DIY Printed Circuit Board Fabrication

To make the printed circuit boards, it is important that you get the correct supplies and do a lot of reading before starting. This will make you aware of the dangers of the etchants, the time commitment required, and the quality of the results that you can expect--allowing you to make an informed decision about whether this is something you want to do or if you would prefer to send your design to a PCB fabrication house. If you enjoy building things and/or saving money, it will be a fun process. To prepare, I read the following websites and used a combination of techniques and (sometimes conflicting) advice gleaned from them. Contradicting some opinions, I used anhydrous ferric chloride as an etchant—it does release heat when being dissolved in water, but etched very well. You can buy anhydrous ferric chloride online from several sources, including MPJA and eBay.

DIY PCB Links and Instructions
http://www.electricstuff.co.uk/pcbs.html
http://www.ladyada.net/library/pcb/inhouseetch.html
http://myweb.cableone.net/wheedal/pcb.htm
http://sfprime.net/pcb-etching/index.htm
http://www.riccibitti.com/pcb/pcb.htm
http://www.ehow.com/videos-on_8351_etching-copper-circuit-boards.html
http://www.printedcircuitsboards.com/diy-pcb/138/home-made-pcb-easy-pcb-manufacture.html
http://www.bot-thoughts.com/2009/08/simple-diy-pcb-etching.html

Below is an abridged version of the instructions to make your own PCBs. It works well, I found, and can serve as a “cheat-sheet” or checklist for making your own projects or replicating ours. These are the steps once you have a properly scaled PDF of your design and are ready to start fabricating.

1) Use a glossy magazine page with a predominantly light or white background (text is ok). It should have no crinkles at all. Fold 3/4 inch over the top of a piece of printer paper and tape on the back. This will help prevent it from jamming in the printer. Cut at least 1/2inch off the side of the paper (making it narrower so it fits through printer manual-feed without touching the edges, thereby minimizing crinkles). Print the PDF onto it, mirroring if necessary. Confirm you’re your design has the correct mirroring if it will get flipped ink-side-down onto the copper side of the blank PC board.

2) Carefully cut out the printed portions with a reasonably tight border around the ink. Don't get any finger oils on it or touch the ink. Don’t crinkle the paper at all.

3) Cut your blank copper board to size using a shear or a tile/glass blade on a jigsaw. Fiberglass will ruin bandsaw blades, metal jigsaw blades, steel drill bits, and almost anything that is not designed for cutting glass/tile. Tin snips can cut the FR4, but give a jagged edge, which is not ideal before the ironing process. After the ironing process, they are fine to use if your board is small and difficult to clamp down for sawing with a jigsaw.

4) Wash and dry the copper pieces under tap water using hand soap. Wearing gloves, Scotch-rite them uniformly (diagonal streaks, for example) until clean. Acetone clean is optional, next, but you definitely have to clean them using window cleaner and a paper towel to get the copper particles off from the Scotch-brite abrasion.

5) On a piece of cardboard on a hard surface: place the paper ink-side down on the copper and carefully place the iron (maybe a part of it without the vent holes) on top, without moving the magazine paper much. Press down very hard (lean in to it), and hold for 40-60 seconds. Then carefully lift the pressure, move it and re-apply. You want uniform heating and the holes in the iron are the only major obstacle, so just move it around with light pressure or move it a couple times and use heavy pressure without moving. Do this for 4-5 Minutes total.

6) Toss in some warm water (hot tap water works fine) in a bowl. This will begin to dissolve the magazine paper. Be careful because they will be hot after ironing. You can let them cool for a few minutes before picking them up and throwing them in the water.

7) Soak for 20-60 minutes. Skip ahead to do 9 while this is going. You may peel the "upper" layer of paper off after 10-15 minutes, to give the water access to the "lower" side of the paper. After 30-60 minutes (more won't hurt it), rub off all the paper on the non-ink regions, as well as on the ink-regions. Do this with firm pressure of your thumb (no fingernails or anything sharp). You will probably not rub off the ink, so don't worry too much about that--it is adhered fairly firmly. Once you have the paper off, gently pat them dry.

8) Check the design and fill in dark regions with sharpie if necessary, or get paper particles off of the copper regions if it wasn't completely rubbed off.

9) Wearing gloves, mix your etchant in a plastic basin with hot water. I used a book crate (like a milk crate but without any holes). Depending on your etchant, the concentrations will vary, but in general, extra anhydrous ferric chloride won't hurt: it simply won't dissolve once the solution is saturated. It is important that the solution be warm or hot, since etching takes exponentially longer as the temperature decreases. Uniformity may be compromised with lower temperatures as well.

10) Put the boards in and agitate them a lot by stirring, moving them around, and in general getting the most flow of solution over them as you can without splashing. If etching is going slowly, you can leave them without stirring for a few minutes at a time. Depending on the temperature and concentration, etch for 8-35 minutes, checking periodically if the copper has been etched away in the field area. It will sometimes just fall off if you splash it hard enough, since it is chemically removed but still "sitting there".

11) Rinse (still wearing gloves) at the hose, and then dry. Rinse/rub your hands over with water at the kitchen sink (shouldn't be any chemicals left on it after the first rinse), and inspect. If more etching is needed, you should do it before going to the next step.

12) Rub with acetone on a paper towel to get the toner off of the copper board.

13) Drill all the holes on a drill press with tungsten-carbide bits (which won't dull from the fiberglass). A set of wire size drill bits #80 - #56 is inexpensive and should provide all the hole sizes necessary for standard through-hole circuit components. Size up slightly compared to the data sheet recommendations to account for your drilling inaccuracies. With practice, you can drill more than one hole per second with surprising accuracy, just by centering it in your circular copper pads by eye.

14) Test electrically, clean up the edges with an exacto knife or sandpaper, and stuff the board with your components.