The MG Chemicals Professional Prototyping Process

Introduction

In recent decades, the materials available to the small scale electronics prototyper have not kept pace with the requirements of professionals. MG Chemicals has addressed this by releasing our new Professional Prototyping Process.

This process allows electronics engineers to prototype their own double-sided circuit board with plated through holes without having to send the design to a prototyping company.

It is also a valuable learning tool, because it mirrors the actual process used by contract manufacturers.

Some of the chemicals in this process pose significant safety hazards and disposal challenges, and for that reason this process is for professional use only. For amateurs and those making simple one sided boards, the MG Chemicals Basic Prototyping Process is more suitable.

These instructions assume the design of your circuit is completed, it requires a double sided board with through-holes, and you are ready to construct it.

There are 11 basic steps:

1. **Cutting and Routing** – the board is cut to size and routed to the desired shape
2. **Drilling, Deburring, and Reaming** – the through-holes are drilled, the copper that lifts up on the opposite side is sanded smoothed (“deburred”), and refuse material is cleaned out of the holes (“reamed”)
3. **Electroless Copper Plating**– a thin layer of copper is deposited on the inside of the through-holes using a five-step chemical bath system.
4. **Resist Application, Exposure, and Development** – Negative dry film resist is applied, exposed, and developed so that all of the copper that will be eventually etched off is covered by the resist, while the desired circuit and through holes are exposed for electroplating.
5. **Copper Electroplating** – The circuit and through-holes are plated with copper, making the through-holes usable.
6. **Tin Electroplating** – The circuit and through-holes are plated with tin, which will act as the etch resist, protecting the circuit when the unwanted copper is removed.
7. **Resist Stripping** – The resist is washed off with acetone or a sodium hydroxide solution.
8. **Copper Etching** – The board is placed in a sodium persulfate solution, which dissolves the unwanted copper but not the tin plated circuit.
9. **Tin Stripping** – The tin plating is removed (because it is very corroded after step 8).
10. **Solder Mask Application** – Solder mask is applied.
11. **Electroless Plating of Connectors** – Connecters are tin or gold plated using an electroless process.

Note that MG Chemicals does not at this time offer a solution for step 10, Solder Mask Application, only the proper placement in the procedure to apply a solder mask is noted for those capable. MG is developing a solder mask process and will update these instructions when it becomes available.

Before you begin

Read the instructions in their entirety

Be sure you are familiar with the entire process before you begin anything. Certain steps take significant planning.

Note that anytime these instructions refer to “the board” or “the PCB” it is meant to refer to the printed circuit board that is being prototyped.

Get everything you need

These items supplied by MG Chemicals:

- Double sided copper clad board (such as Cat. No. 540)
- Electroless Copper Plating Chemical Kit (Cat. No. 41600A)
- Electroless Copper Plating Tank Kit (Cat. No. 41600B)
- Dry Film Negative Resist (Cat. No. 416-DFR)
- Negative Developer (Cat. No. 4170-500ML)
- Exposure Kit (Cat. No. 416-X)
- Transparency film (Cat. No. 416-T)
- Foam brush (Cat. No. 416-S)
- Electroplating Tank (Cat. No. 41650) (x 2 recommended, one for copper and one for tin, but one can be used for both)
- Copper Anode Set (Cat. No. 41660)
- Copper Plating Solution (Cat. No. 41670-4L) x 2
- Tin Anode Set (Cat. No. 41662)
- Tin Plating Solution (Cat. No. 41672-4L) x 2
- Sodium Persulfate (Cat. No. 4101-1KG) x 2
- Etching Kit (Cat. No. 416-E or 416-ES)
- Tin Stripper (cat. # 41692-1L)
- Resist Stripper (Cat. No. 4185-500ML)
- Liquid Tin (Cat. No. 421-500ML)

Other items required, but not supplied by MG Chemicals:

- Rectifier (0-15V, 0-3A is sufficient for small boards, more amps are required for larger boards, the mathematical calculation can be found in the copper electroplating instructions on page X of this manual, do not use rectifier with more then 25 amp power for safety reasons)
- Magnetic Stirrer, (at least 17cm x 17cm plate surface, 2”x3/8” stir bar, available from Fisher Scientific and other lab supply companies)
- Drill (drill press preferred) and drill bits
- Deburring and reaming tools
- Laminator – almost any basic laminator from an office supply store will do
- Cutting device – fabric cutter, sharp scissors, or exacto knife
- Safelight – a working area lit only by a yellow or red 40 watt incandescent bulb.
- 2 glass or plastic trays large enough to lie the pcb being prototyped
- A measuring cup, about one liter capacity
- Hair dryer

Other options pieces of hardware that might be required:

- A guillotine press or band saw (only if cutting the board to size is necessary)
- A skill saw with routing blade (only if a board of irregular shape is required)

Plan for safety

The chemical hazard issues related to this process need to be taken seriously and plans to mitigate these risks be developed before you start the process.

Read through the material safety data sheets's ("MSDS's") for all chemicals used in this system. These can be found at www.mgchemicals.com/msds , where all of our MSDS are listed by part number.

