Method of chemically metallising through holes on a PCB

The following is a method of metallising through holes on a PCB that is very reliable, produces a professional smooth finish, and is easy to master.

Introduction
Most electronics enthusiasts have made at least one single sided PCB, while others make double sided PCBs as a matter of course. However, connecting one side of the PCB with the other side is something that is a necessity for double sided boards.

Several mechanisms have been employed by enthusiasts for top to bottom connection, but most are either dirty, clumsy, or down right fiddly and time consuming. Such as carbon ink, metal rivets, and pieces of wire through the holes. This is one of the pitfalls that turn many enthusiasts away from attempting double sided PCBs.

There is a valiant effort to demonstrate a chemical solution to through hole plating available on the internet using an ammonia and copper hypophosphite solution, but this suffers from poor reliability, along with very high temperatures required, and the fact that the main chemical is on the list of banned substances in most of the western world, because of its association with class A drug manufacturing.

The process discussed here is a small scale variation of how the professional PCB fabricators perform through hole plating, but instead of using several large tanks of chemicals, a minimum of two containers is required. And the expensive palladium chloride is replaced with a less expensive, but just as effective, metal salt. No high temperatures are required and the full process can be performed quite safely in a small workshop, or even in the kitchen.

To summarise the following process of metallising through holes on a PCB:

- Mechanically de-burr and clean the copper on the board.
- Rinse.
- Chemically de-grease the board.
- Rinse.
- Chemically sensitise the board.
- Rinse.
- Chemically catalyse the board.
- Rinse.
- Electroless copper plate the board.
- Rinse.
- Electro-plate. (optional)

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Safety matters.

Before starting, safety issues must be addressed. Remember, we are working with chemicals. Most are harmless but some are less harmless.

- Always work in a well ventilated area.
- Always wear gloves and eye protection. It is also advisable to wear protective clothing because some of the chemicals used may burn a hole in fabrics.
- Never ingest any of the solutions or chemicals, and if splashed on the skin, wash immediately in cold running water.
- Always be vigilant in cleanliness.
- Always replace the lid on a chemical that is not in use, because spillages can not only be dangerous, but also expensive.
- Follow each step as it is written, and never mix chemicals in random orders.
- Never use metallic containers or implements because they may contaminate the solution being prepared or used.

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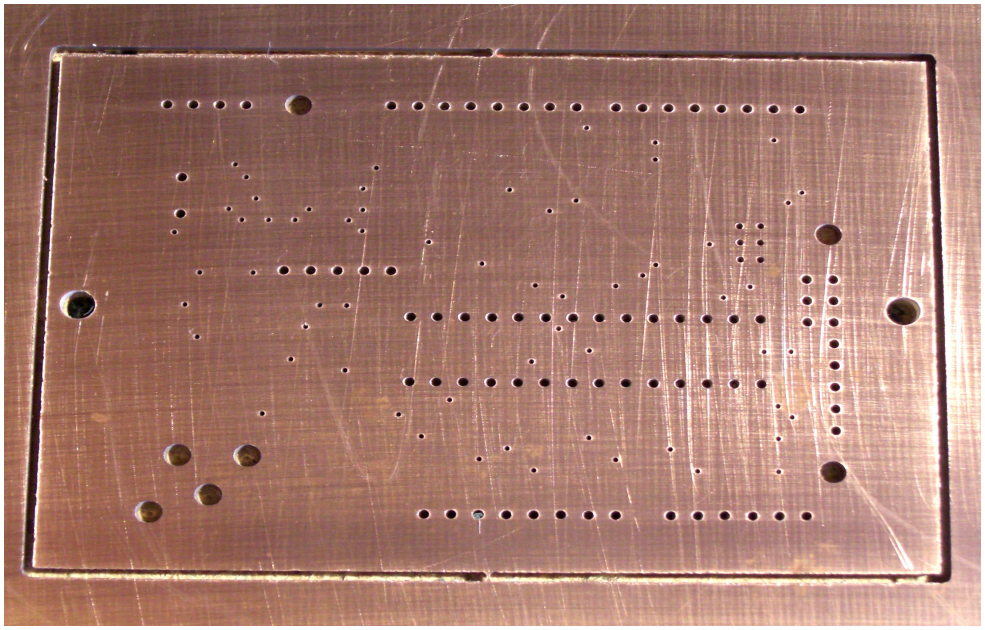
Preparing the board.

The through hole plating mechanism discussed in this article is more suitable for CNC milled PCBs because the board is first drilled, before being covered with copper then the tracks isolated. A photographic method would require masking, which is not in the scope of this article.

