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3,573,176

SELECTIVE ANODIZATION APPARATUS AND PROCESS

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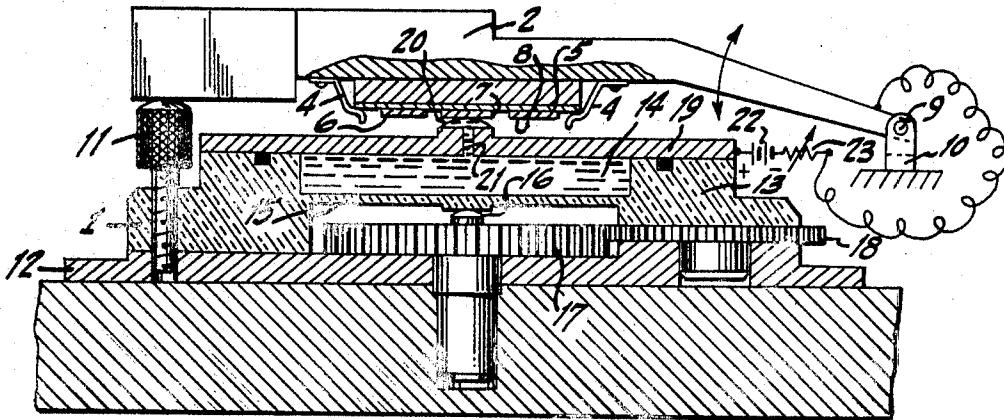


Fig. 1.

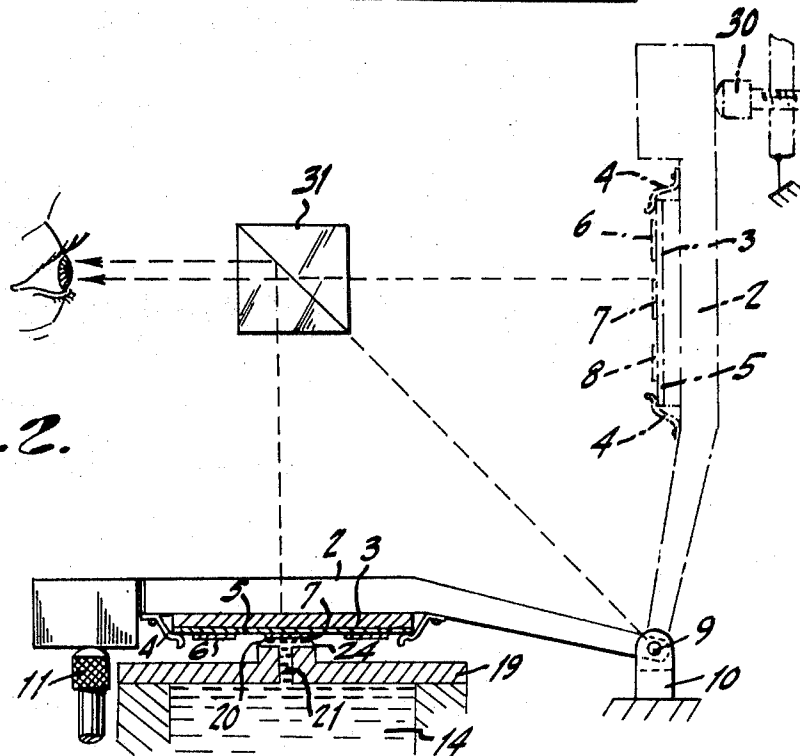


Fig. 2.

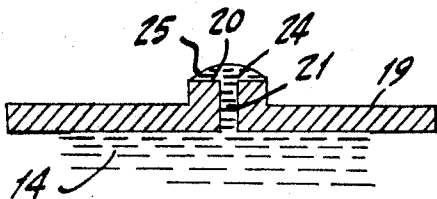


Fig. 3.

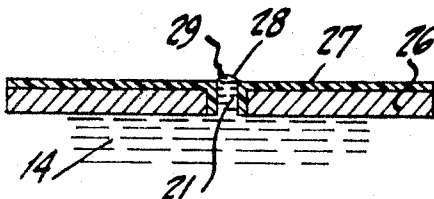


Fig. 4.

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SELECTIVE ANODIZATION APPARATUS AND PROCESS

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4 Claims

ABSTRACT OF THE DISCLOSURE

Thin film tantalum resistors are treated by selective anodization, by bringing an electrolyte into contact with the resistor to be treated and applying a voltage between the electrolyte and the resistor. The electrolyte is disposed on a raised portion of a base plate in the form of a thin liquid layer which is prevented from extending laterally beyond the raised portion by surface tension forces.