The electroless copper plating process involves acids, bases, and in the last step, formaldehyde, a carcinogen; the electroplating baths are highly acidic, and liquid tin contains thiourea, also a carcinogen. These hazards can be mitigated with proper planning, but they must not be taken lightly.

Proper planning must be done to ensure that there is adequate ventilation in place prior to beginning the process. A fume hood is recommended. At all times airborne concentrations must stay below the maximum allowed levels listed on the related MSDS. When adequate ventilation is not available, use a half mask with a cartridge suitable for acidic and organic vapors (available at your local industrial safety supply store).

Protective gloves and eyewear must be worn at all times, and a lab coat is strongly recommended because a drop of some of these solutions will easily create a hole in clothing.

Ensure the workplace is a low traffic area and there is no chance of containers being knocked over or bumped.

Plan for disposal

Some chemicals in this kit are toxic and corrosive. The final step of the electroless plating process contains both dissolved copper ions, which are highly toxic to aquatic life, and formaldehyde, a carcinogen. Copper plating solution and used etching solution will both contain large amounts of dissolved copper. Dealing with these used chemicals is not a simple matter and deserves planning.

DO NOT DISPOSE OF THESE DOWN THE DRAIN.

Waste disposal must be in accordance with appropriate Federal, State, and Municipal regulations, which vary widely region to region, as do the quality of available facilities.

The easiest course of action is usually to store the used chemical solutions individually, and then call a local waste management facility for drop off or pickup. These can usually be found in the local Yellow Pages, and many local governments provide telephone hotlines to help people locate disposal facilities. Be ready to supply our MSDS's so the facility can determine the proper disposal method.

Used solutions should be stored in plastic or glass containers. Do not mix the solutions because reactions can result. All solutions should be sealed tight, to prevent hazardous gasses from escaping,

with the exception of ammonium or sodium persulfate solutions which should be stored in vented containers because they gas off over time. Persulfate is not only in the etching solution, it is in electroless plating tank number 2 as well.

Remember that empty containers may contain corrosive liquids or vapors and must be handled with care.

Material safety data sheets can be downloaded from: www.mgchemicals.com/msds/

Design your circuit for the MG process

How to actually design a circuit is far beyond the scope of these instructions, but there is an important requirement to your design if you intend to follow the MG process as written, and that is a hang hole.

In the electroless copper-plating step and both electroplating steps, the board is suspended off of a hook. During electroplating, this hook provides the electrical connection between the cathode bus bar and the board. If you do not want to insert a hang hole into your board, you will have to come up with another way of suspending your board that includes an electrical connection, however it is easy to insert a hang hole and not have it affect your final product by using a slightly larger copper clad board then necessary. Leaving a small strip of unused board to one side of your circuit, within which the hole can be drilled. That strip can then be cut off of the board when the process is complete.

This hang hole should be XX” in diameter, and sit approximately XX” in from the edge in the middle of one side of the board.

Step 1: Cutting and Routing

Ingredients required

- Copper clad board (“CCB”)
- For cutting: a guillotine press or band saw
- For routing: a skill saw with routing blade

Overview:

If you are going to cut your board down to size, that is the first step in this process. Either a guillotine press or band saw can accomplish this. When cutting your board, remember to leave an extra strip on one side for the hang hole.

If the PCB you are designing is not rectangular, you will want to cut the board to shape now using a routing saw. Detailed instruction on the use of routing tools is beyond the scope of these instructions.

Step 2: Drilling, Deburring, and Reaming

Ingredients required

- Drilling pattern
- Drill and drill bits
- Deburring tools
- Reamer (optional)

Overview

For someone new, this is likely to be challenging because drilling requires some physical skill and dexterity, unless one has access to a robotically controlled drill.

There is three parts to drilling through-holes:

1. Creating the drilling pattern
2. Drilling the holes
3. Deburring and reaming

Creating the drilling pattern

Creating a drilling pattern is relatively easy; print the circuit onto a piece of plain paper. Ensure your circuit pattern marks locations of the corners of your board, so it is easier to align the pattern over the board.

Place the pattern over the board, folding the excess paper around the board, so it protects the backside from being scratched during drilling.

Drilling the holes

The keys to successful drilling are 1) making sure holes are straight, and 2) making sure burrs are minimal.

Making sure holes are straight is most easily achieved using a drill press. If a drill press is not available, professional results may not be achieved, but a decent board can still be made using either a normal hand held power drill or Dremel.

The term “burrs” refers to the copper that is lifted off of the backside of the board, around the holes where the drill tip pushes through. This pushed up copper is removed in the next step (deburring), leaving a small ring of bare laminant around each hole. The larger the burr created during drilling, the more copper you will lose in deburring. Removed copper will be replaced by the electroless process later on, so losing the copper around the hole will not create a short circuit, but copper loss should be minimized to ensure quality. The size of burrs created during drilling needs to be minimized.

Everyone’s equipment will vary somewhat and drilling without creating burrs is somewhat of an art form, so you will need to experiment with the equipment available to you to determine which drill speeds and bits are optimal for you. We recommend practicing by drilling many through-holes on a test board, before trying to drill your first prototype board.

Deburring and reaming

As stated, deburring refers to the sanding or smoothing of the uplifted copper around the back of a newly drilled through-hole. All copper that lifted up from the surface of the laminant must be removed.

