Wet Lamination of Dry Film Photoresist for the Hobbyist

By Adam Seychell

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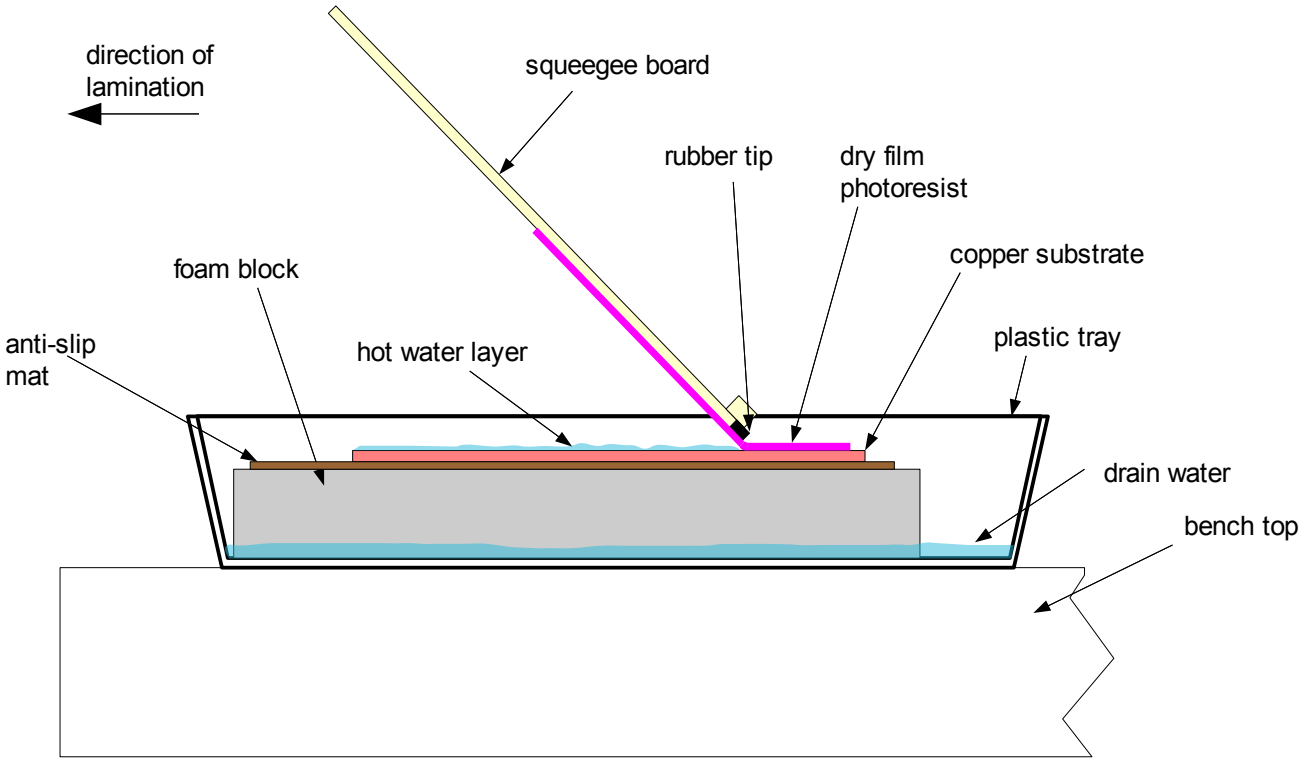
Introduction

The most common method of applying dry film photoresists involve the use of hot roll laminating machines. One variation to conventional hot roll lamination is to cover the copper substrate with a film of water while being feed to the hot roll laminator. This method is known as wet lamination. People in the industry will use wet lamination in order to improve dry film photoresist conformation onto slightly irregular surfaces [1].

Photoresist is commonly used among hobbyists for making circuit boards, or photo engraved nameplates. As I am one of these hobbyists, I had a quest to find the most painless yet reliable method of applying dry film photoresist using readily available equipment. Over the years I had experimented with many techniques before finally reaching the method described in this manual. Wet lamination showed to have the following advantages:

- Water is the source of heat and therefore eliminates the need for a hot roll laminating machine.
- Particles and other surface contaminants are washed away by water.
- Impossible to trap air bubbles.

Drawing 1 illustrates the concept of the wet lamination method described. The photoresist film is initially laid flat on to the wet squeegee board and held down by water surface tension. The film is positioned such that one edge slightly overhangs the rubber tip of the squeegee. Next, the squeegee is turned over and placed with it's edge near the end of the copper plate. Force applied on the squeegee causes the photoresist and copper to bond directly under the squeegee tip. When the squeegee is dragged, the photoresist slides off and transfers to the copper.



Drawing 1: Wet lamination of dry film photoresist using a squeegee board.

