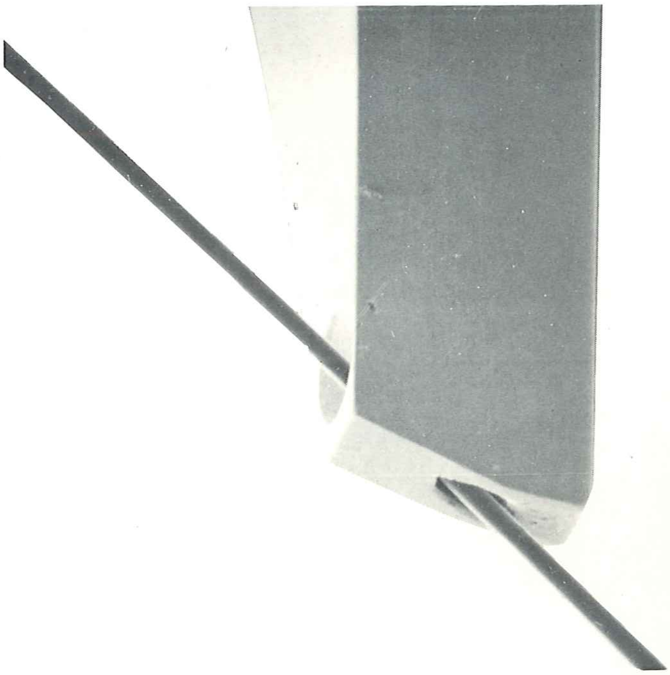
Semiconductor Bonding *TIPS* 2

Technical Newsletter

Aprova Ltd CH-3250 Lyss/Switzerland
Telefon: 032 84 34 46
Telex: 34 662 felma ch

Appendix to our
Semiconductor Bonding Handbook

AutoBonding Tools



were designed for use with Automatic Ultrasonic Bonders. Designed to keep the wire in the center of the bonding foot, they achieve extremely accurate bond placement that is required by Automatic Wire Bonders. The ABT's can be used on both Automatic and Manual Bonders.

When used on Manual Bonders, the ABT's can increase the units/hr since the in-line accuracy required for second bond placement can deviate up to 30 degrees, and the wire will remain under the bonding foot. Standard tools can tolerate about five degrees before the wire is out from under the bonding foot.

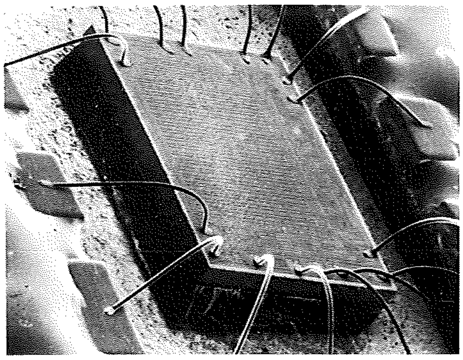
The new ABT's are offered for 30°, 45° and 60° wire feed bonders. Part series are 30ABT, 45ABT and 60ABT- .

Style	Material	Hole/ Bond-length	Tool-Length	Foot Option	Hole H	Bond-length BL	Foot Width W	Tip Thickness T	Suggested Wire Dia
ABT + wire feed angle	W= Tungsten Carbide TI=Titanium Carbide FB=Special Tool Steel	2015	S= .437" L= .828" 3/4= .750"	C= Concave F= Flat	.002	.0015	.004	.014	.001 -
		2020			.002	.002	.004	.014	
		2025			.002	.0025	.004	.014	
		2030			.002	.003	.004	.014	.00125
		3025			.003	.0025	.004	.015	.0015-
		3030			.003	.003	.004	.015	
		3035			.003	.0035	.004	.015	
		3040			.003	.004	.004	.015	
		3045			.003	.0045	.004	.015	.002

How to order: 30ABT-W-2020-L-C or 45ABT-FB-2025-L-F

First Bond
$1\frac{1}{4}$ mil AL- 1% Si Wire
30ABT-W-2020-S-C

The bondability of the die was low and required a bond deformed width of almost 2x wire diameter. Even with this bond deformation the smooth transition from the weldment into the wire will offer a strong bond pull test.



