Updated October 2017

Hints and Tips For Use

First a couple of notes

What is Dry Film. Dry Film is a photo-resist, when strong UV light hits it, where the light hits, it hardens and this hardened form resists etching solutions. The film is comprised of three parts, the blue layer is in the middle, this is the polymer which hardens with UV, on each side of this polymer is a protective transparent film.

How do you use it? In very brief summary, one protective layer (the inside of curl generally) is removed, the now uncovered polymer side is attached to the PCB, the PCB is exposed to UV through a 'mask' which has transparent traces to allow UV to harden the "traces image", the remaining protective layer is removed and the PCB is developed in a solution of washing soda (Sodium Carbonate), then the PCB is etched.

The rest of this document gives you all the steps, tips and tricks which I have learned in using Dry Film! Be sure to read it, save yourself lots of experimenting!

Practice, Practice, Practice. I advise cutting some small squares of film a couple of cm squared and using these to get the hang of affixing it to a board and developing, use some moderately dense small (section of) artwork with the finest traces you want to do, with the narrowest spaces you want to do etc. You might want to practice 5 or 10 times before doing it for real. If you mess one up, just clean it off, and start again.

Units. If you are new to designing circuits you might not know about the unit called "mils". Here in New Zealand (and other civilised countries who use the metric system) when a somebody says "oh it's about 50

mils” they usually mean “50 millimeters”. But when dealing with electronics “mil” means “one one-thousandth of an inch” and it is used a lot even by normally sensible metric people.

So when I write for example “10 mils”, I mean 0.254 millimeters (one quarter of one millimeter), or 254 microns if you prefer. 8 mils is about 0.20mm, and 12 mils is about 0.30mm.

About 10 mils is achievable for a trace width (maybe even 8), and 10 mils keepout (between traces), but for practical purposes 12 mils or greater for both makes your life a lot easier :-)

Cleaning the PCB

To begin with you must clean your blank PCB surface thoroughly.

Most recently, this is my way...

Grab some 150 or finer (higher number) sand paper in a pack from the local cheap-chinese-shop, I would not go less than 150, but 150 is fine (it's what I'm using currently, 150 dry tan coloured sand paper).

Sand the PCB, I sand in 4 directions, vertically, then horizontally, then on an angle one way, and on an angle another way.

Wipe the PCB with a paper towel wet with acetone.

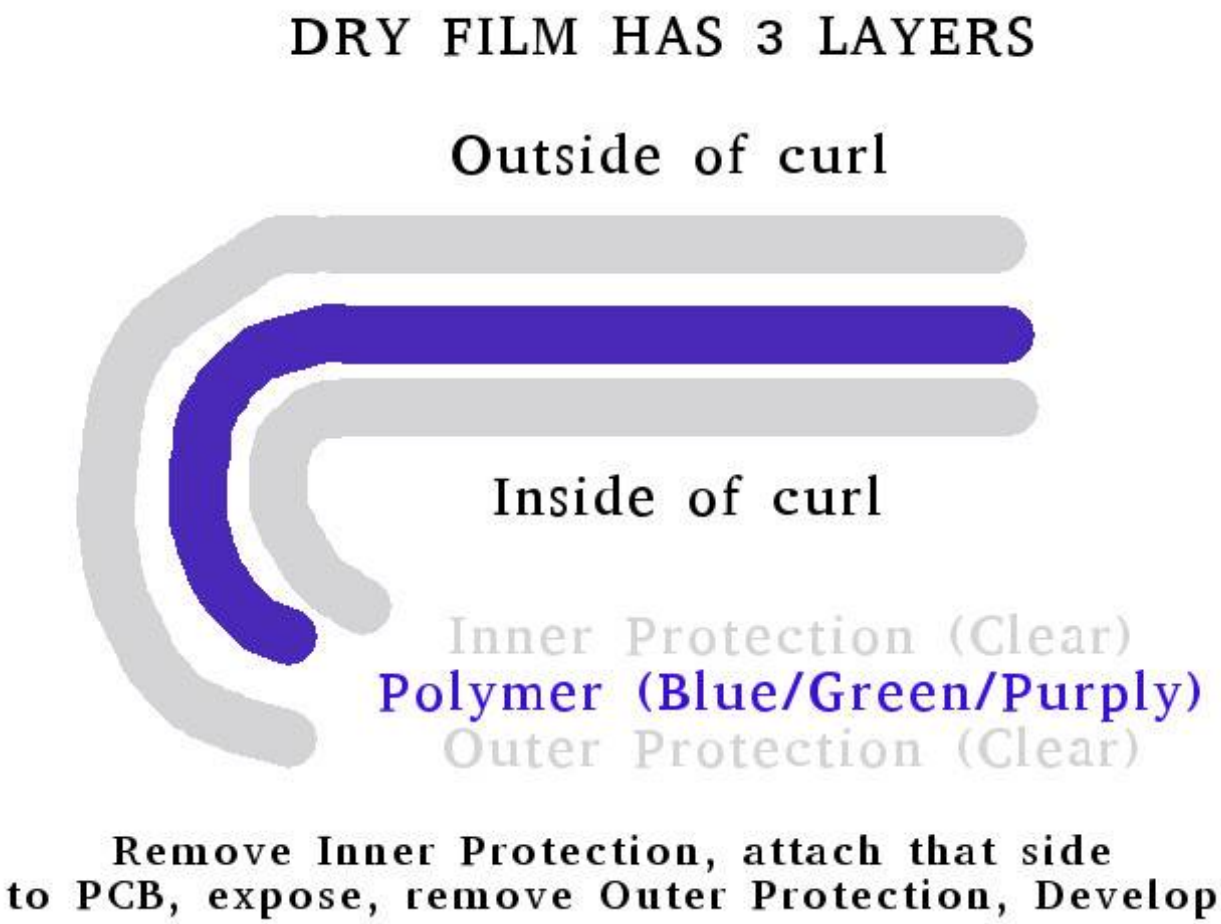
I find that this works just fine, no messing about just good old abrasion.

