



Solder Paste Stenciling

by Nate | August 01, 2006 | 37 comments

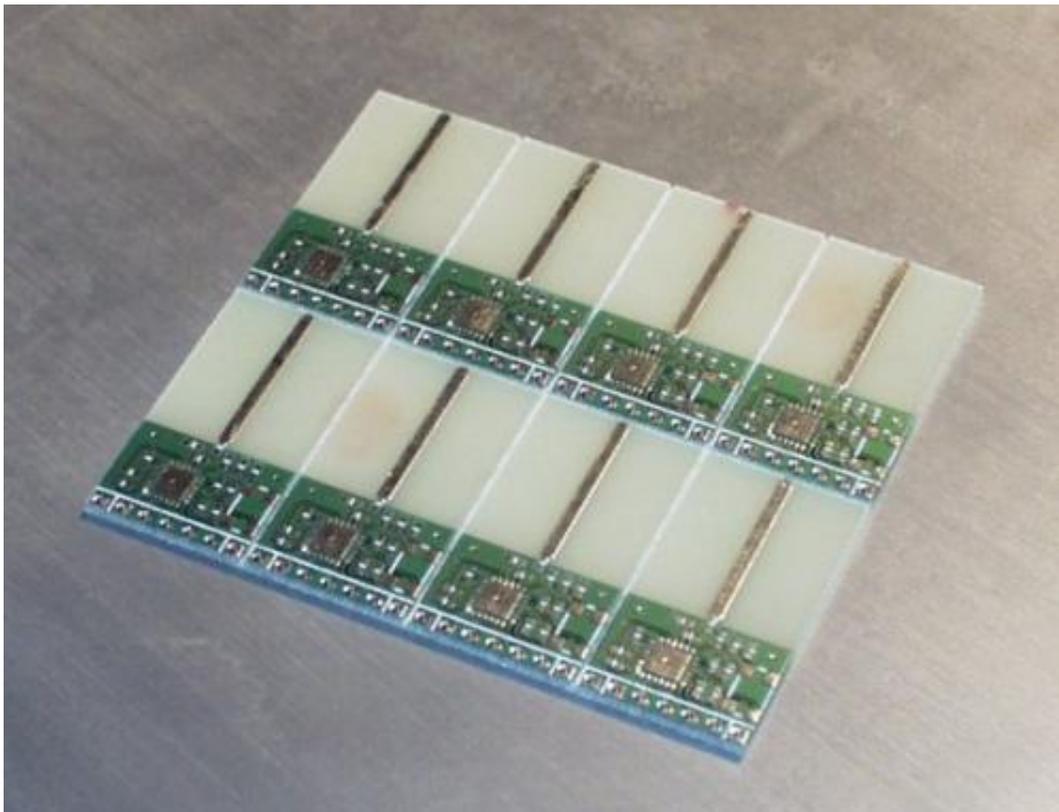
Skill Level: ★★ Intermediate

Here's a quickie tutorial that I wish I would have learned in college - at least as a technical elective - in the Electrical Engineering program at the Univ. of Colorado... Instead, we got to learn the hard way!

We are constantly attempting to share what we've learned about surface mount soldering. This tutorial will show you what it takes to use a cheap-o solder paste stencil to apply solder paste. It's not that hard. There are some up-front costs, but it's easily within the means of the average hobbyist.

We are basically tipping our entire hand by disclosing our manufacturing processes. What do we get out of it? Nothing really. Please take this to heart and tell your friends about our site. We've sunk \$1000s in equipment only to discover much of it was not needed. We hope to educate you enough to avoid our pitfalls.

The usual warnings apply. Solder paste may or may not kill you - just stop licking your hands and you should be ok. One way to tell you've got lead poisoning is dementia. So here at SparkFun, we really don't know if we're washing our hands enough...



Here is what we will be stenciling today!

Tools you're going to need:

- Stencil
- PCB that matches the Stencil
- Solder Paste (Kester Easy 256)
- Wiper of some sort
- Flat spot/table
- Good lighting!
- Rubbing Alcohol
- Lots of paper towels

Optional Stuff:

- Tupperware container
- Mini-fridge
- Screw driver or mixing tool
- Trashed PCBs for framing

SMD Reflow Tutorials:

- Reflow Skillet
- Reflow Toaster

Solder Paste -

Solder paste is a sticky grey substance that is somewhat liquid - well that's a paste now isn't it... Pretty much lead and tin mixed together with flux and some other magic ingredients. We use Easy 256 from Kester. Why? It's a No-Clean paste which means after you are done reflowing the board, you're done! No need to wash the board. Any solder paste will do.

One of the main problems is getting the paste. A 500g jar can cost from \$50-\$200 which is bad enough. The company you purchase it from will most likely charge you an arm and a leg for overnight shipping, cold packaging, and hazardous handling. Yep, lead is considered hazardous. Who knew? To top things off, I mentioned this "lead being hazardous" thing to my sister who works as an Emergency Room Nurse. She pointed out that there are no symptoms of lead poisoning - short of dementia. One has to be specifically blood tested for higher levels of lead. So I'm not sure if this means we're ok, or if we are actually poisoned and the preposterous nature of these tutorials are proof...



Kester Easy Profile 256 - Notice our paste is expired...

The solder paste suppliers insist on shipping cold packed overnight delivery because the solder paste can become 'unusable' if it's temperature is not closely maintained. Of course we didn't find this to be the case - but then again, we're not producing 10,000 units of a board. Just imagine if you screened and placed \$40,000 worth of parts and PCBs only to find out the paste had gone bad. The batch might be lost. Who are you going to sue? Now you know why suppliers are so uptight, but we don't have to be...

We did notice that the paste will change over time without refrigeration. A syringe or tube of paste should be okay in an air tight container, in a cool place (basement), for multiple weeks. Buy your supply accordingly. It may make sense to buy a mini-fridge like we did from Tar-chet. \$60 goes quite a ways these days.



There's some economics here that I refuse to calculate. But we save money by buying paste in larger quantities and then paying extra for storage (money for a fridge and energy costs). In the end, the paste lasts longer and I think it's cheaper in the long term. You could store the solder paste in your normal fridge but every other website says this is a *bad* idea. I'll agree because it costs me nothing. Remember the dementia thing?

Tools -

These are pretty basic. Do note that we are still looking for a good, cheap, replacement for our squeegee.



Mainly, you need a stir stick (screw driver), a whole bunch of paper towels, rubbing alcohol for clean-up, and some sort of a spatula/squeegee. I would recommend using a screw driver that you never plan on using again. For that matter, pretty much everything around the stenciling area gets grubby with dried paste after a few days of usage.

The \$35 squeegee from Madell Tech came with our stencil printer (shown off to the right in the above picture). While the printer was a waste of \$300, we do use the flat metal base - though you can use any flat surface. The problem with the printer is that it uses only framed stencils. Since we had no idea what we were doing initially, this sounded ok. We've never actually bought a framed stencil (>\$150). Stencil printers will hold a framed stencil in place while the operator manipulates the position of the metal base (with PCB sitting on top) under the stencil with small dials all around the base. This would be ideal if we needed to stencil a large number of boards by hand, but for single units it actually really easy just to hold the stencil in place.

This squeegee has a replaceable thin metal blade that flexes nicely when you're applying paste. While I can't tell a difference, Ben claims the blade is wearing out - and this is common with higher end squeegees - but do you think I'll ever replace it? Probably not... As the blade wears out the aperture thicknesses become non-uniform : the blade digs into some holes while riding higher over others. A few stenciled PCBs and you'll see just how not-mission-critical this is. We've had really good results with 0603, 0.5mm pitch QFNs, and BGAs! If you can't readily find a solder paste squeegee, we've used razor blades with pretty good results.



The solder paste is stored in the Tupperware container and that is in turn stored in a zip lock bag. This sealed package is stored in the fridge when not in use. Every time we use the paste, we give it a good stir with the screw driver. If the past seems dry or sticky, we add new paste from the large tube by shoving a (cleaner) screw driver in one end to forward the stopper. This goes against all recommendations so be warned - we are basically adding contaminants by mixing new paste with used paste. We also use the paste fairly chilled - we like the consistency to be thicker when stenciling. Again, the true aficionados claim it should be room temperature. Your guess is as good as ours - practice is the key here.



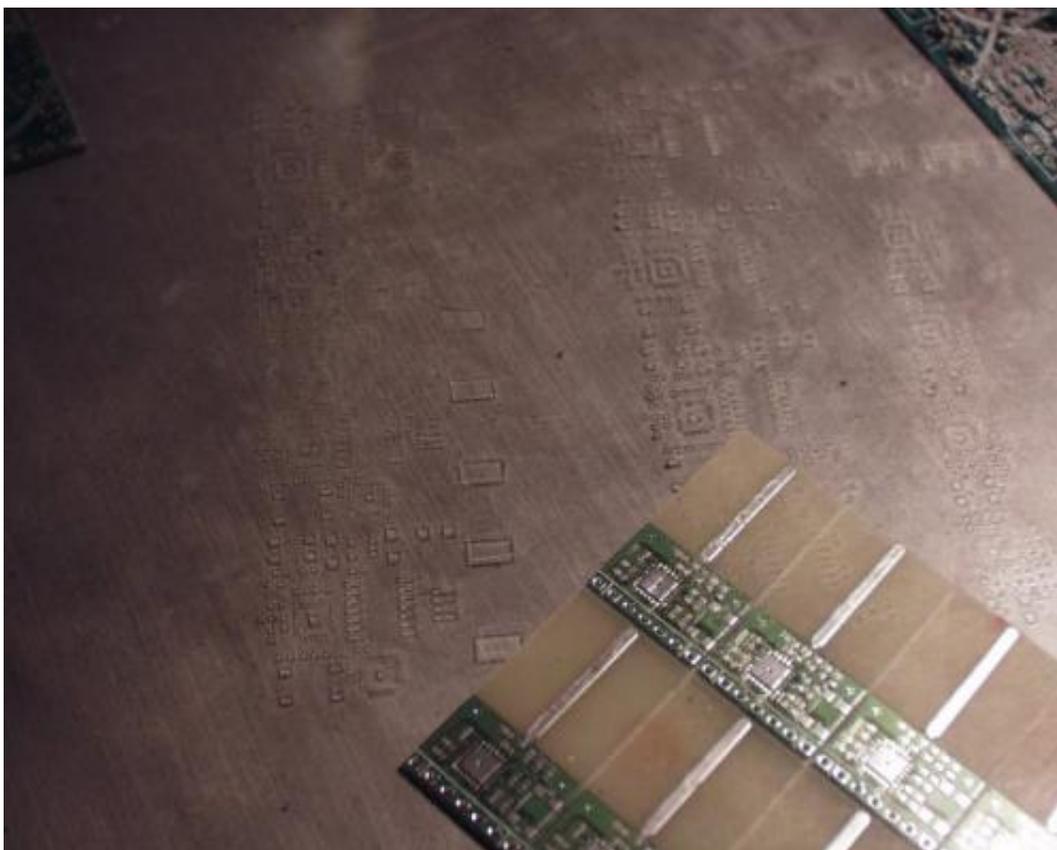
Here the squeegee is shown after its first use. Notice the nice layer on the paddle. It's primed and ready to go again!

The Stencil -

Pololu is a good place to get a cheap plastic stencil. They charge a \$20 setup fee and \$1 per inch after that. They use either a 3mil or 4mil sheet of mylar and can get some pretty good accuracy. Ok, read that again: \$20 setup and \$1 per inch. That means if your PCB is a 3x4 PCB and you've got the top paste gerber (*.gtp Protel) or bottom paste gerber (*.gbp) file, you can have a stencil for \$32. \$32! That's 1/5th the price of anyone else!

The stencil comes as a rolled piece of clear plastic. They can usually cut us a stencil same day or next day. USPS Priority from Nevada is 3 days. Not too shabby.

We use 4mil stencils for larger 0805-1206 parts and 3mil for tight pitch devices. Just ask Pololu for their recommendation. The thinner the stencil, the less paste will be applied. The thinner the paste, the lower the probability of jumpers and the higher probability of disconnects.



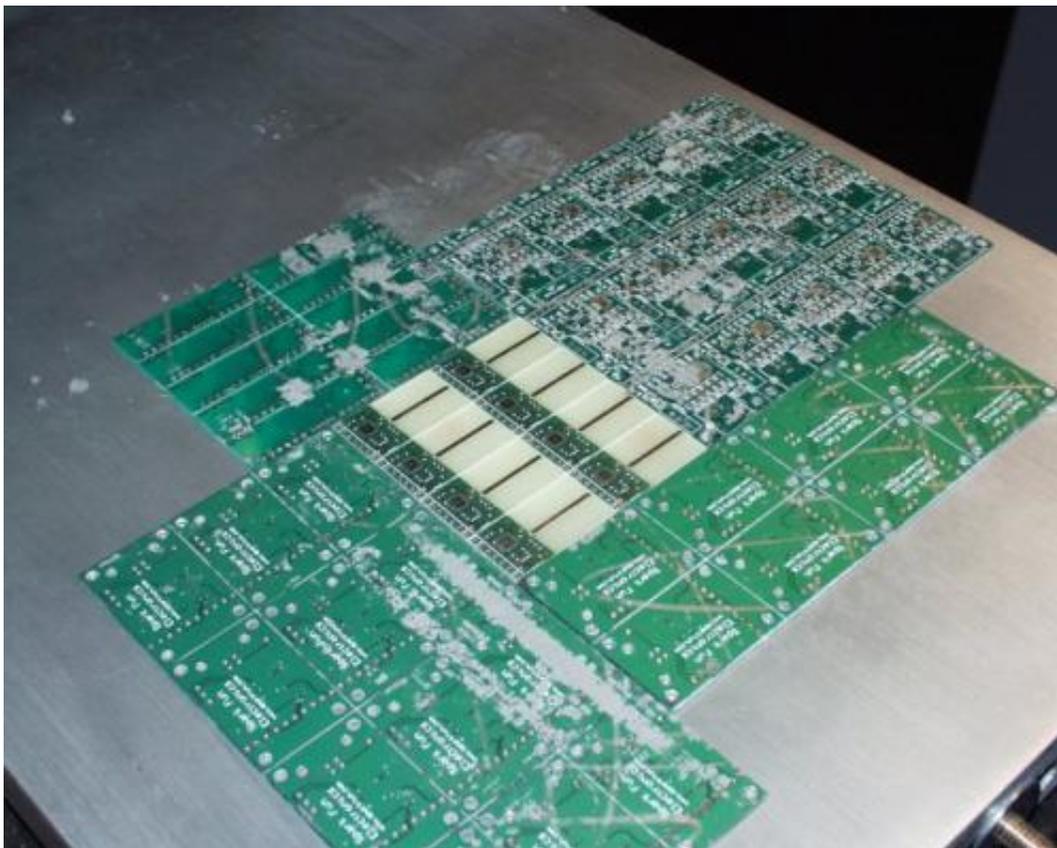
The clear Mylar laser cut solder paste stencil

You may notice that there are multiples of designs and different designs on the same stencil. You can help offset the \$20 setup fee by panelizing your different designs onto one stencil. While this may not help the hobbyist who works on only 1 or 2 layouts at a time, we cram 6 or 8 designs onto one sheet! It works - we promise.

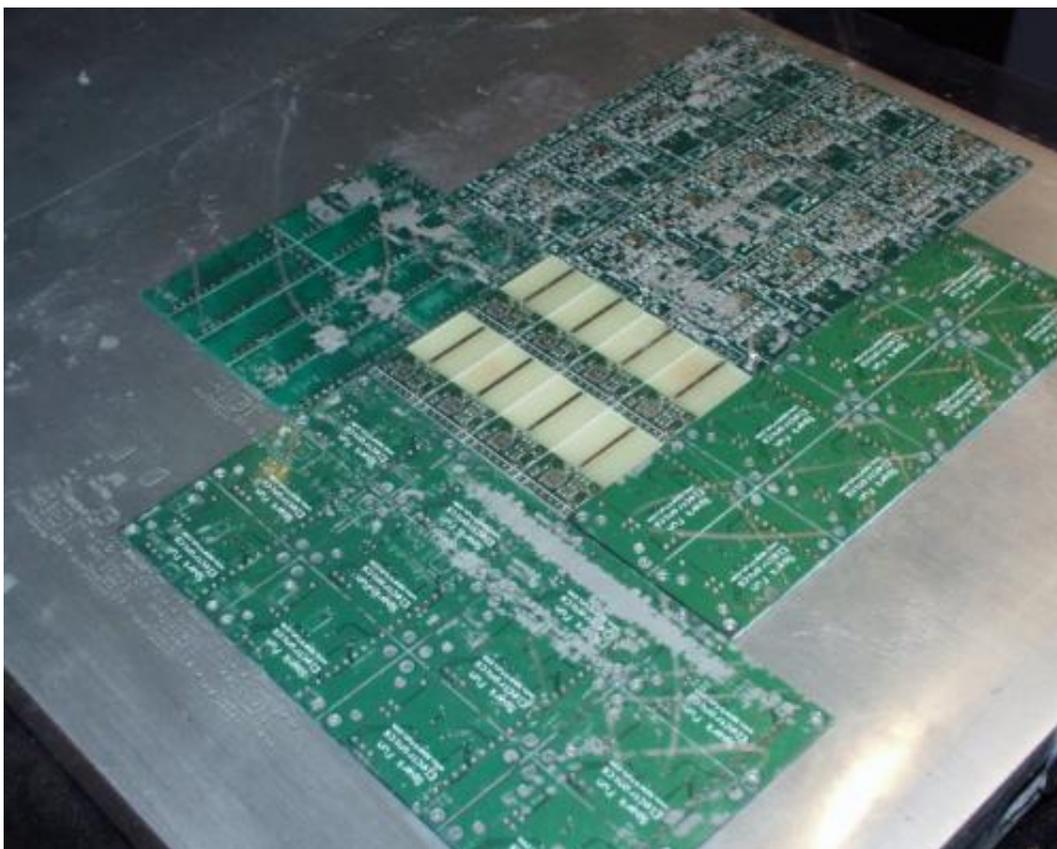
Under the stencil is a 2x4 panel of MiRFs. Uber-tight, 0603 with the QFN nRF2401A IC. We panelize the design and send that panel file to Gold Phoenix. We then send the top paste layer (we rarely put parts on the back of PCBs these days) to Pololu to have the stencil cut. The stencil always beats the PCB in the mail.

Paste Time! -

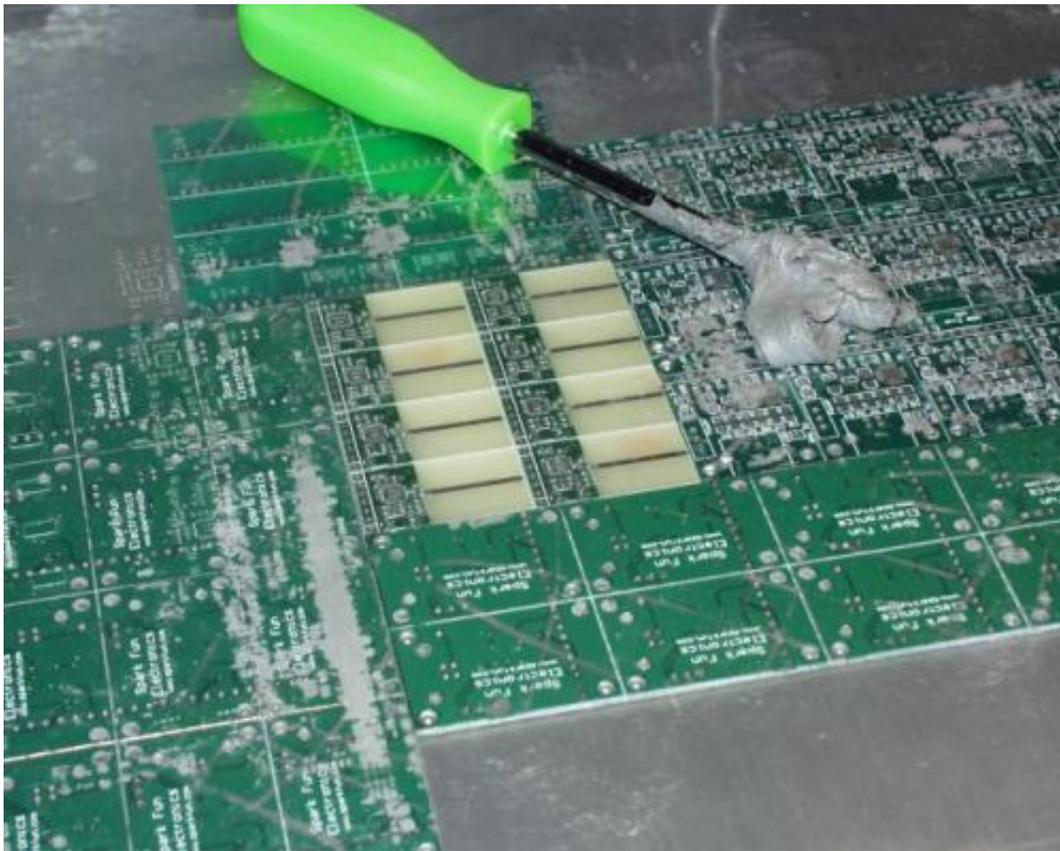
Enough talk - time to paste! First we must surround the boards we want to stencil with other boards of similar thickness. Since we only deal with 0.062" boards, this is a snap.



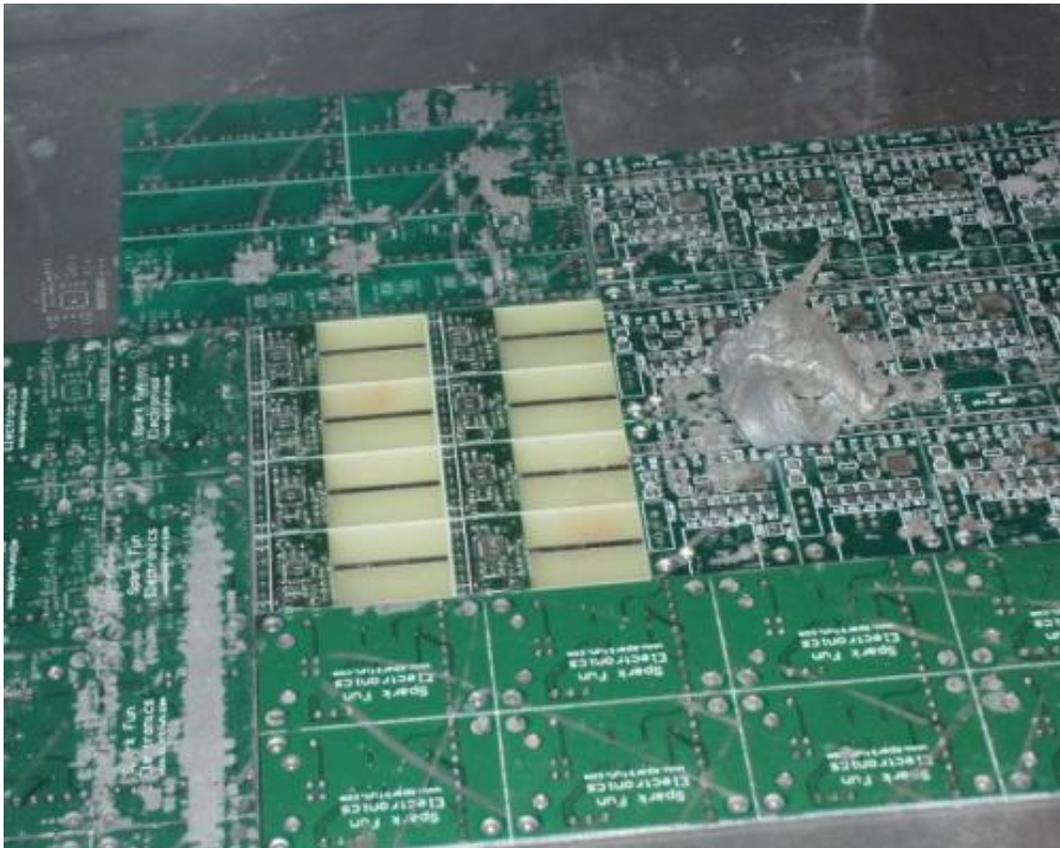
Why the extra boards? As you drag the squeegee across the stencil, the stencil must remain flat or else the stencil will flex/ripple and paste will squeeze into and around the apertures where it's not supposed to be! This way you can drag the squeegee across a completely flat service that is the puzzle array of PCBs. Any trashed PCBs will do - as you can see, we have plenty.



See the stencil? The design we need on this stencil is loosely lined up with the board in the middle.

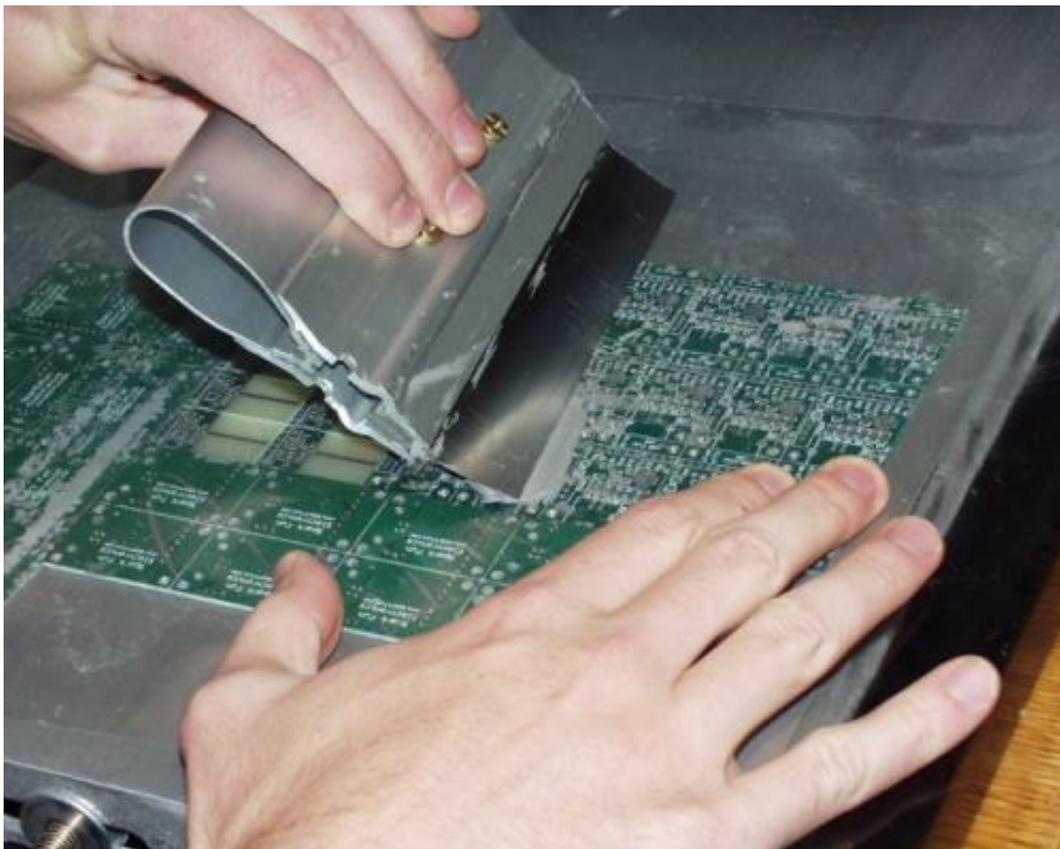


Next, a good glob of newly mixed paste is plopped down. This seems like a lot, especially at \$0.25 a gram, but don't worry, we are going to recover 95% of it! You only have to do this once - the squeegee will contain enough residual paste for 10-15 applications. We use it 3-4 times and then scrape the paste back into the Tupperware dish.



Now is when you line up the stencil. Do you need to be dead on? Pretty close. Can I redo it if necessary? Of course - if you mess up it's not the end of the world, we'll show you! Ben installed a flood light next to the stencil area which helped tremendously with alignment.

Again, note that the paste is actually *on top* the clear stencil (not on the PCB itself).



Once you've got the stencil right where you want it, pin it with your bad hand (I'm left handed so I use my right). Hold the stencil to the framing PCBs underneath. Remember, if the stencil slips, you get to start over.

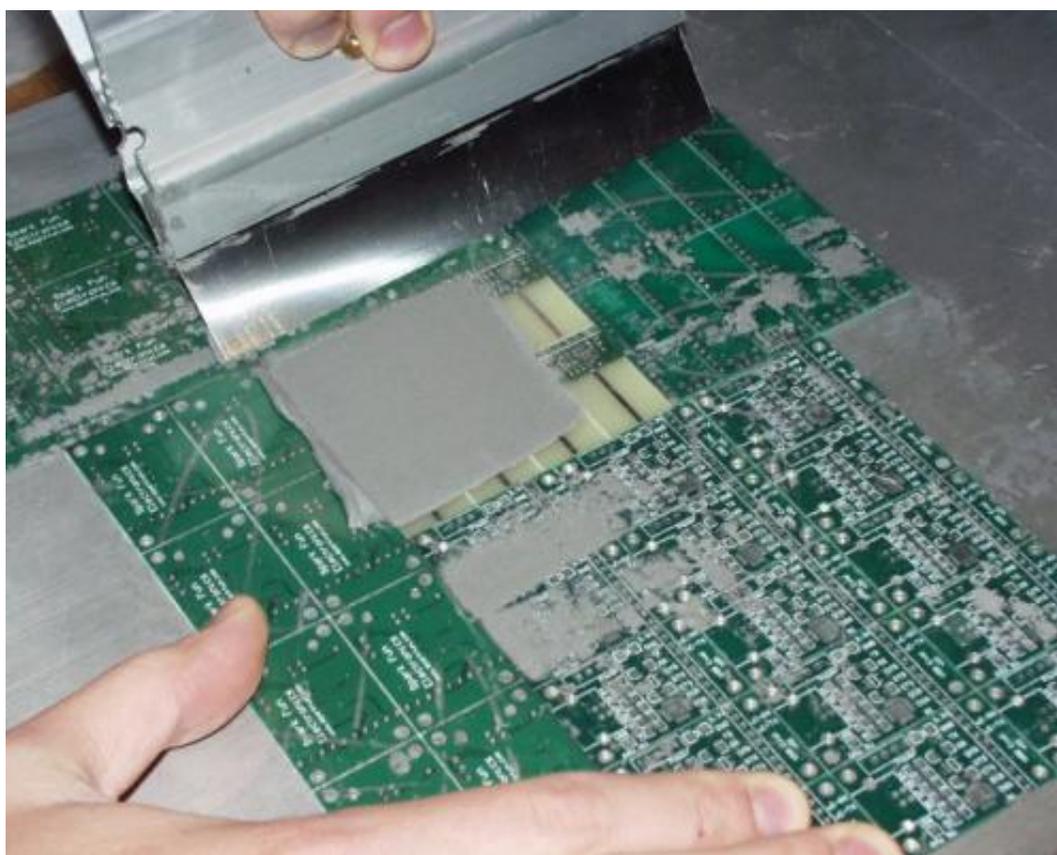
You'll notice I am using a special 'paste squeegee'. I believe we paid around \$50 for this little guy. You can spend upwards of \$500 for some professional SMD squeegees. However, a savvy SFE client pointed out this great woodworking website:

<http://www.leevalley.com/wood/page.aspx?c=1&p=49548&cat=1,310,41069>

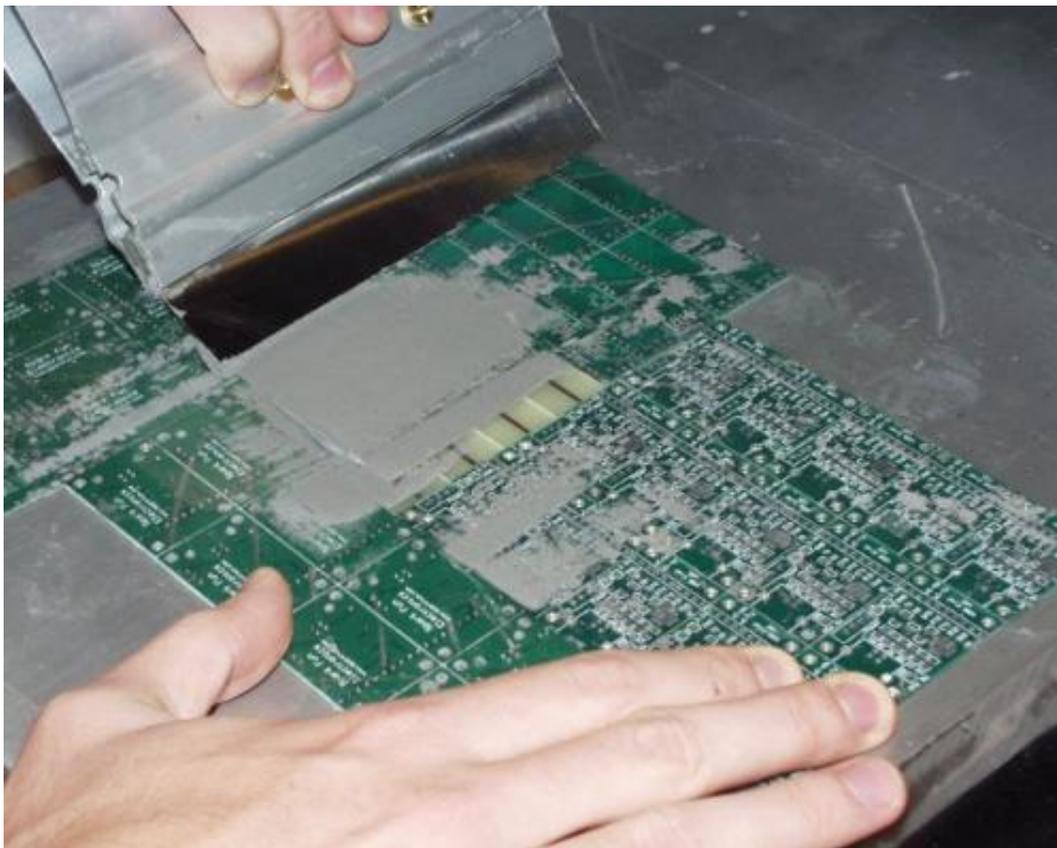
<http://www.leevalley.com/wood/page.aspx?c=1&p=32670&cat=1,310,41069>

<http://www.leevalley.com/wood/page.aspx?c=1&p=32672&cat=1,310,41069>

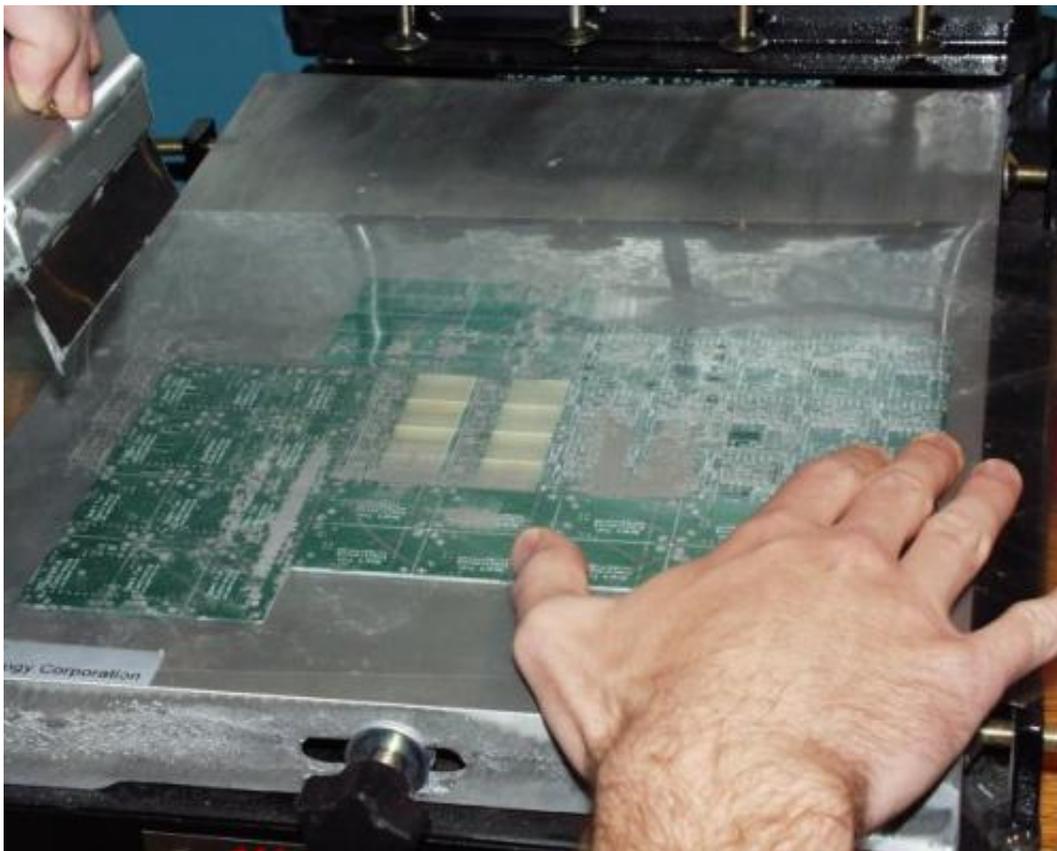
We have not used these mini-scrapers but they look very promising! We've also had some good luck with basic spackle spatulas from the hardware store.



Swipe #1 - I put a thick layer over 6 of the boards, go back and make sure you have everything covered. Pinning hand stays still.



Here is swipe #2 - board is covered. Pinning hand stays still.

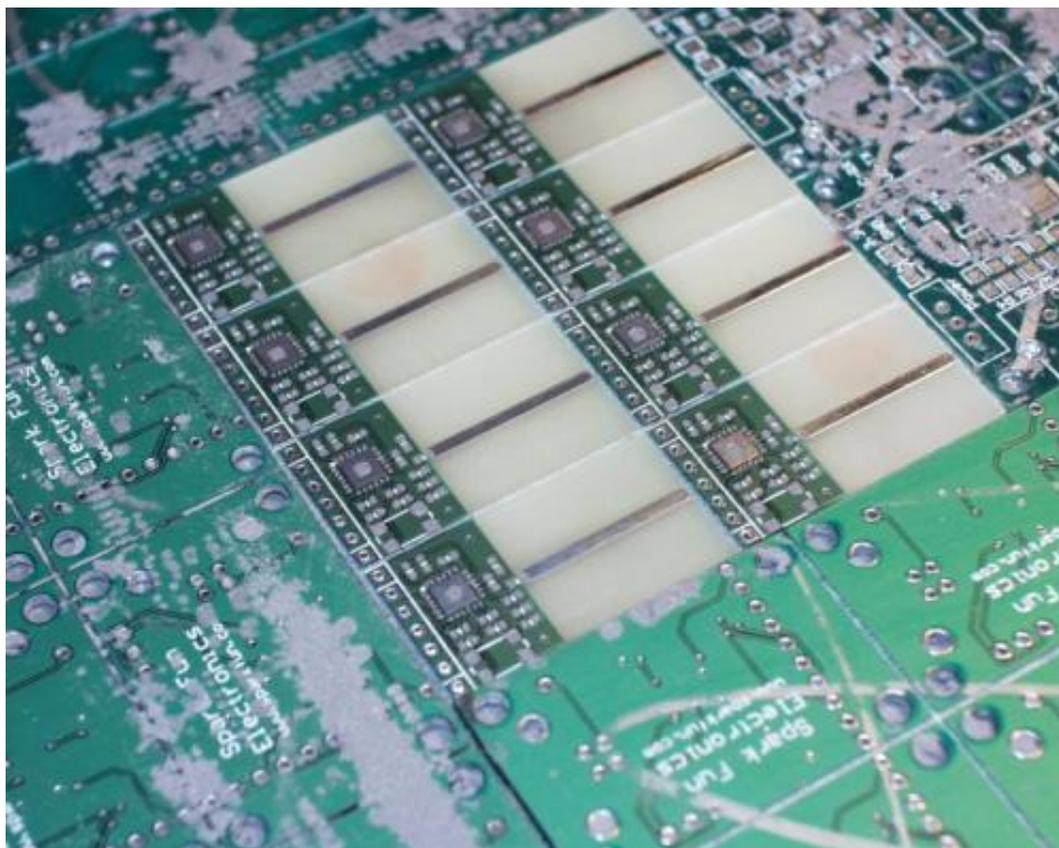


Swipe #3 - finally, we swipe with a more vertical hold on the squeegee removing most of the paste remaining on the stencil - while leaving paste in the apertures filled up to the thickness of the stencil. The stencil is nearly clean and a quick inspection shows that all the apertures are filled (I didn't miss any, I

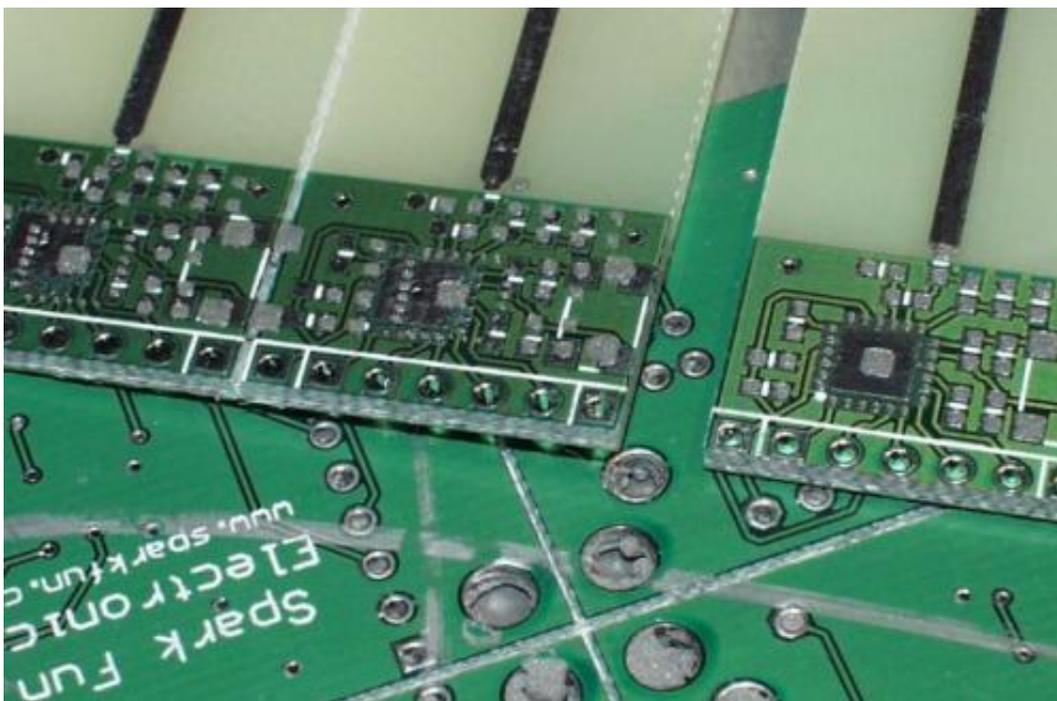
promise!).

Your pinning hand should be holding the stencil firmly in place. Again, if the stencil slips, you get to start over.

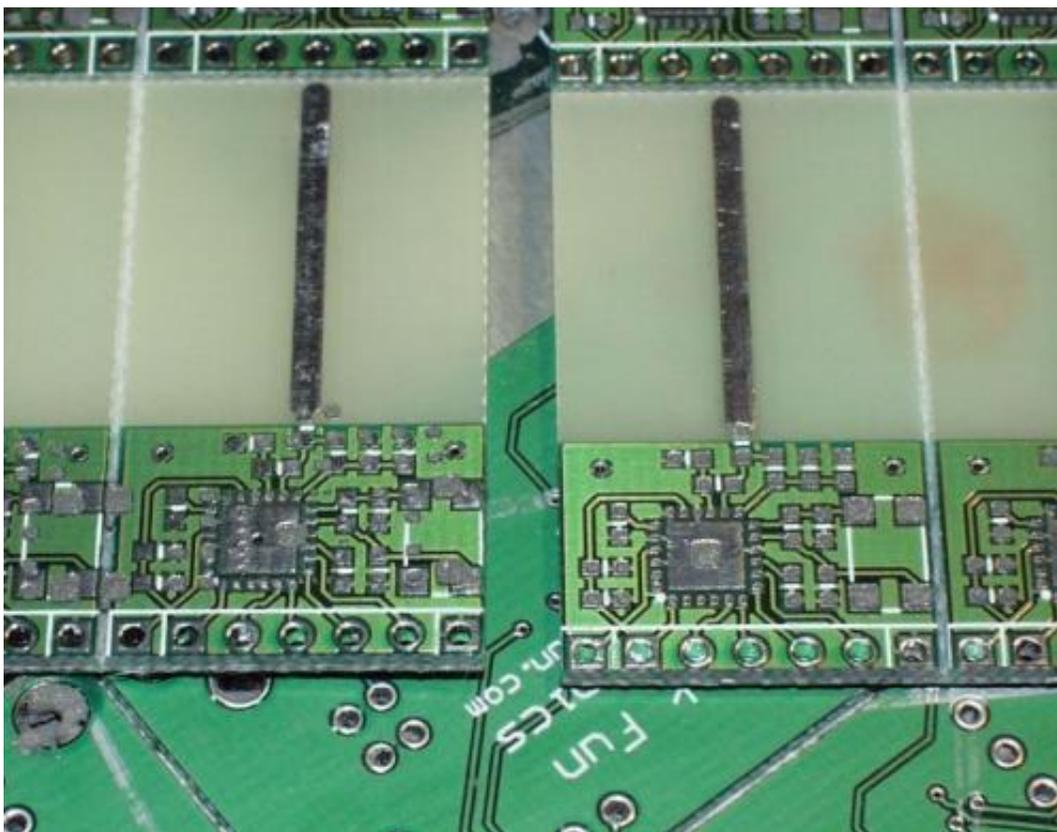
Now, keeping your pinning hand in place, pull the opposite side of the stencil up - lifting the stencil away from your board and towards the pinning hand. In this case it would be the left side of the stencil being lifted towards the right hand. Lift your pinning hand only after the stencil is lifted from the board being worked.



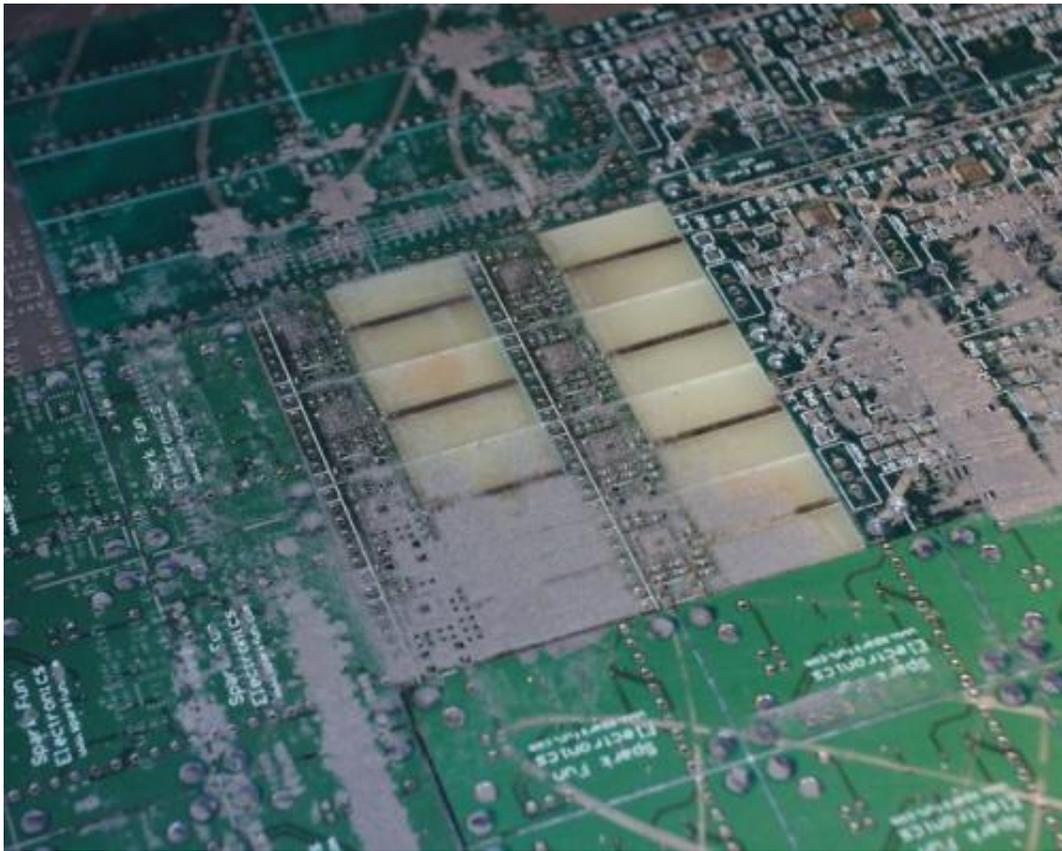
Ohhhh! Ahhh! Ok, so this is a picture of the second board I stenciled. The larger the board, the harder it is to keep opposite corners lined up (true framed stencils will fix that problem). So I screwed the pooch with the first board I stencil. What to do? Take a picture of course!



The first board that I stencil after coffee is on the left. Try #2 is on the right. Obviously the one on the left is so far off, it's not usable. All you have to do is wipe it off with a paper towel. No alcohol or scrubbing needed, just wiper 'er off good and start again by lining up the stencil. It can sit there for probably 45 minutes before the paste starts drying out and turning hard.



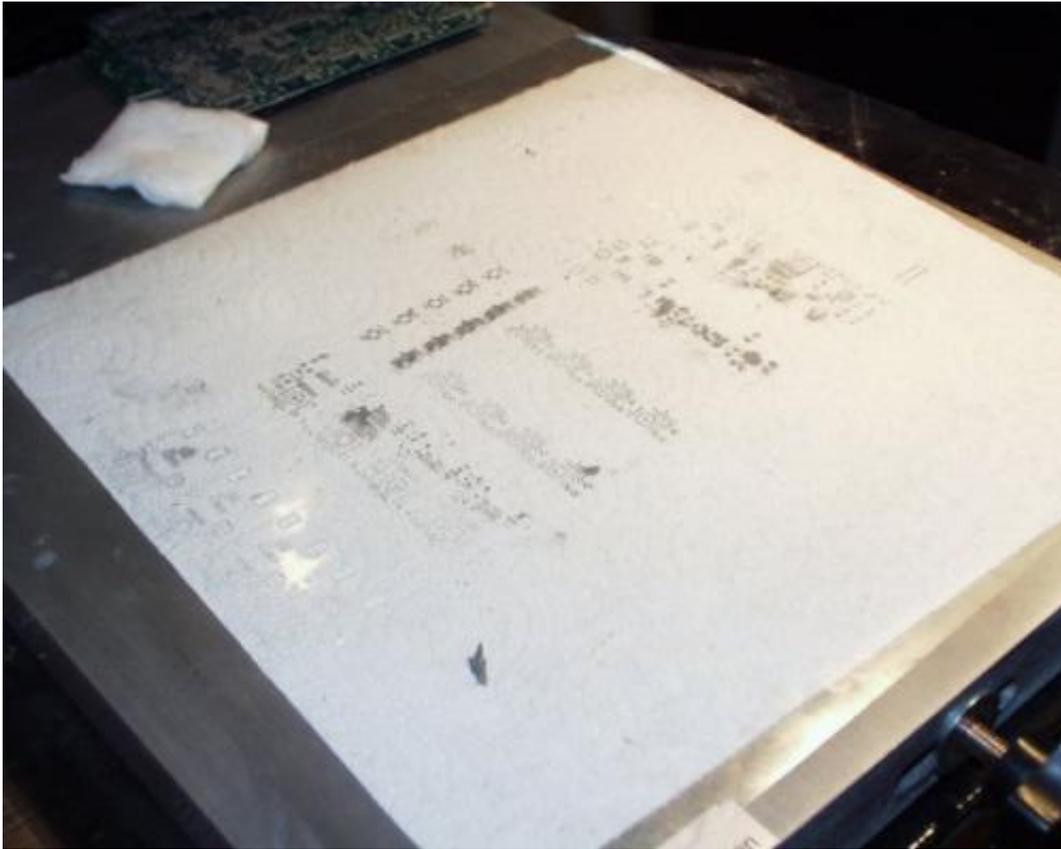
Oh, and the board on the right is probably the best I've ever done. You can be off considerably and still get it to work *very well*. The human eye can actually detect very small difference between the paste and the pad. Don't be too picky your first try - believe me, it will work!



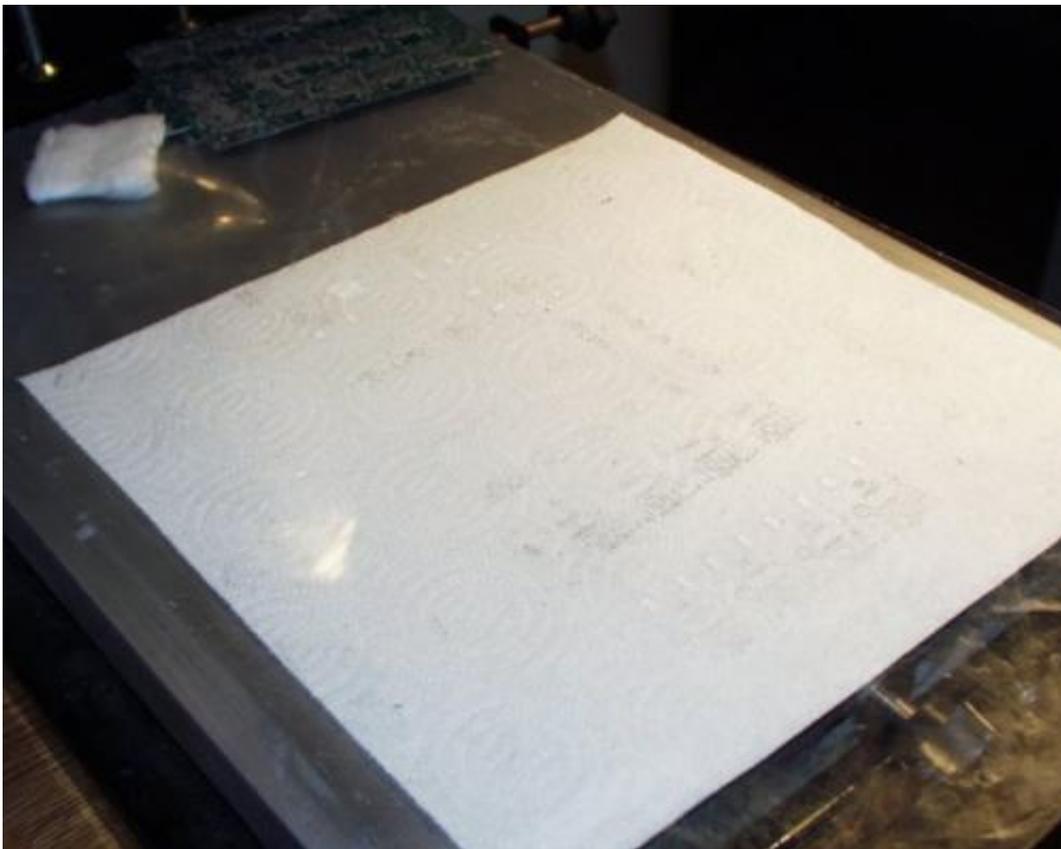
There will be paste left on some parts of the stencil the second time around. You just have to be good at looking through the apertures and lining up the shiny pads. You can stop and clean the stencil, but this is not needed. Practice practice practice!

Cleaning the Stencil -

So you're done playing and it's time to clean up. Rubbing alcohol is your friend.



Place the stencil on a paper towel and wet another paper towel with a little bit of alcohol. Wipe one side clean - it's pretty easy. Some of the excess paste will slide through to the other side. Flip the stencil over and repeat.



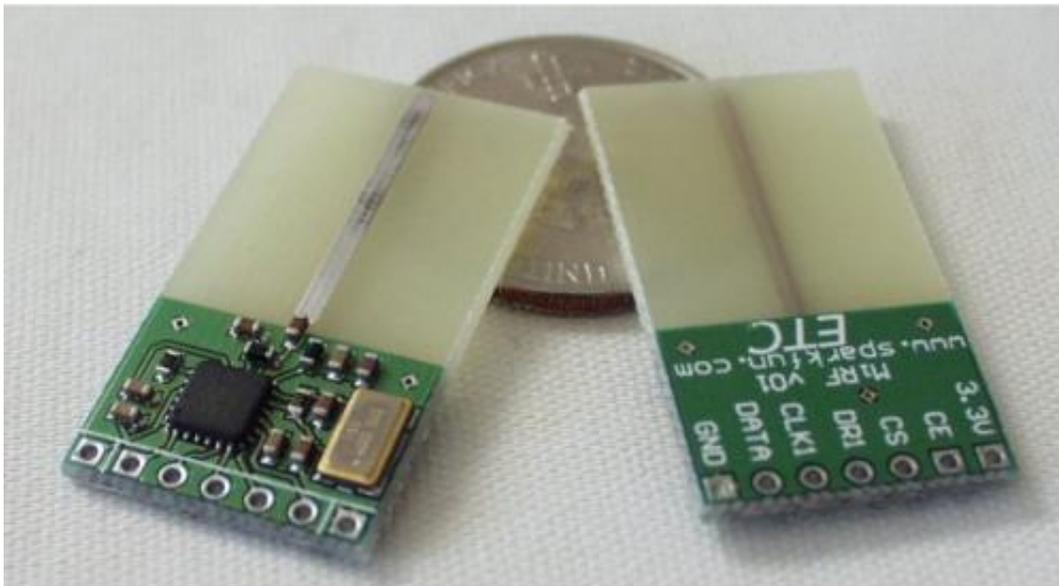
Clean stencil!

We store our stencils flat in a drawer. Don't leave alcohol on them for more than a minute or two or else the plastic Mylar will start to deform (very bad). Be gentle with the stencil and you can use it for >100 applications. We've nearly worn out a stencil but this was probably 100+ applications with nearly as many cleanings. The alcohol will thin the stencil over time.

Placing Components -

Eventually, you will have a PCB with solder paste. Carefully avoid touching the PCB as the solder paste is easily disturbed. Picking it up by the corners is usually the best option.

Unfortunately Jeff populated the MiRFs and cooked them on the Reflow Skillet before I could snap a photo. That's right, we populate the PCBs by hand! *Anyone* can populate even the smallest of parts with only a pair of tweezers.



Placing 0603 components packed tightly around a QFN IC is actually not that bad. It has taken everyone in the office some practice, but all you need are your parts and a print-off indicating where the parts go. Ben can drink a full pot of coffee and plop parts down with amazing speed - just don't take his magical tweezers.