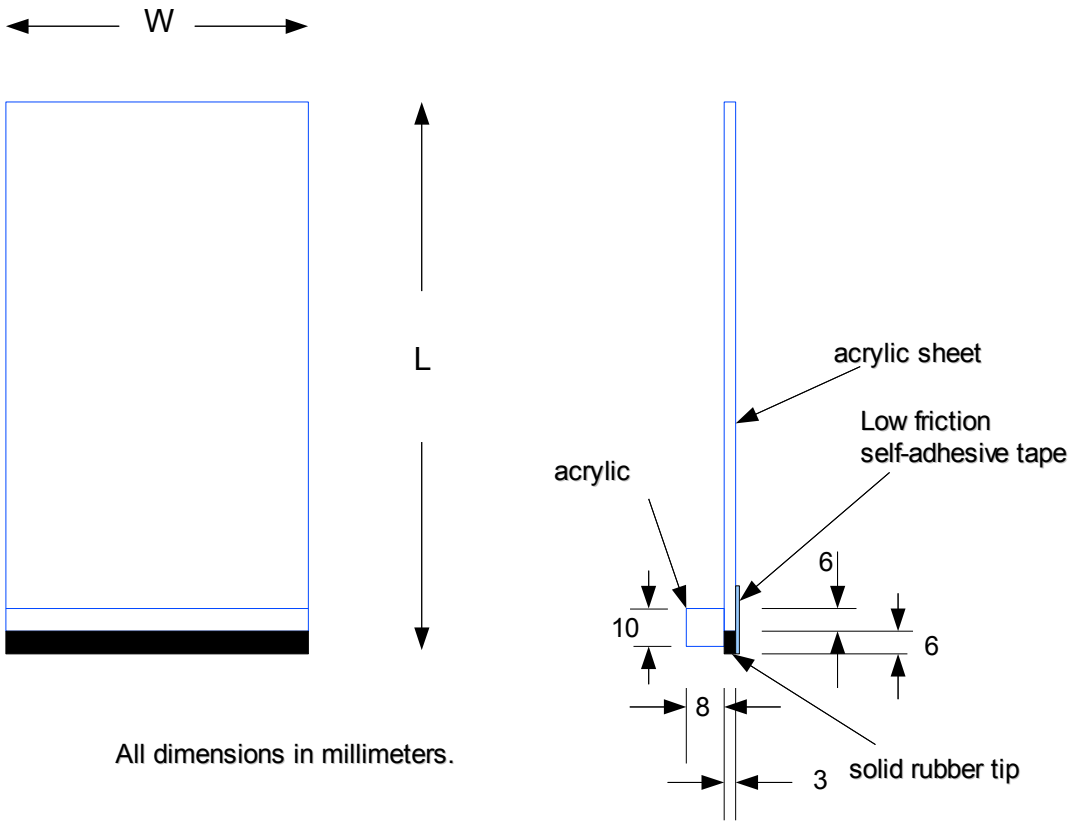
Equipment List

The equipment is simple and low cost but requires a special type of squeegee, which is referred to as a *squeegee board*. Below is a simplified list of tools and equipment required.

- squeegee board
- polystyrene foam block
- plastic tray (examples: photo developer tray)
- anti-slip mat. Must be thin (< 3mm) and soft.
- tweezers
- electric kettle
- 3M Scotch-Brite green abrasive pad or waterproof abrasive paper grit 400 to 800
- plastic ruler
- large scissors
- water spray bottle
- rubber gloves

Squeegee Board

As previously described, the squeegee board is an application tool used for the lamination. Referring to Drawing 2, this squeegee is consists of 3mm acrylic sheet with a rubber strip mounted flush on one edge. This acrylic sheet will flex slightly during lamination and helps maintain consistent pressure. The 8 x 10mm acrylic strip adds stiffness to one edge of the squeegee board and improves pressure uniformity. A small overhang of 2 mm provides local conformation. A layer of polyethylene self adhesive tape is placed over the rubber face and slightly overhanging the rubber edge. This tape reduces the friction at the tip, lowering strain in the laminated dry film photoresist.



Drawing 2: A design example of a squeegee board use for the wet lamination process.

