Palladium Plating of Printed Circuits

By J. E. Philpott, B.Sc.

Where low and stable values of contact resistance are required in a printed circuit, the contact surfaces are locally electroplated with a noble metal. The physical properties of palladium, combined with its relatively low cost and the ease with which it can be applied, make it an ideal metal for this purpose.

During the last decade the printed circuit has been extensively developed and is now in general use in a variety of electronic equipment. It consists basically of a series of conducting tracks bonded on to a non-conducting backing.

Numerous materials and production techniques have been investigated during this period of development and although other types are still in use for certain specialised applications the most common form of printed circuit is based on synthetic resin-bonded paper and copper foil. Such circuits are produced by etching techniques and they have found their way into equipment ranging from domestic radio and television receivers to elaborate defence devices.

The use of printed circuits was originally confined to applications where the conducting tracks replaced the wiring of conventional chassis. The main requirements of the track were that it should be of tolerably high conductivity and that it should readily soft solder. Copper met these requirements adequately, although there has been a growing interest in improving the soldering properties of the surface—particularly after storage. The contact properties of the track were not however of interest, since all connections to the circuit were soft soldered.

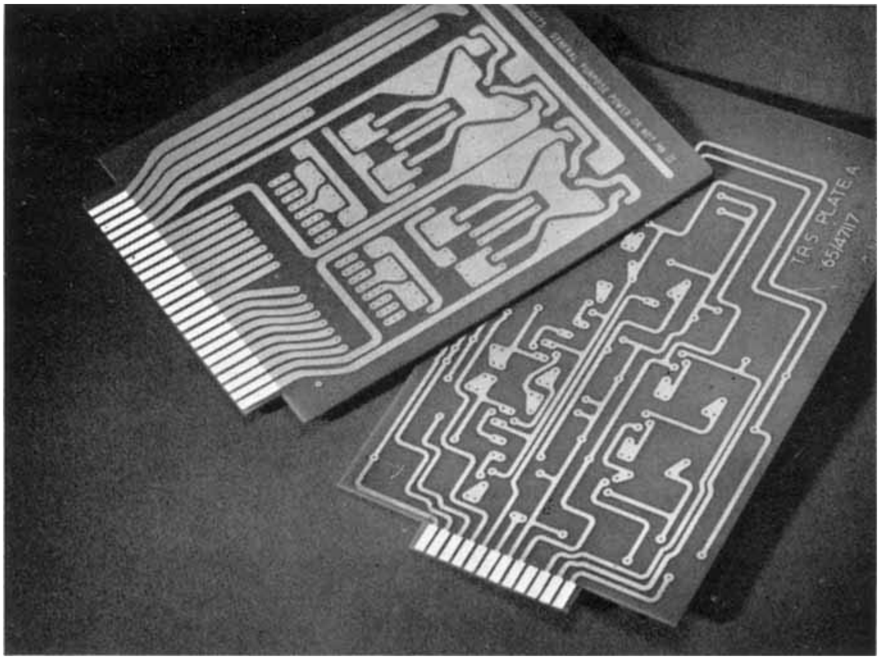
Wider uses of printed circuits have since been developed, and there are now two fields of application where the contact properties of the track are of great importance.

In the first, the printed circuit is used as the major component of a switch, the track replacing the mechanically produced segments or slip rings of the conventional switch.

In the second, one edge of the printed circuit board is designed for plugging into a suitably designed socket. This application is of particular importance to the computer manufacturer since it makes it possible for various sub-circuits, each capable of carrying out some mathematical operation, to be plugged into a computer during "programming". The plug contacts usually take the form of a number of parallel strips at right angles to one edge of the board.

Copper is not an ideal contact material; the oxide layer that it forms on its surface may give rise to high and unstable resistances and it is too soft for the more severe mechanical conditions that may be encountered, particularly in switching duties. Attention has therefore been directed towards providing tarnish-free surfaces that are preferably harder than copper and this has been achieved by locally electroplating a noble metal on to the copper. Four metals have been investigated: silver, gold, rhodium and palladium.

Silver has not been widely used. Although silver electrodeposits are obtainable with a hardness in excess of 100 V.P.N., the metal tarnishes fairly readily in sulphur-laden



Two printed circuits by Ferranti Ltd., designed for plugging into fixed sockets. The contact surfaces are palladium plated

atmospheres, and while this may be of little consequence in many duties, it prevents its use in the light duty conditions normally associated with printed circuits. More important is the tendency of silver to migrate across the backing and so to reduce the insulation resistance between adjacent tracks.

