macdan

TiBook display take-apart, re-assembly and various other related infos

Apple glued the darn thing together, which makes it a tad difficult to replace broken LCDs and hinges. My main additions to the existing literature are my technique for separating the LCD from its bezel, as well as identifying the glues and techniques Apple used to stick it all together in the first place.

As of April 2007 I've also added some info on hinge replacement, differences between various LVDS cables, sleep magnet locations and more. The page is still not as complete as I'd like, but it is looking a little better.

Hope this info is useful, if you have any comments, questions or just wish to chat you can email me at:

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theory and explanation

I figured a way to cleanly peel the bezels off a TiBook display and figured I'd share my technique. If you've ever done this you'll know how difficult it can be to remove the

bezel parts from the LCD without bending the heck out of the metal, especially the front bezel. I did a couple using the pull and peel method and the results weren't pretty.

On a broken-LCD-acquisition I used a piece of thin stiff plastic which I slid around the edges. It popped off the bezels cleanly with virtually no damage.

While it may be possible to open a bezel just part way, I think it's best to completely remove the bezels. Opening just one corner or side bends parts which of course results in . . . well, bent parts. :-\ By loosening the adhesive one can pop the entire thing loose without the need to pry or bend.

That's where the plastic strip technique comes in handy.

The plastic I used came from some sort of blister-packed product. The plastic was marked PETE, which must be some flavor of polyethelyne-whatever. In any case, it's very dense and stiff, but thin enough to be pretty flexible.

I cut up the plastic into a strip maybe 2" wide x several inches long. This is your **Thin Strip o'Plastic Tool** or **TSPT**. It's stiff enough to be slid along under the bezel but not so thick it bends up the metal.

I've since taken apart several more displays using the same method with excellent results.

the takeapart

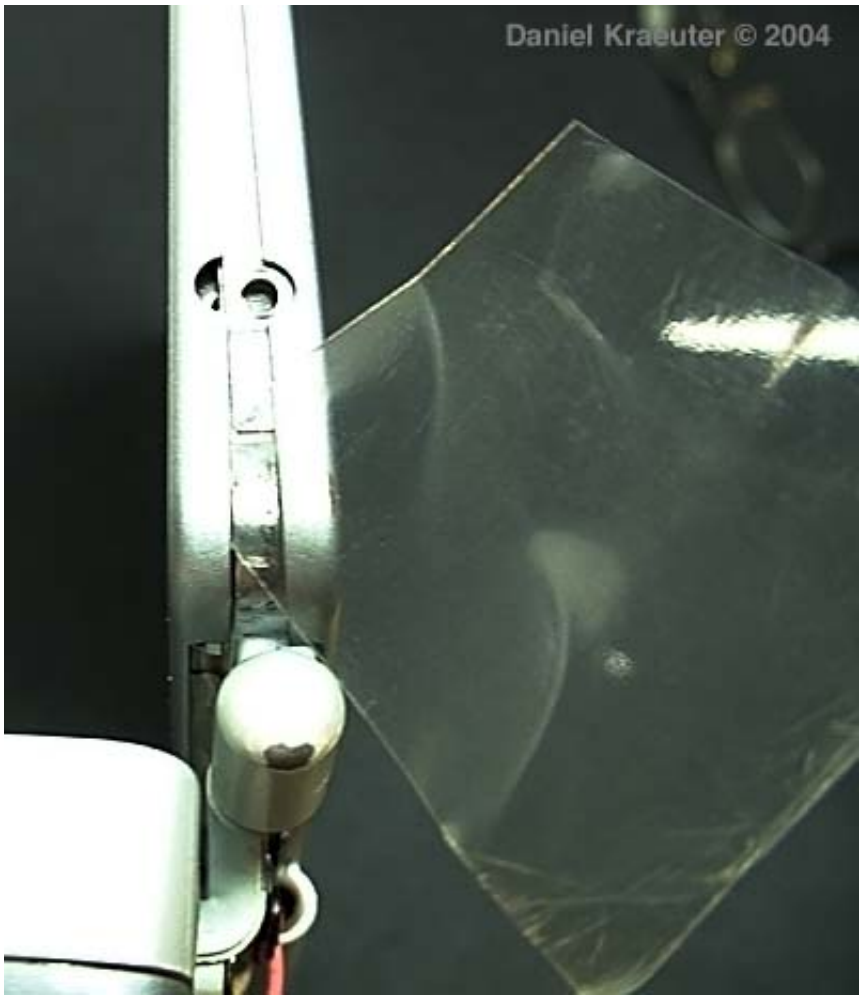
Getting the strip started into the display edge was the toughest part. Once I could get the strip there everything went pretty smoothly. It's good to have extra plastic as well as some scissors handy with which to trim as the corners of the plastic strip get buggered up pretty quick.

