PRINTED CIRCUIT BOARDS

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This invention relates to a process for manufacturing printed circuit boards which can be used in, for example, business, communication and electric machines and tools, and to printed circuit boards manufactured by the process.

Conventional processes for manufacturing printed circuit boards of the so-called copper through-hole printed type have been roughly classified into two processes known as the subtractive process, wherein the printed circuit board is made from a copper-clad laminate, and the additive process, wherein the printed circuit board is made from a copper foil catalyst-included laminate.

The following are examples of the former process. (1) the so-called tenting process which comprises the steps of making holes through the laminate; copper plating the hole walls and the copper foil to the thickness required for the hole walls by electrolysis; covering the hole walls with ink which forms an etching resist film on the required circuits; removing unnecessary portions of the copper foil by etching; and then removing the etching resist film. (2) a modified process as disclosed in Japanese Laid-open Patent Application 13965/1979 which comprises the steps of making necessary circuits on the laminate by etching; making holes through the laminate; forming a pretreating layer on the hole walls and circuits by electroless plating; mechanically removing the pretreating layer from the circuits; forming a solder resist film on required portions of the board; and forming an electroless plated film on the hole walls and required circuits. Alternatively the holes may be made after the solder resist film has been formed.

An example of the latter additive process is as follows. (3) a process which comprises the steps of applying a bonding agent on to a catalyst-included laminate; making holes through the laminate; forming a permanent resist film on those portions other than circuits; forming a copper layer on the hole walls and circuits by electroless plating; and forming a solder resist film where necessary.

However, these conventional processes include various shortcomings as regards quality and productivity. This will be explained in relation to each example of the above mentioned processes.

The process of example (1) is defective in that it takes a long time to remove the copper from the unrequired portions by etching, because the thickness of the copper, which comprises the thickness of the copper foil and that of the through-hole plating, is nearly twice that of a copper foil. Hence, the circuits must be undercut considerably, with a resulting deterioration in dimensional accuracy. The process of example (2) is defective because the circuits are formed by etching, thereafter a layer is formed on the hole walls and the solder resist film, or on the laminate where the copper foil has been etched away, then the layer formed on the circuits by pretreatment for electroless plating is mechanically removed and thereafter electroless plating is conducted. It is difficult to remove completely the layer formed by pretreatment for electroless plating and, therefore, the plated layer remaining on the unnecessary portions brings about short circuits or degrades the insulation resistance between circuits. The process of example (3) is defective in that, since it is necessary to use a special and expensive base material, namely the catalyst-included laminate, it is not only expensive but also unsuitable for general use. Furthermore, as the plating is carried out on permanent resist-formed circuits, the dimensional accuracy

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of the circuits is inferior. This process is therefore unsuitable for circuits which are less than 0.5mm in width, and the formed circuits are liable to lack uniformity as regards width.

It is an object of the present invention to obtain an accurate and cheap printed circuit board without using any special base material.

According to the invention, there is provided a process for manufacturing a printed circuit board, comprising the steps of: making holes at required positions in a copper-clad laminate; forming a catalytic layer on the hole walls and on the copper cladding by dipping the board in a catalyser of the palladium-tin colloid system; forming an etching resist film on required land, wiring and circuit areas; removing unrequired areas of the copper cladding and of the catalytic layer by etching; removing the etching resist film; activating the catalytic layer as a pretreatment for electroless plating; and forming an electroless plated film of copper or nickel on the activated catalytic layer formed on the hole walls and land, wiring and circuit areas.

A solder resist film may be formed on the required portions before or after the formation of the electroless plated film.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 to Fig. 8 are cross-sectional views illustrating a process in accordance with the invention for manufacturing a through-hole printed circuit board.

Referring to Figs. 1 and 2 of the drawings, firstly holes 3 are made at required positions through a conventional copper-clad laminate, which comprises a copper foil 2 on each side of an insulating material 1. These holes may be made by using a drill or a punch. Then a conventional pretreatment for electroless plating

is performed. The laminate is dipped in an alkali degreasing liquid so as to clean the surfaces of the copper foil and the hole walls, and then it is dipped in a 5 vol% hydrochloric

acid aqueous solution to activate the copper foil surface. It is then dipped in an aqueous solution, the so-called catalyser, containing 15g/ℓ ionic concentration of dihydric tin comprising stannous chloride, palladium chloride and hydrochloric acid, 0.25g/ℓ ionic concentration of dihydric palladium and 200mℓ/ℓ of concentrated hydrochloric acid so as to form a tin-palladium colloid type catalytic layer 4 (Fig.3). The surface on which the catalytic layer 4 has been formed by adsorption is then subjected to forced or natural drying so as to have a sufficient adhesive property for retaining an etching resist film, and thereafter an etching resist film 5 is formed at the required areas (Fig.4). The etching resist may be either ink or a dry film, and its formation may be made by means of either a printing process or a photographic process.