A piece of double sided FR4 copper clad board is placed on the CNC machine and all the holes are drilled. The outline of the board is then cut out so that it can be removed from the CNC, through hole plated, then replaced in the exact same position on the mill. Note that for double sided PCBs, registration holes need to be drilled so that the board can be turned over in the mill.

Below is a PCB that is ready to be plated. Note the two registration holes (far left and far right) that also serve as holes for carrying nylon tag fasteners for dipping the board into the various chemical solutions.



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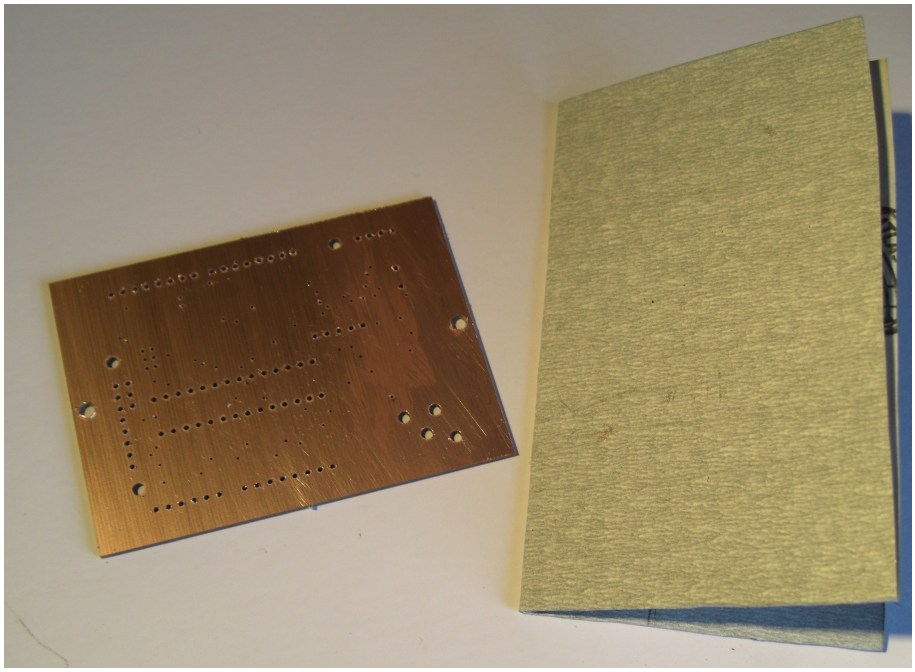
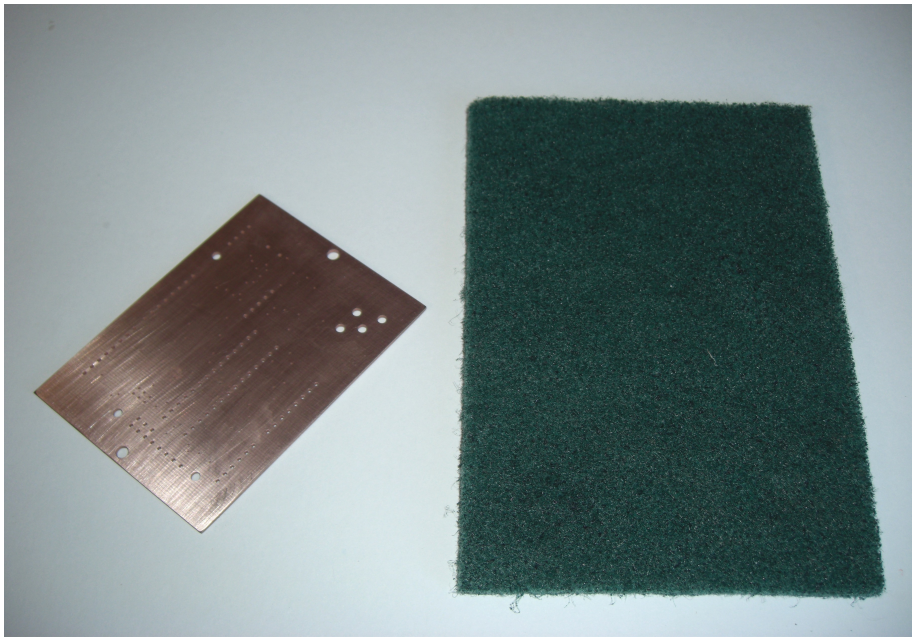
A freshly drilled PCB may look clean, however, it must be chemically clean for good adsorption of the metallic atoms and subsequent plating. Any grease produced as a by-product of the drilling must be removed from the holes and the surface of the copper must be mechanically cleaned so that it is free from oxidation. It cannot be emphasised enough how important the board cleaning process is, so be patient and vigilant when performing the task.