Second Bond
$1\frac{1}{4}$ mil AL- 1% Si Wire
30ABT-W-2020-S-C

The bondability of the lead metalization was very good and required much less bond deformation than the first bond. Note the good termination after the second bond.

ULTRASONIC BONDING ON 1100 OR 1400 EMB BONDERS

3600 SLIMLINE WIRE CLAMP FOR DIRECT PLACEMENT ON 1100 OR 1400 EMB BONDERS

The clamp operates in either a 30° or a 60° wire feed mode and will feed both ribbon or round wire since the wire is clamped on the top and bottom.

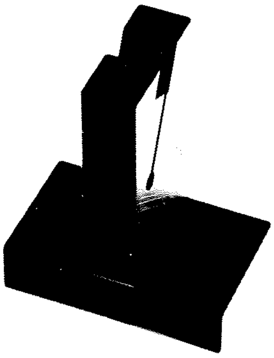
(see previous "Bonding TIPS")

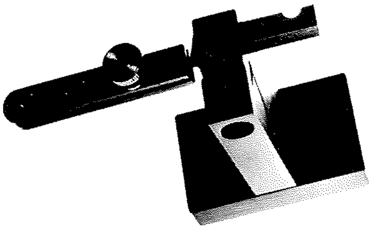
DIAL-A-LOOP B 388

is used to bond ALL packages without changing the lift cam again. The operator can dial in any desired loop heights from 0" to .070".

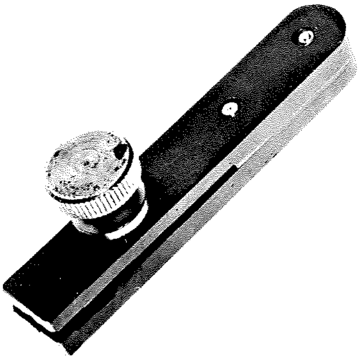
(see previous "Bonding TIPS")

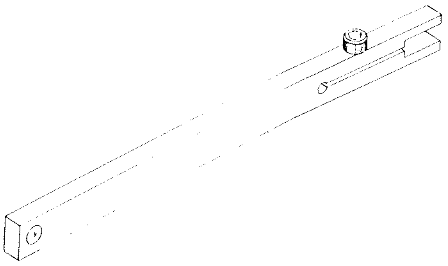
3600 Alignment Fixture
Part No. 3600 AF





3600 Clamp Jaw Vise
Part No. 3600 CJV



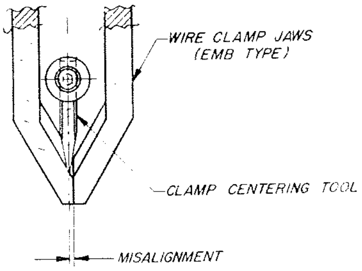


ADJUSTABLE FEED ARM

New adjustable feed arm reduces varying tail length due to too much play in the feed arm linkage.

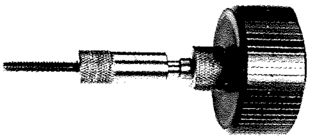
Part No	Description
B363-13	EMB 1100 - 30° feed arm
B363-15	EMB 1400 - 30° feed arm
B363-1	EMB 1100 - 60° feed arm
B363-14	EMB 1400 - 60° feed arm

SHOWING CLAMP TO TOOL MISALIGNMENT. RELOCATE THE WIRE CLAMP BUSHING.



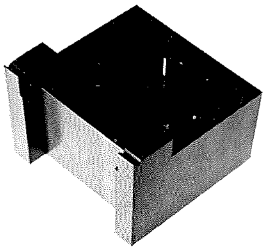
EMB Clamp Centering Tool, Style 0001

Style 0001 EMB Clamp Centering tool is a special wedge used to determine clamp-to-tool alignment. Install the tool and swing the wire clamp to the tool, which, when viewed trough the microscope, will indicate alignment problems.



Bushing Puller, P/N 405BP

The Bushing Puller is a special tool used to relocate, if required, an EMB wire clamp bushing if misalignment has been determined. With proper wire clamp alignment, most side bonding problems are eliminated.



