METHOD OF FORMING MINIATURE ELECTRICAL CONDUCTORS

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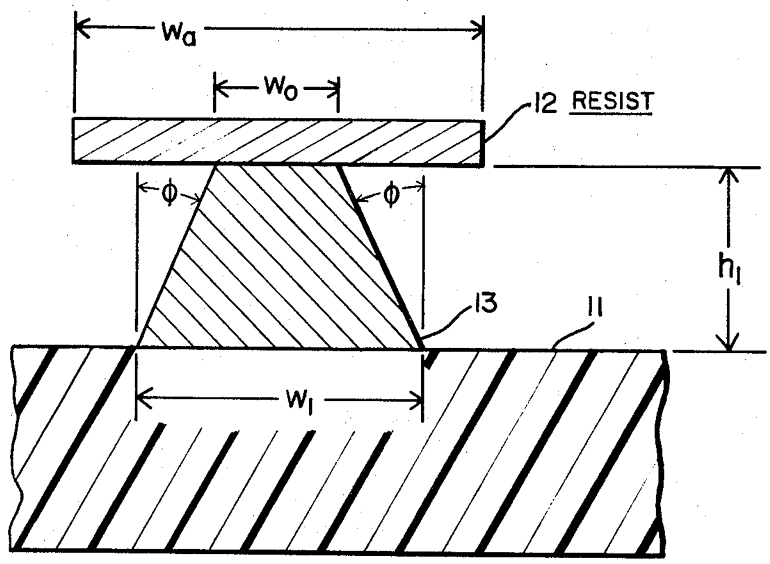
Fig. 1



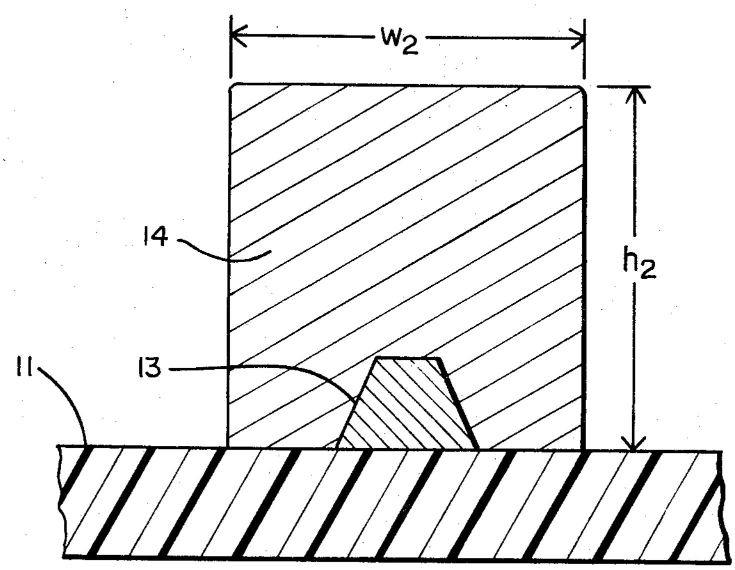


Fig. 2

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METHOD OF FORMING MINIATURE ELECTRICAL CONDUCTORS

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ABSTRACT OF THE DISCLOSURE

A process for the manufacturing of miniature electrical conductors which comprises etching a base material to a predetermined shape followed by electroplating material onto the base material until the desired conductor configuration is obtained.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates generally to miniature conductors and, more specifically, to a process for forming miniature electrical conductors having square corners.

Description of the prior art

Generally conductors having a thin rectangular or square cross section are utilized in electrostatic printing machines or miniature electrical circuits. In those applications one wishes to achieve contact with as large a portion of the conductor surface as possible by having conductors with square corners. In the past it has been difficult if not impossible to make miniature electrical conductors by etching because the etching process produced conductors having a tapered configuration (known in the trade as etch factor). Similarly it has been difficult if not impossible to make miniature electrical conductors by electroplating because the electroplating produces conductors with ridges on the corners. Thus, it has been difficult if not impossible to obtain a conductor having a square cross section or a rectangular cross section using conventional electroplating or etching techniques. The present invention comprises the discovery of a process for producing a substantially square or rectangular cross section conductor through the utilization of both etching and electroplating techniques.

SUMMARY OF THE INVENTION

Briefly, the present invention comprises etching a conductor material to a predetermined shape such as an isosceles trapezoid and then electroforming material onto the isosceles trapezoid until one produces a conductor having square corners.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a cross-sectional view of a material which has been etched away to form a base for electroplating on; and

FIG. 2 shows a cross-sectional view of the base with material electroplated thereon.

DESCRIPTION OF THE PREFERRED PROCESS

In the preferred process of this invention, one places a metal conductor such as copper on a dielectric material or support surface. The support surface may be any typical type of dielectric. Typical of such dielectric support surfaces are polyimide films, however, no limitation is intended thereto. Referring to FIG. 1, we have designated certain reference characters and reference letters to assist in describing the process and relationships of the various dimensions of the article to be formed into a conductor.

