such details be limitations on the scope of the invention except insofar as set forth in the following claims.

We claim:

1. In the method of forming a low noise, thin film resistor comprising the steps of applying an electroconductive film having a resistance less than a predetermined desired value on a dielectric substrate, and thereafter removing a portion of said film to increase the length to width ratio thereof, the improvement comprising rubbing the edges of said film at the

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portion surrounding region thereof with a rubberlike member, so that current noise of said resistor is reduced.

2. The method of claim 1 wherein said rubberlike member is composed of material selected from the group consisting of natural and synthetic rubbers.

3. The method of claim 1 wherein said step of applying an electroconductive film comprises applying a hard metallic oxide film.

4. The method of claim 3 wherein said step of applying a hard metallic oxide film comprises applying a tin oxide film.

5. The article produced by the method of claim 1.

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