

[54] **METHOD FOR THE PRODUCTION OF
MICROSCOPICALLY SMALL METAL OR
METAL ALLOY STRUCTURES**

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[51] **Int. Cl.**..... **C23b 5/48**

[58] **Field of Search**..... **204/15; 117/212; 156/8,
156/18**

[56] **References Cited**

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[57] **ABSTRACT**

This invention deals with the deposition of a microscopically small metal or metal alloy structure in which a relatively thin metal or metal alloy such as a nickel-iron alloy is vapor deposited upon a carrier after which a photoresist layer is applied over the thin layer. Channels in the form desired in the ultimate pattern are then produced using the conventional photographic technique, to leave the desired pattern exposed in the previously deposited thin layer. A thin layer of gold is then applied to the exposed layer and a thicker metal or metal alloy layer is then galvanically deposited on the gold layer. The remaining photoresist layer is then removed, followed by the removal of the remaining thin layer of metal or metal alloy. The process may also include the deposition of a thin layer of gold over the thicker layer of alloy.

6 Claims, 3 Drawing Figures

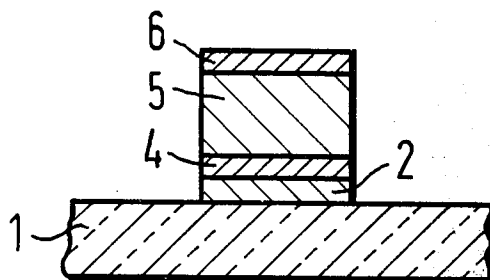


Fig.1

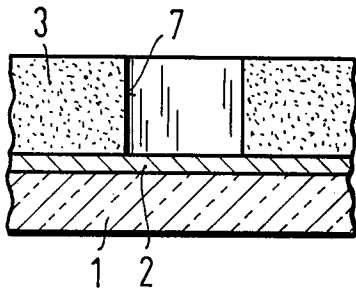


Fig.2

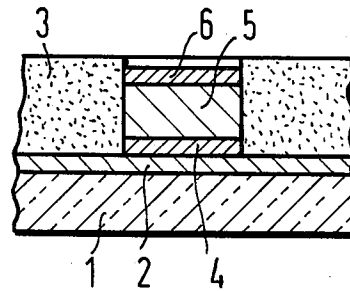
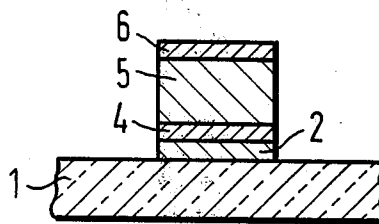


Fig.3



METHOD FOR THE PRODUCTION OF MICROSCOPICALLY SMALL METAL OR METAL ALLOY STRUCTURES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is in the field of producing microscopically small metal or metal alloy structures by successive deposition of a thin metal layer, followed by a gold layer, and a relatively thick metal or metal alloy layer. The conditions are such that the lateral erosion of the structure is minimized.

2. Description of the Prior Art

Microscopically small metal or metal alloy structures are required, for example, in the production of manipulation patterns for cylindrical magnetic domains and for the micro-wiring of integrated circuits. If the required line width of these structures, such as occur in the aforementioned manipulation patterns amounts to approximately 3 to 20 microns, it has proven to be extremely difficult when using the photo-etching method to keep the sub-etching, that is, the lateral erosion of the structure sufficiently small in the zone of the structure protected by the photo lacquers. In order to avoid these difficulties, a number of other prior art methods have been used heretofore such as described, for example, in "AIP Conference Proceedings" No. 5, 1971, page 215 in "Appl. Phys. Letter" Vol. 17, page 328 (1970) and in the "Journal Appl. Phys.", Vol. 42, page 1,362 (1971).

This invention is directed to a relatively simplified method for preventing sub-etching of the structures when using the conventional photo lacquer techniques in the production of microscopically small metal or metal alloy structures.