The Procedure

Cut photoresist to size

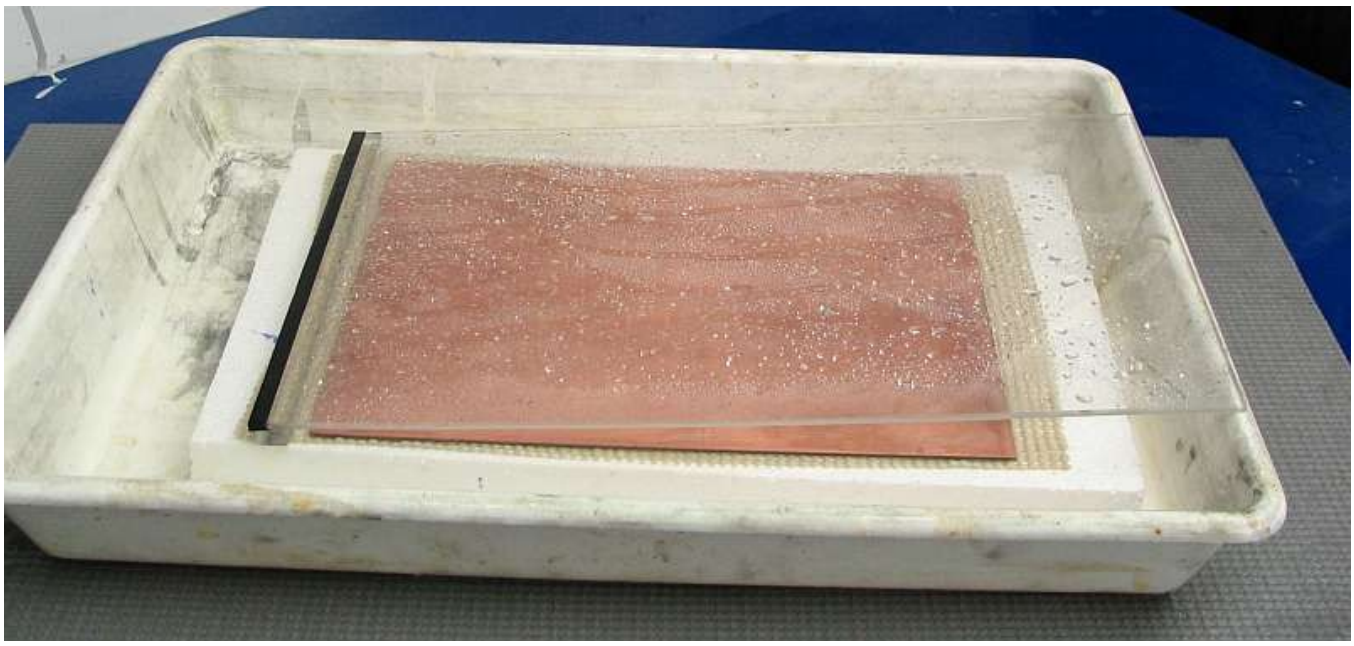
Remove photoresist film off the roll. Cut with scissors or knife. To allow some freedom in positioning the laminated photoresist, the cut sheet should be oversize by at least a 5mm boarder to the actual exposed artwork area.

Clean substrate and roughen surface.

Scrub copper surface clean using Scotch-Brite pad or waterproof abrasive paper grit 400 to 800 (wet and dry) . To assist in the scrubbing, place copper on a flat ridged surface such as a piece of glass and wet scrub inside a tray or sink. Once the copper is clean, remove and rinse thoroughly under running water.

Notes:

- After cleaning there should be a continuous film of unbroken water over the copper surface. See Illustration 2.
- Good photoresist adhesion requires clean and grease free copper surface.
- If water continues to bead after scrubbing, then the copper is probably particularly dirty with organic contaminates. In these circumstances you should add a strong alkaline degreaser to the water during scrubbing. Rinse thoroughly under running water, followed by spray rinsing using a hand spray bottle.