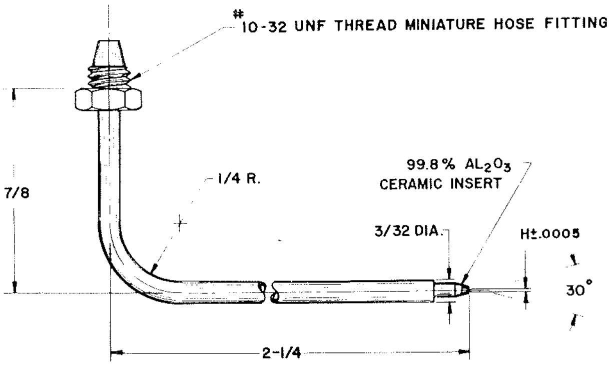
Transducer Alignment Fixture, P/N 314TAF

The Transducer Alignment Fixture is required for proper installation of a transducer assembly on EMB 1100 wire bonders. This Fixture aligns the tool hole axis of the transducer with the bonder head. The Fixture is an extremely practical tool for every bonder maintenance department.

HYDROGEN FLAME-OFF TORCH

CERAMIC INSERT

Additional information to page 48 of our "Semiconductor Bonding Handbook"



PART NO.	HOLE DIA. H
HTD-2	.002
HTD-3	.003
HTD-4	.004

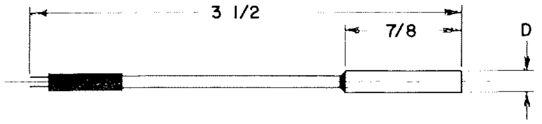
OTHER HOLE DIAMETERS AVAILABLE

HEATERS

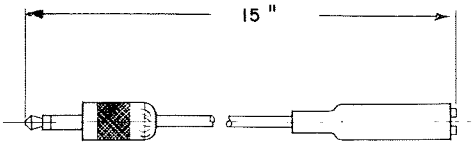
Additional information to page 47 of our "Semiconductor Bonding Handbook".

CARTRIDGE HEATER

SINGLE ELEMENT



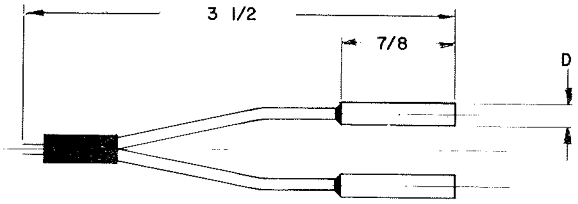
Part No.	D	Rating
H10-4 E	.125	12V. 14W
H10-5 E	.156	12V. 20W



HEATER EXTENSION CORD

STYLE **HEC**

TWIN ELEMENT



Part No.	D	Rating
H20 E	.125	12V. 28W
H50 E	.156	12V. 40W

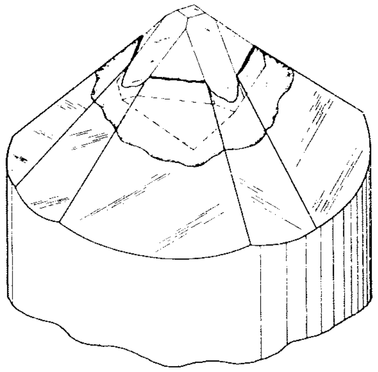
Cartridge Heaters
H10-4 + H10-5 and H20 + H50
were replaced by
H10-4E + H10-5E and H20 E + H50 E,
with Heater Extension Cord HEC.

BONDING WEDGES

Use the right material for longer tool life when bonding Gold or Aluminium Wire:

Aluminium Wire	Special selected Tungsten Carbide "W" (1001-W-2530-L-C)
Gold Wire	Special Tool Steel "FB" (1001-FB-2525-L-C) or Titanium Carbide "Ti"

"FB" gives much less wear with Gold Wire underneath the bonding foot than both "W" and "Ti".