BACKGROUND OF THE INVENTION

The invention herein described was made in the course of or under a contract or subcontract thereunder with the Department of the Army.

This invention relates to the electrolytic treatment of conductive material, and more particularly to electrolytic treatment of a selected surface region of such material.

The electrolytic treatment of conductive materials in general, and metals in particular, is in widespread use. The term "electrolytic treatment," as employed in this specification, is defined as a process which comprises contacting a conductive body with an electrolyte, and applying a potential difference between the electrolyte and the body to produce a chemical or physical change in the structure of the body. Electrolytic treatment as herein defined includes electrolytic anodization, electrolytic etching and electroplating.

In electrolytically treating a metal surface, it is often desired to so treat only a selected portion of the surface, or to treat the surface to establish a particular pattern of anodization, etching or electroplating. The techniques most commonly employed for such selective electrolytic treatment involves deposition of a masking layer on the surface to be treated, and definition of the desired pattern in the masking layer, so that only the portions of the conductive body not protected by the masking layer are exposed to the action of the electrolyte.

Such masking techniques are relatively complex, particularly where high resolution is desired. The use of a masking layer often results in deterioration of the underlying conductive material, due to chemical interaction with the developing and stripping solutions required when the masking layer is shaped by photoprocessing methods.

Selective electrolytic etching techniques are known in which a jet of electrolyte is spewed forth from an orifice to impinge upon the conductive surface to be etched. Such "chemical milling" or "jet electrolytic etching" are techniques exemplified by U.S. Pats. 3,302,907 and 3,278,411. Another technique heretofore described utilizes an etching "pencil" with a spongy applicator tip containing the electrolyte, as described, e.g., in U.S. Pat. 3,346,477.

These prior art techniques, although not requiring masking, provide poor resolution and do not permit the precision alignment which is required for processing of, e.g., the microminiature printed and thin film circuitry utilized by the electronics industry.

SUMMARY OF THE INVENTION

Apparatus is provided for electrolytically treating a body having an exposed electrically conductive region, by

applying an electrolyte to the conductive region. The apparatus comprises a base member which has a treating surface area for receiving the electrolyte. The apparatus includes surface tension means for confining the electrolyte to the treating area, so that the electrolyte extends above the treating surface. The apparatus also includes means for positioning the body to be treated adjacent the treating area, so that the conductive region of the body contacts the electrolyte. Means are provided for applying a potential difference between the conductive region to be treated and the electrolyte.

In the drawing:

FIG. 1 shows an electrolytic anodization apparatus according to the preferred embodiment of the invention;

FIG. 2 shows the manner in which the apparatus shown in FIG. 1 is aligned to the region to be anodized.

FIG. 3 shows a portion of the apparatus of FIG. 1;

FIG. 4 shows a portion of the apparatus of FIG. 1, according to an alternative embodiment of the invention.

DETAILED DESCRIPTION

In the manufacture of thin film circuitry, a metallic layer comprising, e.g., tantalum or hafnium is evaporated onto a ceramic substrate. A circuit pattern is defined in the evaporated layer, either by employing a suitable evaporation mask or by selectively etching the evaporated metallic layer. A portion of the, e.g., tantalum layer is designed to serve as one or more resistor elements, while another portion of the layer may be intended to serve as one electrode of a capacitor structure.

The dielectric for the capacitor elements is formed by converting a portion of the tantalum film to tantalum oxide by electrolytic anodization. The resistance of the tantalum resistance elements is increased to the desired value by anodizing each element to be adjusted, by converting part of the tantalum comprising the resistance element to the insulating oxide.

Suitable apparatus for anodizing such tantalum thin film capacitor or resistor elements, as shown in FIG. 1, comprises an anodizing fixture 1, and a rotatable metallic substrate support 2. Secured to the metallic substrate support 2 is a ceramic substrate 3, which is held in place by metal spring clips 4. A tantalum thin film 5 is disposed on one surface of the ceramic substrate 3. The tantalum film 5 has been deposited according to an electrical circuit pattern which contains three tantalum thin film resistance elements 6, 7 and 8. Each of the resistance elements 6 through 8 is electrically connected to a peripheral portion of the tantalum film 5 which is in turn electrically contacted by one of the spring clips 4. Thus an electrical connection is provided between each of the resistors 6 and 8 and the metallic support 2.

The support 2 is rotatable about a pivot 9, which is maintained in position by a fixed bearing member 10.

The rotatable support 2 is maintained at a proper spacing from the anodizing fixture 1 by means of the set screw 11, which is threaded to engage corresponding threads in the base plate 12 of the fixture 1.