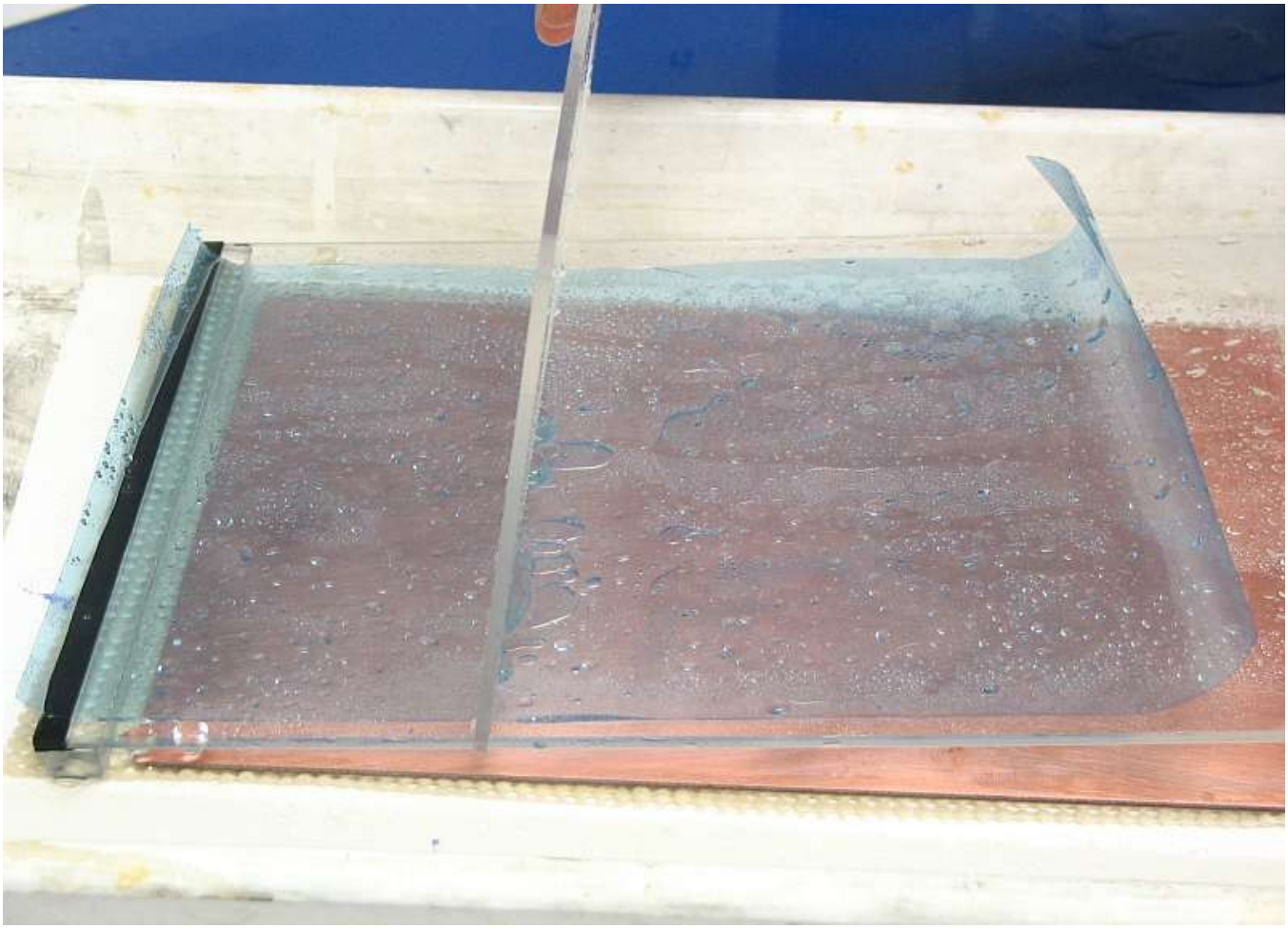


Prepare foam block, copper, and squeegee board into tray

As shown, place foam block, followed by anti-slip mat and copper substrate. The squeegee board is placed above the copper with rubber strip facing up as shown in the photo.

Notes:

- Visually inspect the copper and squeegee board surfaces for foreign particles. Remove particles with the spray water bottle.
- When doing doubled sided panels, always use a soft material under the bottom side as heated dry film photoresist is very soft and easily deformed on pressure points applied on the bottom.



Place photoresist

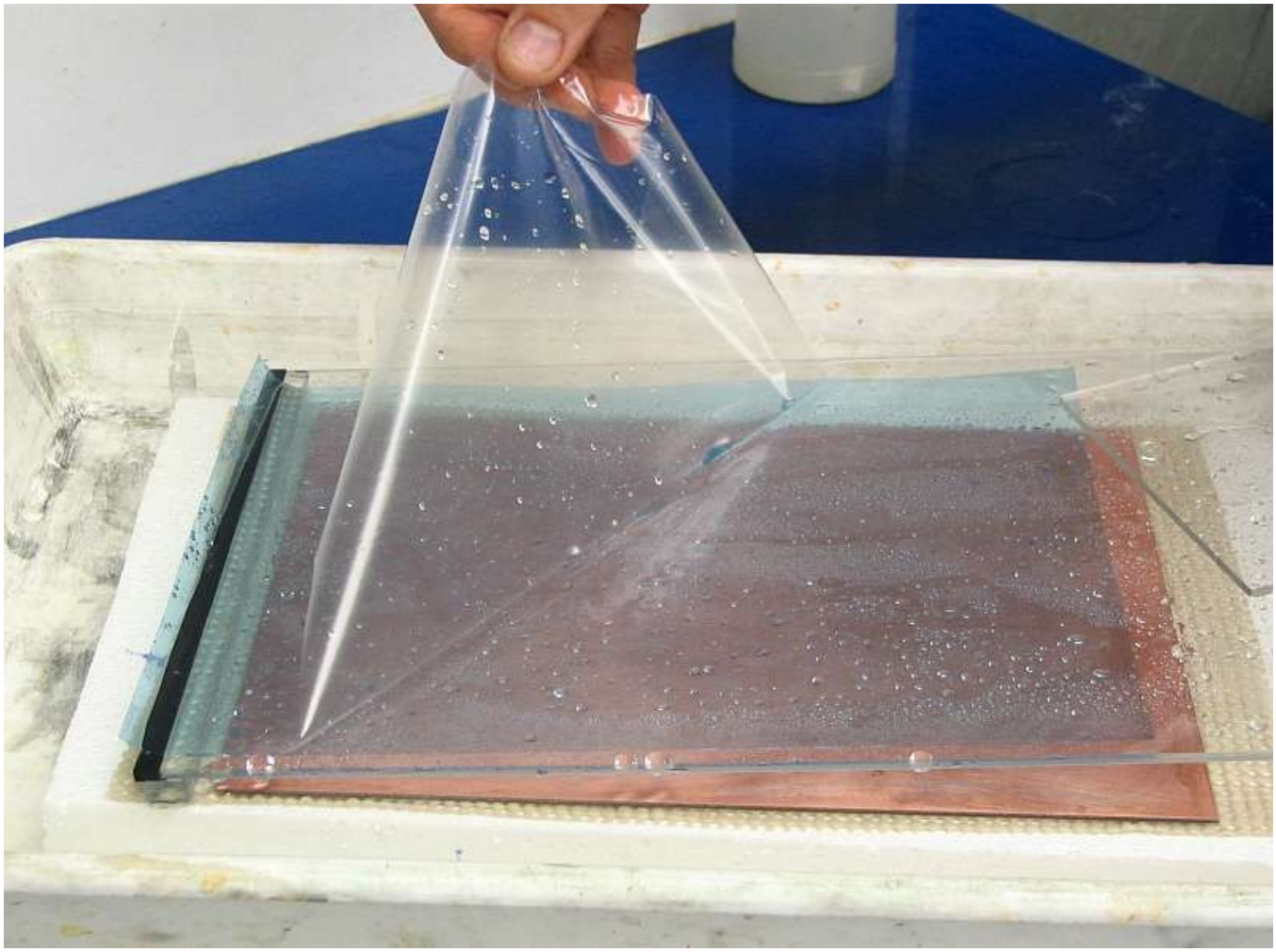
Wet squeegee board with the spray bottle to provide the necessary water tension for holding the film in position. Place film with protective *polyethylene* backing material facing up. Large sheets will often trap harmless air bubbles between the film and acrylic.