Attaching The Film

A good attachment without bubbles and wrinkles is the key to success.

The film needs **moderate** heat and pressure to properly adhere enough to resist.

Presented in this document are two (~~three~~) methods, one using a Clothes Iron (or Hot Air, or even a Hair Dryer) and one using a Laminator.



Wet Lamination Method (Clothes Iron, or Hot Air)

This method is my current favourite, it is sort of my own devising and works quite well at least for the small (7x10cm or less) boards I most commonly make.

In addition to the dry film you will need a "travel spray bottle" of water, you can buy such bottles at your local cheap-chinese-stuff store, and some sellotape.

Start by cleaning your PCB as detailed previously.

Now with the PCB clean and dry place it on a flat surface (that's not going to care if it gets hot, your mum's dining table probably not a good place).

Set your iron to a cool setting, 60-70 degrees works for me, usually just a couple clicks off the lowest possible setting. Clothes irons are not that accurate at temperature regulation, give it a few minutes to settle before you check the temperature (if you have a temperature probe).

Take your travel bottle of (room temperature) water and give a couple pumps to put a light mist onto the PCB, you don't need to drench it, just a light spray. It doesn't matter if it's not totally even coverage.

Now take your piece of film (about 1cm larger than required for easier handling). Stick a piece of sellotape on each side of the film at one corner, pull the two pieces apart, the bottom (inside of curl) layer should pull away (this side goes against the board).

Now “drape” the film onto the misted pcb, and take a small wad of paper towel and use that to smooth the film down from the center to the edges pushing out the water and air, check for bubbles and dust, you can usually peel the film up a bit and get rid of them at this stage.

Once you have the film smoothed down onto the pcb, take your clothes iron and literally iron the film onto the pcb. You don't need to press it through to the other side of the planet, it's really the heat you want, and mild pressure, this is what causes the adhesion.

If you don't have a clothes iron, you can also use hot air from your reflow station, and I have heard also of using a hair dryer but not tried that myself, just heat and rub the film down on to the pcb.

Pay special attention to the edges of the board, these are the problem areas, roll the iron over the edges.

If you have a little wrinkle, bubble, tear, in the polymer (photo) layer, try using the tip of the iron to “buff” it out, the polymer is soft at this 60-80 degree temperature and can be “smooshed around” with the iron tip to smooth small problems out.

After perhaps 60 seconds of ironing things should be nice and toasty, not so hot you can't hold your hand onto the PCB, but hot enough that it's not comfortable to do so :-)

A note on temperature; if you go too hot, you will get quite obvious ugly blisters under your film, this is no good those blisters will just wash off when you develop, clean it off (or cut/scrape/clean those areas and re-laminate a patch if you want to try that, sometimes you can get away with it :)), reduce your iron temperature and start again with a fresh piece.

If you go too cold, the film will also not attach well

during development and etching.

Caution: clothes iron temperature regulation may be quite poor - your fancy pantaloons probably don't care if they were ironed at 80 degrees or 110 degrees so clothes irons are pretty simplistic at controlling their temperature. If you have a temperature probe for your multimeter use it to get a feel for where to set your iron's dial and note which parts of the baseplate are hotter/cooler, aim for 60 to 75 degrees at the hottest point.

For Double Sided Boards you must allow the board to cool down to room temperature again before you try and attach the second side.

You should allow the board to cool to room temperature before you expose.

If you find that the photo layer isn't stuck to the pcb totally (try peeling the top protection layer up a little on a corner) and you are sure your cleaning was well done then you know that you needed to warm it up more, or more evenly (spread the iron around), or a fraction more pressure, the most likely places to have a problem are the edges. Before exposure you can always try to iron it down a bit more to try and get that to stick.

Now, continue to Exposure!

Laminator Method

If you have a laminator, then using this can produce a good result, but you will want to do some preparation first.

Clean your blank PCB as previous.

Place PCB on a carrier and attach a piece film cut to about 5mm larger on each side than you need to the top end-stop, with "tail" attached to film (see next page for diagrams of my carrier setup).