Gold or gold alloys are widely used for conventional light duty plugs and sockets and give outstandingly good electrical performance. Unfortunately, the gold baths in general use (like the silver baths) are strongly alkaline, and when used for printed circuits they readily attack the bond between the copper and the base material. Some work has, however, been carried out on the development of low pH gold electrolytes.

Rhodium is excellent for light duty switches, and rhodium plating is used extensively on printed circuit switches; the great hardness (800 V.P.N.) of electrodeposited rhodium gives a remarkably long service life although the high state of stress of the metal may sometimes give rise to lifting or cracking. The bath from which rhodium is deposited is extremely acid and although this does not affect the bond between the copper and the base material it may attack exposed areas of the base material and reduce its insulation resistance.

Palladium is coming increasingly into use for the plating of printed circuits, particularly for plug applications. Electrodeposited palladium has a hardness in the range 300 to 400 V.P.N. and is relatively free from internal stress, so that the plate does not suffer from curling and peeling troubles. It is tolerably free from porosity, and a deposit only 0.00005 inch thick will remain tarnish-free in store and give a short operating life; for improved working life deposits up to 0.0002 inch should be applied.

The physical properties of palladium combine to make it an ideal metal for the plating of printed circuits. In addition, its low specific gravity, coupled with its relatively low intrinsic cost, make it of particular economic interest and importance in this field.

Properties of Electrodeposited Palladium	
Specific gravity	11.9
Resistivity, microhm-cm at 0° C	10.7
Electrical conductivity, per cent IACS	16
Thermal conductivity, CGS units	0.17
Vickers hardness (annealed)	300—400
Thermal emf against platinum, (100° C) mV	0.57

Several palladium baths are reported in the literature, but the best of these for use with printed circuits is that based on tetrammino-palladium nitrate. The bath is simple and stable in use, has good throwing power, and gives satisfactory deposits in normal applications, but is especially useful with printed circuits because it is practically neutral, allowing direct plating on most base metals backed by phenolic resins without affecting the bond.

The bath consists of an aqueous solution of tetrammino-palladium nitrate, containing 30 g of the salt per litre. It is preferably contained in a glass-lined or polythene vat.

Insoluble anodes are used in the bath and these are normally of platinum gauze, although graphite and stainless steel anodes have been used. Graphite anodes tend to disintegrate with age and the possibility of contamination by organic material originating from the bonding resin also exists, while with certain types of stainless steel anodes corrosion has been known to occur, causing a brown precipitate of ferric hydroxide to form in the bath.

Generally, printed circuits are grease-free when received for plating, and no trichlorethyelene treatment is necessary. Initially the printed circuits are cleaned with stiff bristle brushes in water and are then gently scoured with fine pumice powder. This serves to remove grease from the surface and to abrade away any oxide film. Proprietary domestic cleaning powders should not be used for cleaning because some contain soaps which produce insoluble calcium soaps in hard water and these cannot be completely rinsed off the metal surface without a great deal of trouble.

The base metal track on the printed circuit is generally of copper, and after cleaning this can be directly plated with palladium. Where necessary the palladium plate can be confined to certain areas of the printed circuit by using a chlorinated rubber masking paint or masking tape.

Plating Conditions

The bath may be operated in the temperature range 60 to 80°C at current densities ranging from 5 up to 20 amp/ft^2. In the upper part of the temperature range it is possible to increase the current density appreciably without "burning" the work. The rate of deposition at 5 amp/ft^2 is approximately 1.2 mg per square inch per minute.

As with all insoluble anode processes the metal content of the plating bath is slowly reduced as the bath is worked, and it is necessary for replenishment to be made at regular intervals.

The palladium metal plated out of solution may be replaced at the rate of 6 g of the salt for every ampere-hour, and the palladium content of the solution should not be allowed to drop below the level of 20 g/l.

Careful control of the palladium content of the bath will give a maximum service life, but after prolonged use it will be found that the pH of the solution is gradually reduced due to the increasing concentration of ammonium nitrate.

Rejuvenation of worked solutions by the removal of ammonium nitrate from the bath is not practicable and it is advisable to make up fresh solution. The palladium in worked solutions may be precipitated by addition of an organic reducing reagent such as hydrazine or formaldehyde, and the precipitate filtered off and returned to the supplier.