Initiate backing film separation

Using pointy tweezers, poke or scrap a small area of the backing film at a far corner. You should see backing film start to separate. Use the tweezers to peel away a few centimeters from this corner. If the film is proving difficult to remove you may be peeling the polyester protection film.

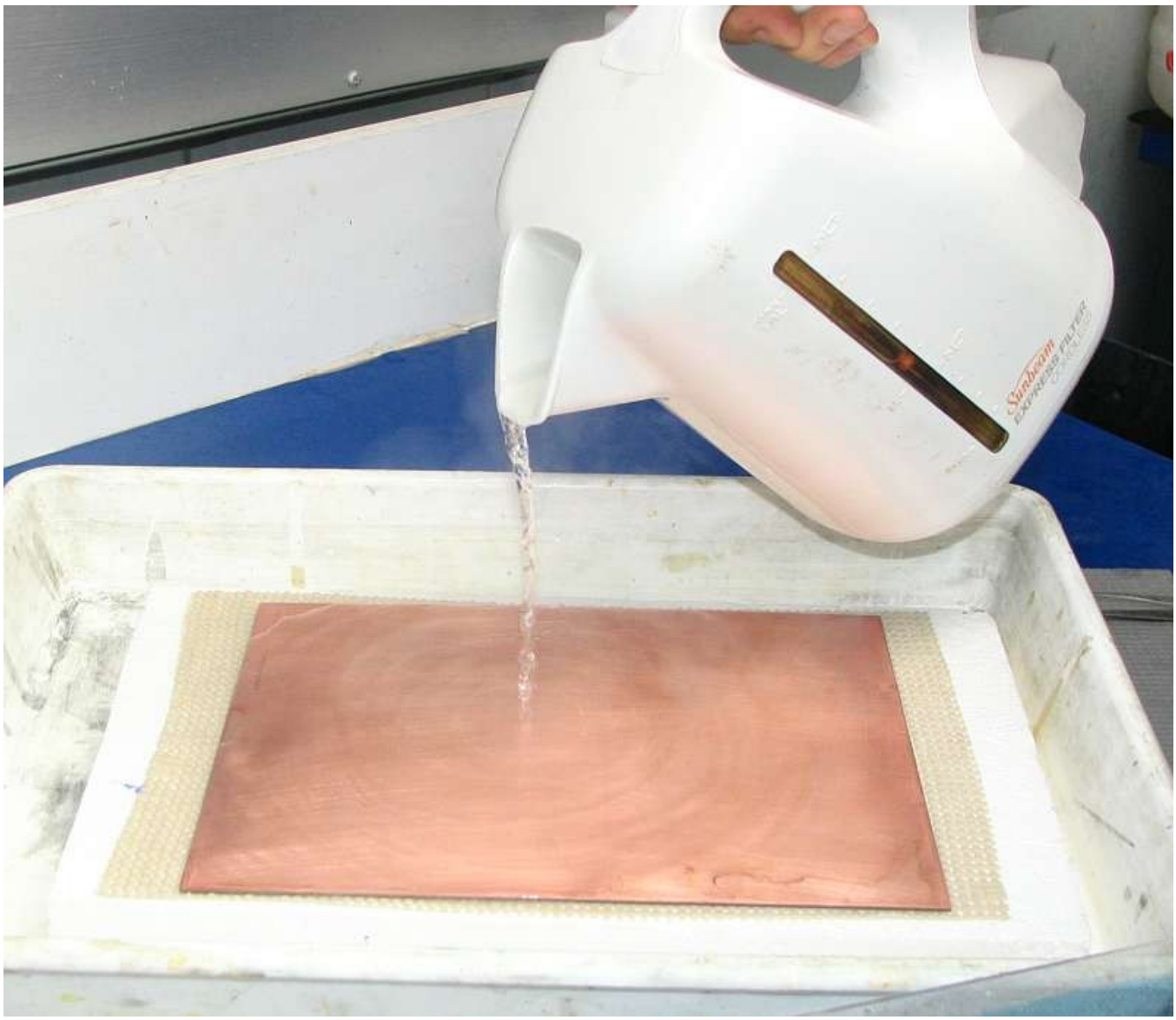
Notes:

- Be careful not to mistake the much thinner *polyester* film on the exposure side with the relatively soft *polyethylene* protective backing film.