It is better to cut 5mm larger on each side than you need, but if you do use right up to the cut edge of a piece of film have a careful look at the edge, sometimes there is a visible "border" of lighter colouring (more transparent) running down an edge (as it comes off the roll), if visibly different this border should be avoided as it's performance may be degraded a bit.

Note – film has top and bottom (PCB) side, the bottom is the inside of the curl and that goes against the PCB. If your film was sent flat, the cardboard wrapping is marked with which is top and which is bottom.

The film has a protective layer on both sides with the soft resist material in the middle. Flip film over and remove the bottom side layer – easy way, stick a piece of sellotape on each side of a corner of the film, pull the two bits of tape apart, the bottom layer will peel off (actually, it's really not a big deal if the top layer comes off instead, seems to work either way up, but inside-of-curl-down is "the norm").

Hold film vertical by the tail and feed into laminator, lowering the tail as you go, this eliminates air bubbles.

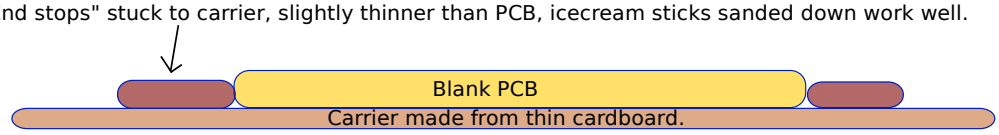
Cut off the tail. You may then want to run it through the laminator a couple more times.

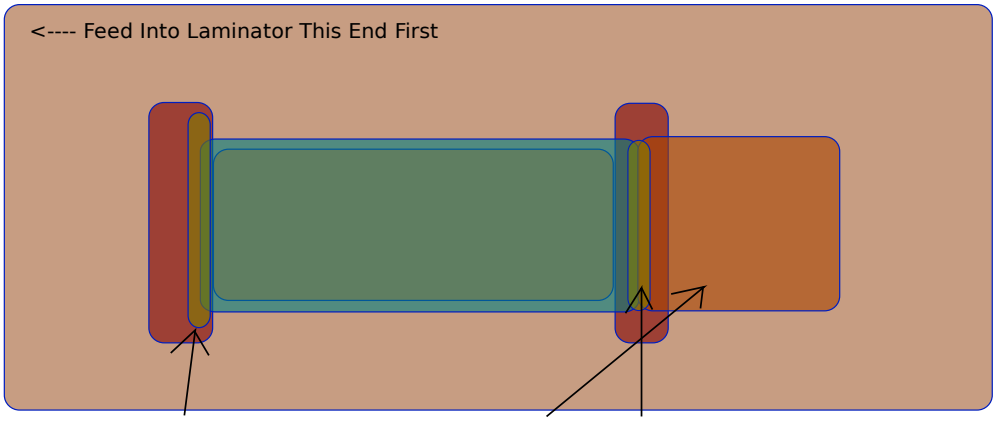
If you did get a bubble in there, prick it with the tip of a craft knife and run it through the laminator, or buff it with the tip of a cool clothes iron.

Allow to cool, then remove PCB. Laminated boards can be stored in the dark ready to use, not sure how long for, I've stored them for 2 weeks before using without any trouble, so perhaps “forever” is the answer.

Laminating Dry Film onto small boards, James' tips!

"End stops" stuck to carrier, slightly thinner than PCB, icecream sticks sanded down work well.





Film taped to "top" end stop as a "hinge". Cardboard tail taped to top surface of other end of film

Flip over backwards about the hinge, remove bottom protective layer.
Hold tail and lift film vertical.
Feed into laminator, lowering the tail as you go.
Laminator should not be too hot, not too cold (a real goldilocks zone!)
Once fed through, slice off the tail and feed through a couple more times in different directions.
Allow board to cool set for 10 minutes out of the light, then remove board from carrier.

Exposure:

You need a negative artwork, transparent areas will remain on the board as resist, black areas will be removed.

[You can of course produce the artwork however you like, but if your system is capable to use it you might like to see this script that converts Gerber files produced by common PCB design packages into to PDF artwork https://github.com/sleemanj/gerb2etch]

I recommend a good 2mm border on your artwork - that is, no traces closer than 2mm to the PCB edge, the reason is that the most likely place for the resist to lift or get a poor exposure is at the edges.

Top tip: The "resolution" you can get is very high, even with our rough-and-ready setup, exposing to the sun using tracing paper. However, if you put traces very close together (about 8 "mil", 0.21mm or less) any "UV bleed", overexposure... can lead to traces in the resist which are touching. This is easily fixed before etching but to save you the trouble, remember that thin traces are easy, but close traces are hard.

I'd suggest sticking with a "keepout" of around 0.254mm (10 mil) at the minimum, and your traces could go down to 8 mil – that said, for repeatability, I don't recommend trying to get below 12 mil, sure you CAN do 8 mil, but they are so tiny that it is very very easy to damage them, and there just isn't easily fixable with a pen at that sort of size.