FIG. 1 shows a dielectric material **11** having a conductor **13** with a resist material **12** located on top of conductor **13**. In this figure conductor **13** has been etched to its predetermined base shape which is an isosceles trapezoid. While FIG. 1 shows conductor **13** with straight well defined sides, in actual practice the etched sections are slightly curved and have somewhat of an irregular surface.

The characteristic dimensions denoted in FIG. 1 are as follows: w_a represents the width of resist material **12** on conductor **13**, w_0 represents the width of the top of the isosceles trapezoid formed by conductor **13**, w_1 represents the width of the base of the isosceles trapezoid formed by conductor **13** and h_1 represents the height of the isosceles trapezoid. The most important dimension of this process are the angles designated by ϕ. Typically, ϕ should be maintained on the order of about 10° to 30° in order to obtain a conductor having the shape shown in FIG. 2.

FIG. 2 shows the final electroformed conductor **14** with the square corners. In this particular embodiment, conductor **14** has a square cross section, however, the cross section could also be rectangular. The width of conductor **14** is designated by w_2 and the height of conductor **14** is designated by h_2. To illustrate the process of the invention, reference should be made to the following typical examples. Although in practice multiple conductors are simultaneously etched and then electroplated, for purposes of illustrating the process of the invention only one conductor will be described.

EXAMPLE 1

In order to obtain a conductor with square cross section, a copper sheet of thickness h_1 of 1.4 mils was placed on dielectric **11**. The copper was selectively covered with a resist having a width w_a of 2 mils. The copper was then etched until the dimension w_2 was approximately 1 mil and the dimension w_1 was about 1.5 mils. With a thickness h_1 of 1.4 mils, one obtains an angle ϕ on the order of 10°. With these dimensions base conductor **13** has the shape of an isosceles trapezoid. Next, resist material **12** was removed and copper was electroplated on top of base conductor **13** until the dimension w_2 and h_2 were approximately 5 mils. When conductor **14** reached this size the corners of the conductors were substantially square.

EXAMPLE 2

In this example all the dimensions were identical to Example 1 with the exception that the thickness h_1 was .7 mil rather than 1.4 mils. This produced an angle ϕ which is approximately 20°. With this angle ϕ the electroplating produced a conductor with a substantially square cross section and a final dimension of approximately 5 mils by 5 mils.

EXAMPLE 3

In another example, the dimension w_0 was 2 mils, dimension w_1 was 3 mils, the height h_1 was 1 mil and the width of the resist w_a was 4 mils. In this particular process the angle ϕ was approximately 27° and the final dimensions w_2 and h_2 were on the order of about 5 mils.

In all of the above examples the initial dimensions were such that a final configuration turned out to be approximately square in cross section, however, lengthening the dimension w_1 with respect to its height produces a conductor that is rectangular rather than square.

The particular reason that our process produces a conductor with square corners is through the combination of the two techniques of etching and electroplating. That is, the etching process undercuts resist material **12** to form a sloping side making angle ϕ which is indicated in FIG. 1. This is a natural occurring process if the article is etched in an etching bath without any compensation techniques. It is this undercutting phenomena which prevents one from etching small conductors with square corners. On larger conductors which are over 15 mils thick one can oftentimes compensate for angled sides, however, it is difficult if not impossible to do where there are multiple conductors to be formed which are typically less than 10 mils in thickness. Thus, etching produces a base configuration with substantially the shape of an isosceles trapezoid.

In electroplating a naturally occurring phenomena is build-up of electroplated material on the corners. This build-up on the corners if used with a square shaped base member or cathode, will produce an offset or enlarged corner on the cathode. Thus, one cannot electroplate small conductors with square cross sections because of the naturally occurring phenomena of build-up on the corners. However, because the corners of our base conductor **13** have been undercut or beveled due to the etching, the electroplating technique and etching techniques compensate for each other to produce a conductor with square corners. That is, the electroplating techniques produce a build-up on the beveled corners that results in a conductor with square corners.

While many examples have been tried in producing a particular square corner on the conductor, the suitable ranges of the angle ϕ have ranged from approximately 10° to 30° and the ratio w_2/w_1 has been found to range from approximately 3 to 4 and the ratio h_2/h_1 has ranged from approximately 2.8 to 8.0. However, the ratio of the dimensions are not significant, only typical to obtaining a conductor with a square cross section. The important and critical dimension is the maintaining of the angle ϕ in the range of 10° to 30° to produce a conductor which has square corners.

We claim:

1. In the production of printed circuits by chemical milling, a process for making the electrical conductor lines having square corners comprising the steps of:

(a) first etching the electrical circuit pattern from a layer of electrically conductive material attached to a layer of insulating material; then

(b) continuing the etching to reduce the thickness and width of the conductors to dimensions less than the desired final dimensions; and then

(c) electroplating material to build up the width and thickness of the conductors to the final dimensions.

2. The process of claim **1** wherein the step of etching the electrical circuit pattern is continued until an isosceles trapezoid having sides that make an angle ϕ with a line perpendicular to a base of the isosceles trapezoid, said angle ϕ ranging from about 10° to about 30°.

3. The process of claim **2** including the step of applying a layer of etchant resist on top of the electrical circuit pattern.

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DARRELL L. CLAY, Primary Examiner

U.S. Cl. X.R.

174—68.5; 204—32; 317—101 B