Remove Backing Film

Remove the backing film by pulling the corner with your fingers while holding down the photoresist edge with your fingers tips or similar object. As more of the backing film is peeled the water tension helps prevent photoresist from lifting off the squeegee board and lay perfectly flat. Discard the backing film.

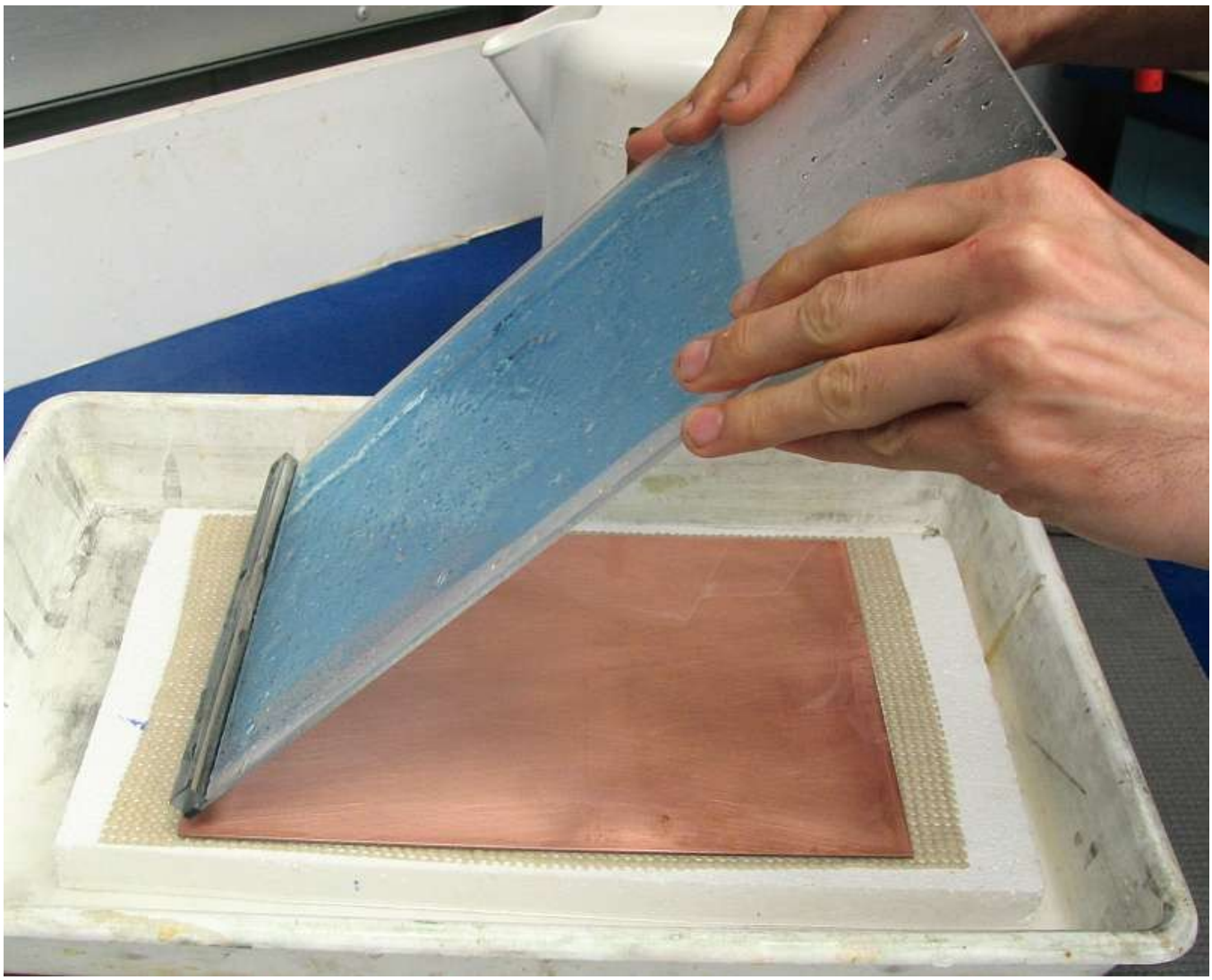


Heat Substrate

Temporally move the squeegee board aside. Use the kettle, slowly pour very hot water (≥ 80ºC) over copper for at least 5 seconds. This will assures the copper is properly heated (> 45ºC). It also gives the copper one final rinsing.