Personally, I try to stay at 13 mil or thicker traces, with 12 mil or wider keepout unless there is just no other way, it makes for much less fiddling about if you can stay above 10 mil.

Tracing paper is a good medium for printing your artwork on, you don't need to use transparencies. You can either use a single copy or print two copies, and

stick them together to increase the darkness of the black areas.

Using a single copy may require a quite short exposure depending on your printer's toner density (1 minute 20-30 seconds for me using UV leds), and any imperfections in the artwork will need to be touched up with a pen first, using two copies will mean that the exposure is longer (2 or even 3 times as long), but the imperfections in your printer's tonor is less of a problem. Personally, I use a single copy, but, experiment with your own!

Can you use an inkjet? Some people do and find it works, some people tried and found it doesn't, so short answer is, maybe – depends on your ink!

It may be useful to put a strip of packing tape (or perhaps contact book covering) over each print to protect the toner - depending on your printer, toner may rub-off tracing paper easily, tape protects it while you are aligning your two copies, and doesn't affect the exposure much. But for very fine detail, avoid this if possible.

Apply the artwork, tonor-side-to-board, make sure it is tightly against the board (a piece of glass on both sides to make a sandwich and a couple of quick-clamps or even bulldog clips to hold it together is one way, put something on the back of the PCB in the sandwich to ensure that the board is pressed FIRMLY to the artwork) and expose to Ultraviolet light (eg, the Sun).

Time of exposure varies. Experiment to find your sweet spot. To give an idea, about 10 minutes in full Sun produces a strong exposure, possibly a bit too long. Under UV LEDs about 2 to 5 minutes for a double-copy tracing paper, about 1-2 minutes for a single-copy with an array of 5mm leds, and for my current box with 4 1Watt UV leds it's a super fast 22 seconds.

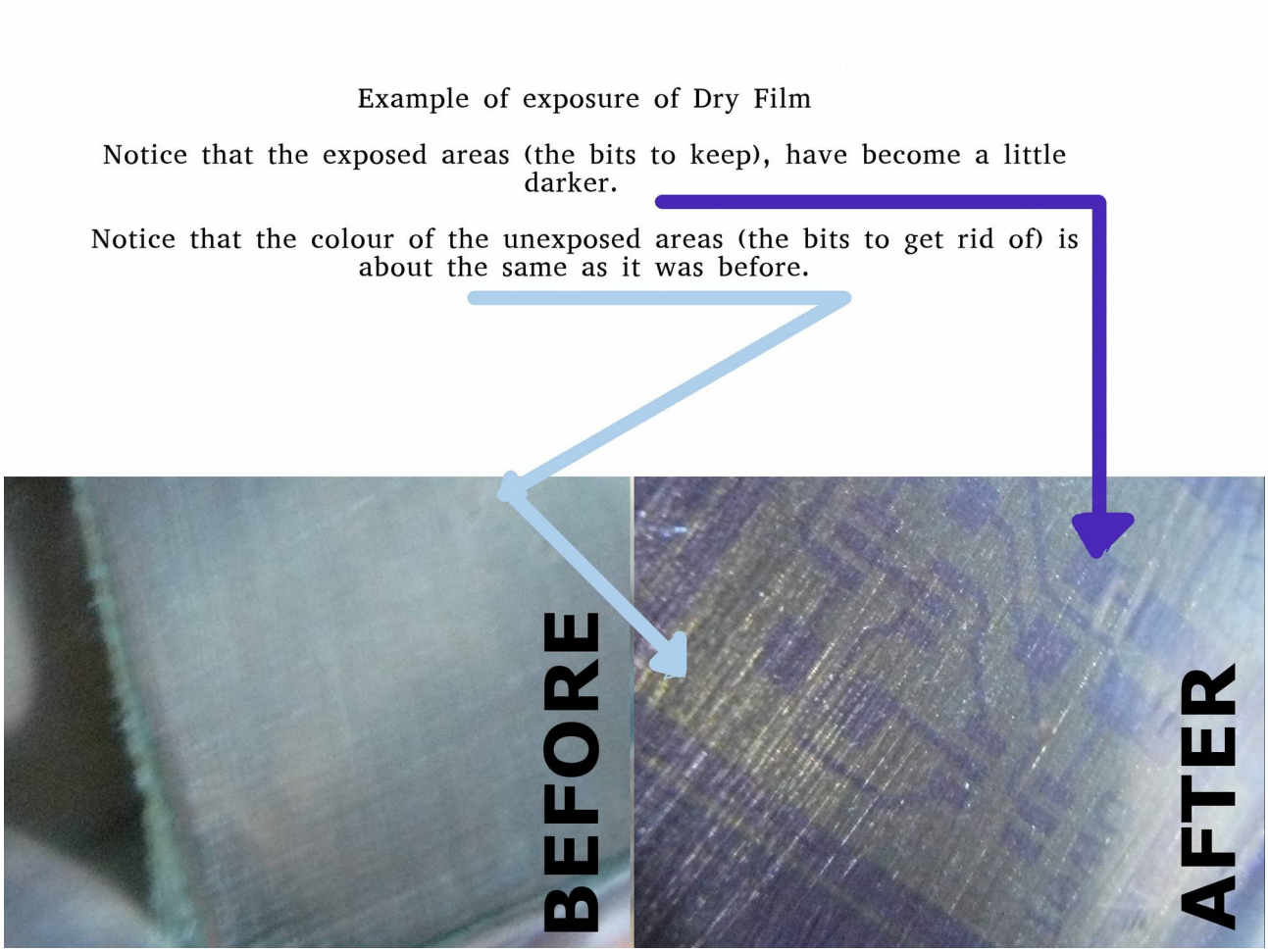
You don't need to be too precise with double-copy,