Remove any burrs caused by drilling with a very fine grade glass paper (sometimes known as finishing paper). Do this to both sides of the PCB in order to remove any large surface marks.



Rinse the board in cold tap water and make sure no debris is left in the holes. Blow the holes clear with compressed air if required.

Using a scotch pad, clean the surface of the copper thoroughly, then rinse again and make sure no debris is left inside the holes.



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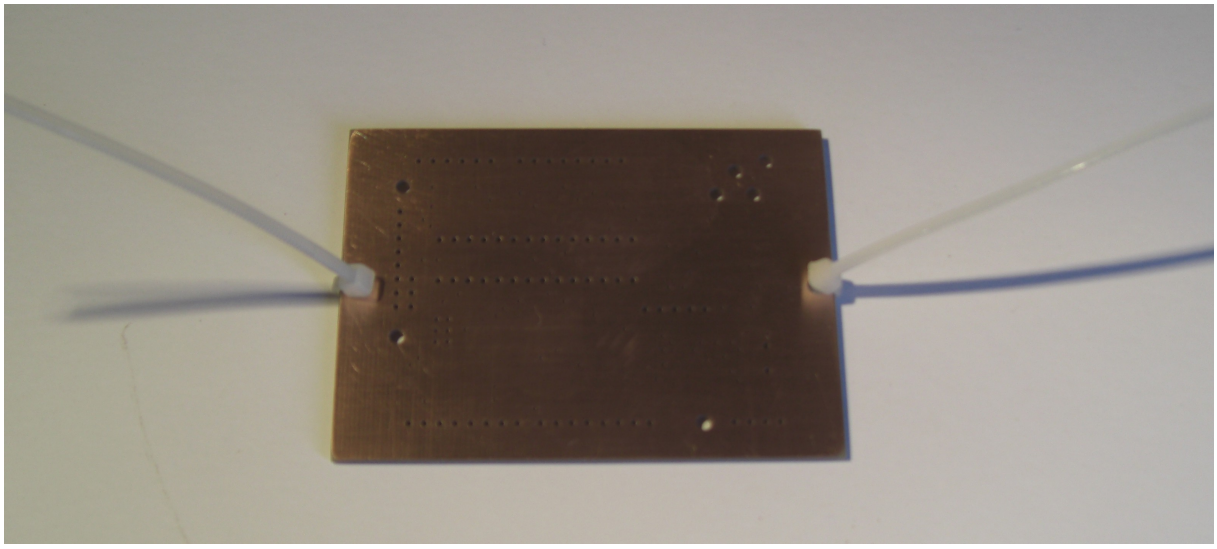
Insert two nylon fasteners into the aligning holes of the PCB in order to act as carriers for each of the chemical solutions:



De-Greaser Usage:

- Place the board in a container of de-greasing solution and warm it to between 40°C and 45°C, which will allow any grease to be removed more readily. Agitate the warmed solution containing the board intermittently for approx 5 minutes in order to ensure that the board is fully de-greased.

- After approx 5 minutes, remove and rinse the board in running cold tap water for a few seconds.

The board is now chemically clean and ready for the next steps.

Warning. The de-greasing solution is a strong alkaline that can irritate skin and wear away clothing. Always wear gloves, clothing protection and eye protection.

Note. The de-greasing solution can be used for several boards before it is exhausted, but must be replaced when it becomes too contaminated with dirt and grease. i.e. When it turns too dark and cloudy.

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Sensitising and Catalysing the board

We now need to prepare the board for copper to be placed inside the hole walls. We do this by depositing metal ions through adsorption, then reducing them closer to the metal itself, before electrolessly depositing copper all over the board, including the non-conductive holes.

The catalysing process consists of two separate solutions. Their usage is discussed below:

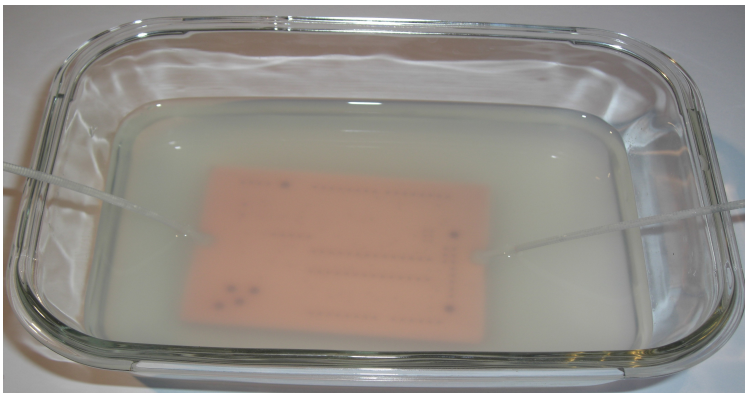
Sensitising and Catalysing method:

- Shake the bottle, and pour a quantity of Sensitiser Solution (enough to fully submerge the PCB) into a clean container large enough to hold the PCB.