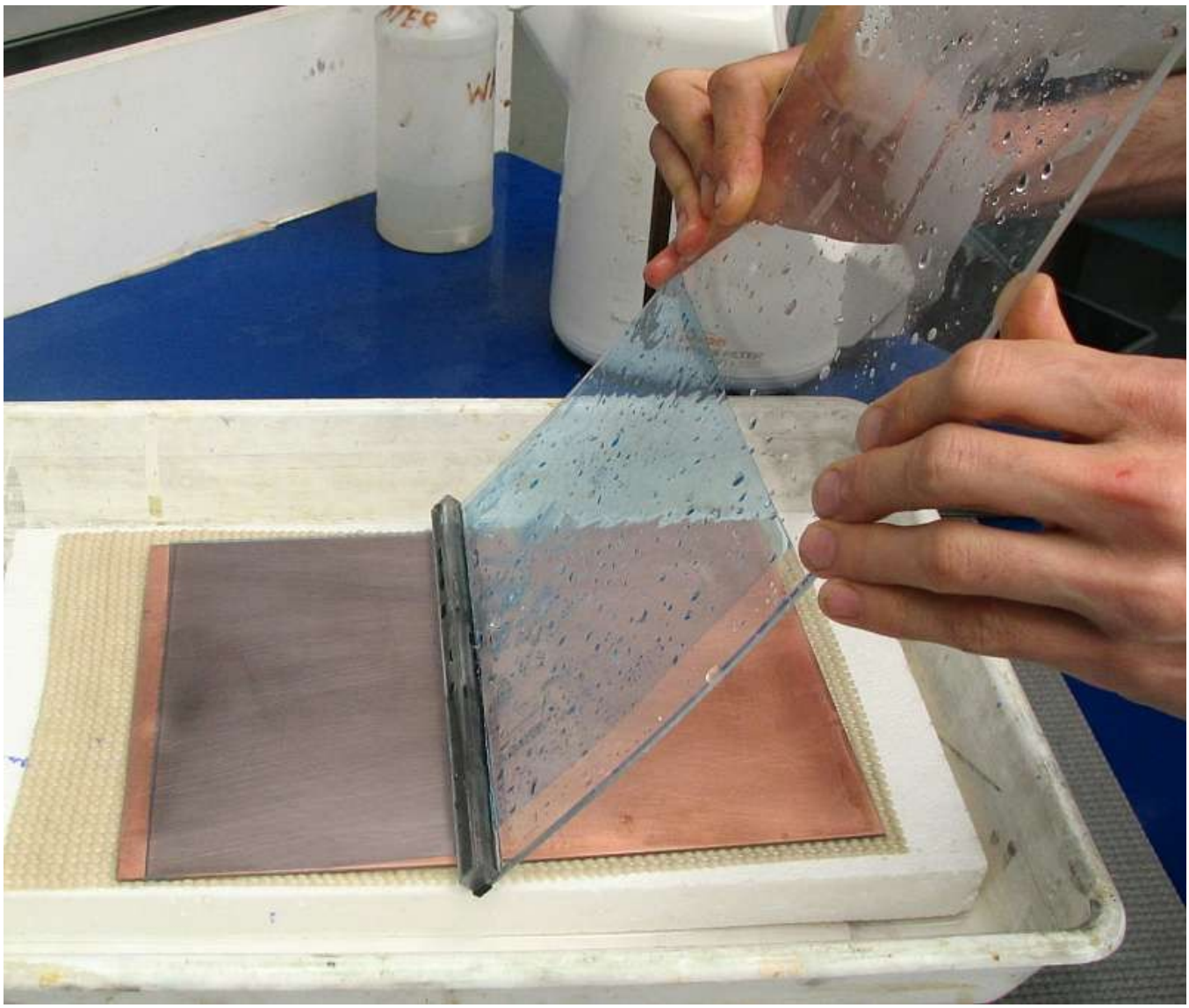
Notes:

- It is important that the hot water does not contain dirt or particles.



Prepare for lamination

Position the squeegee board with the photoresist facing the copper as shown in the photo. Hold it 45 degrees to the copper and carefully lower the rubber edge (with overhanging photoresist) onto the far side of the copper edge as shown. Press down, and hold.



Lamination

Using both hands, apply generous force to the squeegee while dragging towards you keeping the angle approximately 45 degrees. The photoresist will slide off the squeegee and transfer to the copper. As a very approximate guide, I have found the drag speed should be 3 to 8 cm/second. Slow speeds also allows temperatures to drop. Extremely fast draging may trap water or lead to wrinkling.