there's plenty of wiggle-room if your artwork is dark enough, it's quite hard to go wrong! With single-copy it's a bit more exacting.

[Protip: if you want to tune-in your exposure times, try my PCB test pattern artwork and procedure available here https://github.com/sleemanj/pcb-test-pattern]

Once exposure is complete remove the artwork and you will CLEARLY see the traces “burned” onto the board.

Leave the board to further cure in a dark place for a few minutes.



NB: Exact colour of pre-exposed film varies between manufacturers and types, but for the most part they work the same, exposure time might vary slightly.

Developing:

Carefully remove the top protective layer from the film, if your lamination technique and cleaning was good you won't pull up any of the traces, if it wasn't, you will.

Place board in a developing solution, the solution is Washing Soda (Sodium Carbonate, also often as Sodium Percarbonate, Sodium Peroxyhydrate, they will all work), which you can purchase at the supermarket.

It is used in a very wide variety of products especially in the laundry, look for powdered forms.

For example “Sard Wonder Oxy Plus” in any laundry aisle works well, as should any other similar powdered laundry stuff with Sodium Carbonate/Percarbonate/Peroxyhydrate.

You can also buy pure Sodium Carbonate in the laundry aisle of most supermarkets, look for natural fabric softeners!

Mix about 30g of the sodium carbonate containing laundry powder of your choice into 1 Litre of water. Doesn't need to be precise. Mix it up real good, I put it in a pepsi bottle and give it a good old shake.

30g/L at room temperature works for me.

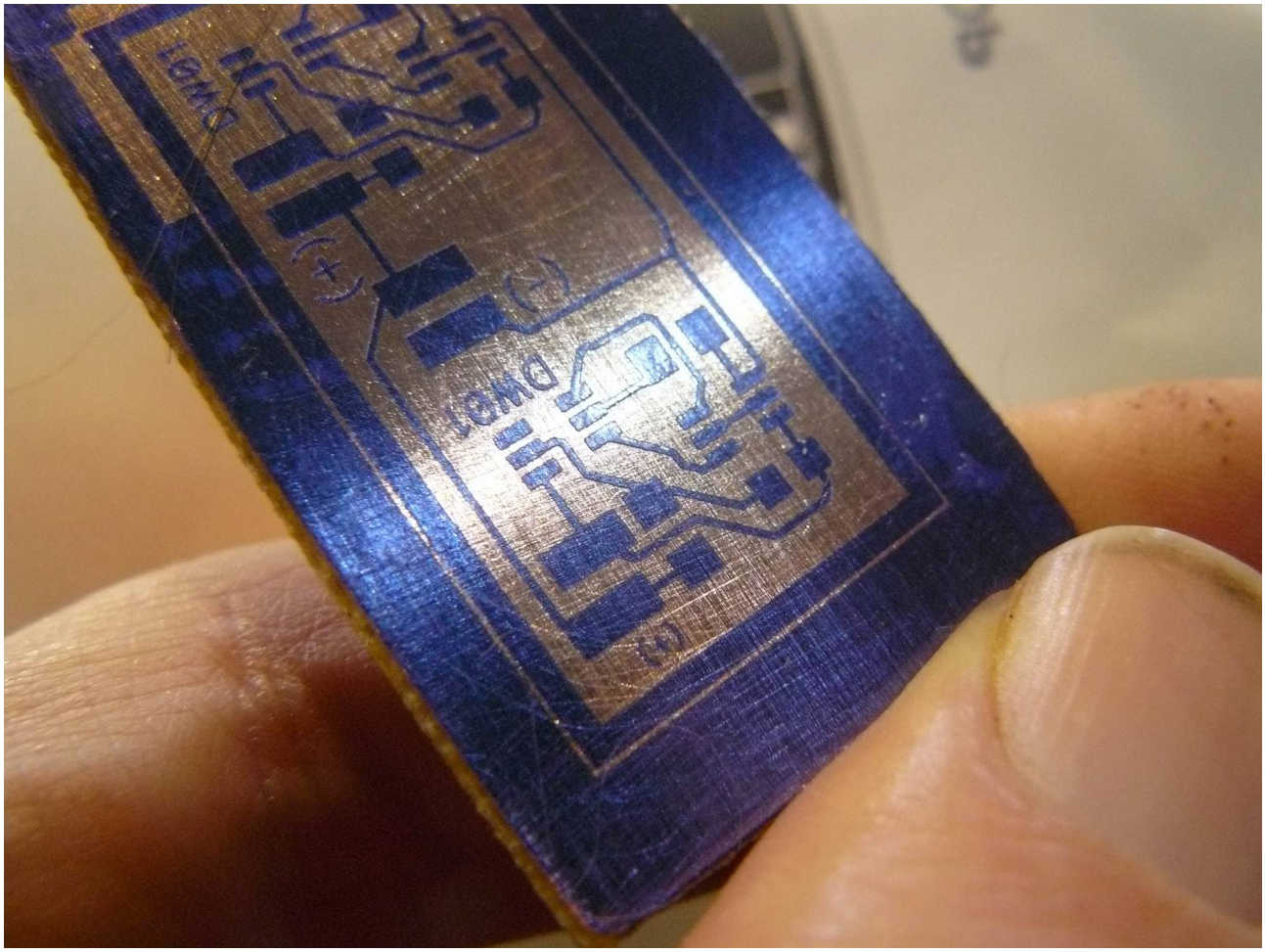
Let the board develop for a couple minutes (watch it though), swoosh the liquid over it. The unexposed areas will dissolve leaving the traces in place. You can lightly massage the board with your fingers to help the process along.