- Shake the bottle, and pour a quantity of Catalyser Solution (enough to fully submerge the PCB) into a separate clean container large enough to hold the PCB.

Note. Both the sensitiser and the catalyser solutions need to warmed up to approx 30°C before they can be used. This is easily accomplished by placing them into a warm oven. Do not overheat the solutions over approx 45°C otherwise they may be rendered ineffective and may need to be discarded and replaced.

- Place the freshly cleaned board into the warmed sensitiser solution and leave it there for 5 minutes, with some intermittent slight agitation in order to ensure that the fluid is fully inside the holes and no air pockets are present. Maintain the appropriate temperature while the board is submerged.



- After approx 5 minutes remove the PCB and rinse it under cold tap water for a few seconds.

- Place the rinsed board into the warmed catalyser solution and leave it there for 5 minutes, with some intermittent slight agitation in order to ensure that the fluid is fully inside the holes and no air pockets are present. Maintain the appropriate temperature while the board is submerged.

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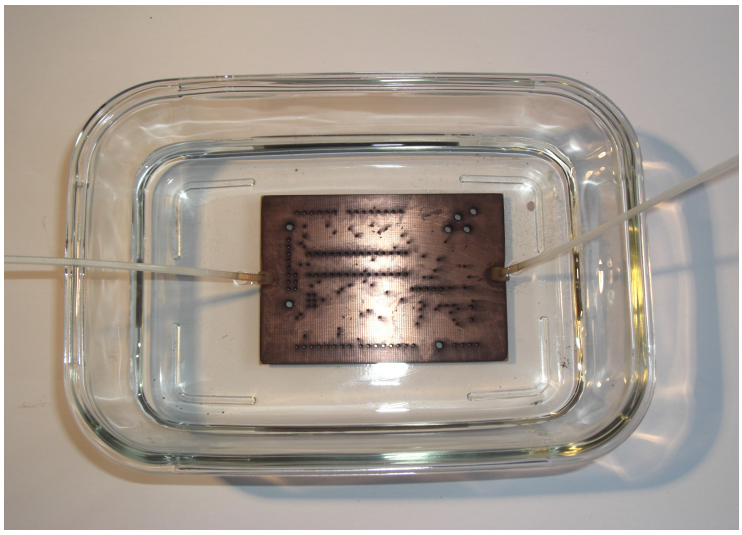

- After approx 5 minutes remove the PCB and rinse it under cold tap water for a few seconds.

The PCB has now been sensitised and catalysed and is ready for the electroless copper bath. The board may have a dark appearance around the holes. This is an indication that the process has worked successfully, but the dark appearance may not be as prominent as the above image, depending on the age of the solutions used.

Note. The sensitiser and catalyser solutions can be used for many boards. In time, some of the metal may drop out of the catalyser solution. When this happens, the solution can still be used, but if too much drops out, it will need to be discarded and a fresh solution used.

The sensitiser solution should be potent for many months as long as it is stored in a cool dark place, that is not subject to temperature extremes.

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Electroless copper plating of the board.

Experiments have shown that the catalysed board will not survive galvanic copper plating, because the deposited metal atoms are too fragile to survive the aggressive nature of an acid bath, causing non-conductive rings and voids in some of the through holes. Therefore, we will electrolessly copper plate the board, ensuring an even coating of well adhered copper on all the non-conductive surfaces. i.e. the inside of the holes.

Activating the electroless copper plating solution.

