Thin-Film Stretch Techniques

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1 Preparing the Frame

Before we even look at the thin-film, the frame should be setup suitably for the stretching process. It should be cleaned with IPA; there should be a copper "landing strip" placed, and all surfaces should be smooth. This means the inner corners of the frame should be checked for notches or burrs that might tear the film; the copper landing strip should be smoothed down and also checked for sharp points; and the copper tape should be cleaned thoroughly with IPA to remove any residual adhesive on the top surface.

The procedure for applying the copper strip is a 2-person project with the goal of having the a strip of 2-inch wide copper tape on the inner surface of the frame. One edge of the tape is adjacent to the anti-corona steel ring while the other edge is roughly 1mm from the inner corner of the frame. In order to lay the tape down, one person tacks down one and and, starting at that end, tacks down the entire strip of tape (see Figures 1-2). The second person, meanwhile, tensions the far end and controls the aim of the tape (see Figure 3).

Once the tape is laid down, it can be burnished with such instruments as a wooden spoon or wax paper like the copper tape backing material (see Figure 4).

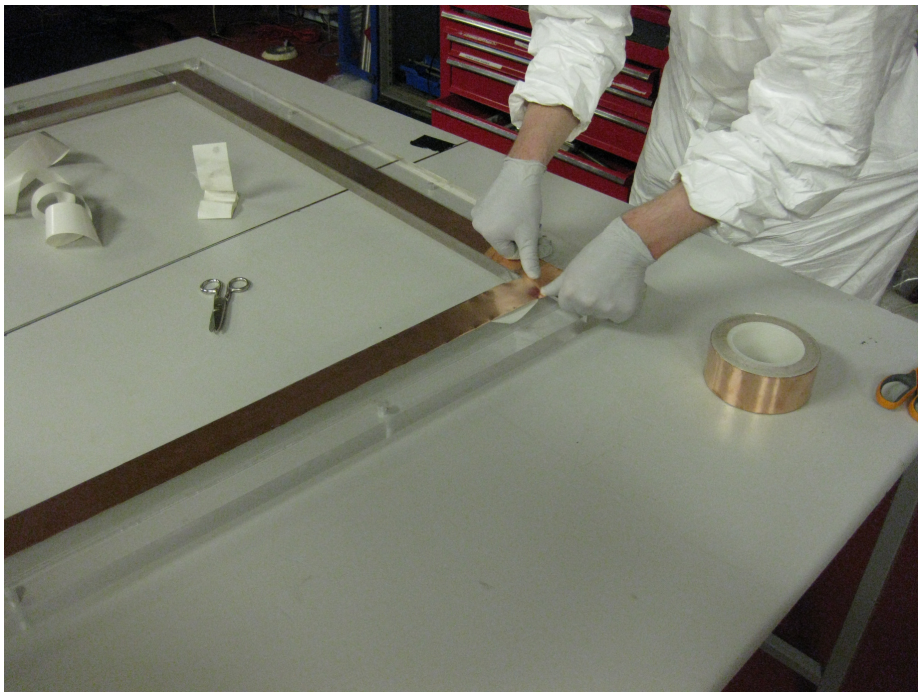

Figure 1: Daniel Walker secures one end of the copper tape in the desired location while Eric Lee tensions the other end (off-camera). The pictured frame is a practice stretch frame and does not have an anti-corona ring to reference against.

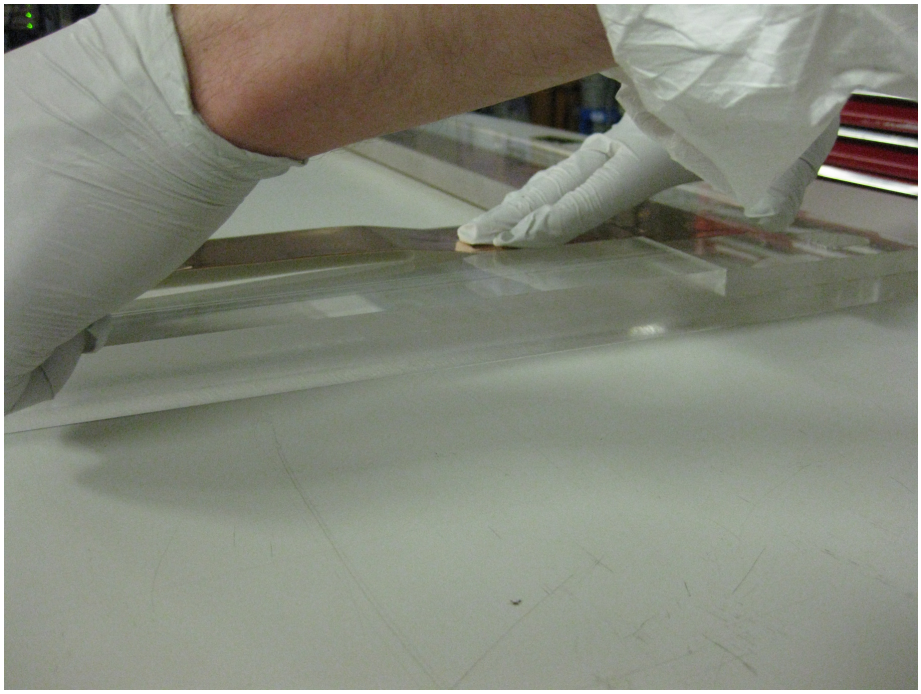

Figure 2: Daniel removes the wax paper backing and tacks down the copper tape.

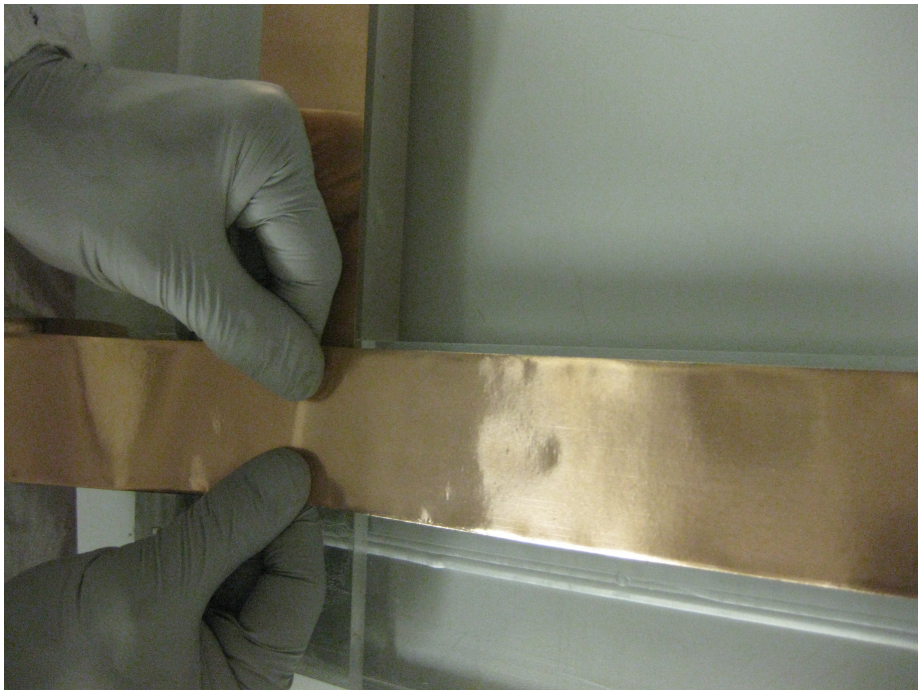

Figure 3: Eric supplies tension by holding the tape roll. He also helps keep the tape line straight by providing fine lateral adjustments.

Figure 4: Daniel smooths down the copper tape with a piece of the wax backing paper.

2 Cutting the Film

The preferred method of cutting the film is with the sharpened paper-cutter; however white-tape method is provided as a backup.

2.1 Paper-Cutter

Before touching the film, it is important to lay out a good work area. The paper-cutter itself (sharpened to remove burrs) is clamped down to the table and every surface that the film may touch is a non-stick surface - in our case, we have laid down manila folders. Finally, a line is drawn parallel with the film to ensure a square cut and a second line is drawn perpendicular to the film to demark the length of one full panel. Figure 5 shows a prepared work area. A supply of manila folders, clean nitrile gloves, and spectra-lined cut resistant gloves should be kept nearby.

When the actual cutting is performed, it is best to sandwich the film between two layers of manala folder. Doing so protects the film and prevents it from folding over between the blades. The first step in this process is to lift the blade and feed the film on a piece of manila under the raised blade. By first pushing it through and then, once clear of the blade, pulling it the rest of the way there is no point in which delicate fingers cross the cutting plane (see Figure 6).

After grasping the film on the far side of the blade, it can be pulled to the appropriate distance (measured earlier; see Figure 7). During this process, someone else must control the film roll to feed out film from the roll (see Figure 8). Once the film is pulled through to the correct length, held taut, and square to the blade, the cutting can commence. A piece of manila below the film is adjusted to extend past the cutting plane (see Figure 9) and another piece is placed above the film, sandwiching it (see Figure 10). The manila sandwich is held on the edges, so as not to damage the film, and the blade is brought down to slice through the film and manila.

After cutting the film in this way, it is sometimes stuck to the manila along the cutting edges. We use a rounded manila strip to separate the two, inserting it between the film and manila and pulling away from the center of the thin-film panel.

Figure 5: Eric Lee and Daniel Walker finish preparing a work area for cutting the thin-film. Here the paper-cutter is secured with wood clamps and the layout surface for the film (including the top of the paper-cutter) is covered with manila folder. Eric and Dan are performing the final measurement to mark the length of one full panel from the cutting line. The blade of the paper cutter is kept closed and secured whenever possible.

Figure 6: Daniel Walker has pushed the thin-film on its manila base past the cutting plane of the paper-cutter, allowing Eric Lee to grab ahold of it and pull without passing his hands through the cutting plane.

Figure 7: Eric pulls the thin film until it is aligned with the proper-length measurement drawn earlier. He also ensures the film is perpendicular to the cutting edge of the paper-cutter.

Figure 8: While Eric pulls on the far end of the film, Daniel feeds the film off of the roll and applies tension from his end. Shown above is a folded package of practice 2μm thin-film rather than the proper roll one would see from the final-product material.

Figure 9: A piece of manila is present below the thin-film and extending past the edge of the paper-cutting, protecting the film from that edge and helping sandwich the film.

Figure 10: When the film has been rolled out to the appropriate length, a second piece of manila is placed above the film, completing the manila sandwich. Here the sandwich is secured for cutting by pressing down on the edges so as not to damage the film.

2.2 White-Tape

If no paper-cutter is available, a good cut can instead be performed with the use of the artist's low-tack tape. This technique is not preferred due to the poor quality of the cut and the residue left by the tape. The low-tack tape is used because of the ease with which it can be removed from the film; however it is still best to always pull away from the center of the film when possible. Not only does this cause potential rips to propagate toward the edge rather than toward the center of the film, but one also tends to create fewer tears.

When using the low-tack tape as a backing to cut the tape, one places two strips of tape across the film. Each strip has removal tabs on both ends. The first strip spans from near the middle of the film to a few inches off on one side; the second strip begins overlapping the first and ends a few inches off the other side. This layout is chosen so that each strip of tape can be removed by pulling away from the center - this would be impossible with a single long piece of tape.

Once the tape is laid out, one can cut through the tape and film with any pair of sharp scissors, using the tape as convenient handholds and tack-down points as necessary. After the cutting is performed, the tape is removed from the new panel with the utmost care. The tape may be left on the side still attached to the roll to secure the end; however this entire edge should be removed if the tape is left on for more than a few hours.

3 Stretching the Film

3.1 Laying of the Tape

The laying of the tape requires some technique and finesse to not embed wrinkles in the film, which are generally permanent. The easiest way to do this is to first hold the film taut and smooth in the area where you would like to apply the tape. Then place the tape, back (removal-tab side) first, placing it on the copper tape; it tends to naturally curl up, thus avoiding the thin-film. Then gently roll your finger over the tape, back to front, pressing it down onto the taut and smooth film. This allows you to reliably place pieces of tape down without wrinkling the film beneath them. Figures 11-14 illustrate this process.

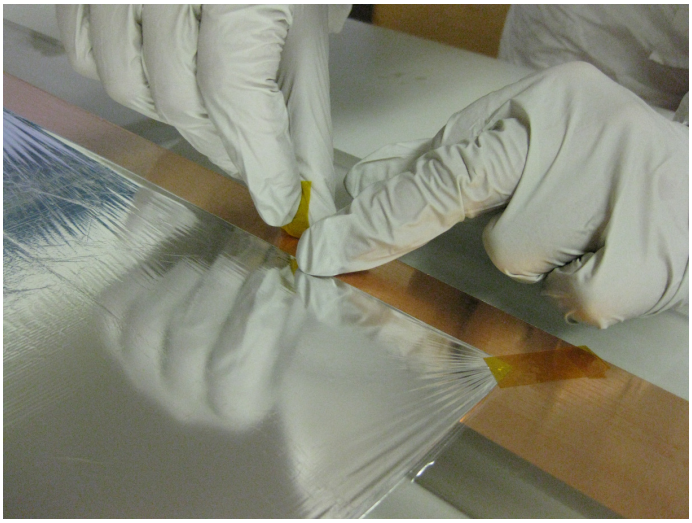

Figure 11: With the film held taut, the rear end of the kapton tape is laid down onto the copper landing strip.

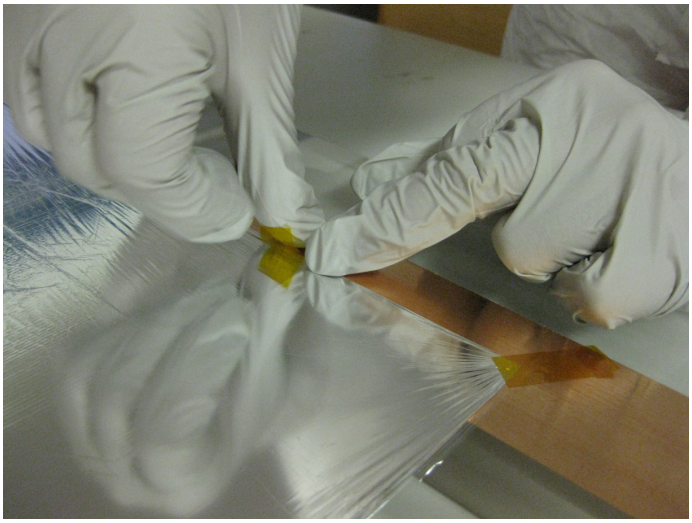

Figure 12: Still holding the film taut, Daniel rolls the tape forward onto the film.

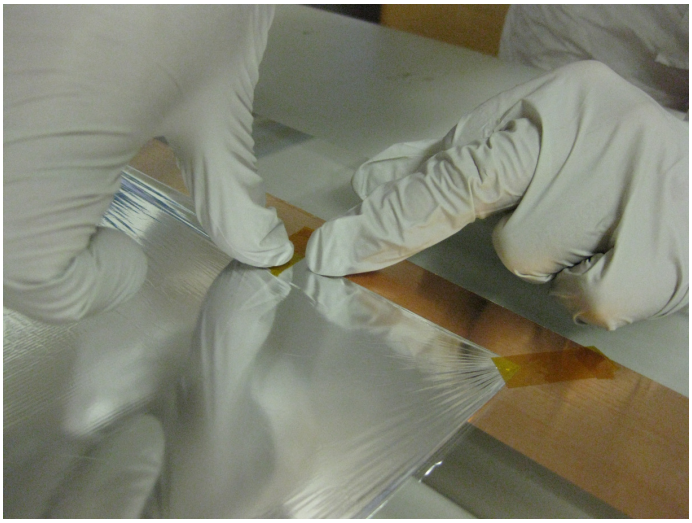

Figure 13: Daniel finishes the application of a piece of kapton tape by pressing down firmly on it.

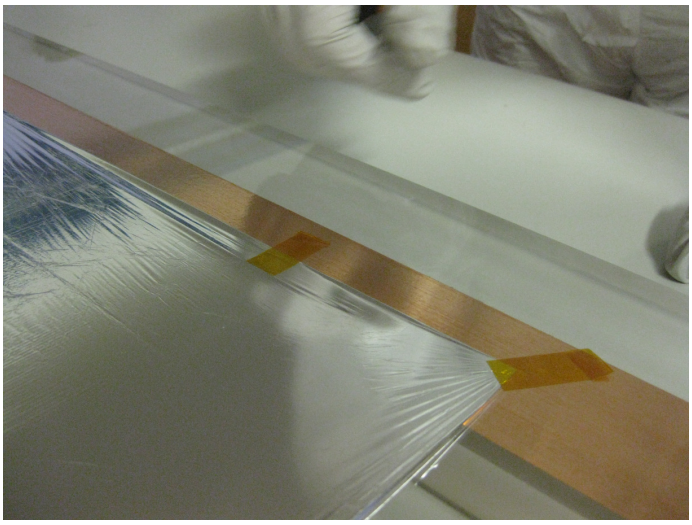

Figure 14: This piece of kapton tape covers only smooth film.

3.2 The Actual Stretch

The minimal preparation work we perform for the actual stretch is limited to the cutting of tape. We cut pieces 0.5in kapton tape in short (1-2cm) lengths and keep these near as ripstops; if a tear develops, we quickly place one of these pieces over the tear to prevent it from propagating further. We also make many (about 10) strips of 3-6cm of which one end is folded over about 1cm to create an easy removal tab.

Stretching a panel begins by aligning the panel. The first panel is aligned so that the edge overlaps the copper tape by 1-2 cm (see Figure 15); later panels are aligned so that the corners are as close as possible to the neighboring strip without overlapping[1]. The aligned corners are taped down in place, using the kapton tape with release tabs such that the location can be adjusted later. The other two corners are taped down loosely to keep the film from flapping around (see Figure 16).

The second, and later, kapton strips are coordinated between people at either end of the film. These strips are placed about 5cm apart. Both people stretch the film with fingers until a good tautness is obtained, then apply tape to secure that stretch (see Figure 17). This process continues for each pair of kapton tape strips, moving away from the aligned side and ending with stretching the far corner appropriately.

[1]The importance of not overlapping is unknown.

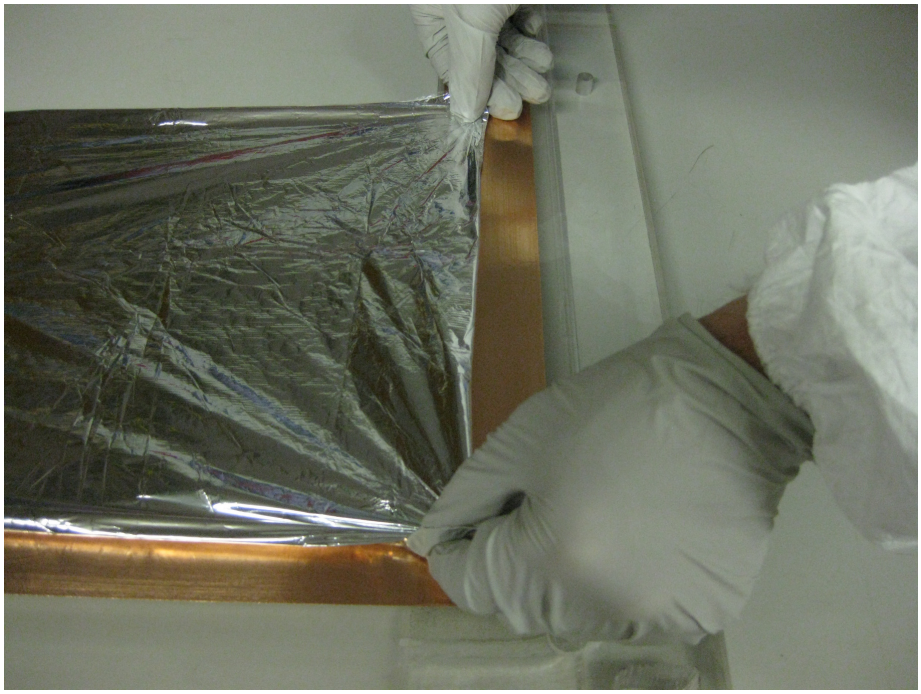

Figure 15: The fresh thin-film panel is aligned to be parallel with its neighbor; in this case, the neighbor is the copper landing strip, which the thin-film panel overlaps.

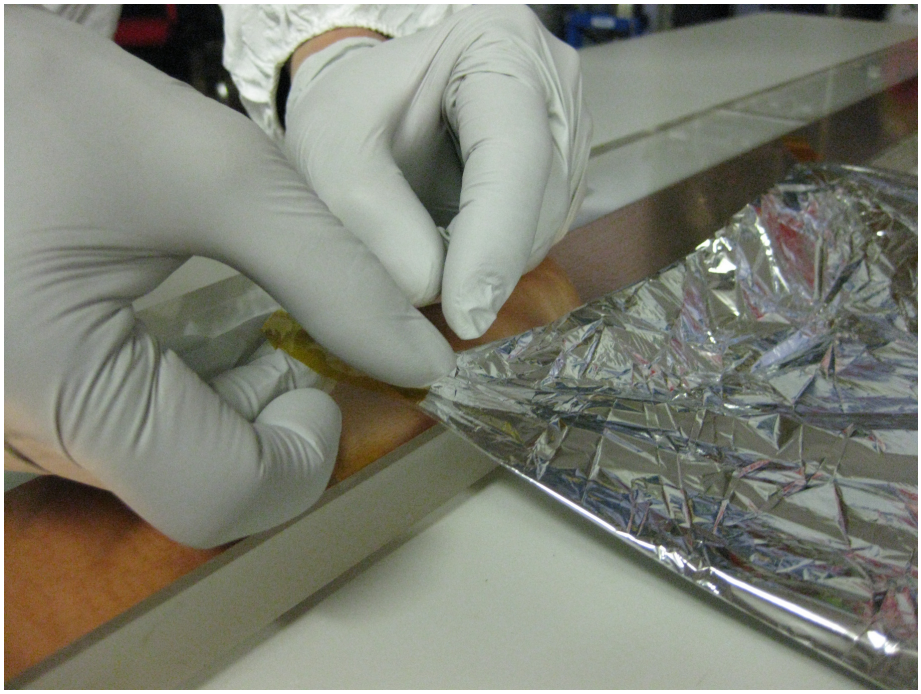

Figure 16: The aligned corner is taped down in the appropriate place; the far corner is taped down loosely to allow for intermediate adjustments.

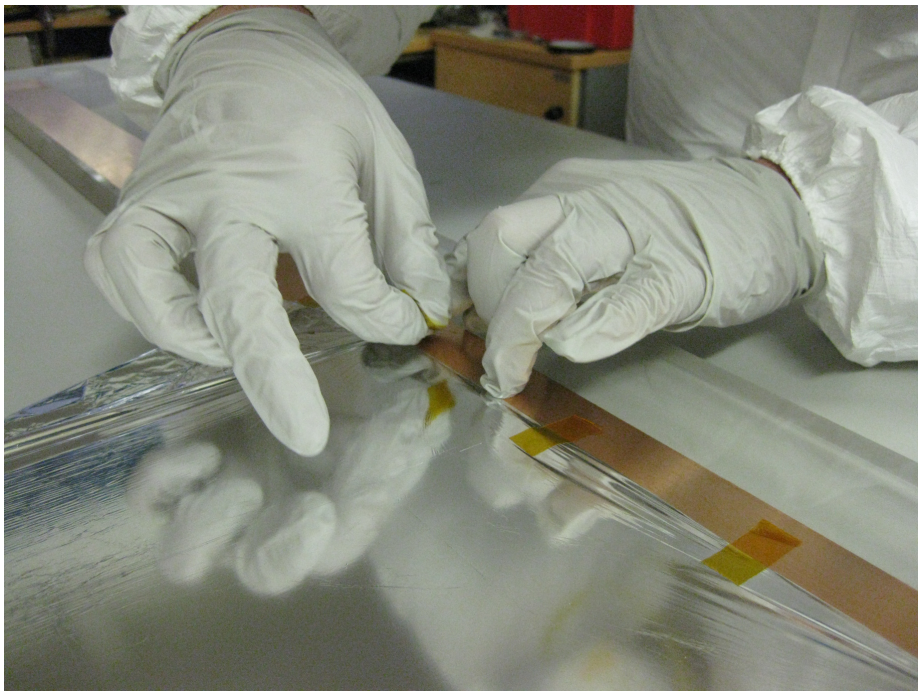

Figure 17: The two stretchers work together to lay down piece of kapton tape (with release tabs), starting from the aligned edge and moving toward the free edge.

3.3 Rolling the Fourth Panel

The gap that the thin-film cathode must span is 39-43 inches, and the mylar rolls we can acquire are 12 inches wide. This means we must use 3.25-3.6 film widths - one panel must be narrower than the full width. Due to the difficulty in performing good cuts with the film, we deal with this complication by folding the excess of the fourth panel over onto itself and tape down the folded section within the frame.

The fourth panel begins normally by aligning one edge with the neighboring panel. On this panel, the "far corner" is not on the corner by placed 1-2 cm from the inner edge of the anti-corona ring. A third piece of kapton tape may be necessary between these two corners. The panel is stretched as normal .

Once the fiducial part of the film panel is stretched, the excess must be folded. This is most easily done by folding it in half three or four times. The excess is folded in half by the two persons, one on each side, coordinating to fold the loose edge down to the outermost (closest to the anti-corona ring) edge of the last piece of kapton tape. Once the entirety of the excess is folded enough to fit within the edge of the frame, the corners are secured. Finally, three to five pieces of longer kapton are placed along the long edge of the film, spanning from the copper tape, across the folded portion, and onto the main part of the panel (it is useful to press the air out of the rolled portion of the film to lay these pieces down). Figure 18 for a completed fourth panel.

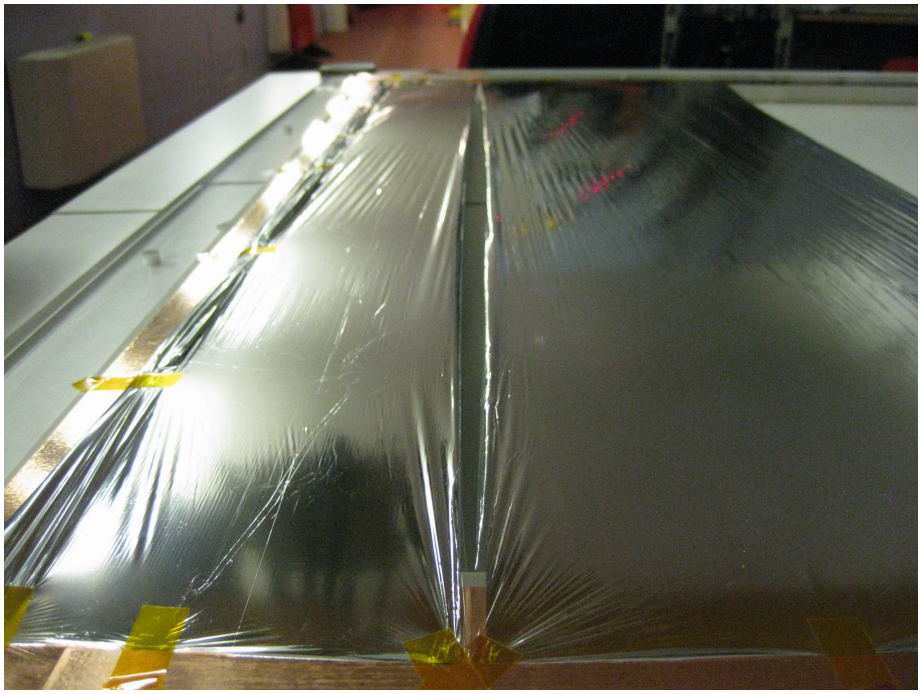

Figure 18: The excess portion of the fourth (leftmost) panel is rolled up and secured with a few longer pieces of kapton tape, which have release tabs.

3.4 Inter-Panel Connection Tabs

See the specific Connection Tab memo for these.

After applying the inter-panel tabs, the entire stretch can be improved. Lay the frame back onto a table and adjust any of the kapton stretch points (with release tabs) to remove wrinkles from the thin-film. This is especially important with the lateral points as they were unable to tension across the frame prior to the application of the inter-panel tabs.

3.5 Copper Connectivity Tabs

It is assumed to be important to directly contact both the front and the back surface of the thin-film to the copper landing strip in order to assure proper conductivity. This is done by applying at least one copper conductivity tab to each panel of the thin-film. This process uses four small pieces of paper and tape (see Figure 19): Two rounded lifting shims; one folded copper tab; one piece of copper tape to connect the tab to the landing strip; and one piece of 1" wide kapton to cover the tab.

The steps to apply a copper connectivity tab are as follows:

1. Use the paper shim to lift up the thin-film (Figure 20).
2. Lay the folded copper tab onto the landing strip, and slide it forward until it overlaps the film by about 1cm (Figure 21).
3. Remove the paper shims, allowing the film to fall onto the lower jaw of the copper tab (Figure 22).
4. Press the copper connectivity tab down firmly onto the film (Figure 23).
5. Connect the tab to the landing strip with a piece of copper tape (Figure 24).
6. Cover the entire tab with 1" kapton tape to prevent possible tears (Figure 25).

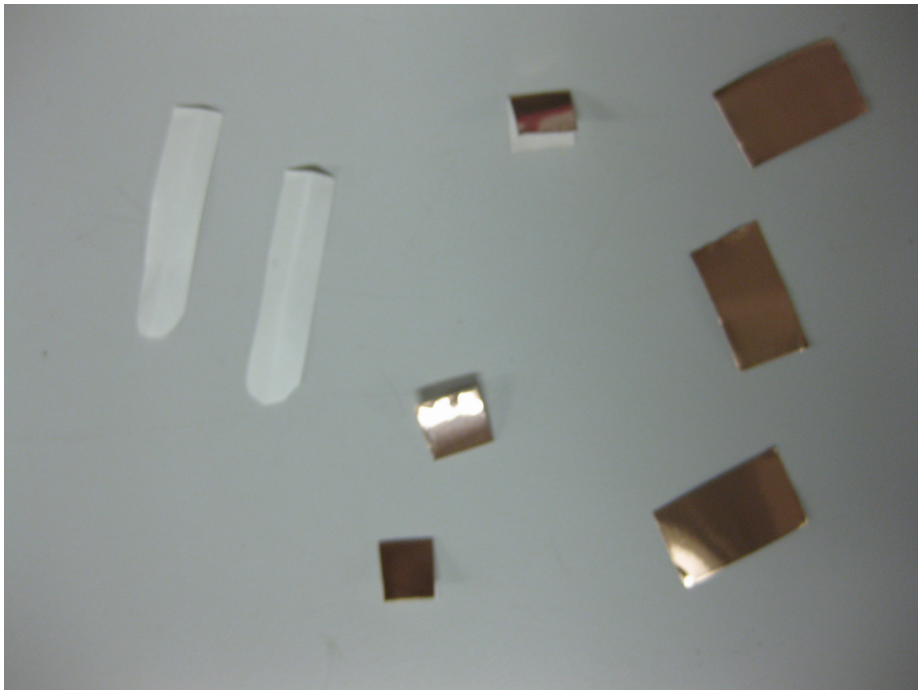

Figure 19: There are four items necessary to create the copper connection tabs. Two paper shims (left); the copper connection tab itself, which is a piece of copper partly folded onto itself (middle); a rectangle of copper to connect the tab to the landing strip (right); and some 1" wide kapton tape (not shown).

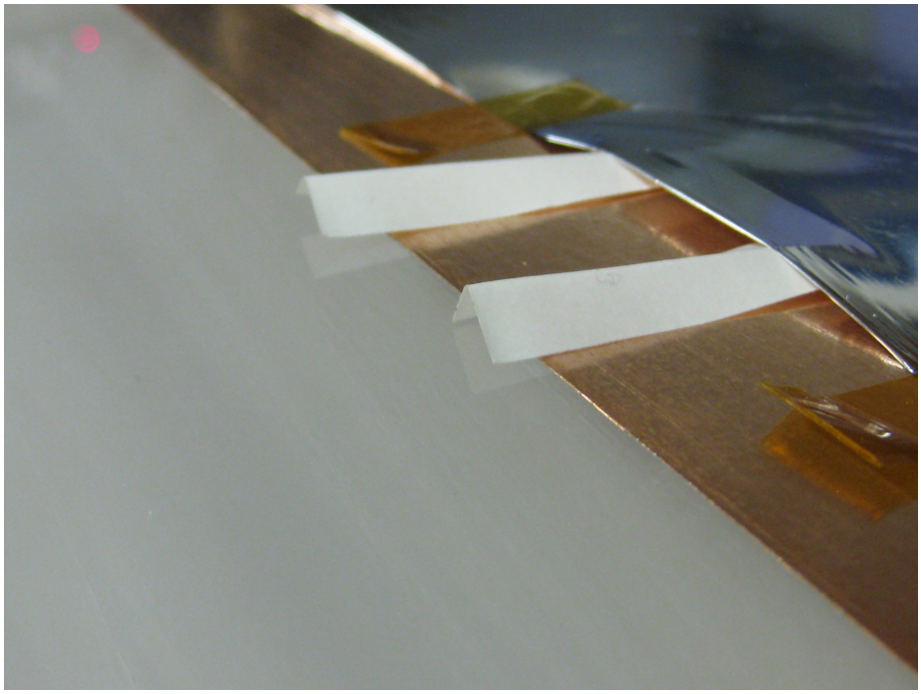

Figure 20: Two paper shims lift up the thin-film.

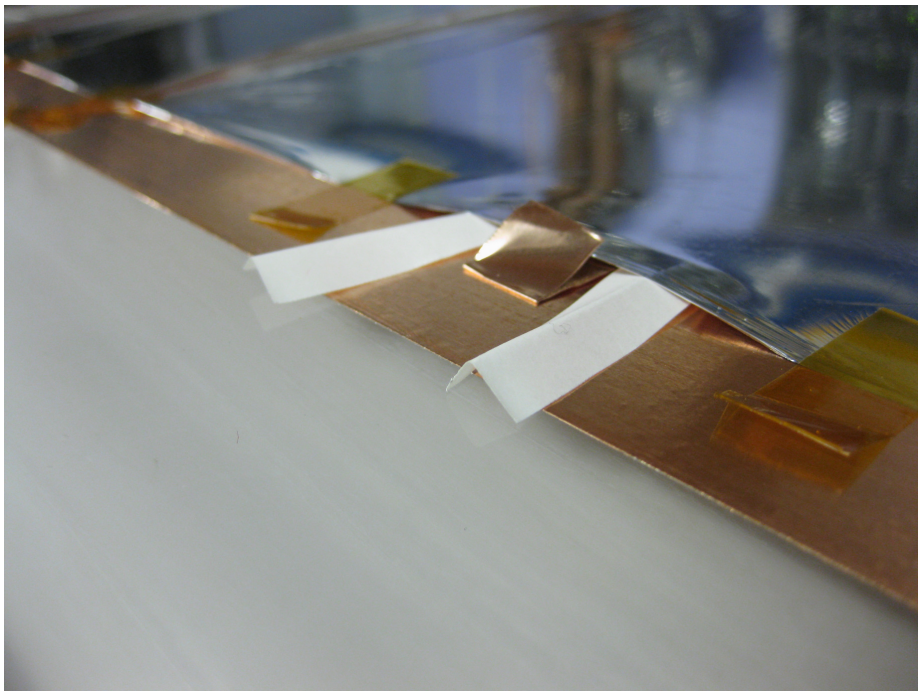

Figure 21: The folded copper piece is the actual connection tab; it is folded over so that its conductive adhesive makes contact with both the top and bottom surfaces of the thin-film. After it is shaped, it is placed onto the copper landing strip and gently eased forward until the film sits 1-2cm inside its jaws.

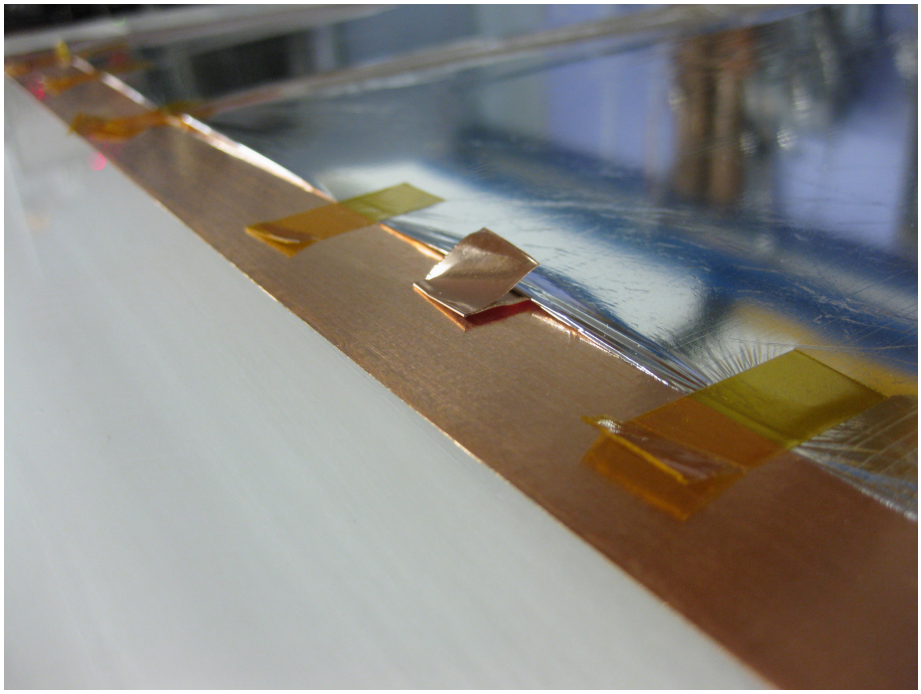

Figure 22: Once the copper tab is in place, the paper shims are removed.

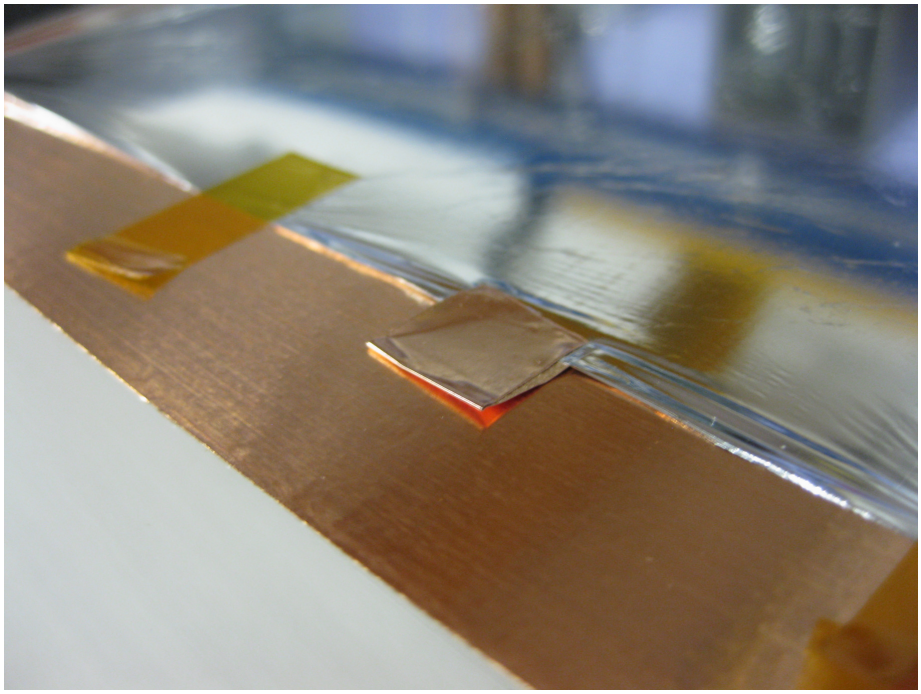

Figure 23: The copper tab can now be pressed firmly, securing it to the thin-film.

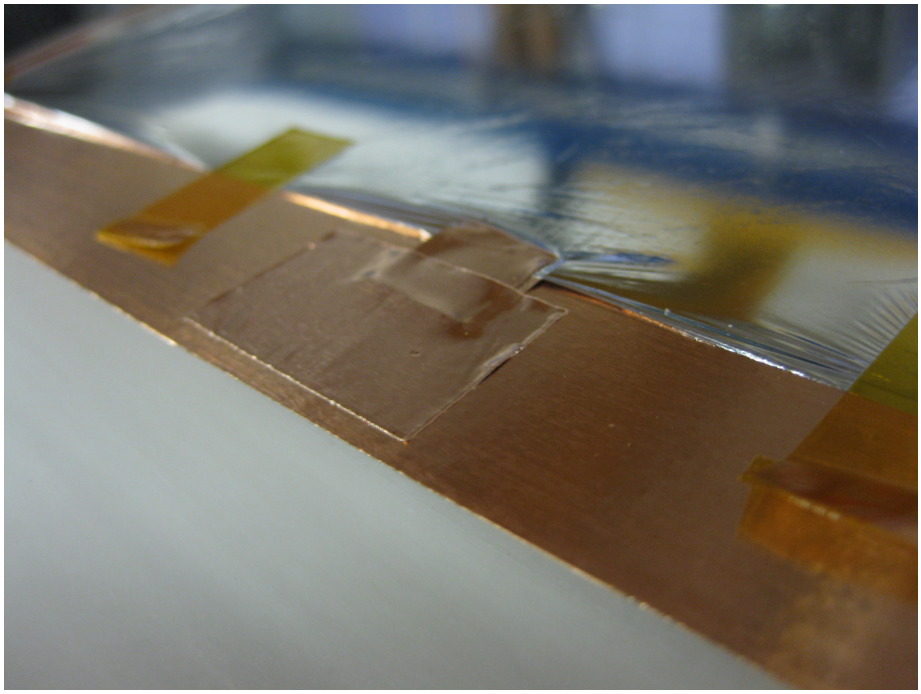

Figure 24: A new rectangle of copper tape is laid down over the back edge of the copper connection tab. This piece does not overlap the thin-film.

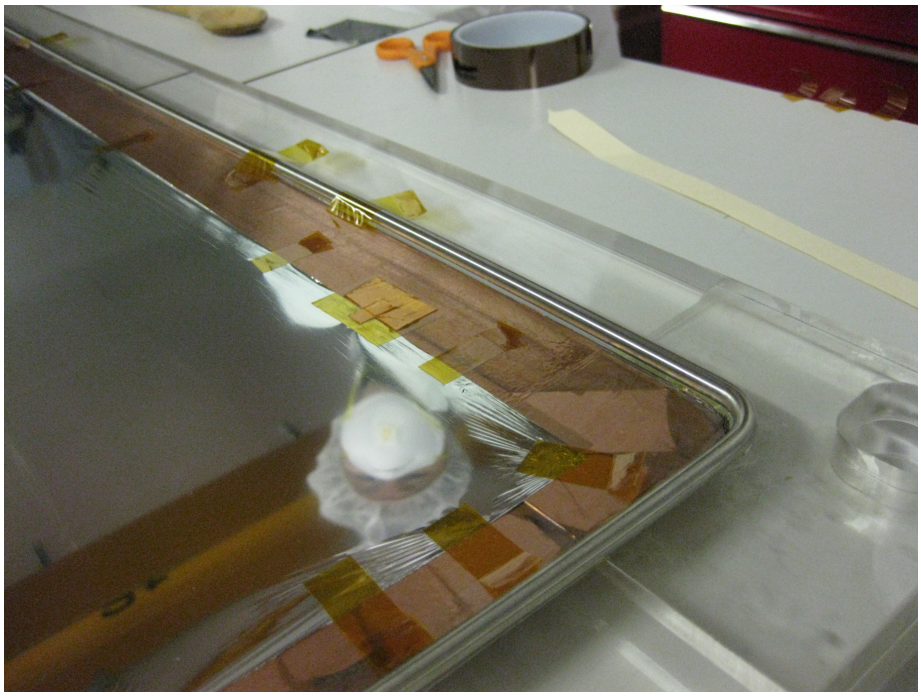

Figure 25: Finally, a piece of 1" wide kapton tape is placed over the the entire area where the thin-film contacts the copper adhesive. The copper connection tab is now complete.

3.6 Finishing the Cathode

The final step of the cathode thin-film stretch is to cover the three exposed and taped edges. This is done by placing long strips of the 1" wide kapton tape onto the edge of the thin-film. It is useful to begin and end each of these strips on one of the previously-laid 0.5" pieces used to stretch the film; these pieces with release tabs can then be used to remove the wider strips if necessary. Figure 26 shows a close-up of the edge of a finished cathode.

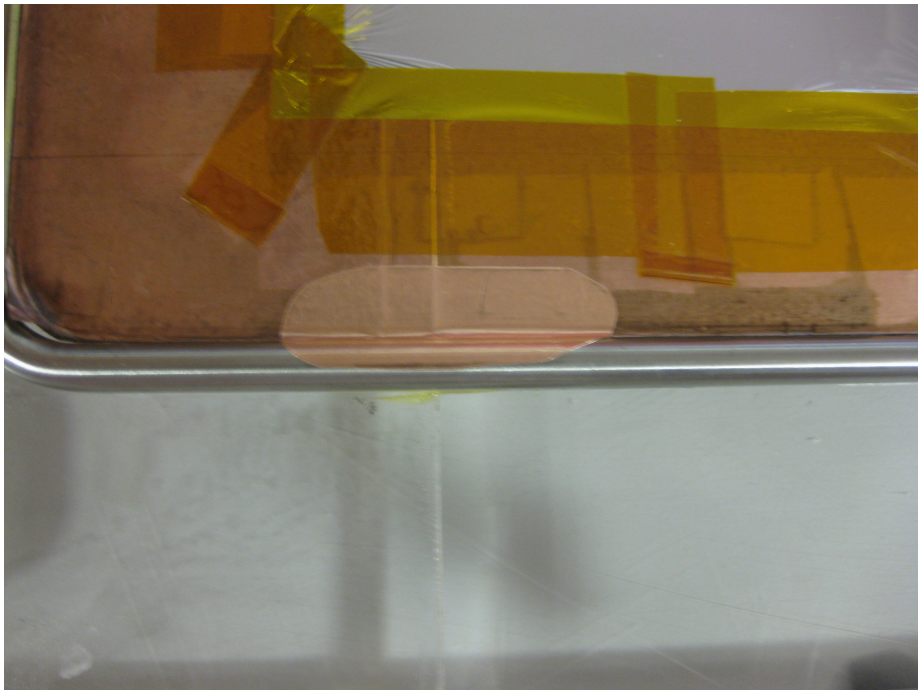

Figure 26: A piece of 1" wide kapton tape is laid down over the exposed edge of the thin-film. This piece begins and ends on the kapton tape strips left over from the stretching process; the strips with release tabs can then be used to lift the wider strips if necessary.

4 Removing Thin-Film

When removing the thin-film for storage, it is important not to take pieces of kapton tape with the film; these will inevitably catch onto the middle of the film and permanently adhere, reducing the once-beautiful panel to a tangled mess. Cutting through the film directly can also be difficult; due to the tensions applied during the stretch process, a tear going into the middle of the film often develops.

The easiest way to remove an old panel and save it, then, is to place a new piece of 1" wide kapton tape nearly all the way across the film panel (leaving the very edges un-taped so as not to extend the tape past the edge). This tape should be centered on the edge of the frame for ease of cutting. One may then safely cut through this new strip of tape on each edge and remove a panel of thin-film free of tears or exposed adhesive (see Figure 27).

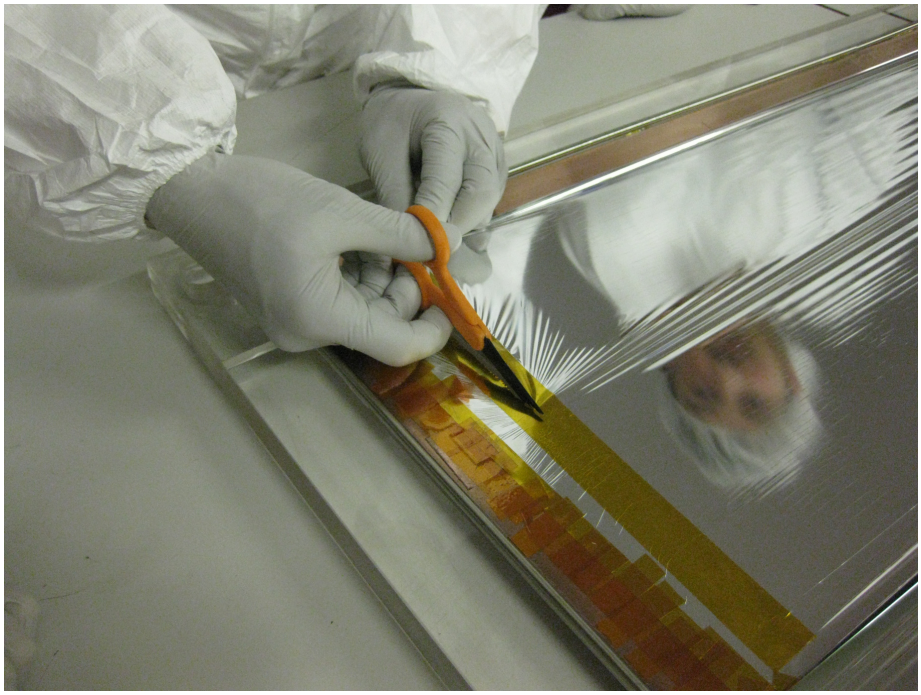

Figure 27: A wide piece of kapton tape is placed across the thin-film panel, coming just short of spanning the entire width. This tape can then be safely cut through to remove any thin-film panel which must be saved.