Using a vibrating type toothbrush very gently can really help developing. Don't scrub, just "wipe" really, the traces are strong enough to resist the brush, but not totally hard yet so you can damage them. Obviously, don't use your actual toothbrush, maybe now is a good time to buy a new one and relegate your old one to PCB duty.

It's done when it looks like all the left over gunk has gone and you have nice clean traces, look at the pads and holes, look to see if there is any gunk still sticking between close together traces.

Rinse the board under running water to get rid of all the developing solution. Then dry it by patting with a paper towel.

Eye protection is perhaps a good idea, washing soda in your eyes could be a bit unpleasant, but apart from that it's not dangerous.

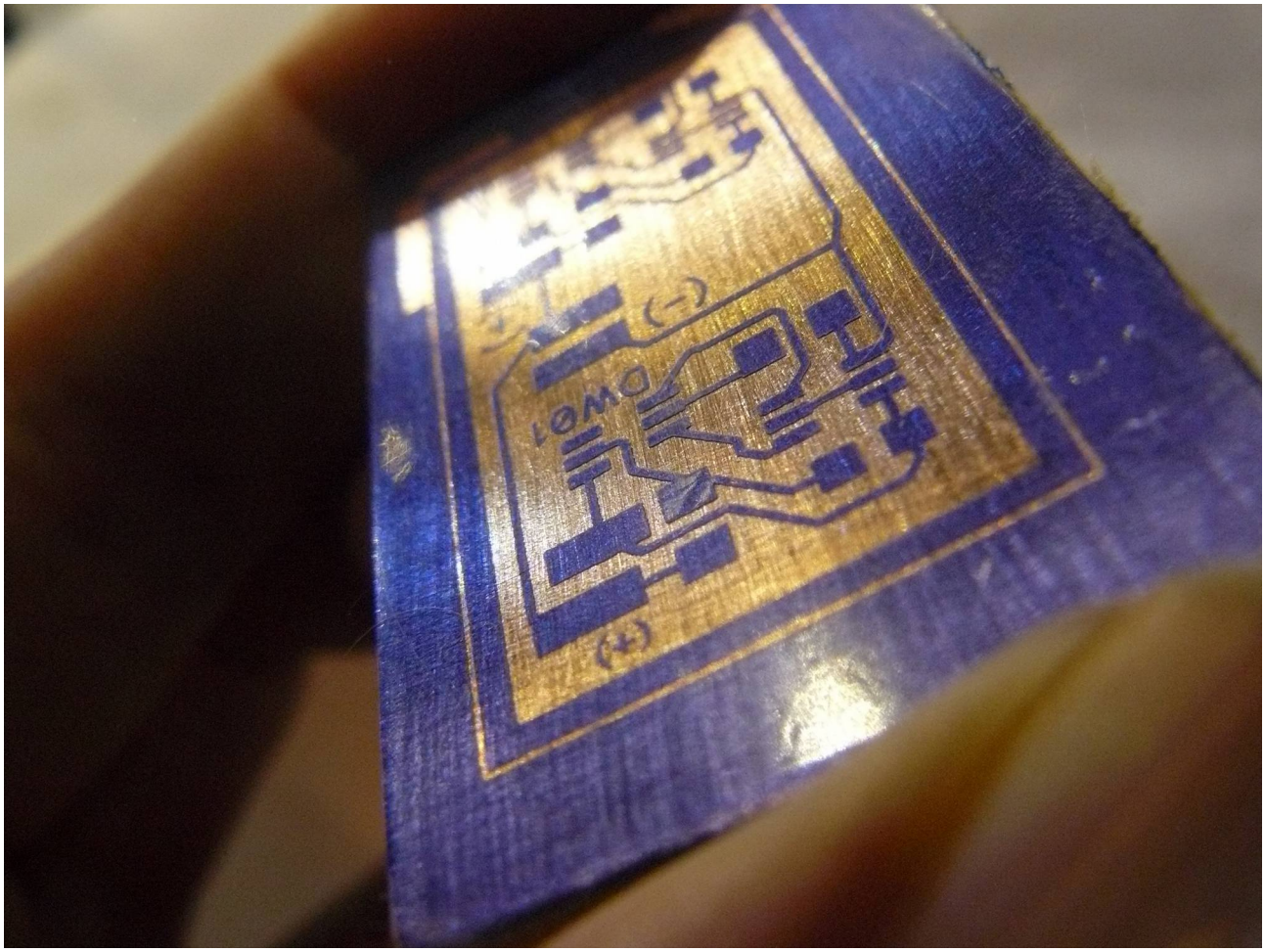


After developing (2-3 minutes) and rinsing the copper to be removed is clean and all "gunk" removed.

Hardening Exposure:

After developing to put the developed board in full UV (no artwork/mask necessary) for a longer exposure, this will “harden up” the developed traces completely. I use a hardening exposure twice as long as the original exposure.

After the hardening exposure, you may notice a slight blue tinge on the bare copper areas which indicates some resist residue, you can easily remove this with a few seconds in the developer and a rub with your fingers or a toothbrush, then immediately rinse in water again.



After the hardening exposure, little change is apparent just a bit darker. Notice there is no bluing of the copper to be removed indicating the developing was long enough and not overexposed. If there was bluing,it can go back in the developer briefly to clean it up then rinse.

Drying:

The developed traces will feel a bit tacky. It's a good idea now to either let the board air-dry, or use a hair dryer or hot air rework station to dry the board until it's not tacky any more.

If you try and touch-up a tacky board, you're going to have a bad time.

> **Reader Rodrigo from Brazil contributes...**
>
> For the "problem" of sticky/wet dry film after exposure you can quickly resolve this by applying acid to the board, it stops immediately the basic solution attached to the dry film, making it very consistent and 'hard'.
>
> Acid can be just kitchens vinegar! Just works great!

Touch Up:

Photoetching is pretty reliable especially once you have done a few boards to get the hang of it - but you may still need to touch up now and then, a bit of dust in the wrong place, a scratch deeper than you thought, bubble, wrinkle, slightly over or under developed or exposed areas - remember you're a hobbiest probably working in your shed, not a process engineer in a clean-room, some touch up is inevitable and it's much better to do it before etching.