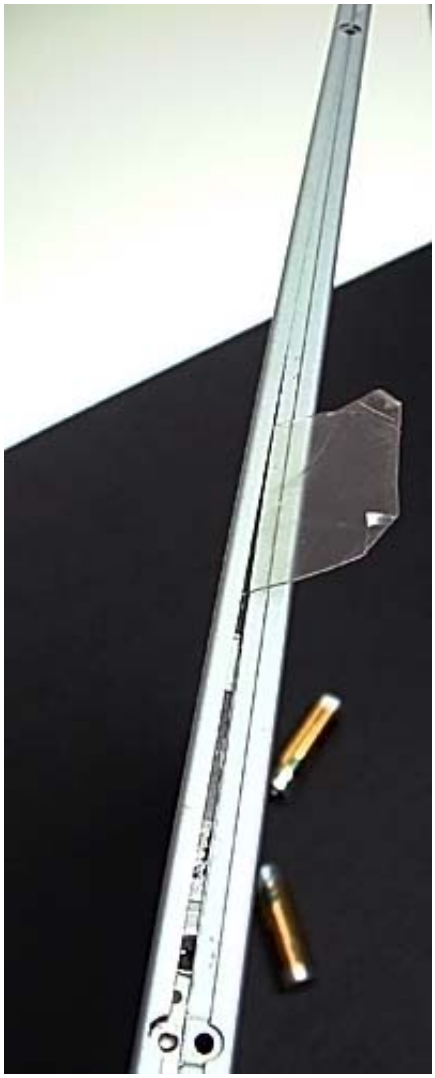
I had to do some prying to spread the corner by the hinge which allowed me to slip the strip in. Here's pics sliding the strip along under the bezel.

I find that if I get stuck on one section I can usually get another part going until I have gotten most all of it unstuck. At that point, the whole thing seems to just kind of pop apart in my hands.

The key for me has been to not force anything. If I find I cannot get any further in one place, I move on until I find a place I can do something. It really takes a bit of patience and persistance to get that fragile bezel face off without buggering it up badly. I buggered up a couple before I got the hang of it. :-)

Just a note here to report a warning from one reader . . . the LCD has a metal frame around it just under the external bezel. It is possible to accidentally get your plastic strip tool under that and damage the LCD itself. Just be aware that you want to remove only the outer painted bezel, not the underlying LCD frame.





About the display and its construction

The working strength of the display comes from its gluedup construction. It's assembled with some very strong tough adhesives which turn the individual parts into a very strong assembly, a monocoque. If any of the parts of the glued up system are missing the structural integrity of the whole is compromised.

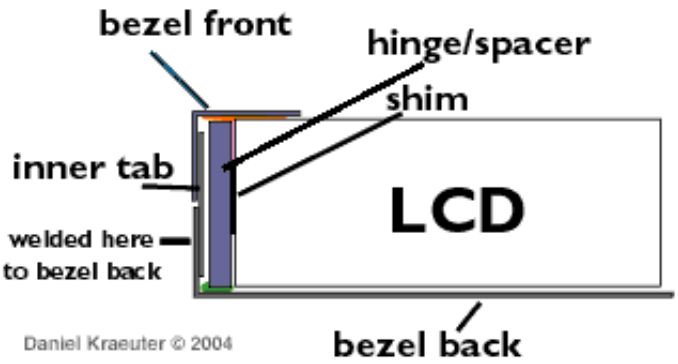
The bezel back is a formed shallow titanium pan, painted on the outside. There are titanium tabs or flanges welded to the side and top edges. The welds holding the tabs to the back are fragile, so be careful not to damage them opening the display. The LCD is screwed to the bezel back through holes in the tabs.