SUMMARY OF THE INVENTION

In the process of the present invention, a thin continuous metal or metal alloy layer vapor deposited on a carrier such as a glass carrier. A photo lacquer layer is applied onto the metal or metal alloy layer and channels corresponding to the desired metal or metal alloy structure are formed in the photo lacquer layer in the usual manner, that is, by exposing the lacquer to a light source through a mask having the desired pattern formed therein and then removing the exposed portions by means of a suitable solvent, leaving the unexposed photoresist layer. The removal of the exposed channels of the photoresist material exposes the underlying thin continuous layer in these areas. A thin gold layer is galvanically deposited on the exposed metal or metal alloy layer. Next, a thicker deposit of the same metal or metal alloy is galvanically deposited onto the gold layer. The remaining photo lacquer layer is then removed, followed by the removal of the originally deposited thin metal or metal alloy layer.

The method of the present invention can be carried out without significant difficulty. The edge sharpness of the structures which result is quite precise. The dimensions of the structures are not significantly affected by etching treatments. In addition, small non-homogenities in the photo lacquer which can otherwise lead to an unwanted etching of the layers do not interfere. It is possible by means of the method of the present invention to produce structures with close dimensional tolerances, having dimensions on the order of 5 to 20 microns, and to produce structures reproducibly

in conformity to the mask in the required layer thicknesses. The uniform thickness and edge sharpness of the structures are insured primarily by the thin gold layer.

The preferred method according to the present invention is suitable for the production of manipulation patterns for cylindrical magnetic domains, utilizing a magnetostriction-free nickel-iron alloy such as an alloy containing about 79 to 83 weight percent nickel, and 21 to 17 weight percent iron. This nickel-iron alloy is vapor deposited onto a substrate such as glass to a thickness of approximately 100 to 500 Angstroms and, more preferably, to a thickness of about 300 Angstroms.

The photoresist layer is then applied and exposed through a mask and developed photographically to provide the configuration of channels desired in the final product. The exposed portions of the photoresist layer are removed by a suitable solvent in accordance with the usual photo mask technique. Following this, a thin gold layer measuring several hundred Angstroms in thickness (200-800) and preferably 600 Angstroms is deposited over the thin nickel-iron alloy. Next, a relatively thick nickel-iron layer measuring several thousand Angstroms in thickness, usually about 10,000 Angstroms in thickness, is galvanically deposited over the exposed portions of the gold layer. A second thin gold layer is then preferably galvanically deposited onto the thicker nickel-iron layer, the gold layer acting as a protective layer during the subsequent etching away of the thin nickel-iron layer. The gold is preferably galvanically deposited on the iron-nickel layer to a thickness of several hundred Angstroms, usually about 600 Angstroms.

For the removal of the non-reinforced thin nickel-iron layer, it is advisable and preferred to immerse the carriers processed in the manner described above when freed from the residual photo lacquer layer in a slightly acid gold bath, for instance Autronex C1 bath of Sel-Rex International containing 8 grams gold/liter and having a pH of 3.5, whereby the nickel-iron thin layer is removed and replaced by a correspondingly thin gold layer which can be easily etched by means of conventional gold etching means. An exchange reaction takes place in the bath which is caused by the potential differences occurring between the nickel-iron and the gold layers, whereby the nickel-iron goes into solution and is replaced by an equivalent amount of gold. The entire nickel-iron layer, usually 200 to 300 angstroms thick, is dissolved in a few minutes and is replaced by a gold layer of comparable dimensions. Without affecting the galvanically applied nickel-iron layer, the gold layer can be etched away by means of a suitable gold etching means such as a dilute potassium cyanide solution with a concentration of about 20 grams KCN/liter H₂O to 120 grams KCN/liter H₂O, for example, 60 grams KCN/Liter H₂O.

Presently used nickel-iron etching solutions such as solutions of ferric chloride attack the galvanically reinforced nickel-iron layer and also the thicker nickel-iron layer to a substantial extent when the 200 to 300 Angstrom thick nickel-iron layer is being removed. In the gold bath according to the present invention, however, only the 200 to 300 Angstrom nickel-iron layer is removed from the thicker nickel-iron layer.