The fixture 1 further comprises a Plexiglass container 13 mechanically secured to the base plate 12. The container 13 has an internal cavity 14 which serves as a reservoir for electrolytic liquid. A suitable electrolyte such as dilute oxalic acid is disposed in the reservoir 14. The bottom surface of the reservoir 14 comprises a thin web portion 15 of the container 13. The web portion 15 is flexible and may be deflected by a threaded rod 16. The threaded rod 16 engages corresponding threads on a control gear 17, which is in turn geared to a liquid level setting gear 18. Rotation of the setting gear 18 results in vertical movement of the rod 16, thus varying the amount of electrolyte forced out of the reservoir 14.

The reservoir 14 is covered by a metallic profile plate 19, which is mechanically secured to the Plexiglas container 13. A rubber O ring disposed between the profile plate 19 and the Plexiglas container 13 prevents undesired leakage of electrolyte from the reservoir 14.

The profile plate 19 has a raised treating surface portion 20, the dimensions of which correspond to the area to be electrolytically treated. An aperture 21 in the profile plate 19 communicates with the treating surface 20 and the reservoir 14, so that upon adjustment of the rod 16, the web 15 moves upward to force electrolyte from the reservoir 14 onto the treating surface 20, which is hydrophilic with respect to (i.e. wetted by) the electrolyte. The amount of electrolyte forced from the reservoir 14 through the aperture 21 onto the treating surface 20 is carefully adjusted, so that the electrolyte covers the surface 20 and is retained thereon by surface tension forces which limit the lateral extension of the liquid electrolyte layer covering the treating surface 20.

An electrical contact to the electrolyte 21 may be provided by the profile plate 19, which in this case comprises a suitable metal such as copper. Alternatively, the profile plate 19 may comprise an insulator such as Plexiglas, in which case electrical contact to the electrolyte may be provided by a suitable conductor (not shown) extending to the reservoir 14 through the side of the container 13.

In the event that the resistance element to be anodized has sufficient resistance so that it can be biased to exhibit a substantial voltage drop (on the order of 0.5 volt or more), no other electrical connection to the electrolytic liquid need be provided.

By an alignment technique to be hereafter described, the fixture 1 is moved (by means of a two-dimensional micro-positioning table, not shown) so that when the support 2 is rotated about the pivot 9, a selected resistance element 7 is brought into contact with the electrolyte layer disposed on the raised surface of the profile plate 19. The set screw 11 is adjusted so that the resistance element 7 contacts the liquid electrolyte layer disposed on the raised surface 20, but does not contact the surface 20 itself. Typically, the distance between the resistance element 7 and the raised surface 20 may be on the order of 0.1 to 0.5 millimeter.

Electrolytic anodization of the resistance element 7 is effected by applying a potential difference between this resistance element and the electrolyte, by means of a battery 22 and a variable series resistor 23 connected between the profile plate 19 and the support 2. The value of the resistance element 7 is monitored (by means not shown) during the anodization process, and the anodization is terminated when the desired resistance value is attained.

In addition to employing the apparatus shown in FIG. 1 for electrolytic anodization, it may also be employed for electrolytic etching of or for electroplating a suitable metal onto a metallic film. To perform these processes, it is only necessary to provide an electrolyte suitable for the particular process to be realized, and to properly adjust (i) the polarity and voltage of the battery 22, and (ii) the electrolytic treatment current by means of the variable resistor 23.

The manner in which the liquid electrolyte layer is retained on and limited in lateral extent by the raised surface 20 will be more clearly understood from FIG. 2, which shows an enlarged view of the profile plate 19 and the adjacent portion of the reservoir 14.

As shown in FIG. 2, the size of the reservoir 14 is adjusted (by means of the rod 16 and web 15, as previously described) so that a thin layer 24 of liquid electrolyte is disposed on the raised surface 20. Since the surface 20 is hydrophilic with respect to the electrolyte, the liquid layer 24 adheres to the surface 20 to form a meniscus 25 which terminates at the edges of the raised

surface 20. The liquid layer 24 therefore assumes the same lateral dimensions as the raised surface 20.

The height of the meniscus 25 above the surface 20 is typically on the order of a few tenths of a millimeter.

The surface tension forces between the liquid layer 24 and the raised surface 20 limit the lateral extent of the liquid layer 24 to the raised surface, so that no liquid is disposed on the part of the profile plate 19 adjacent the raised surface 20. Since the liquid layer 24 therefore remains static, no substantial quantity of electrolyte is consumed during the electrolytic anodization process. Furthermore, by suitably shaping the raised surface 20, the liquid electrolyte layer 24 may be correspondingly shaped, so that electrolytic anodization may be performed in accordance with any desired pattern.