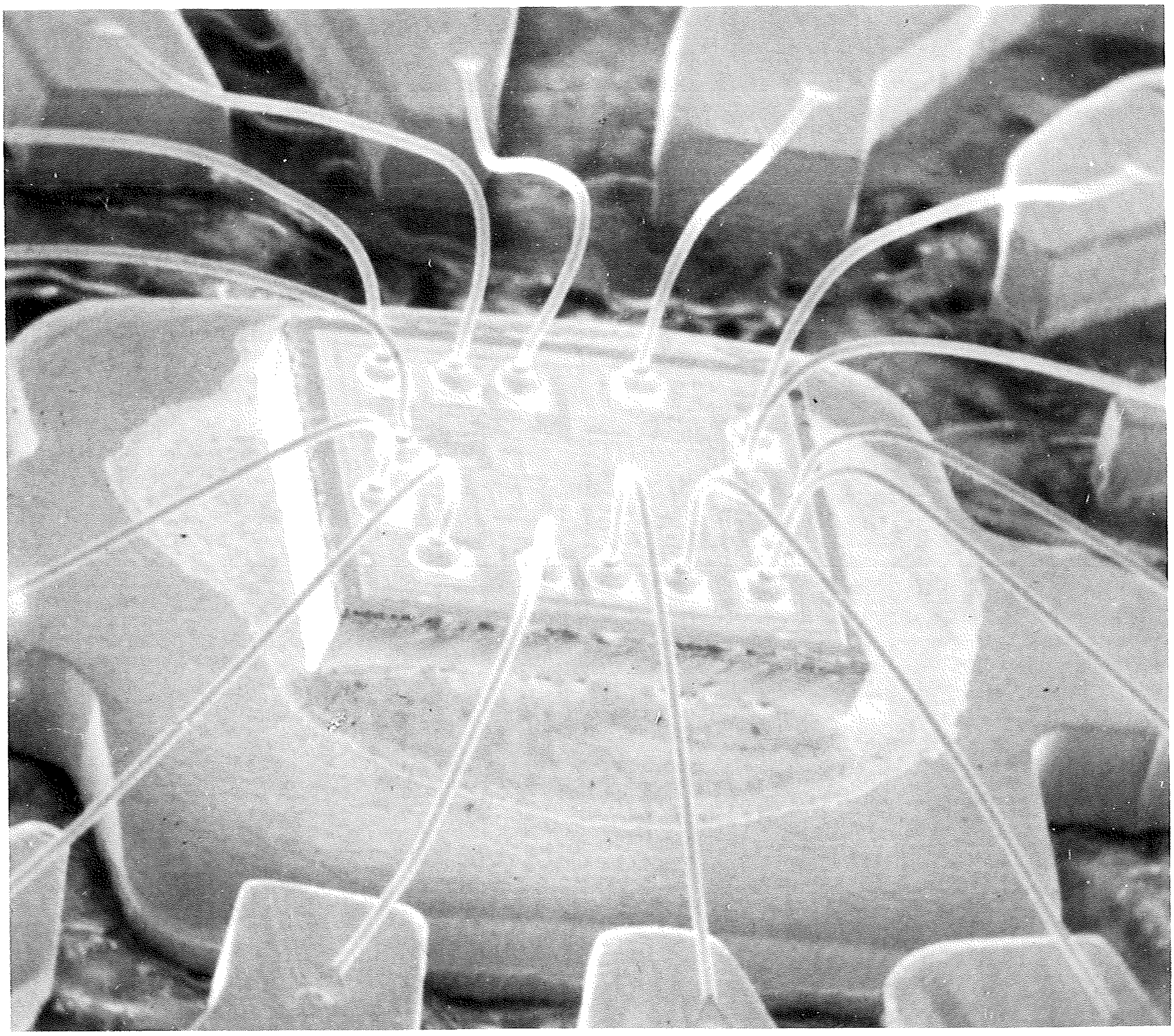


We reconstruct your

DIAMOND SCRIBING TOOLS

We need with tools to be reconstructed

- drawing of tool configuration
- or at least exact part number with original manufacturer name



CAPILLARY BONDING

You find technical information:

- a) Tool Selection, general information
- b) Capillary Design Affects Tailing
- c) Temperature effects on Wire Looping
- d) Wire Elongation effects on Wire Looping
- e) Selecting the optimum Substrate Temperature
- f) Wire Sag caused by Insufficient Tip Lift
- g) Losing the Tail

SOLUTIONS TO BONDING PROBLEMS

Where?