There are a variety of deburring tools available. Essentially anything can be used that is capable of sanding down copper without removing an excessive amount in the process. A Dremel drill kit contains many suitable attachments. A sanding or sharpening stone will also work alright, but sandpaper will likely not be strong enough.

Reaming refers to cleaning the copper refuse out of the hole after the deburring process, which commonly pushes copper back into the holes. The best way to ream your holes is with a reaming drill bit, which is a bit similar to a common drill bit, but the threads are more vertical and it is a bit smaller. You just re-drill the holes with the reaming bit and it cleans them out. If you do not have access to a reaming drill bit, you can use a regular bit that is a bit smaller then the one used to initially drill the hole. You might find it easiest to simply hold the drill bit by hand and clean the hole out that way. There are hand held reamers available on the market as well.

More on reaming and deburring can be found on the internet:

- http://en.wikipedia.org/wiki/Burr_(metal)
- http://www.deburringtools.com/
- http://en.wikipedia.org/wiki/Reamer

Ensure the surface of both sides of the board is as smooth as possible and the through-holes are entirely cleaned out before moving onto the next step.

Step 3: Electroless Copper Plating

Ingredients required

This process requires these items supplied by MG Chemicals:

ELECTROLESS PLATING CHEMICAL KIT **CAT. NO. 41600A** **CONTENTS:** 1 x Alkaline Cleaner - Cat. No. 41601-250ML 1 x Micro Etch Part A - Cat. No. 41602-250ML 1 x Micro Etch Part B - Cat. No. 40603-250G 2 x Catalyst Part A - Cat. No. 41604-1L 1 x Catalyst Part B - Cat. No. 41605-250ML 1 x Accelerator - Cat. No. 41606-250ML 1 x Plating Solution Part A - Cat. No. 41607-250ML 1 x Plating Solution Part B - Cat. No. 41608-250ML 1 x Plating Solution Part C - Cat. No. 41609-250ML	**ELECTROLESS PLATING TANK KIT** **CAT. NO. 41600B** **CONTENTS:** 5 x 1 Gallon High Density Polyethylene Tanks 5 x 1 Gallon High Density Polyethylene Lids 1 x 3/8" x 8 ¾" Copper Bar 1 x 8 Gauge Copper Hook 1 x Air pump 1 x ¼" x 2' Poly Tubing 1 x package of M.G. 416-G Nitrile Gloves

The Electroless Plating Chemical Kit contains enough chemicals to prototype five 5"x3" copper clad boards. Once mixed, two of the solutions will only last two days, so it is a good idea to have more then one prototype lined up before beginning, so the kits entire potential can be used before it expires. This kits needs to be repurchased to repeat the process.

The Electroless Plating Tank Kit contains five tanks, one for each step in the process, each labeled with dilution instructions and immersion times, along with a hanging bar and hook, a package of nitrile gloves suitable for resisting the acid solutions in this process, and an air pump and tube to keep the solution in step 5 agitated. These tanks are designed to be used for boards that are 5”x3” or smaller. If you intend to plate larger boards, you will need to design your own tank system. This kit does not have to be repurchased to repeat the process.

Other ingredients recommended but not required:

Magnetic Stirrer with Stir Bar (2 x 3/8”), – Some users may find magnetic stirrers to be expensive, but it is strongly recommended that one be used in this process. Nearly every step in this process requires steady agitation for an extended period of time. Users might accomplish this by hand stirring with a rod, or by using air agitation, but one will generally not achieve professional results with those methods. These instructions are written assuming the user has a magnetic stirrer available.

Aqueous Heater (cat no. 416-H) – This process will function at room temperature; however, superior results are achieved if the solutions are slightly heated. The optimal temperature for each step is 25C, except for the last step where the optimal temperature is 30C.

Hair dryer –For quickly drying the board after rinsing, to prevent water from corroding the board

Measuring cup - For water, preferably about 1 liter capacity

Rinsing tray - Large enough to fit the board being prototyped

Overview:

After drilling, de-burring, and reaming the through holes, the electroless plating process is used to apply a thin layer of copper to the inside of every hole. This layer is not sufficient to carry the current in the finished circuit, but it is sufficient to plate to with a regular electroplating process, which normally would not adhere to the inside of the holes because the board is made of non-conductive material.

There are three steps to this process:

1. Cleaning the board,
2. Setting up the solutions
3. Immersing the board sequentially in each solution

Cleaning the board

Ensure your pre-drilled board is cleaned using an abrasive powder and an abrasive pad. Rinse with water and quickly dry using a hair dryer. Keep board in a dust free area until you are ready to begin step 3.

Setting up the solutions

In this step you prepare your working solutions by mixing each chemical with water in the appropriate tank using the magnetic stirrer.

Each chemical bottle and plating tank has been clearly labeled as to what step it relates to, so start by taking the bottles of the chemical kit and placing them next to the tank they belong with.

Generally, in each step you put the specified amount of water into the tank, place that on the magnetic stirrer, insert the stir bar into the middle of the tank, turn the stirrer to medium power to create a vortex, add in the chemicals required by that tank, and then mix for the specified amount of time. However, each step has its own specific requirements, so follow these exact steps:

Tank 1:

1. Place Tank 1 on the magnetic stirrer
2. Fill tank to with 2250 ML of room temperature water.
3. Insert the stirring bar, turn magnetic stirrer to medium power and create a vortex
4. While mixing, add entire content of Alkaline Cleaner (Cat. No. 41601-250ML)
5. Mix entire solution for 2-3 minutes.