First have a look for any traces that just look a bit iffy to you. Any possible breaks or traces that look a bit thinner than you wanted, sharp corners that seem a bit precarious, traces that look a bit light coloured (underexposed areas).... grab your handy etch resist pen (see my Trade Me listings) and lay down some ink.

You may need to clean the pen tip by drawing a stroke on some paper now and then because of the resist residue.

Remember it's MUCH easier to prevent potential etching problems now with a dot of ink than it is to fix them after etching!

Next you want to look for any places where “resist traces” are or might be touching, or have resist gunk still stuck between them. Any you find, use a pin or tip of a craft knife to clean them up.

If your traces are really close together (8mil or so), it's a good idea to have a look under a magnifying glass etc to check for any gunk still lurking, it's easier to clean it up now with the tip of a pin or blade than to clean up copper bridges later.

If you are getting a lot of left over gunk, you're not developing it long enough, your developer is a bit weak/used-up, you need to agitate it a bit more, or your exposure was a bit long.

Etching:

Left as an exercise for the reader :) Use your favourite etching method.

Stripping:

Once etched, to remove the resist, make a much stronger solution of Washing Soda, warm it up (or make fresh with hot water), and drop the board in it.

Leave it for a while (might take 15 minutes to an hour, hotter = faster). The resist will float off the board. A bit of a rub with fine sandpaper, or a scrubbing pad will take care of any stubborn bits and leave you with a beautiful shiny perfectly etched PCB!

Eye protection is a very good idea, strong hot washing soda in your eyes could be REALLY unpleasant.

Alternatively, you can put the PCB in “bath” of acetone, it will take maybe a minute to strip off in acetone, on the downside you have a bath of acetone evaporating in your office, which may not be ideal.

Further Reading:

Here are a couple of links that helped me when I taught myself to use Dry Film.

http://www.instructables.com/id/Killer-PCBs/

http://www.youtube.com/watch?v=r9e0H21ev7g

https://stillwater.sharepoint.okstate.edu/ecendesign/Training%20Documents/PCB%20Etching/Required/5180_Data_Sheet_Dry_Film_Photoresist_(How_to_Laminate).pdf

http://members.optusnet.com.au/eseychell/PCB/photoresist/Wet_Lamination_of_Photoresist_for_Hobbyists.pdf

Previous Cleaning Tips

For posterity, here are some older tips on cleaning, as on a previous page these days I just go straight for the sand paper, wipe it down with acetone and call it a day.

~~- Get some crème cleanser (jif etc, whatever) and paper towels, set to scrubbing that board~~
~~- Rinse with water~~
~~- If really bad I will sand with fine (1000-2000 grit) sand paper (actually as I get lazier and lazier, I often just go straight to sanding with 1000 grit and skip the jif :-))~~
~~- Wipe with solvent (meths or acetone depending on how dirty it is).~~
~~- An optional dunk/wipe in tarnish remover ("Ceraclen Silver Dip" from supermarkets works well http://www.ceraclen.co.nz/products.aspx) - lately I havn't bothered unless it's majorly dirty~~
~~- Wipe with meths~~
~~**- Rinse with water - this is really important, any cleaner residue will cause you problems.**~~
~~- Dry and ensure surface is dust free~~

~~**It can not be stated enough that your blank PCB must be scrupulously clean for any method of etching you use.**~~

Previous Dry Adhesion Clothes Iron Method

For posterity, this is an older "dry" method I used with a clothes iron, virtually the same as the "wet" method I now prefer just without the water, the "wet" method is a lot easier and more reliable in my experience to get the film down without bubbles/wrinkles.

~~This method sort of my own devising works quite well at least for small boards (a little practice makes perfect).~~

I've perfectly done it with boards of about 7x7cm, and have had good success with even larger boards. You may find that there is more chance of having to touch-up areas after developing, but that's no big problem.

For what it's worth, I have a laminator, but I still use this method often because I'm too lazy to warm up the laminator and setup a carrier board, my "shed clothes iron" heats up in seconds.

Anyway, start with cleaning your PCB as detailed previously.

Place your PCB on a piece of paper which is on a flat surface (that's not going to care if it gets hot, your mum's dining table probably not a good place).

Set your iron to a cool setting, 55-70 degrees works for me, usually just a couple clicks off the lowest possible setting.

Place iron on top of the PCB, we want to use the iron heat to help dry the PCB of any remaining moisture.

Now take your piece of film (which you've cut a good 1cm larger than you need on all sides) and remove the inside-of-curl protective layer - stick a piece of sellotape on each side of the film at one corner, pull the two pieces apart, the bottom (inside of curl) layer will remove easily (actually, it's really not a big deal if the top layer comes off instead, seems to work either way up, but inside-of-curl-down is "the norm").

Now, tricky bit, smooth the film onto the board, avoiding wrinkles and bubbles. How you do this, is a matter of preference! I'm sure you'll find a way that works for you with some experimentation. [See also: Wet Lamination Method, below]

If you did get a little bubble in there that you can't work out, don't despair, take a tip of a craft knife, or a pin, and just pierce the bubble then smooth it

out. Later when you are ironing it, just use the iron tip to buff that mark and smooth it a bit more. You might have to touch it up after exposure.

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Take your clothes iron, (once again, **on a quite cold setting** 55-75 degrees works for me). Put it on top of the board for a few seconds.

After 20 or 30 seconds things should be getting warmed up, slide the iron around gently with just a little pressure, just like ironing your shirt, paying special attention to the edges of the board, these are the problem areas, roll the iron over the edges.

Use the tip of the iron to gently rub the edges again, and any "problem spots" which you fixed or noticed. If you have a little wrinkle, bubble, tear, in the polymer (photo) layer, try using the tip of the iron to "buff" it out, the polymer is soft at this 60-80 degree temperature and can be "smooshed around" with the iron tip to smooth small problems out.

Once you think it's hot all over and looks smooth, that's it, slice the board off, cool it, and away you go. I usually do 20 or 30 seconds of pre-warming under the iron, and maybe 30 to 60 seconds of gentle rubbing, it's not that critical. Practice makes perfect.

A note on temperature; if you go too hot, you will get quite obvious ugly blisters under your film, this is no good those blisters will just wash off when you develop, clean it off (or cut/scrape/clean those areas and re-laminate a patch if you want to try that, sometimes you can get away with it :)), reduce your iron temperature and start again with a fresh piece. If you go too cold, the film will also not attach well during development and etching.

Blisters can also be caused by moisture, hence pre-warming helps to drive that off.
Caution: clothes iron temperature regulation may be quite poor - your fancy pantaloons probably don't care

~~if they were ironed at 80 degrees or 110 degrees so clothes irons are pretty simplistic at controlling their temperature. If you have a temperature probe for your multimeter use it to get a feel for where to set your iron's dial and note which parts of the baseplate are hotter/cooler, aim for 60 to 75 degrees at the hottest point.~~

~~**For Double Sided Boards it is advisable to let the board cool a bit before you try and attach the second side.**~~

~~**Of course, you may have stuck film to both sides at once to begin with, in which case still take notice of temperature when ironing the second side because the board is already pre-heated, if your iron is hot enough it could blister due to over-heating when you do the second side.**~~

~~If you find that the photo layer isn't stuck to the pcb totally (try peeling the top protection layer up a little on a corner) and you are sure your cleaning was well done then you know that you needed to warm it up more, or more evenly (spread the iron around), or a fraction more pressure, the most likely places to have a problem are the edges. Practice, and remember, if your iron is too hot, you will get blisters, just clean and start again.~~

~~**Now, continue to Exposure!**~~