Making PCBs in small

Making printed circuit boards for your own designs or for projects described in this and other magazines can be very satisfying. With new techniques and products the process is simple, clean and efficient.

There are a number of methods available to the constructor who wishes to make his own printed circuit boards (PCBs) but this article will focus on the methods used at Electronics Australia to produce project prototypes. Except for the scale of production the techniques involved are essentially the same as those used in commercial electronics manufacture, using photographic processes.

Although the materials described here cost more than etch-resistant inks and paints, the higher cost can be justified by the advantages of the dry resist process. Artwork processed as a photographic film can be used repeatedly, producing consistent results with a minimum of mess and fuss. No special skills are required once the initial PCB pattern has been created, making the method ideal for small manufacturers and hobbyists.

After the design of a circuit has been finalised the first step in making a printed circuit board is to create the artwork representing the PCB pattern. For this purpose we use actual size adhesive tapes and IC pads, such as those made by Bishop Graphics and the Japanese Izumiya company. These are rubbed down in the required pattern on a sheet of transparent plastic to produce a positive image, with areas of copper represented by tapes over the clear plastic.

The next step is to transfer the circuit board image to film to create a permanent copy of the artwork. Artwork created with tapes and adhesive materials are not suitable for multiple use or permanent storage as the tapes tend to come adrift in time.

To create a film copy of the artwork, UV sensitive photographic material is used. When the taped copy is clamped together with a suitably-sized piece of 3M Reversal Film type 8007 and exposed to ultraviolet light a negative image is created, with areas of copper represented by clear film and areas of opaque film representing those parts which must be etched clear of copper.

In researching this article we used a UV light box from Kalex. This professionally produced box uses four UV tubes and is fitted with a slide-out drawer and shelving to permit exposures to be made on one of two levels to cater for the different properties of photosensitive films, copper-clad board and 3M "Scotchcal" materials.

An exposure time of 10 seconds is all that is required to transfer the artwork image to the sensitised film, although if in doubt it is best to over-expose rather than under-expose the material. Following developing in a chemical bath the film produces a high contrast negative ready for use in exposing a sensitised copper-clad board. Of course, before the image is developed, futher exposure to UV light can mar the image. For this reason the film must not be exposed to sunlight or fluorescent tubes, although a low-wattage incandescent lamp can be used in the work-room as dark-room conditions are not required. The black plastic bags used for shipping the sensitised films are ideal for temporary storage and transport of films between exposure and developing.

Once transferred to film the artwork can be usd to create as many printed circuit boards as are required. A special type of copper-clad board coated with UV light-sensitive etch resist is used here. Called "Riston" (trade name) board, this material is exposed to ultra-violet light through the negative produced in the previous stage. Again the Kalex light box can be used, although the optimum exposure time for the Riston board is slightly longer at around 90 seconds.

When treated with the developer, areas of the resist exposed to ultraviolet harden and become impervious to the effects of the etching chemicals while unexposed areas are not affected.

As supplied the Riston board is covered by a protective plastic film which should be left in place during exposure and removed before the board is developed. For best results the board should be left for around 15 minutes between exposure and developing to allow the chemical coating to stabilise.

A pool of developer sufficient to cover the board is all that is required (say about a dessertspoonful for an average board), although additional developer can be added during the process. Kalex supply their own brand, either in a concentrate ready-to-use 25% solution.

When developed the copper areas of the board take on a dark blue colour. This is the etch resist which will prevent these areas from being affected by the etchant solution. A properly exposed and developed board should have copper areas which are hard and resistant to scratches. If the exposed area is soft it is most likely that the exposure time was insufficient and there will be a loss of definition in the finished board. Over-exposure, on the other hand, will enlarge the PCB tracks and close up small hole patterns, leading to problems when the board is etched.

After treatment in the developer bath the board should be washed in running water to remove all traces of the developer. Etching is the next step. Any of the commonly available etchants can be used, including ferric chloride or ammonium persulphate, can be used here. Both are poisonous and corrosive, and in addition ferric chloride will discolour fabrics and other materials it contacts.

Etchants are usually sold in powder form and mixed as required. Plastic containers should be used for etching as the chemicals will attack metal. Between uses all solutions should be stored in clearly labelled bottles. Warming the solution or mixing the powder with hot water will reduce the etching time.

Commercially available etching tanks use racks to hold the boards and a pump to circulate the etchant to reduce the time taken for the etching process. Kalex make two models, one a full-featured version for mass production and the other a simple two-compartment tray with supports for PCBs. Vertical mounting in this model restricts the size of PCBs to approximately 15cm ×9.5cm, although boards up to 19cm square can be etched if they are laid flat in the tank.