An alternative construction for the profile plate, which limits the lateral extent of the electrolyte to the predetermined area, is illustrated in FIG. 3, in which a metallic profile plate 26 is provided with a coating 27 which has a low surface free energy, so that the coating 27 is hydrophobic with respect to the electrolyte. Where the electrolyte comprises an aqueous solution, the layer 27 may comprise a suitable plastic such as polytetrafluoroethylene.

Due to the hydrophobic nature of the layer 27, the upper portion 28 of the liquid electrolyte disposed in the aperture 21 has a convex meniscus 29. Surface tension forces between the hydrophobic layer 27 and the electrolyte 28 limit the meniscus 29 to the dimensions of the aperture 21. The size of the reservoir 14 is adjusted (by means of the rod 16 and web 15, as previously described), so that the convex meniscus 29 extends slightly above the adjacent surface of the hydrophobic layer 27.

The profile plate 26, shown in FIG. 3, is employed in precisely the same manner as the profile plate 19, the resistance element to be anodized being brought adjacent to the layer 27 so that the resistance element is contacted by the liquid electrolyte meniscus 29.

It should be understood that the aperture 21 need not be circular, but may have an elongated shape corresponding to the length of the raised portion 21 of the profile plate 19, or may have an elongated straight or curved shape determinative of the pattern of the convex electrolyte meniscus 29 associated with the profile plate 26.

The manner in which the particular resistance element 7 to be anodized is aligned with the liquid electrolyte layer 24 disposed on the raised surface 20 of the profile plate 19 is illustrated in FIG. 4. After securing the substrate 3 to the rotatable support 2, the support is rotated to an alignment position shown in phantom view in FIG. 4. A set screw 30 limits the movement of the support 2, so that in the alignment position the tantalum film 5 is situated in a plane substantially normal to the raised surface 20 of the profile plate 19.

A prismatic light splitter 31 is situated along a line bisecting the angle between the plane of the tantalum film 5 (in the alignment position) and the plane of the raised surface 20. While viewing the superimposed images of the raised surface 20 and the particular resistance element 7 to be anodized (through suitable magnifying optics, not shown), an operator adjusts the horizontal position and orientation of the profile plate 19 so that the images viewed through the light splitter are in alignment.

The profile plate 19 is mounted on a suitable two-dimensional micropositioner (not shown), for horizontal adjustment. When the profile plate 19 has been properly adjusted, the light splitter 31 is moved away and the support 2 is rotated to its operating position, i.e. so that the resistance element 7 contacts the liquid electrolyte layer 24 disposed on the raised surface 20 of the profile plate 19.

I claim:

1. Apparatus for electrolytically treating a body having

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an exposed electrically conductive region, by applying an electrolyte to said region, comprising:

a base member having a predetermined treating area adapted to receive said electrolyte, said base member also having an aperture in a given surface thereof, the periphery of said aperture at said given surface defining said treating area, the portion of said given surface adjacent said aperture being hydrophobic with respect to said electrolyte;

means disposing said electrolyte in said aperture so that said electrolyte has a convex meniscus extending above said given surface, said electrolyte being confined within the periphery of said aperture at said surface by surface tension forces;

means for positioning said body adjacent said treating area so that said region contacts said electrolyte; and means for applying a potential difference between said region and said electrolyte.

2. Apparatus according to claim 1 further comprising a reservoir for said electrolyte communicating with said aperture.

3. A process for electrolytically treating a selected portion of an electrically conductive layer, comprising the steps of:

providing a base member having a given surface, said member having an aperture communicating with a predetermined portion of said surface;

disposing an electrolyte in said aperture, the part of said given surface adjacent said aperture being hydrophobic with respect to said electrolyte, so that said electrolyte has a convex meniscus extending above the surrounding part of said given surface and confined to said aperture by surface tension force;

positioning said layer and said member so that said meniscus contacts said selected portion of said conductive layer; and

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applying a potential difference between said conductive layer and said electrolyte to electrolytically treat said selective portion.

4. A process according to claim 3, wherein said positioning step comprises:

securing said layer to a rotatable support;

rotating said support to an alignment position substantially normal to said predetermined portion of said given surface;

providing optical means for simultaneously viewing images of said predetermined portion and said selected portion;

moving said portions with respect to each other to align said images; and

rotating said support to an operating position so that said selected portion is substantially parallel to and slightly spaced from said predetermined portion and in contact with said electrolyte.

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U.S. Cl. X.R.

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