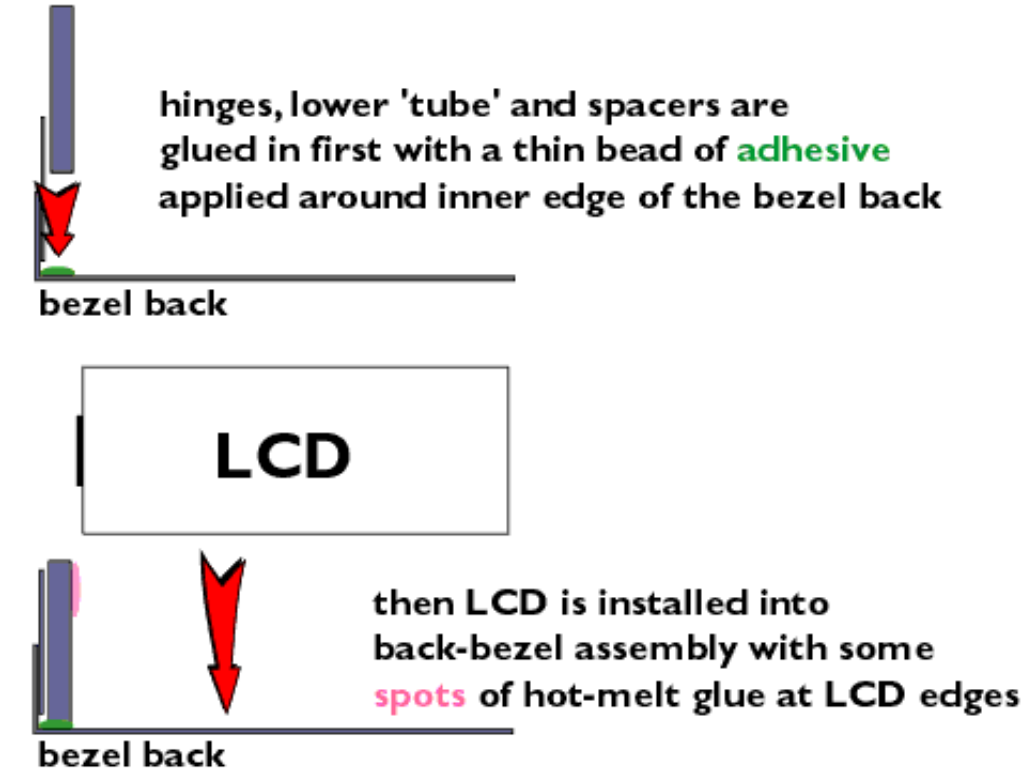
The bezel face is made of aluminum (I believe), painted to match. It's very thin and easily bent, and once distorted very difficult to straighten back to its original appearance. It is attached to the display assembly entirely with adhesive.

The hinges are of a cast pot metal and somewhat brittle. Their longterm strength comes from being fastened into the bezel back with a structural adhesive.

There are thin shims near each side screw which fill a slight gap. If missing the tightened side screws can easily crush the hinge sides, the spacers and/or the back bezel inner tabs.

Here's a crossection of the assembled display.





Glue

There are three types of glue used in the display.

- a thin bead of dark gray very dense and tough epoxy-like stuff (actually a 2-part acrylic adhesive) goes around the entire inside ot the back bezel. It holds the hinges, the center 'tube' and the spacers in the upper sides and top. (Green in the image above.)
- a clear, rubbery glue, almost

certainly hot-melt, is used to (temporarily, most likely) locate the LCD into the bezel back assembly (Pink above)
- a thin layer of a brownish, very hard, but somewhat brittle glue fastens the bezel front to the LCD edges and spacers and hinges. (Orange above)

Here's some additional info, gleaned from Apple's patent application. The adhesive discussed below used to assemble the main body does appear to be the same as that used to attach the hinges and spacers, as described above.

I've wondered what sort of adhesive Apple used in the TiBooks. I stumbled across some relevant info in one of Apple's patents, "patent number 6,574,096 - Use of titanium in a notebook computer". (Here's a search that calls up all of Apple's patents, an interesting adventure in its own right.)

Patent number 6,574,096 has lots of details on the TiBook's design and construction, plus it has interesting 'discussions' about Ti glue - go down about 2/3 of this page (or just repeatedly search the page for 'glue'.)