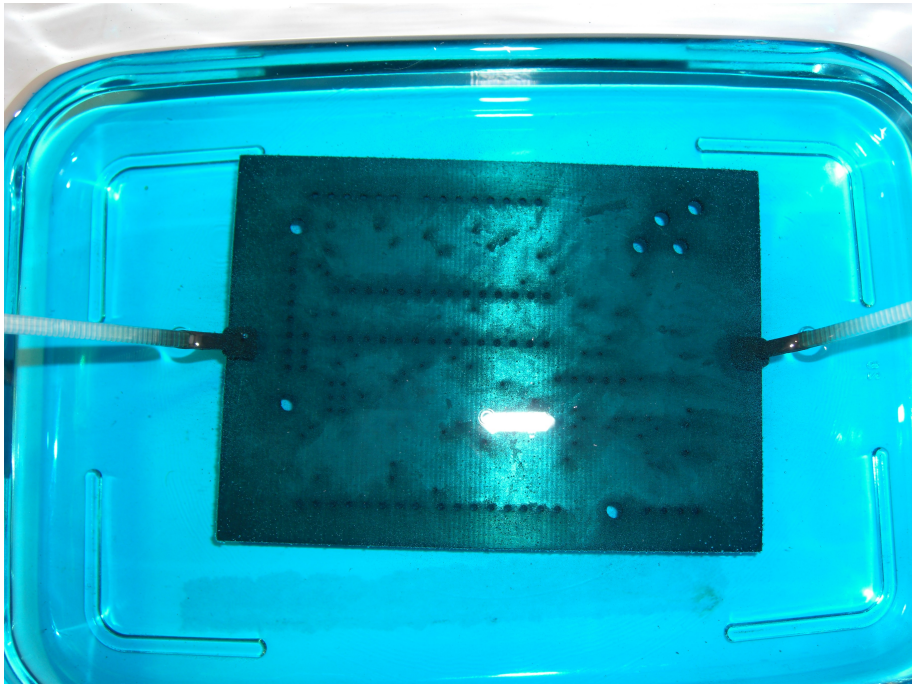
Add 1.0ml of 37% formalin (aqueous formaldehyde), for every 100ml of the electroless plating solution and stir for a few seconds. The electroless copper plating bath is now ready to use.

Warm the solution to approximately 30°C, then place the freshly catalysed board into it. Gently agitate the board in the solution in order to ensure that no air pockets exist within the holes. Place the container holding the board and solution into a pre-heated oven set to 30°C for 1 hour.

Note. A higher temperature will increase the copper plating speed, but at the expense of the solution's stability.

After a few minutes, bubbles will start to form around the board. These are hydrogen, but don't be alarmed because there is too little produced to cause any explosions or even ignitions.

Every 15 minutes or so, gently agitate the board and turn it over so that bubbles are not caught in the holes. After approximately 15 minutes, there will be signs of copper being deposited around the edges of the board.



The container used in the above picture contained 200ml of electroless copper plating solution, therefore 2.0ml of 37% aqueous formaldehyde was used.

After and hour, examine the board, preferably through a microscope or loupe, and ensure that the holes are fully coated with copper, even if a thin layer. If not, leave the board in the plating

solution for a further hour. Once there is copper throughout the holes, the board may be placed in a conventional electro-plating bath to thicken the copper, or left in the plating solution to thicken it up.

If left in the plating solution, there is no need to maintain the 30°C temperature. Room temperature will suffice (21°C to 25°C), but 30°C will speed up the deposition process somewhat. If copper coverage is not complete, repeat the de-greasing and sensitising/catalysing process.

If everything is OK with the metallisation of the holes, the board can then be placed in a conventional electro-plating bath for 20 minutes or so. However, if left in the electroless plating solution long enough, this is often not required as long as the through holes are not going to carry high currents.

Important Note. Temperatures too far above 45°C, or the addition of too much formaldehyde, will cause the electroless plating bath to decompose, commonly known as a crash.

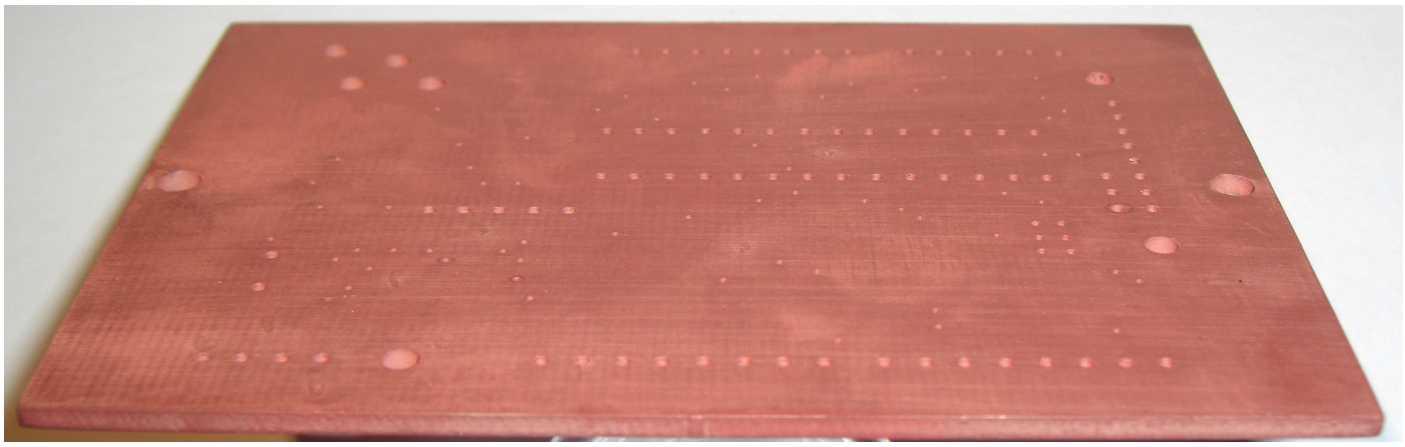
If copper is seen deposited on the sides of the container, the solution is beginning to crash.