BRIEF DESCRIPTION OF THE DRAWINGS

A further description of the present invention will be made in connection with the attached drawings in which:

FIG. 1 is a greatly enlarged view illustrating the structure after the channels have been formed by the photographic process;

FIG. 2 illustrates the structure after the deposition of the two gold layers and the intermediate metal alloy layer; and

FIG. 3 is a view of the structure after removal of the residual photoresist layer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A nickel-iron layer 2 which is approximately 200 to 300 Angstroms thick is vapor deposited upon a carrier 1 composed of glass, ceramic or other insulating material. A photo lacquer layer 3 is applied onto the nickel-iron layer 2. Channels 7 having the configuration of the desired nickel-iron structure are then provided in the usual way by exposing the surface to the light through a suitable mask and removing the exposed areas in which the channels are to appear, leaving the underlying nickel-iron layer 2 exposed in those areas.

In the next step of the procedure, a gold layer 4 measuring several hundred Angstroms in thickness, and usually around 600 Angstroms is galvanically deposited on the exposed nickel-iron layer 2, using an suitable commercial gold bath. Subsequently, a relatively thick nickel-iron layer 5, whose thickness is measured in thousands of Angstrom units, preferably about 10,000 Angstrom units galvanically deposited over the predeposited gold layer 4. Next, a second gold layer 6 serving as a protective layer, and measuring several hundred Angstrom units in thickness, usually about 600 Angstroms, is galvanically deposited on the relatively thick nickel-iron layer 5.

The remaining photo lacquer layer 3 is subsequently dissolved as illustrated in FIG. 3 and the structure thus produced is placed into a slightly acid gold bath, whereby after a few minutes the entire non-reinforced nickel-iron layer 2 of approximately 300 Angstroms in thickness, is removed and replaced by a correspondingly thick gold layer. This gold layer can be easily etched away by a gold etching means such as a dilute potassium cyanide solution. The removal of the unrein-

forced nickel-iron layer in certain areas by means of the exchange reaction in the gold bath and the subsequent gold etching is particularly desirable in the manufacture of signal detectors for cylindrical magnetic domains.

It should be evident that various modifications can be made to the described embodiments without departing from the scope of the present invention.

I claim as my invention:

1. A method for the production of microscopically small metal or metal alloy structures comprising vapor depositing a thin continuous layer of metal or metal alloy on a substrate, applying a photoresist layer over the thus deposited layer, forming channels in said photoresist layer corresponding to the desired pattern thereby exposing said continuous layer in the channels, galvanically depositing a thin gold layer on the exposed portions of said layer, galvanically depositing a thicker metal or metal alloy on said thin gold layer, removing the remaining photoresist layer, treating the remaining thin metal or metal alloy to replace the metal or metal alloy layer with a gold layer, and etching away the last-named gold layer.

2. The method of claim 1 in which said metal is a nickel-iron alloy.

3. The method of claim 1 in which said thin continuous layer of metal or metal alloy has a thickness of about 100 to 500 Angstroms.

4. The method of claim 1 in which the second layer of gold has a thickness of several hundred Angstroms.

5. A method for the production of microscopically small metal structures which comprises vapor depositing a thin continuous layer of a nickel-iron alloy onto a substrate, applying a photoresist layer over the thus deposited layer, forming channels in said photoresist layer corresponding to the desired pattern thereby exposing said continuous layer in said channels, galvanically depositing a first thin layer of gold over the exposed portions of said layer, galvanically depositing a thicker layer of nickel-iron alloy over said first thin layer of gold, removing the remaining photoresist layer, treating the remaining structure in a slightly acid gold bath to replace said thin nickel-iron layer with a gold layer, and etching away the last-named gold layer.

6. The method of claim 5 in which the gold etching is carried out by means of a dilute potassium cyanide solution.

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