From the above page:

- "Virtually any type of glue suitable for bonding injection molded materials to titanium or titanium alloys may be used. An exemplary glue suitable for use in various embodiments of the present invention is Lord's glue 201/19 manufactured by the Lord Corporation of Cary, N.C."

Here's on Lord Corporation's web site is their "Engineered Adhesives" page. I had a heck of a time finding just what sort of glue is '201/19', but eventually found infos in this doc.

ACRYLIC ADHESIVES - LORD 201/19

- Applications - Bare metals, plastics and composites
- Working Time - 5-8 minutes
- Handling Time - Fast, 12-16 minutes
- Full Strength - 2 hours, heat cure typically not recommended
- Easy to dispense, Self-leveling
- Comments - Minimal surface preparation, fast cure, good environmental resistance.

Now I just need to follow up and find a source from whom I can actually purchase some of this stuff . . .

Permatex makes something which appears to be a similar product called PermaPoxy 5 minute Plastic Weld. Recently I bought a tube in a local auto parts store. It does stick very nicely to metals and plastics, but it's best used in a well ventilated area as the fumes are ferocious!

Putting it back together

- **replacing hinges**

The hinges, surrounding spacer and central lower 'tube' are glued into place using 2-part acrylic adhesive. You'll want to pry out the remains of the old hinge(s) as well as old glue along the area where the replacement hinge is going to lie. Use a solvent of some sort (like alcohol or paint thinner) to make sure the area is free from oils and dirt before glue-up.

Keep in mind the hinges are 'handed', not interchangable between sides, so make sure you've got the proper side in hand before mixing and applying adhesive.

Run a bead of adhesive along the edge of the hinge and press the hinge into place inside the bezel back. Use clamps to hold the hinge in place while the adhesive cures,

spring-loaded clothespins work well.

Before proceding any further, ensure the center tube is solidly glued, if not use some more of the same acrylic adhesive to stick it back in place, clamp and let cure.

I'd let the glue cure overnight at least, just to be sure it's holding well. IN fact, I'd do a bit of tugging and prying at the well-cured glued parts just to be sure they are solidly attached. If you can easily pull up your newly attached hinge, you'd better try again before finishing up the job, eh?

- **Replacing the LCD**

If you don't need disturb the hinges or other bits surrounding the LCD inside its bezel, it's a pretty straight forward job. The LCD isn't really glued to the bezel back at all, just a couple of dabs of hotmelt and the four screws on the sides.

Once the LCD is installed into the bezel rear, some (masking) tape around on the very edge of the LCD screen face will keep squeeze-out off the screen. In fact, it's probably a good idea to mask all nearby external painted surfaces.

The bezel face can be reattached using an adhesive suitable for glueing metal to metal. I'd **not** use epoxy. I don't know what Apple used, but the original stuff is thin, brown, hard and brittle. For starters, I'd suggest common household cement. Here in the states Duco is a widely available name brand, but anything similar ought to work.

You might want to test-practice with the old broken LCD before the final assembly to determine the appropriate amount of glue to use. It always enhances one's confidence level when you've practiced first. :-D

Run a thin bead of glue around the LCD frame's face, being careful to keep the glue more to the LCD's outer edge than the

inner (you want minimize squeeze-out onto the LCD screen.) Position the bezel face on the LCD and using **lots** of clips (springloaded clothespins are perfect) clamp all around. Might be a good idea to wipe off any squeeze-out **before** it dries, though if you've masked well it shouldn't be necessary.

In situ or take apart?

If the LCD data cable is intact **it's possible to do the job without dismantling the 'Book** to remove the cable from the unit's base, do the LCD replacement with the bezel back and hinges still in place. Removing the data cable from its internal connector does require nearly complete disassembly of the 'Book.

The internal backlight connector has to disconnected of course, and on the pre-DVI 'Books is a PITA to get at, but it **is** possible. With the keyboard out you can feed in the new LCD's backlight cable through the hinge opening and guide into its socket from the KB side. I found a thin very long-nosed ex-medical tweezer very useful feeding the cable through the hinge opening. See below for more details.

Still, it's not terribly difficult to remove the entire display and that method is to be preferred as it allows you to work on the display unencombered by the PowerBook's body. The ifixit web site's takeapart guides are quite good.