Thereafter, unrequired areas of the copper foil are removed by etching with a solution comprising 400g/ℓ of ferric chloride and 3g/ℓ of hydrochloric acid or the like (Fig.5). The catalytic layer 4 adsorbed on the copper foil is completely removed simultaneously with removal of the copper foil by etching. Consequently, the catalytic layer 4 no longer exists on the areas where the copper foil has been etched away, but that part of the catalytic layer formed on the wall of the through-hole 3 is not removed, and is retained because it is adsorbed directly on the insulating material. This is the most marked characteristic of this invention. Due to this layer, electroless plating cannot take place anywhere other than on the required portions during the subsequent circuit forming process, and deterioration in insulation resistance between the circuits may no longer be caused. In this connection, it is to be noted that a known solution of ammonium persulphate or an alkali etchant may be used for etching purposes.

Next, the etching resist film 5, which is no longer

required, is removed, in the usual manner, using trichlene or methylene dichloride (Fig.6). Then, a solder resist film 6 (Fig.6') is formed on required areas for preventing the circuits from bridging and/or for protecting the surfaces of the circuits and the insulating material from steam and the like at the time of soldering components. This solder resist film has recently become indispensable for industrial printed circuit boards in order to secure long reliability of the boards and is regarded as important, especially in the case of the copper through-hole type of printed circuit board. The solder resist film 6 is preferably formed of an epoxy-type ink, but may be formed of a liquid or dry photosensitive resin film.

Next, the laminate is dipped in a 10% sulphuric acid solution to activate the catalytic layer 4 so that electroless copper plating may be properly carried out in the succeeding step. The laminate is then dipped in an electroless copper plating bath so as to form a plated copper film 7,by electroless plating reaction, on the wall surfaces of the holes 3 on the catalytic layer 4 and on required circuit areas on the surface of the copper foil 2 (Fig.7').

Examples of the bath composition and the plating condition of this electroless copper plating are as follows.

The following composition and conditions may be used effectively for high-speed plating:

Sodium ethylene diamine tetracetate	40g/ℓ
Copper sulphate ($CuSO_4.5H_2O$)	10g/ℓ
Paraformaldehyde	10g/ℓ
Sodium cyanide	100 ppm
pH	12
Temperature	60°C.

The following composition and conditions may be used effectively for low-speed plating:

Rochelle salt	40g/ℓ
Copper sulphate	10g/ℓ
Paraformaldehyde	15g/ℓ
Sodium hydroxide	8g/ℓ
Sodium cyanide	100 ppm
Temperature	25°C

The thus-obtained electroless plated copper film 7, as stated previously, is formed with strong adhesion selectively only on the catalytic layer 4 formed on the wall surface portions of the holes 3, and on the land and circuit areas, and therefore does not form on the other unrequired areas.

Fig.7' shows a board prepared by the steps which have been described above, i.e. a finished printed circuit board according to this invention. In this connection, it is to be noted that the solder resist film 6 may be formed prior to the electroless plating as shown in Fig.6' and finished as shown in Fig.7', or the film 6 may be formed after the electroless plating has been applied as shown in Fig.7 and thereafter finished as shown in Fig.7'. When the solder resist film 6 is not required, electroless plating may be applied directly on to the board as shown in Fig.6, and the board may be finished as shown in Fig.7.

When comparing the printed circuit board obtained according to this invention with those obtained according to the conventional manufacturing processes as regards performance and cost, the results obtained therefrom can be summarised as shown in the following table.

	Our process	Conventional processes		
		Example (1)	Example (2)	Example (3)
Base material used	cheap	cheap	cheap	expensive
Time required for manufacturing	short	short	short	long
Probable minimum circuit width	0.1 mm	0.3 mm	0.2 mm	0.5 mm
Intercircuit insulation resistance	10^{12}-$10^{13}\Omega$	10^{12}-$10^{13}\Omega$	10^{7} - $10^{8}\Omega$	10^{12}-$10^{13}\Omega$
Danger of short circuits	none	none	exist	exist
Soldering rate	100%	80%	80%	60%
Solder resist forming accuracy	easy	easy	difficult	easy

Although the above-described embodiments are concerned with a process for manufacturing plated through holes and circuits with an electroless copper plated film, the plated through holes and circuits may alternatively be formed by using electroless nickel plating.

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CLAIMS

1.A process for manufacturing a printed circuit board, comprising the steps of: making holes at required positions in a copper-clad laminate; forming a catalytic layer on the hole walls and on the copper cladding by dipping the board in a catalyser of the palladium-tin colloid system; forming an etching resist film on required land, wiring and circuit areas; removing unrequired areas of the copper cladding and of the catalytic layer by etching; removing the etching resist film; activating the catalytic layer as a pretreatment for electroless plating; and forming an electroless plated film of copper or nickel on the activated catalytic layer formed on the hole walls and land, wiring and circuit areas.

2. A process as claimed in any one of claims 1 to 3, wherein a solder resist film is formed on required areas before or after the electroless plated metal film has been formed.

3. A process as claimed in claim 1 and substantially as hereinbefore described with reference to the accompanying drawings.

4. A printed circuit board manufactured by a process as claimed in any preceding claim.