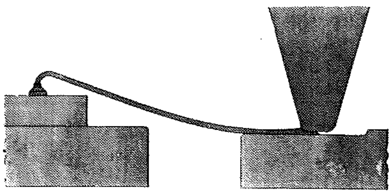
Semiconductor Bonding Handbook
Semiconductor Bonding TIPS 1

c) - g) following pages
6 - 11

Temperature Effects on Wire Looping

With proper wire tension and drag, and with proper capillary used, the following is general description of wire looping characterized when the substrate temperature is less than 320°C.

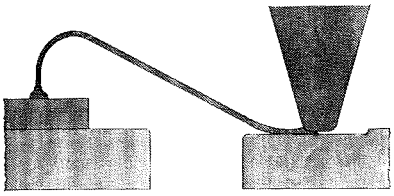
elongation 0.5-2.5%



300°C

Figure 1

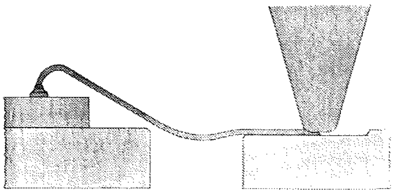
8-12%



300°C

Figure 2

4-7%

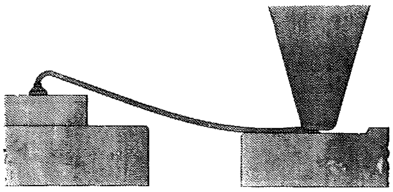


300°C

Figure 3

However, if the substrate temperature is increased to somewhere over 320°C, then the heat starts annealing (softening) the wire. The heat changes the wire to a higher elongation (softer, more flexible) and also lowers the "break load".

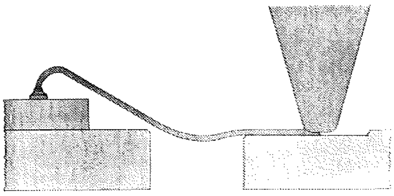
0.5-2.5%



340°C

Figure 4

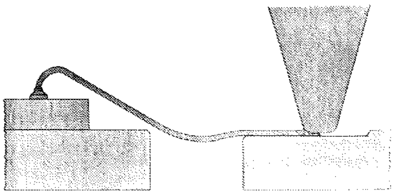
4-7%



340°C

Figure 5

8-12%



340°C

Figure 6

Note that with the higher substrate temperature the good looping of the 4-7% elongation wire as shown in Figure 2 now acts like that of the softer 8-12% of Figure 3. Note that the higher temperature has destroyed the original wire specification that was coming off the spool. The high temperature, however, has little effect of high elongation wire, because it is already annealed.

Wire Elongation Effects on Wire Looping

General specifications for unstabalized gold wire are:

Elongation	Minimum Break Load *+ wire dia		Characteristics
	.001" (25 my)	.00125" (32 my)	
1) 0.5-2.5%	15 gms	22 gms	Hard and stiff
2) 3-5%			
3) 4-7 %	7 gms	10 gms	Semi-hard
4) 6-9%	5 gms	7 gms	Soft and very flexible and relaxed

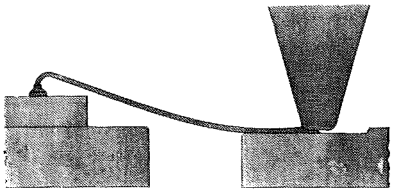
* Also called tensile strength
\+ Not gram gage reading of pull test

When the bonder is properly set up with:

1. The correct capillary bore diameter for wire
2. Sufficient tip lift
3. Correct amount of wire tensioning and drag
4. The substrate temperature less than 320°C

Then the following loops show what can be expected when using different elongation wires.