Completely removing the entire display, I can replace a complete display assembly in roughly 1 hr total, but I expect a first-timer might take several, even with a manual onhand. Even if one fixes the existing broken display, it still makes a lot of sense to remove the complete panel, makes things alot easier to manage. The data cable is very vulnerable to damage, so be super careful whenever you have to fiddle with it.

LCDs and cables

The LCDs

All the LCDs are of the same form, with the same connectors and screw-hole locations. Any LCD will fit into any of the bezels.

Here's some LCD part numbers of which I'm aware:

400/500/550/667 pre-DVI models - 1152x768

- Samsung PNs LTN152W1-L01, LTN152W2-L01
- AU Optics Corporation - PN B152W01
- LG/Philips PN LP152W1

667/800/867/1gHz DVI models - 1280x854

- Samsung PN LTN152W3-L01, LTN152W4-L01, LTN152W5-L01 (?)
- AU Optronics Corp B152EW01

The earlier LCDs work fine on the DVI models, but at the lower rez of course. Interestingly, a DVI LCD worked on my 400mhz test unit, but it displayed only the lower rez output to the upper left of the screen. It had 128 pixels of odd static-like artifacts at the right edge and repeated pixels from the top at the bottom edge.

Some potential **non-Apple LCD sources:**

- VPR Matrix 110 Laptops.....15.2" Wide Screen. B152EW01
- VPR Matrix 220A5 Laptops
- VPR Matrix 200A5 Laptops
- VPR Matrix 185A5 Laptops
- Gateway M500 Laptops

The cables

There are three cables from the display assembly to the main section of the 'Book. On the lefthand side are the LVDS cable (the main data cable) and the sleep LED cable. On the righthand side is the backlight cable.

The LVDS cable is a multiple wire jobbie (20 wires?) and is the largest and most fragile of the three cables.

The sleep LED cable is usually blue and white. The backlight cable is usually pink and white, though I have seen LCDs with BL cables in other colors, including blue, and gray.

The backlight cable is part of the LCD, it plugs into the invertor in the main body, either directly or via an 'extension cable', depending on which model TiBook you have. It is **not** removable from the LCD.

- **The display LVDS data cable**

The LVDS cable is separate from the LCD, one end plugs into the back of the LCD and the other into the logic board just inside and below the left hinge. The LVDS connector location on the 'Books' logic boards remains the same over all TiBook models.

- **LVDS cable differences**

There are several different LVDS cables and while all appear functionally identical, practice reveals differences. I did some testing with a DVI TiBook and some pre-DVI LCDs, and the difference seemed to be in the cable, some cables able to communicate the correct rez and others not. Here's the two possible results:

A) System sees an 1152x768 LCD and displays that rez properly

. or

B) System imagines a 1280x854 LCD, which doesn't all fit on the real 1152x768 LCD and thus the extra pixels are

'offscreen' and not visible.

LVDS cables on a DVI 667, with pre-DVI LCDs

- -LG/Phillips LP152W1
- -Samsung LTN152W1 and LTN152W2

cable PN#.....LCD.....output

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590-5081 rev A.....LP152W1.....1280x