This can sometimes be remedied by filtering the solution, vigorously cleaning the, now empty, container to remove the copper residue (preferably with an acid to dissolve it), then placing the PCB back into the solution.

If too much copper has been deposited on the container, the solution will need to be replaced, and a careful check on the temperature and amount of formaldehyde should be made.

Note. The unactivated electroless copper plating solutiion can be stored for many months as long as it does not experience extremes in temperature or bright light, or come into contact with a reducer such as formaldehyde.

The image below is a board that has gone through the plating process and is ready to be placed back onto the CNC machine for track isolation:



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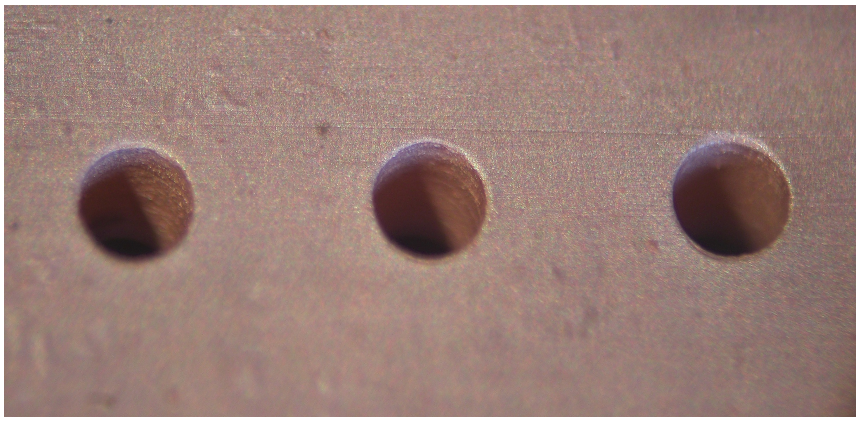
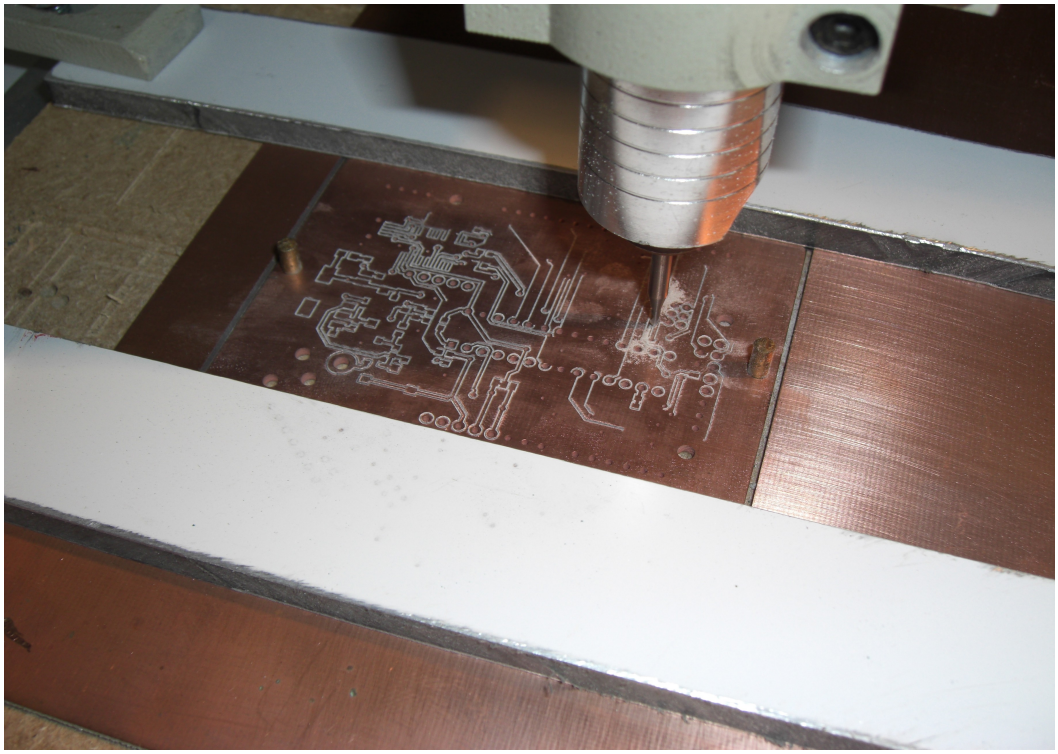
The image below is a close-up of some of the plated through holes after a few hours in the electroless copper plating bath:



Below is the board back on the CNC milling machine having the tracks isolated:



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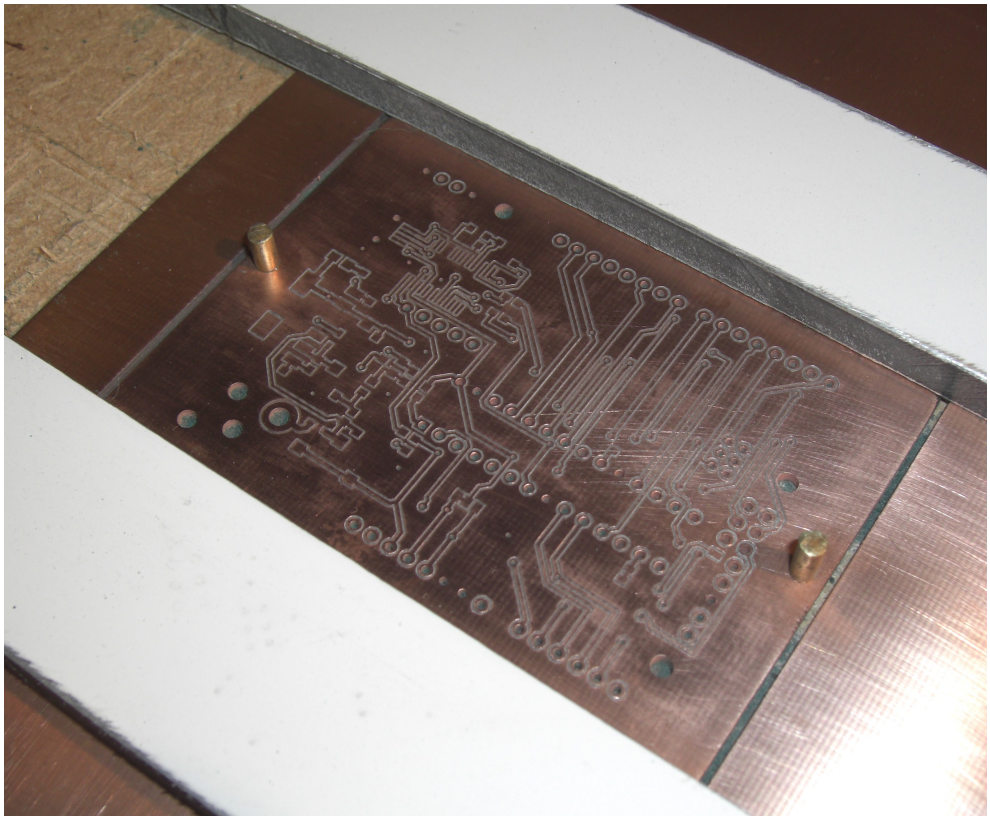
The image below is the board once all the tracks have been isolated. And is ready to be cut out of its matrix (extra board used for the aligning holes and clamping mechanism):