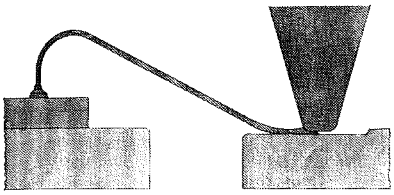
elongation 0.5-2.5%



300°C

Figure 1

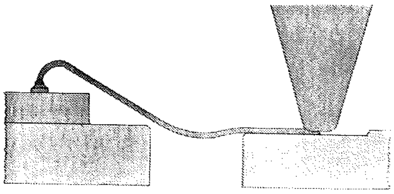
4-7%



300°C

Figure 2

8-12%



300°

Figure 3

Hard-Low Elongation Wire (Figure 1, less than 3%)
is rather strong and stiff. However, the wire directly above the ball is soft because it was annealed and softened during the ball formation. In forming a loop most of the bending will occur in this soft section above the ball. This can be a very sharp bend depending upon wire drag and second bond distance and location. If it is too sharp of a bend then later on wire creep failure can occur. The wire being rather stiff is relatively straight from the ball to the stitch bond. However, this stiff wire tends to lay down close to the substrate at the second bond due to the cantilever action of the capillary against the wire at the stitch bond.

Annealed High Elongation Wire (Figure 3, greater than 8%)

is soft and flexible. It bends easily. Very little tension pressure is required to exceed the elastic limit of the wire. It can take a permanent set easily. The wire can be both easily bent and pulled straight again with little tension.

In high speed bonding it easily bends and is susceptible to wire sagging. Because it bends easily it does not always stuff back up the capillary properly, and too much wire can be left in the loop for proper loop formation.

This wire is more susceptible to tailing because the break load if the wire is low. One mil wire typically has 4-5 grams break load.

Stress Relieved 4-7% Elongation (Figure 2)

This wire offers the best all around looping and bonding performance for both TC and thermosonic bonding for the majority of applications. It is well suited for both manual and high speed automatic bonders.

Short Downhill Bonding

In cases where one must downhill bond very close to the die then a slightly softer more flexible wire such as 6-9 % elongation is recommended (See Figure 4 and 5). This situation is commonly found on many Hybrid circuits.

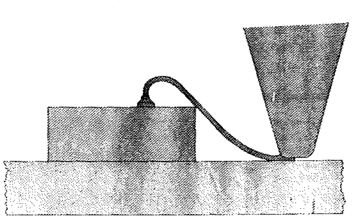


Figure 4

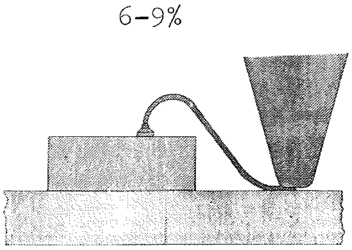


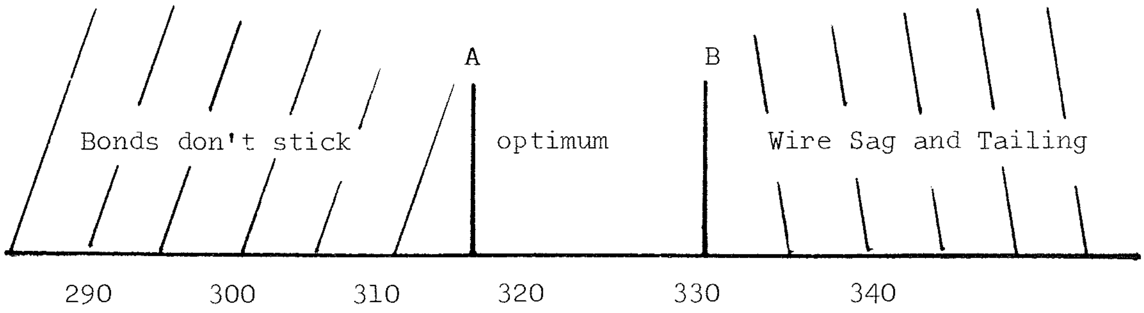
Figure 5

In the case of Figure 4 the 4-7 % elongation wire may be too rigid and not flexible enough. The wire is cantilevered by the capillary and does not sufficiently bend, causing the loop to be pulled down with the capillary. Here the softer more flexible wire of 6-9% (Figure 5) bends more easily and the loop is not pulled down as much.