590-5081 rev A.....LTN152W2.....1280x

590-5156 rev A*.....LTN152W1.....1280x

- *Foxxconn - blue and gold wires, w/green tape*

590-5156.rev.B.....LP152W2.....1152x

590-5156 rev B*.....LTN152W1.....1152x

- *blue wires*

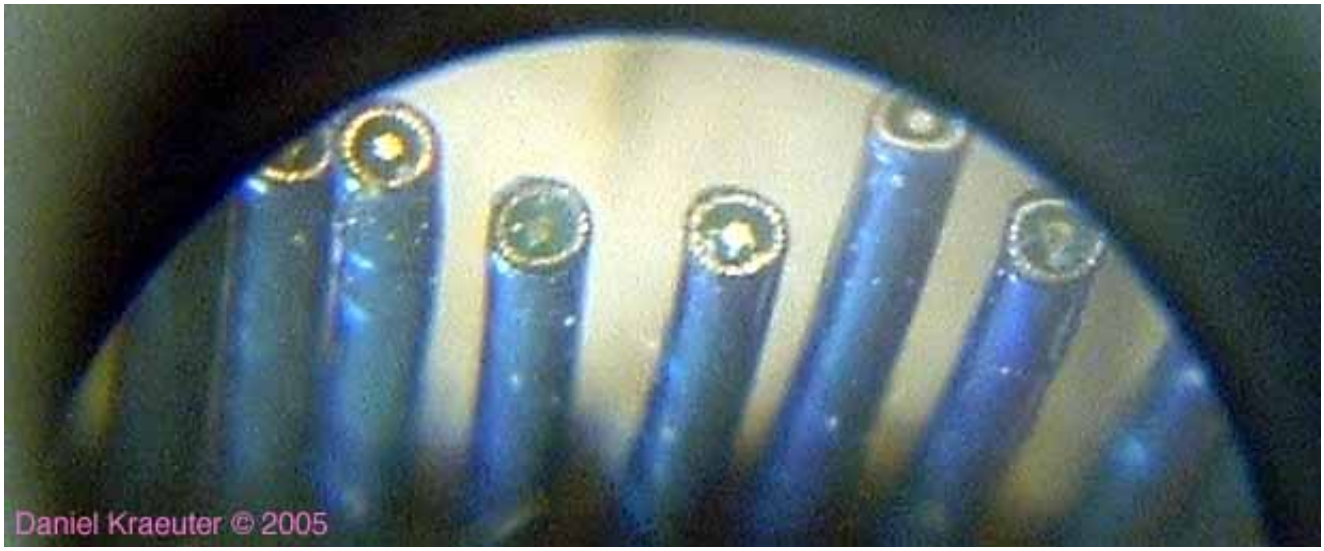
590-5156-01*.....LTN152W1.....1152x

- *green wires*

Sadly, I didn't keep track from which TiBook each of the cables was sourced, as that would have been rather useful to know. :-(

Disclaimer: *Please note I won't guarantee the above data to be valid on any machine other than the one on which I did my testing.*

The LVDS cable is composed of a bunch of tiny coax cables, each roughly 0.3mm in diameter. Use extreme care handling the cable as it is very easily damaged. If it does get damaged, it's pretty much junk as it's virtually impossible to repair.



- **The sleep LED cable**

The sleep LED cable has a plug at one end and the sleep LED at the other. It plugs into the logic board right next to the LVDS cable. The LED on the other end is clipped into the center tube below the display and is removeable, though unclipping it is near enough impossible without removing the LCD from the display housing. The sleep LED connector location on the 'Books' logic boards remains the same over all TiBook models.

- **The backlight cable**

Pre-DVI have their inverter boards in a different place than do the DVI models, and so the procedures for disconnecting and reconnecting the BL cable vary. In both cases the inverter can be plugged in without removing the LB, but each requires a slightly different procedure. The BL cable feeds through the hinge hole, then . . .

- **pre-DVI models**

The inverter on the pre-DVI models is located under at the right rear of the case, just to the right and forward of the hinge hole. If you pull the keyboard and/or take off the bottom you can more readily see where it plugs in. If you look through the hinge-hole you can **just** see the plug in its socket. Use a small flashlight or something to help see inside there. It's pretty easy to pull the old

one out, but a PITA to work the new one in. Just take care to note the orientation of the old BL's plug.

The plug is pointed to the right viewed from the 'Book's front. If you grab those wires and tug gently to the left the plug will come out of its socket. Be sure to note the orientation of the plug as it comes out, it only fits into its socket one way. That's the easy part. The PITA is getting the replacement back in.

Here's my 'procedure' for plugging in the damn thing:

First, with the re-assembled display attached to the main body by the hinges but with the hinge covers off, open the display 90 degrees and stand the whole 'Book on its side. The right side if you're right-handed (the left if you're a lefty?). As I'm a righty I'll describe it from that POV.

I have a skinny long-nosed tweezer with which I can work the plug through the hinge-hole (with my right hand.) With my left hand I then use a screwdriver or similar to guide the plug, through the KB opening, directing the plug downwards (to the 'Book's right.) Using the tweezer from the back through the hinge-hole and a screw driver through the KB opening I am able to orient the plug and push it into place.

I have to say, this is even more difficult (for me anyway!) than it sounds, it's the single biggest PITA of the entire LCD replacement job. However as it's an even bigger PITA to strip the entire 'Book, I suffer on through til I get the damn thing into place.

- **DVI models**

The DVI TiBooks are easier, the inverter is located up by the optical drive with an 'extension cord' running back to the LCD's BL plug. To access the connection, remove the power-in board and the fan (though IIRC a 667-DVI doesn't have a fan there, just an empty bracket.) You can then get at the BL plug's connection to the 'extension cord'.

Hinges

Original hinges are made of some sort of pot metal, the most recent new replacement units are apparently made of steel. It is possible to reuse old hinges as long as they are intact without any cracks.

Sleep magnets

- **locations:**

A tiny cylindric magnet taped to the back of the LCD trips a sensor under the palmrest.

Looking at the back of the LCD with the top edge up, the magnet location relative to the upper LH corner:

- 400 and 500 - right 4 3/4" and down 1 1/4"
- . . . . r-121mm and d-31mm
- 550 and later - right 7 3/4" and down 2 3/4"
- . . . . r-197mm and d-70mm

Those positions of course can also be located on the palmrest ('Book open and facing you) measured from the near righthand corner, left and toward the back. You can trigger sleep with the lid open by placing a magnet there. Heck if you **didn't** have an exact location you could just slide a magnet around the palmrest until the 'Book nods off.

LCD failure modes

There are a number of obvious failure modes about which folks complain, here's some of the more common problems and their likely causes:

- **partial blanking of the LCD (eg: lower third of screen)**

Probably a bad cable, generally caused by physical damage. However, edge separation of the LCD from its integrated controller board's cabling can also cause this problem.

First case requires cable replacement, second requires LCD replacement.

- **all-white screen, external display still works**

Maybe controller failure on the LCD itself, but more likely failed output circuit on the logic board. See my page on the subject here.

- **vertical lines**

Almost certainly failure of contacts at the edge of the LCD itself. Replace LCD.

- **dark screen, image faintly visible**

Failed backlight - either the backlight's power source (invertor) or a failed TTFL bulb in the LCD itself. It's also possible the wiring from the inverter to the LCD have been severed or grounded. Last case can destroy inverter, check wires before replacing inverter.

- **dim screen**

Old backlight bulbs give off less light as they age. Generally the cure is to replace the LCD, but it is possible to replace just the bulb itself though the job is not for the faint of heart.

- **moving display causes display issues**

Usually caused by failing LVDS cable, though LCD edge connection failure can also be the cause. While keeping the entire assembly still, try squeezing the edges of the display gently to see if you can stimulate the problem. If merely squeezing the edge causes it, it's almost certainly an LCD problem.

Some info about LCD edge connections

The built-in controller on these LCDs connects to the actual LCD panel at its edges via flexible ribbon cable adhered with

anisotropic conductive film, or ACF for short. The following quote comes from http://www.microbonding.com/gb/hs_gb.htm

> Anisotropic conductive film, commonly known as ACF, is a epoxy system that has been used for almost 30 years in the flat panel display industry to make the electrical and mechanical connections from the drive electronics to the glass substrates of the displays. Since 10 years, this technology is largely employed to directly connect the drivers on glasses; this process is called Chip On Glass (COG).
>
> ACF works by trapping conductive particles between the corresponding conductive pads on a substrates and the piece to be connected (die, LCD, other substrates,...). ACF consists of a very stable matrix of 3-5μ polymer spheres, each nickel-gold plated and then coated with a final insulating layer that protects them against shorting through contact with a neighboring particle.
>
> During the bonding process, the insulation in the Z-axis where the balls are trapped is pushed away, allowing the Ni-Au layer on the particle to conduct electricity between the IC and the substrate, while not shorting in the X and Y directions. The epoxy cures, locking the particles in this compressed state. The resin matrix used by ACF is either thermopastic or thermoset, thus bonding is done through simultaneous application of heat and pressure with a thermode.

It is possible to replace failed ACF adhesive

film with new, but the technique requires some specialized tooling to ensure the bond is properly complete. There are several outfits that can do the job, but generally cost is higher than simply replacing the LCD.

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revhist

2007.04.27 - reorg and added some details (hinge assembly, LVDS cable diffs, sleep magnet locations, LCD failure modes, LCDs and ACF)

2005.01.18 - added LVDS cable crossection image

2004.08.26 - updated LCD and cable details, added some more take-apart

2004.04.26 - new page