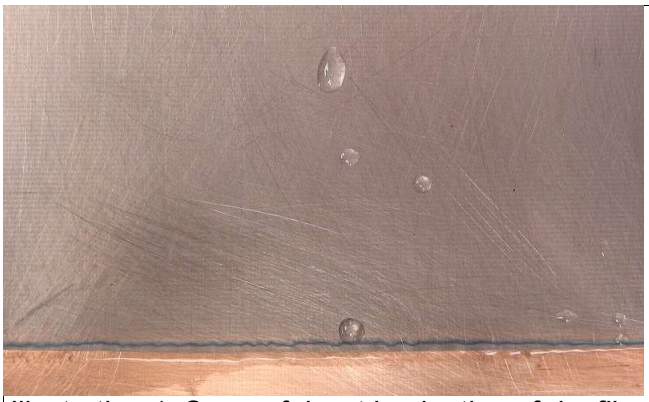
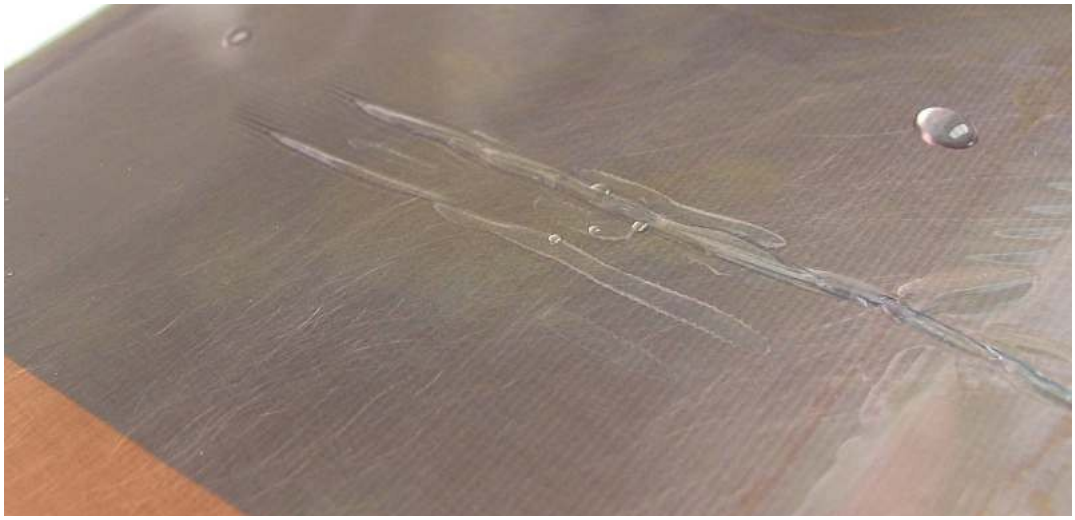


Illustration 1: Sucessful wet lamination of dry film on blank PCB material

Lamination Defects

Common defects of the lamination process include: wrinkles, poor adhesion, and trapped particles. Below is a brief explanation of each these common defects.

Wrinkles



Lamination wrinkles can be due to one or a combination of:

- Photoresist film not laying flat on squeegee board *prior* to lamination.
- Very low squeegee pressure. Any wrinkling of the film on the squeegee board is less likely to be flattened during lamination if the squeegee pressure is too low.
- Erratic squeegee speed and pressure or reversing in direction slightly causing resist to wrinkle at the squeegee tip.

Trapped particles

Trapped particles usually occur from insufficient rinsing of the copper substrate and/or squeegee board.

Poor adhesion

Poor resist adhesion causes areas of exposed photoresist to lift off the copper after developing. Damage of fine traces and artwork features are especially susceptible to adhesion problems. This is the most common defect in lamination and can be caused by a number of ways.

- Contaminated copper surface is often a cause of poor adhesion. A properly cleaned copper surface should form a continuous break free film of water. Grease and oil contamination drastically reduces adhesion. See Illustration 2
- Low temperatures or insufficient pressure during lamination can cause increased trapped water under photoresist.
- Developing too soon after lamination. Laminated dry film photoresists will tend to increase bond strength over time. Is is recommended to at hold for least 5 minutes.

Illustration 2: Showing both a contaminated (left side) and clean (right side) surface. Note the water beading on the contaminated side.

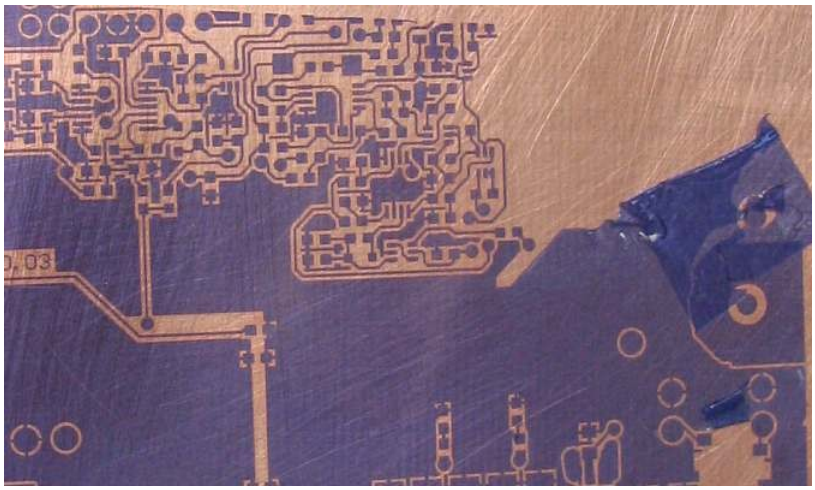


Illustration 3: Demonstration of poor photoresist adhesion due to cold lamination and/or very short hold times (< 30 seconds) before developing.

Where to Buy

Dry film photoresist is an industrial product and therefore normally only sold in quantities that are too large for most hobbyists. Standard packaging are boxes containing 2 rolls, each 500 foot in length. Roll widths range from 12 inches and up. Please visit my home page for information on buying small quantities of dry film photoresist.

Bibliography

1. "Tech Talk: Fine Lines in High Yield (Part LVII) - Wet Lamination of Dry Film Photoresist", Karl Dietz, July 2000, CircuitTree.
http://www.circuitree.com/Articles/Column/ac577d14667d7010VgnVCM100000f932a8c0____