Tank 2:

1. Place Tank 2 on the magnetic stirrer
2. Fill tank to exactly 2150 ML with room temp. water.
3. Insert the stirring bar, turn magnetic stirrer to medium power and create a vortex
4. While mixing, add entire content of Micro Etch Part A (Cat. No. 41602-250ML). This may increase the temp. of solution.
5. While mixing, slowly add Micro Etch Part B (Cat. No. 40603-250G) - **Caution**: Before adding Micro Etch Part B, make sure the solution is at room temperature. Adding content when the water is above room temperature may cause a reaction.
6. Mix until all crystals from Micro Etch Part B have been totally dissolved.

Tank 3:

1. Place Tank 3 on the magnetic stirrer
2. Fill tank with 250 ML of room temperature water.
3. Add both bottles of the Catalyst Part A (Cat. No. 41604-1L).
4. Insert the stirring bar, turn magnetic stirrer to medium power and create a vortex
5. Mix for 2 minutes.
6. While mixing, add the entire content of Catalyst Part B (Cat. No. 41605-250ML).
7. Mix entire solution for 2-3 minutes.

Tank 4:

1. Place Tank 4 on the magnetic stirrer
2. Fill tank with 2250 ML of room temperature water.
3. Insert the stirring bar, turn magnetic stirrer to medium power and create a vortex
4. While mixing, add entire content of Accelerator (Cat. No. 41606-250ML).
5. Mix entire solution for 2-3 minutes.

Tank 5:

This solution must be kept under constant agitation using the Air Pump supplied in Electroless Plating Tank Kit or it will degrade and not function properly.

1. Fill tank with 1750 ML of warm water (30°C / 86°F).
2. Connect the1/4” Poly Tubing to the air pump and place the other end into the warm water tank. Plug air pump in to start the agitation. Keep pump above the solution level to avoid siphoning of solution back to pump.
3. Add the entire contents of Plating Solution Part A (Cat. No. 41607-250ML). Allow mixture agitation for 2 minutes before adding the next bottle.
4. Add the entire content of Plating Solution Part B (Cat. No. 41608-250ML). Allow mixture to agitate for 2 minutes before adding the next bottle.
5. Add the entire contents of Plating Solution Part C (Cat. No. 41609-250ML).
6. KEEP UNDER CONSTANT AGITATION. – do not remove the air agitation from this tank unless it is to replace it with the magnetic stirrer, or you are done with the process.

Immersing the board sequentially in each solution

In this step the board is immersed in each tank in numerical order, always under agitation, for a specified amount of time. It hangs off of the copper hook, which hangs off of the copper bar, by which you pick up and move the board from tank to rinsing solution to tank, as the process goes on.

To begin, thread the copper bar through the eye of the hang hook then hang your board on it. Note the location of the notches at the top lip of each tank. These notches are to hold the bar in place when you immerse the board in that tank. When the following instructions say to immerse your board, place the bar on that tank so that the board hangs down into the solution. Make sure the board is completely submerged but not so deep that it interferes with the magnetic stir bar. When it is time to remove the board from the solution, lift the bar off of the tank and move to the rinsing tray, rinsing both board and hook.

After threading the hook on the bar and hanging your board on the hook, follow these steps in order:

Tank 1:

1. Place tank 1 on the magnetic stirrer.
2. Place the magnetic rod in the center of the tank.
3. Turn on magnetic stirrer and set at medium speed.
4. Immerse your board into the solution.
5. Continue to immerse the board for a total of at least 7 minutes.
6. Take board out of solution, thoroughly rinse the hook and board with water, and quickly move to the next tank.

Tank 2:

1. Place tank 2 on the magnetic stirrer.
2. Place the magnetic rod in the center of the tank.
3. Turn on magnetic stirrer and set at medium speed.
4. Immerse your board into the solution.
5. Continue to immerse the board for exactly 1 minute.
6. Take board out of solution, thoroughly rinse the hook and board with water, and quickly move to the next tank.

Tank 3:

1. Place tank 3 on the magnetic stirrer.
2. Place the magnetic rod in the center of the tank.
3. Turn on magnetic stirrer and set at medium speed.
4. Immerse your board into the solution.
5. Continue to immerse the board for 7-9 minutes.
6. Take board out of solution, thoroughly rinse the hook and board with water, and quickly move to the next tank.

Tank 4:

1. Place tank 4 on the magnetic stirrer.
2. Place the magnetic rod in the center of the tank.
3. Turn on magnetic stirrer and set at medium speed.
4. Immerse your board into the solution.
5. Continue to immerse the board for 5-6 minutes.
6. Take board out of solution, thoroughly rinse the hook and board with water, and quickly move to the next tank.

Tank 5:

1. Place tank 5 on the magnetic stirrer.
2. Place the magnetic rod in the center of the tank.
3. Turn on magnetic stirrer and set at medium speed.
4. Immerse your board into the solution.
5. Continue to immerse the board for 30 minutes.
6. Take board out of solution, thoroughly rinse the hook and board with water.
7. Dry the board quickly using a hair dryer, and place in a dust free area.

Observe board after the electroless process. Both the surface of the board and the interiors of the through-holes should have light brown color.

If you feel that there are some dark spots, residue on the board after you finished the electro-less process, then **gently** clean the board using an abrasive powder such as Comet and an abrasive pad. Rinse it with water and then quickly dry it using a hair dryer. Keep the board in a dust free area until you are ready to begin the lamination process.

Step 4: Resist Application, Exposure, and Development

Ingredients required

These items supplied by MG Chemicals:

- Dry Film Negative Resist (416-DFR)
- Negative Developer (4170-500ML)
- Exposure Kit (416-X)
- Transparency film (416-T)
- Foam brush (416-S)

Other items required, but not supplied by MG Chemicals:

- Laminator – any baseline laminator from an office supply store will do
- Cutting device – sharp scissors or fabric cutter
- Safelight – a working area lit by a yellow or red 40 watt incandescent bulb.
- 2 glass or plastic trays, one to contain the developer solution and one for rinsing water
- A measuring cup and water

Overview:

Working under safelight, a portion of dry film resist is cut off of the roll and laminated onto the prototype board.

A positive transparency of the desired circuit (where the black lines denote the circuit) is placed over the board; the board is exposed with daylight-fluorescent light, and then developed. The unexposed resist is thus removed, and the exposed resist remains, so the desired circuit is bare and the copper that will later be removed is under the remaining resist.

The resist is applied to act as a plating resist, not an etch resist. In the next step copper will be electroplated onto the circuit and through holes. In the step after, the copper circuit will be electroplated with tin, and it is the tin will be the etch resist, protecting the circuit when the excess copper is removed by submersion in sodium persulfate.

There are five steps in this process:
- Printing the circuit on a transparency
- Creating a safelight environment
- Application
- Exposure
- Development

Printing the circuits on transparencies

Before beginning this step you will need to print the circuits for each side of the board onto heat stabilized transparencies (MG #416-T) using a laser printer, 600 dpi or greater. An ink jet printer will not work because the ink is not sufficiently opaque.

After printing, overlay your transparencies and examine them to ensure the through-hole locations match. Hold each one over the drilled board to ensure they line up with it as well.

The circuits should be mirrored before printing, so that when the transparency is placed on the board, the ink will be on the bottom and thus flush against the board. If the ink is on the top of the transparency, during exposure light hitting at an angle can potentially get under the edges of the image, resulting in a fuzzy exposure.

Make sure the corners of your board are marked on the transparency, so it is easy to align it.

Creating a safelight environment

Dry film resist is exposed by ambient light, so a dimly lit work area must be created. A darkroom lit by a red or yellow 40 watt incandescent bulb is optimal, but a plain 40 watt bulb across the room with a little

stray light coming in here or there will be fine for short intervals. **Fluorescent lighting and sunlight will expose the resist prematurely**.

Do not remove the resist from the black bag unless you are in your safelight environment. Make sure it is back in the bag before you turn the main lights back on. Work with laminated boards in safelight until after the applied resist is developed, after which it is ok to turn your room's main light back on.

Application

Clean the board using fine steel wool or similar abrasive pad and rinse well with water. Dry the board quickly with a hair dryer to prevent corrosion.

Enter your safelight environment, and take the resist out of the package. Cut off a portion of resist large enough to cover both sides of your board, folded over one side, leaving a 1cm edge all of the way around. The easiest way to do this is to lay the resist flat, lay the board on it, and then cut around the board with a fabric cutter, flipping the board over one side while cutting to double the area. If you do not have a fabric cutter, sharp scissors or an exacto knife will work fine.

The resist has a protective coating on both sides, a soft coating on the side facing the inside of the roll and a harder coating on the outside. Remove the soft coating from the resist that has been cut for use (This can be tricky to do so be patient).

Next, apply the resist to the board by folding it over one edge, sandwiching the board between the two sides so they come together forming a 1 cm strip of excess resist around the board, except for the side the resist is folded over. Ensure the resist is flush against the board and free of wrinkles (you may have to practice a few times to do it wrinkle-free). Also, ensure that the side with the protective coating removed is against the board.

Turn on the laminator. Wait until the laminator's 'ready' indicator is on. Feed the board into the laminator, with the side the resist is folded over going in first. When the board comes out the other side, put it through the laminator for a second time.

A higher end laminator is not necessary, but if one is being used, the settings for this resist are as follows:

- Seal bar temperature: 50 – 80 ◦C (120 – 176◦F)
- Laminator roll temperature: 100 – 115 ◦C (212 – 239◦F)
- Speed m/min(ft/min): 2.0 +/- 1.0 (6.5 +/- 3.3)
- Pressure kg/cm2(psi): 2.5 +/- 1.5 (40 +/- 20)

Store finished board in a dark and dust free environment until ready for use.

Exposure

In the safe light environment, set up the exposure kit, but do not turn it on. Place the laminated board under the center of the light fixture. Place the appropriate transparency on the board, being very careful to align it properly (where the black lines are on the transparency is where the circuit will end up on the board, ensure hole locations match the transparency).

Carefully place the clear acrylic cover over the transparency to hold it in place.

Turn on the exposure light and expose the board for 12 minutes.

Turn off the exposure light, and remove the acrylic cover and transparency.

Flip the board over, and cover with the transparency printed with the circuit for that side, replace the acrylic cover, and then turn on the exposure light on for another 12 minutes.

Turn off the light and then remove the board.

Examine the board to ensure the exposed resist has turned from green to blue, indicating successful exposure.

Development

While the board is exposing, dilute one part MG cat# 4170-500ML Negative Developer with 10 parts room temperature water into a tray large enough to comfortably fit the board being developed. Mix enough solution to be 1" – 2" deep in the tray.

After the board is exposed, still in safelight, remove the outer protective coating from the resist (which might take time, be patient), and place the board into the developing solution. Gently agitate the solution with the smoother brush, flipping the board over now and then to ensure both sides develop evenly, and keeping an eye on the board's progress. Towards the end of the process, take the board out of the solution now and then and inspect it closely to determine if it is done developing or if you need to put it back into the solution for more.

When the board is placed into the developing solution, all of resist that was not exposed to light will be removed, but the time can vary greatly, between 30 to 120 seconds. Because of this variance, it is important that developing be observed instead of timed. The development stage is completed when the desired circuit and through-holes are bare copper, and the remaining copper that will later be etched off of the board is still completely covered with dry film resist.

When development is completed, quickly rinse the board in water and dry with a hair dryer. After this it is ok to work with the board in normal light again.

Step 5: Copper Electroplating

Ingredients required

The following ingredients are supplied by MG Chemicals

- Electroplating Tank (cat. no. 41650)
- Copper Anode Set (cat. no. 41660)
- Copper Plating Solution x 2 (cat. no. 41670-4L)
- Sodium Persulfate (cat. no. 4101)

The following ingredients are also required:

- Rectifier (0-15V, 0-3A is sufficient for small boards)
- Magnetic Stirrer, (at least 17cm x 17cm plate surface)
- Hair dryer

Rectifier

A rectifier is required for electroplating, but it does not have to be powerful. Entry level rectifiers with a current capacity of 3 amps, have enough power for most boards that fit in the MG Electroplating Tank, but some users may find it necessary to use up to 10 amps.

Plating boards 5”x3” or smaller involves such small currents and voltages that the risk of electrical shock during normal operation is very minimal, however, always be wary of the risk of electrocution when working with open circuits and treat the open bus bars and solution as if they are electrical hazards. Always wear nitrile or rubber gloves when touching any electrified part of the system. Limit the risk by never using a rectifier with current generating capacity greater then 25 amps. Hooking up a large rectifier incorrectly can create a hazard.

Magnetic Stirrer

A magnetic stirrer is not necessarily required, other agitation methods may suffice; however, a magnetic stirrer is highly recommended to achieve professional results.

It is very important that your magnetic stirrer be of sufficient size so the etching tank can sit on it without being unstable; the plate should be at least 17 cm by 17cm. It is not difficult to obtain a magnetic stirrer of this size. Do not use a small magnetic stirrer intended for beakers, because the etching tank might easily tip and spill corrosive acids.

Overview:

In this step 1.0 mil of copper is electroplated onto the board to build up the current carrying capacity of the through-holes.

This is a straight-forward process with five steps:

- Calculating the required current
- Micro-etching the board
- Setting up the electroplating tank
- Electroplating
- Cleanup

Calculating the required current

Before placing your board into the tank you will need to calculate the amount of current required.

Start by calculating how much copper area you want to electroplate on your board.

18 amps is required per square foot of copper to a achieving a thickness of 0.001” (1.0 mil or 25 microns) in one hour.

The current (i) required to plate a different size of copper to the same thickness is directly proportional to this, so i = (18 amps) * A /(144 in^2), where A is the surface area to be plated in square inches.

Example

What is the current required to plate a 5” x 3” board, with the circuit covering approximately 40% of the surface area of the top side of the board and 30% of the bottom side of the board?

1. Calculate the surface area being plated

A = 5” * 3” * 40% + 5” * 3” * 30% = 10.5 in^2

2. Calculate the required current

i = 18 amps * 10.5 in^2 / 144 in^2 = 1.3 amps

Micro-etching the board

Before plating the board, it is useful to quickly etch the surface. This removes oxidation and allows for better plating. Be careful though, if you leave the board in this solution for too long it will remove the thin layer of copper currently in the through-holes.

Take 20 grams of M.G. Chemicals’ Sodium Persulfate (Cat. No. 4101-1KG) and dissolve into 2 liters of room temperature water, mixing thoroughly until powder is dissolved.

Immerse the board in the solution for 10-15 seconds only. Rinse right away with the tap water, and dry quickly using a hair dryer to prevent oxidation.

Setting up the electroplating tank

There are three bus bars in this tank kit; the two with red wires are the anode bars, and the one with the black wire is the cathode bar. Insert the anode bars through the left and right sets of holes on the tank, and the cathode bar through the holes in the middle of the tank.

Hang 4 copper anodes on each anode bus bar, making sure they are evenly spaced across the bars.