Selecting the Optimum Substrate Temperature

In order to solve wire sag, looping and tailing problems, it is imperative that substrate temperature specifications set be reviewed by each product. Across the board specifications calling for substrate temperatures greater than 330°C for all products may actually be causing a decrease in product yields.

Each product has its own optimum bonding temperature. Depending upon the bondability of the materials being bonded. For material with average bondability the optimum bonding temperature will be found somewhere between 310-325°C.



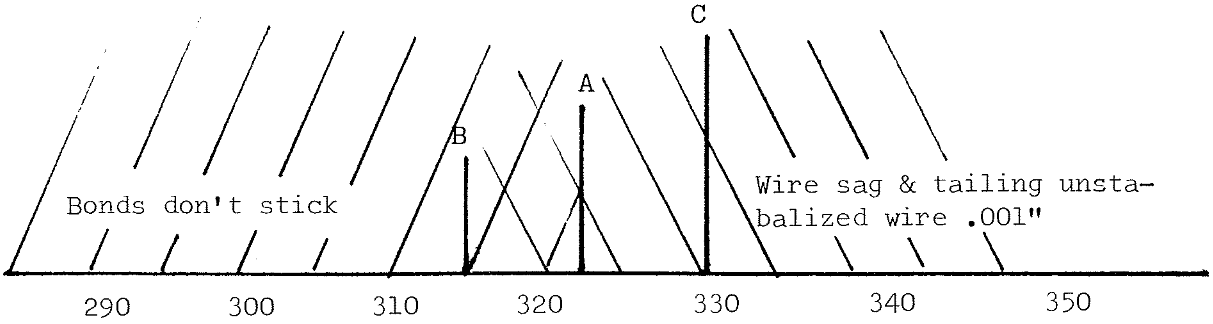
Substrate Temperature °C

SUBSTRATE WITH AVERAGE BONDABILITY

Figure 7

To find the optimum bonding temperature reduce the temperature to a point where bonds fail to stick (Point A, Figure 7). Then increase the temperature to a point where tailing or wire sag starts to occur (Point B, Figure 7). This determines the temperature limits. The optimum temperature will be found between these limits. Make bond pull tests. Pay particular attention to selecting a temperature where <u>zero</u> "lift-offs" occur.

Substrates with low bondability may require higher temperature in order for the bonds to stick. In this case, one may find that is no way to select a temperature where the bonds stick without having wire sag and tailing problems.



Substrate Temperature °C

SUBSTRATE WITH LOW BONDABILITY

Figure 8

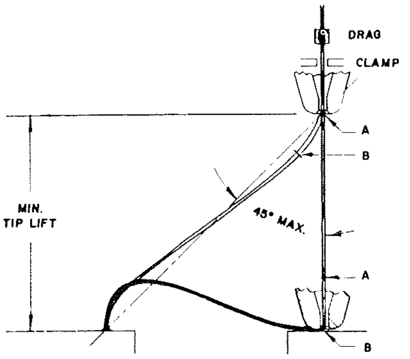
In the case where wire sag problems occur at a lower temperature than the bond sticking temperature there are several things that can be done:

1. Use of stabalized wire may be tried. This will allow one to use increased temperature before sagging starts to occur. (Point C, Figure 8)
2. Use of larger diameter wire. This is a common reason to change from .001 wire to .0013" wire. The increased wire strength due to increased crossectional area helps prevent wire sag.

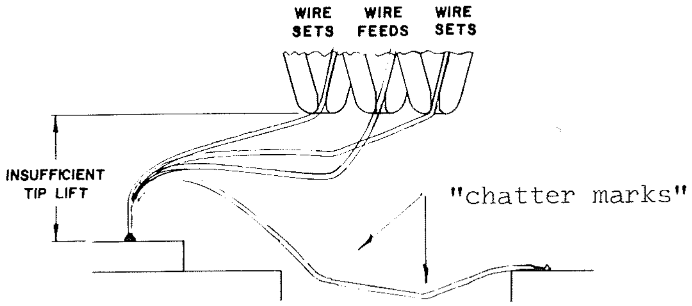
3. Use ultrasonic assist (thermosonic). Use of ultrasonics will allow a decrease in substrate temperature, well below the temperature where sagging occurs.
4. Use of ceramic capillary will decrease the substrate temperature required for bonds to stick. Also try ceramic capillary with no additional heat, i.e. unplugging the cap heater.