For home and hobbyist use a plastic tray is perfectly adequate as long as it is sufficiently large to allow the full immersion of the required board.

After etching the board should be washed in clear running water to remove all traces of the etching solution and the hardened etch-resist removed with steel wool and methylated spirits. Once the bare copper is exposed the board can be trimmed to size and drilled, ready to form the basis of an electronic masterpiece!

quantities

by PETER VERNON

The Kalex UV light-box is designed for exposure of sensitised film, boards and labelling materials.

The Kalex UV light box

The Kalex UV light-box is intended for use in the commercial application of the PCB techniques described in the accompanying article. It has been designed to process 3M Scotchcal, 3M I.N.T. labelling materials, 3M exposure film and Riston 3000 boards.

Four Philips T1 03T UV tubes with a peak wavelength of 420 nanometres are built into the top of the box for this purpose, although the box can also be used in other applications where UV light exposure is required by fitting tubes which peak at lower wavelengths if necessary. An "instant start" feature ensures that the tubes come on immediately, without flickering, as Kalex have eliminated the starters and provided transformers to preheat the tube filaments.

The light box measures 42.8 × 78.8 × 29cm (W × D × H) and is finished in wood grain veneer. The artwork or PCB to be exposed is placed in a drawer which slides in and out of the box and held in place by a plate of glass on a foam rubber backing surface. Materials with dimensions of up to 55 by 26cm fit comfortably in the box.

Two intensities of exposure are available since the sliding drawer can be fitted on one of two levels created by internal shelving in the box. The upper level places the artwork about 10cm from the UV tubes, but requires the sliding drawer to be fully removed from the box and turned upside down before re-installation. Both sides of the bottom surface carry foam backing, but the removable glass sheet must be re-located, a process that would be simplified if it was fitted with some sort of lifting handle.

On the front panel of the drawer is a dial for setting the mechanical exposure timer, a toggle switch controlling power to the tube filaments and two indicator lights; "power on" and "exposure in progress". Mains power is controlled by the switch on the wall socket as there is no mains power switch on the light box. A microswitch in the cabinet ensures that the UV lights cannot be switched on with the drawer open.

The timer is a mechanical type with the dial marked with numbers from 0 to 6 and graduated in tenths. A separate timming control sets the overall range of the timer from one of three ranges; 0-3.6 seconds, 3-60 seconds and 36-720 seconds. A small screw-driver is needed to make this adjustment, although we found that once set on the 60 second range further adjustment was not required when exposing UV sensitive films. With the tray on the lower level however, from one to two minutes is required to correctly expose Riston copper clad board, making the 12 minute range necessary.

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This etching tank includes mounting racks, a heater and pump circulation of etching fluid.

The box is 100% light-proof when the sliding drawer is closed but the mechanical timer and exposure indicator light provide confirmation that the light box is in operation. Once the selected exposure time is set on the timer dial, closing the drawer activates the microswitch and turns the lights on for the set period. Opening the box or switching off the power to the tube filaments instantly turns off the lights and sets the timer back to the start of the specified period, ready to be activated again when the drawer is closed.

This arrangement is ideal for exposure of multiple boards or artwork, as the timer need only be set once, at the start of the process. It also means, however, that when the box is first switched on the timer comes up with whatever setting was last used.

Kalex also make a smaller light box, the "Portu-vee", designed to the same high standard and suitable for exposure of materials with dimensions of up to 25 × 18cm. Unlike the larger unit this is a fully portable device, somewhat similar to a suit-case with four UV tubes mounted in the lid and a carrying handle on one side.

A commercial etching tank is also available, fitted with a 10W magnetic pump to circulate the etchant or developer. The pump is mounted externally and pumps through two tubes mounted vertically at diagonally opposite corners of the tank. The tubes are drilled to produce a series of jets in the liquid, augmented by liquid circulation to the pump input across the bottom of the tank.

A heater is mounted at the same corner as the tank outlet where suction from the pump prevents the warmer solution from rising to the top of the tank, ensuring a more uniform bath temperature. Racks for mounting printed circuit boards are also included, and the tank is compartmentalised to allow etched or developed boards to be rinsed by the circulation of fresh water through a hose connection from the water supply. An outlet hose allows waste water to be channelled away from the work in progress.

Kalex can also supply a full range of 3M and Riston materials, developers and etchants and all requirements for manufacturers and hobbyists wishing to produce their own professional standard PCBs. For further information contact the company at 101 Burgundy St, Heidelberg, 3084 or their branches in Yarraville and Melton, Victoria. Phone (03) 458 2976.

The Kalex "Portu-vee" light box is suitable for smaller jobs and is fully portable.