Fill the tank with two 4 liter jugs of MG Chemicals Copper Plating Solution.

Attach the bus bar wires to the rectifier, the red wires from the anode bus bars to the positive (+) terminal, and the black wire from the cathode bus bar to the negative (-) terminal.

Place the etching tank on the magnetic stirrer.

Copper Electroplating

Hang your board on the hang hook and suspend it from the middle of the cathode bar. Check the placement of the board. The board should be positioned so there is approximately 1 - 2” of solution over the top of the board. Make sure the board is parallel with the anodes.

Drop the stir bar into the solution, aiming for the center of the tank. Turn on the magnetic stirrer and adjust the speed until you create a vortex in the solution.

After the vortex is created, turn on the rectifier and set the current to the level calculated earlier. Do not adjust the voltage.

If you see a voltage and no current, or there is a current but it fluctuates for more then 2 minutes, then there is either a loose connection or significant corrosion on the bus bars and hang hooks. This is very common if the bus bar and hang hook are not removed and cleaned in between uses.

If this occurs, take board out of tank and rinse with tap water and dry quickly with the use of hair dryer. Check to make sure all connections are tight. If a loose connection is found, tighten the connection and try the electroplating process again. If no loose connection is found, remove the bus bars, hook, and anodes and scrub the contact areas with steel wool or other abrasive cleaner, rinse with water, dry, reassemble the tank, and try the electroplating process again.

Keep the board in the solution for one hour.

Periodically check on the current in the rectifier display to verify it is consistent; periodically verify the magnetic stir bar is functioning normally in the center of the tank (it can slide to the side and agitation will not be optimal). It is critical that both are performing properly.

Never leave the board in the electroplating solution for more then two minutes if either the magnetic stirrer or rectifier are turned off.

After 1 hour of electroplating, take the board out from the plating tank and rinse right away with tap water. Quickly dry the board with hair dryer.

The two gallons of copper solution used to fill the electroplating tank contain enough active ingredients to plate at least 150 square inches with 1.0 mil of copper.

Clean up

A quick clean up of the electroplating tank and accessories is recommended because the acidic vapors of the plating solution quickly corrode the bus bars and hooks when not in use, and this corrosion prevents current from flowing properly when the tank is reused.

Once finished electroplating for the day, remove all anodes, hang hooks, and bus bars and wash them all with an abrasive pad or abrasive cleaner and warm water. Dry everything quickly using a hair dryer to prevent oxidization.

Keep in mind that copper electroplating solution contains copper ions which are lethal to aquatic life, and therefore must never be disposed of down the drain. Review the disposal considerations discussed earlier in these instructions.

Step 6: Tin Electroplating

Ingredients required

The following ingredients are supplied by MG Chemicals

- Electroplating Tank (cat. no. 41650)

- Tin Anode Set (cat. no. 41662)
- Tin Plating Solution x 2 (cat. no. 41672-4L)

The following ingredients are also required:

- Rectifier
- Magnetic Stirrer, 17cm x 17cm square surface
- Hair dryer

Overview:

In this step 0.2 mils of tin is electroplated onto the board to act as an etch resist.

In the following steps, the plating resist will be washed off and the board placed in sodium persulfate solution, which will remove all copper not protected by tin.

This process is nearly identical to the copper plating process, the only difference is that tin anodes and tin plating solution are used in place of copper anodes and copper plating solution.

There is no need to re-calculate the required current; use the same current that was used for copper electroplating.

There no need to microetch the board before tin electroplating.

Setting up the electroplating tank

Insert the anode bars through the left and right sets of holes on the tank, and the cathode bar through the holes in the middle of the tank.

Hang 4 tin anodes on each anode bus bar, making sure they are evenly spaced across the bars.

Fill the tank with two 4 liter jugs of MG Chemicals Tin Plating Solution.

Attach the bus bar wires to the rectifier, the red wires from the anode bus bars to the positive (+) terminal, and the black wire from the cathode bus bar to the negative (-) terminal.

Place the etching tank on the magnetic stirrer. Drop the stir bar into the solution, aiming for the center of the tank. Turn on the magnetic stirrer and adjust the speed until you create a vortex in the solution.

Tin Electroplating

Hang your board on the hang hook and suspend it from the middle of the cathode bar. Check the placement of the board. The board should be positioned so there is approximately 1 - 2” of solution over the top of the board. Make sure the board is parallel with the anodes.

Drop the stir bar into the solution, aiming for the center of the tank. Turn on the magnetic stirrer and adjust the speed until you create a vortex in the solution.

After the vortex is created, turn on the rectifier and set the current to the same level used to electroplate the board with copper. Do not adjust the voltage.

If you see a voltage and no current, or there is a current but it fluctuates for more then 2 minutes, review the copper electroplating instructions where this issue is discussed.

Keep the board in the solution for 12 minutes.

Periodically check on the current in the rectifier display to verify it is consistent; periodically verify the magnetic stir bar is functioning normally in the center of the tank (it can slide to the side and agitation will not be optimal). It is critical that both are performing properly.

Never leave the board in the electroplating solution for more then two minutes if either the magnetic stirrer or rectifier are turned off.

After 1 hour of electroplating, take the board out from the plating tank and rinse right away with tap water. Quickly dry the board with hair dryer.

The two gallons of tin solution used to fill the electroplating tank contain enough active ingredients to plate at least 750 square inches with 0.2 mil of tin.

Clean up

Once finished electroplating for the day, remove all anodes, hang hooks, and bus bars and wash them all with an abrasive pad or abrasive cleaner and warm water. Dry everything quickly using a hair dryer to prevent oxidization.

Review the disposal considerations discussed earlier in these instructions.

Step 7: Resist Stripping

Ingredients required

Resist Stripper (cat. no. 4185-500ML)
416-S

Overview:

This step is very simple; the resist is washed off of the circuit board with Resist Stripper.

Procedure:

Put the prototype board into a flat glass, metal, or plastic container and pour in enough Resist Stripper to generously cover the board. Agitate the solution and scrub the resist with the 416-S Smoother Brush until all of the resist is completely dissolved and stripped from the board.

Step 8: Copper Etching

Ingredients required

Sodium persulfate (cat.# 4101-1KG), 1 or 2 bottles depending on etching tank volume

416-E Professional Etching Kit OR 416-ES Economy Etching Kit and 416-H heater

M.G. Chemicals cat #416-E Etching Kit contains:

- A seven liter polyethylene tank with clear acrylic lid
- Mounting bracket
- #416-AP Heavy Duty Air Pump
- 3 way adjustable airline manifold
- Triple line sparging unit
- #416-AH Air Hose for sparging unit
- #416-H 200 Watt vertical Heater
- External Tank mounted digital thermometer
- #416-G Nitrile disposable gloves

M.G. Chemicals cat #416-ES Etching Kit contains:

- 5.6 liter (1.5 gallon) plastic tank and lid
- Light duty air pump
- Single line sparging unit including air hose
- Single pair of latex disposable gloves

Overview:

The board is placed in a copper etching solution until all copper not protected by the tin is removed.

The recommended etching solution is sodium persulfate, because etches copper but not tin. Ammonium persulfate will also work and will etch the pcb slightly faster, but it is not as human friendly and will not etch as much copper as sodium persulfate, so sodium persulfate is recommended.

Ferric chloride solutions are not appropriate because they usually contain hydrochloric acid, which strips tin.

An etching tank is required. Almost any plastic or glass container with a volume of at least 5 liters will do, but proper tank geometry, board placement, agitation, and heat are required for efficient etching, so a complete etching kit like the MG 416-E Professional Etching Kit is recommended. The 416-ES Economy Etching Kit is less expensive, but lacks a heater, which can be purchased separately (cat. No. 416-H).

Instructions

Fill your etching tank with at least four liters of sodium persulfate solution, mixing 250 grams of sodium persulfate per liter of water. Larger volumes of solution will etch boards faster, but do not overfill the etching tank; leave at least 10% unused volume.

Heat the solution to 50C using the heater supplied with your etching kit, an aquarium heater, or heating plate.

Place the board in the etching solution. Continually agitate with air or a magnetic stirrer, ensuring there is good flow of solution across both sides of the board. Remove the board from the solution when all copper is removed.

Total etching time may be anywhere from 20 minutes to 6 hours depending on the solution temperature, the quality of agitation, and the minimum spacing between traces on the board (greater detail takes longer to etch).

Tin resists sodium persulfate very well, so the board can be left in the solution for a long time with little risk of stripping the tin.

Step 9: Tin Stripping

Ingredients required

Tin Stripper (cat. # 41692-1L)

A glass or plastic container in which the board can be immersed in solution.

Overview:

The board is immersed in tin stripper until the tin is removed from the board.
When this step is complete, the board will be ready for solder mask application.

Procedure

Place the board in the glass or plastic container and pour in enough tin stripper to immerse the board. Agitate the solution until the tin has been dissolved and the traces are bare copper. This should take 1 – 5 minutes.

Once the tin is removed from the board, take the board out of the solution, rinse with water, and quickly dry with a hair dryer to prevent corrosion.

Step 10: Solder Mask Application

Ingredients required

None available at this time.

Overview:

This is the point in the procedure where solder mask should be applied, however, MG Chemicals is still developing this procedure and does not have a solder mask application method available just yet. These products should be available by the end of 2009. Check the MG Chemicals website for updates.

In the mean time, customers may be able to devise their own solder mask techniques for use at this stage.

At the end of this stage, the board should be coated in solder mask, with only the connectors exposed.

Step 11: Electroless Plating of Connectors

Ingredients required

421-500ML Liquid Tin

Overview:

The board is immersed in an electroless plating solution, and copper connectors are plated with tin, to prevent corrosion.

This step may be performed even if solder mask was not applied, only the entire circuit will be plated instead of only the connectors.

Instructions:

Thoroughly clean and dry the board.

Pour Liquid Tin into a glass or plastic tray, large enough to lay the board in.

Immerse board in the solution for 3 to 5 minutes, agitating the solution and board to ensure both sides are evenly exposed and fluid passes through the through-holes.

Remove the board as soon as all exposed copper has been covered with a continuous layer of tin.

Rinse with warm water and dry quickly with the hair dryer.

The MG Professional Prototyping Process is now complete!

Electroless Copper Plating Quick Reference Chart