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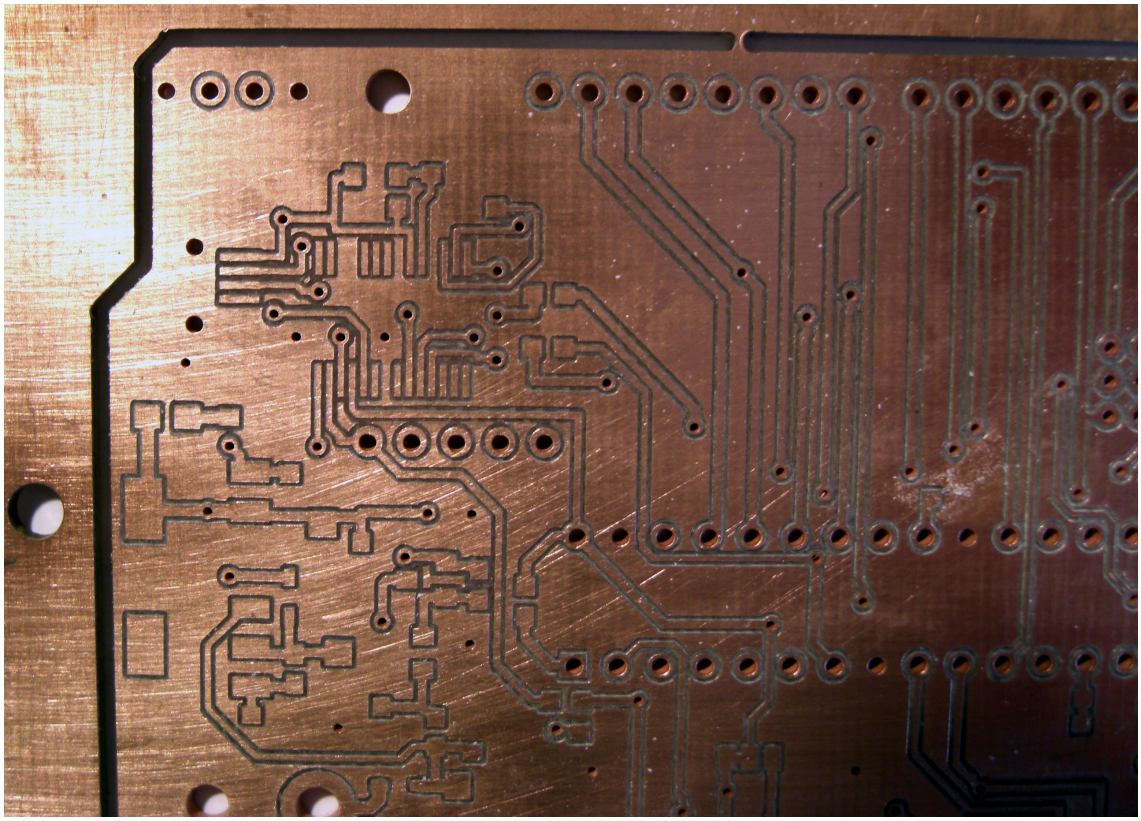
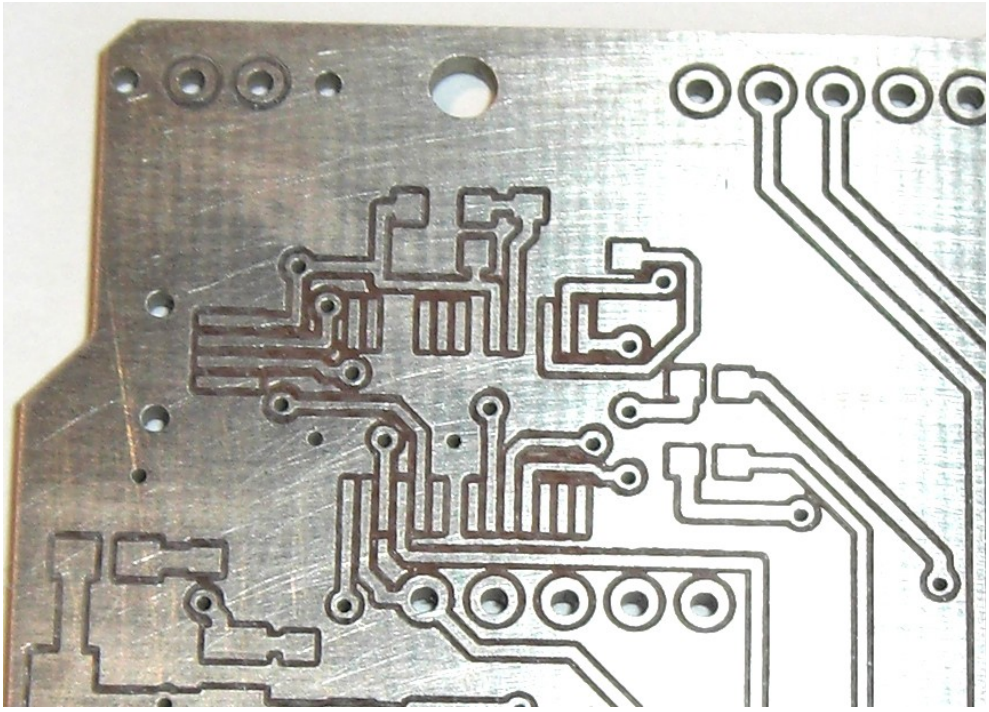
Below is a close-up view of the PCB's isolated tracks and the final board outline. Notice the small tab in the cut-out so that the board stays in place while it is milled:



The image below is the same board, but with chemical tinning applied:



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A flowchart is shown below illustrating the required steps for through hole plating: