Wire Bonding Notes

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Setting bonding parameters

1. The buffer is selected with a combination of the buffer switch (I, II, III) and the rightmost thumbwheel switch position. Switching between I, II, and III is obvious; click the thumbwheel switch to change the buffer number within each of these.
2. The main buttons for editing are the edit and enter buttons.
    a. Adjust power, time, and so on starting with the edit button.
    b. Adjust machine parameters starting with the enter button.

   In both cases the edit button steps through the choices once in the menu mode. Values can be changed either with the Tail switch (good for small changes) or by entering the values into the thumbwheel switch and hitting the enter button.
3. Exit the menus and keep changes at any time by hitting the reset button.

Height adjustment

The best height seems to be about 10 mils above the surface when the micromanipulator is in its neutral position. If the work is too high the bond is thin where the wire pays out to the next bond, and the wire is likely to break off there. If the work is too low the bond is thin at the further end, so it's possible that the wire will break at the second bond. Low work might be useful for very short bonds.

Movement

Bring the tool down to the surface gently and position the wire on the bond pad and under the anvil. Then, without any lateral motion, smoothly press down on the micromanipulator until the ultrasound fires. Lift straight up or up with a little movement away from you; the wire should feed out smoothly. Move the tool away from you to the next bond, position the wire on the pad and under the anvil, and again press down on the micromanipulator. Neither the work nor the tool should move laterally during any bond – securing the work is important.

Looping

The idea here is to lift the tool vertically after the first bond, then have the wire "lock" in the tool before making the second bond. I still haven't got this working well– the wires tend to lie flat and don't loop, although Al tends to kink up a bit of its own accord. One thing that works in a somewhat controllable way is to overshoot on the second bond, then move the tool back while keeping it close to the bonding plane. The wire then locks and loops up, or sometimes sideways.

Wire notes

- A length of 1 cm of one mil wire will burn out with about 0.4 A (Al), or 0.55 A (Au) (Harman p. 60).
- For high-power devices a loop height of about 1/4 of bond length is a good compromise between thermal cycling and shorting problems (Harman p. 232). This is considered a high loop; lower power devices can have smaller loops if the mechanical motions are small.

Bonding notes

- Soft substrates need lots of power. How much is still unclear, and it must depend on the normal amount of power for a given wire material. From Harman p. 270, it seems that normal forces (~30 g) and a time of perhaps 50-60 ms is appropriate. I gather that a quick, high power blast is the right way to bond.

Changing wire spools

The wire spool is held in place by friction from two rubber o-rings in the axle. To remove the spool, pull on it gently while holding the fixed end of the axle with the other hand to prevent dragging the head around. The wire should feed off the top of the spool. New spools are marked with the end to start – the wire end is held in place with a dab of tape. *Be very careful not to touch the wire on the spool – finger oil will contaminate the wire surface.*

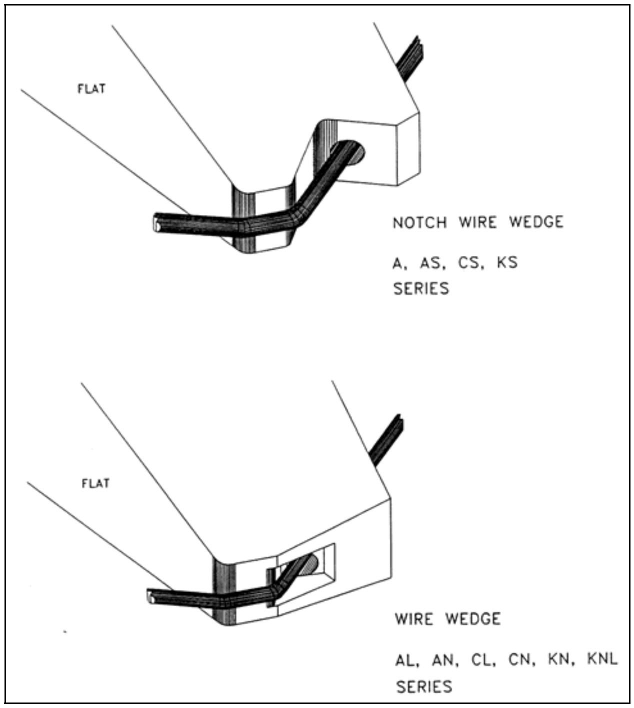
Changing tools

The tool is held in place by a setscrew on the front of the "horn." There is a small Allen wrench and an alignment jig in the supply box. To remove the tool, loosen the setscrew and pull the tool down gently (supporting the micropositioner handle) with a pair of needle nose pliers or tweezers. DeWeyl says to use pliers because tweezers may slip and damage the tip. The opposite for installing – flat to the back, and push up until the top of the tool clears the top of the horn. Then, using the middle hole, hang the alignment "L" on the Allen wrench. Bring the tool down until the tip just brushes the alignment bracket, then tighten the setscrew. The top of the tool will be nearly flush with the top of the horn.

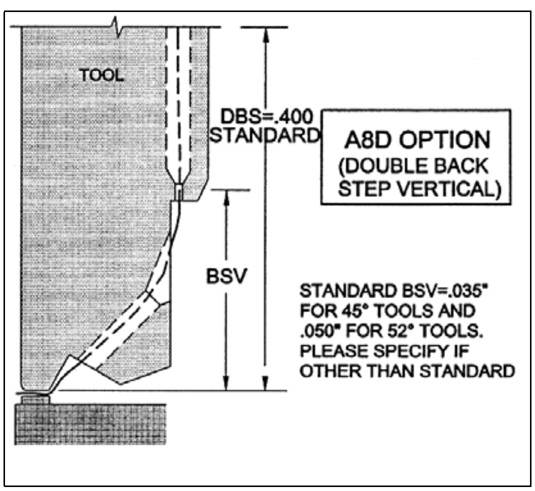
Threading the machine

Much of the manual wire handling method here seems to be to get a relatively straight section, or at least an unkinked section, then grab about 2–3 mm behind the wire end. If the wire kinks, start over.

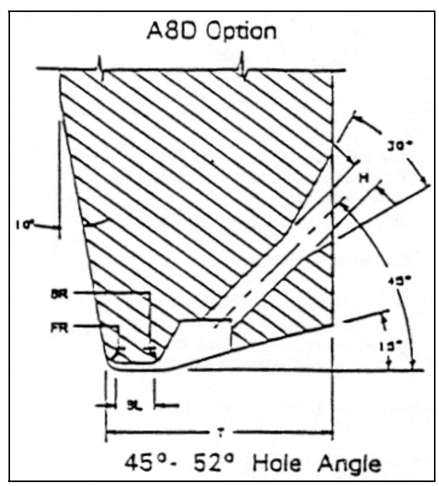
1. The wire is pretty springy and likes to tangle on the bobbin holder and the screw that holds it in place. There doesn't seem to be much that one can do about this except to make sure things are feeding smoothly before getting too far.
2. Threading the wire down the feed tube is only slightly tricky: if it doesn't feed straight, the wire is prone to kink. The wire will kink once it hits the jaws – even if they're open, the wire's likely to hit. If the wire kinks and it seems possible that there is enough to run through the tube, it's worth fishing between the tube bottom and the top of the jaws with tweezers to see if it's come through. If so, pull a bit out and run it through the open jaws. To open the jaws, click the Clamp switch to the right (open*)*; to close the jaws, click the switch to the left (feed*)*. Holding the switch in the open position cycles the clamp, pushing the wire in relatively large steps that are useful for threading. Holding the switch in the left position feeds in small steps that are more useful during the bonding process.
3. Once the wire's through the jaws, close the jaws and snap or cut off the end to insure that it will feed smoothly down the tool stem. Open the jaws again, wind backwards on the bobbin to make a short wire, then feed the wire end into the tool stem with the tweezers. One good method is to grab the (straight) wire a couple of mm from its end and feed this first part down the bore. Once that's done, hold the clamp switch to the right or left to push wire down the tube. Pushing to the right makes large feeds, which is nice for getting the wire down the tube, but short feeds from the left position seem to thread down through the narrower hole at the bottom better. The spool turns while this happens, and watching it is useful for monitoring progress.
4. Feed about 3-5 mm of wire out of the bottom tool stem. If the wire is kinked, close the clamp and break off the wire end with the tweezers – grip the wire, roll the tweezers 90°, and then pull sharply but gently. After the wire is straight, open the clamp or make sure it is open – otherwise an incautious tug on the wire can break it.
5. Watching through the microscope, focused on the tool's tip, grab the wire about 2–3 mm behind its end. Pull back gently, away from you, to clear the area behind the tool. Hold the wire at an angle of about 30° from vertical, tip pointing toward you. Line it up the end with the side of the tool for reference, then fish around on the back to thread the wire through the tool. It can be useful to look at the figures on the next page or one of the unmounted tools to understand the geometry. The wire feeds into a funnel-shaped opening about 1/5 of the way up the ceramic part of the tool, but there's little depth perception through the microscope. It's a little hard to tell when it comes through – perhaps the best sign is that it lines up nicely with the tool centerline and moves fore and aft more than side to side.
6. Release the loop and grab the wire end. Pull gently to bring the wire behind the tool through, removing any loop in the wire behind the tool.
7. Click the Clamp switch to the left (feed). The machine will tell you to bond off the tail.



Figures of notch and standard wire wedge bonder tips from the DeWeyl catalog. We use wire wedges as shown in the lower figure.



Cutaway view of wire feed down tool and into tip from the DeWeyl catalog. Not to scale.



Detail of wedge tool tip, probably scale or close to scale, from the DeWeyl catalog.

Bonding tool

Our standard tool is a DeWeyl M-KNL-V-O-1/16-.625-52-C-2025-MP-A8D. This tool is specified for aluminum and gold. This is a:

- Ceramic tool
- KNL series (wedge, not notched wedge)
- Vertical/deep feed
- Standard front/back radius
- 1/16" shank diameter
- 0.625 inch tool length
- 52° hole angle
- Concave anvil shape
- 0.002" hole diameter, 0.0025" bond length
- Polished radii, matte finish bond flat
- A8D option for wire control (small hole at bottom of shank)

Wire type

For its ceramic tools, DeWeyl specifies gold wire with 0.5-2% elongation. For gold, this elongation corresponds to hard gold. The elongation must be low enough that the wire pull breaks the wire after the bond, rather than just stretching the wire (Harman p. 53). DeWeyl does say that some application may find acceptable performance with 1-3% elongation (annealed) wire. Annealed wire is more appropriate for ball bonders (Harman p. 50) and has a longer shelf life than hard wire. From Harman (p. 45 ff) :

> "In general, the breaking load of *hard*, as-drawn wire decreased rapidly (from 5-15%) within six weeks of manufacture (thus, hard-wire is seldom recommended for volume production, where reproducibility is required). It continued to decrease, but more slowly, over the two-year period. The exception was hard Al, 1% Mg wire, which was essentially unchanged over the two-year test period. All stress-relieved and annealed wires of both Au and Al stayed within their breaking-load specification for the entire two-year test period. The elongation characteristics were more ambiguous than the breaking load, changing upward or downward but within the specification extremes, and generally recovering to the median by the end of the test…
>
> "The conclusion drawn from the shelf-life study is that, in general, small-diameter annealed or stress-relieved wire (not hard, as-drawn) can be used for up to two years with only minimal changes in its breaking load, although its elongation… The *caveat* is that the wire must be stored at approximately constant room temperature, and exposure to direct sunlight, drafts from an open door, or possible heat sources *must be avoided*."

Aluminum wire for ultrasonic wedge bonding is often supplied in a stress-relieved rather than annealed or hard-drawn form (Harman p. 53). Again, elongation seems to be the key parameter: 1-3% heat-treated wire is available from California Fine Wire. Hard-drawn wire is probably too brittle to work well, as it will more easily develop cracks in the first bond's heel; the wire flexes here during loop formation before making the second bond.

Adjusting the load cell zero point

To see the load cell in real time, go to the force adjustment menu in the machine parameters setup, accessed with the enter button. Gently lift the bonding tool assembly by hand – the force should drop to zero. If it doesn't, adjust by opening the machine's cover (this has a power safety shutoff with a microswitch in the right rear corner that will have to be defeated with a little weight), get back to the force reading, and then lift the assembly and adjust pot R1 on the main board (far left) to zero the force offset. Return the bonding tool assembly to its neutral position and readjust the bonding force with the spring-loaded knurled nut just above the bonding tool assembly.