Wire Sag caused by Insufficiant Tip Lift

In addition to lowering substrate and capillary temperature, the following may help to solve wire sag.



The proper tip lift or tip lift cam is important. The longer the wire run, the higher the tip lift should be. Wire sag can be caused by feeding the wire out of the capillary at an angle greater than 45° to the capillary bore. Insufficient tip lift causes the wire to bend beyond its elastic limit when pulled out of the capillary. The wire takes a permanent set, causing it to sag.



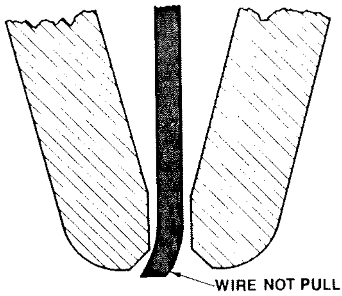
Wire sag caused by improper tip lift

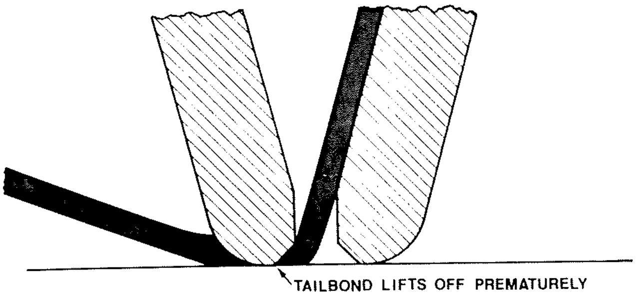
1. Wire binds and takes permanent set
2. Wire releases and feeds out
3. Wire binds again and takes a permanent set

This type of wire sag can be identified by observing small "chatter marks" on top of the wire close to the second bond. This is where the inside chamfer of the capillary has dug into the wire. This can also be a sign of the wire drag being too tight.

Losing the Tail

A problem of "losing the tail" can occur. That is, after the stitch bond is made, the wire breaks prior to feeding enough wire out of the capillary to form the next ball, and the wire is lost up the capillary terminating the bonding cycle. Essentially, the tail-bond weldment strength is very low, resulting in premature "lift-off" of the tail.





"Losing the tail" is a common problem observed when thermosonic bonding many metallized ceramics. It is due to the metallization being very low in bondability.

UBC and UTS style capillaries have large inside chamfers designed to increase the weldment area of the tail-bond in order to increase the tail-bond weldment strength. Special UTS was designed for bonding to prints (style PUTS-).

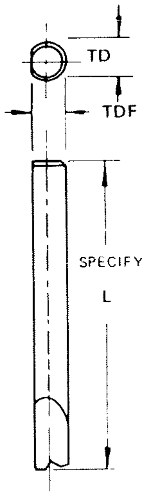
Should "losing the tail" occur with these capillaries, the bondability of the metallization must be increased. The easiest way to increase bondability is to increase the substrate temperature. Substrate temperature of 100-150°C is common for thermosonic bonding of metallized ceramics. Higher temperatures, of course, can be used. If problems continue to exist, the metallization stystem should be changed.

LARGE WIRE BONDING WEDGES

GROOVED

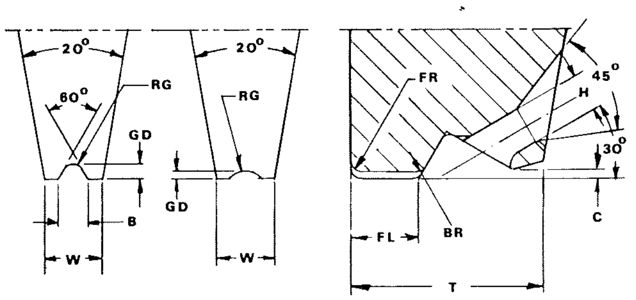
.003-.016 Wire - 30° Hole.

Style 1015A and 1016A.



Shank Dia.	TD ± .0001	TDF ± .0005
1/16	.0624	.057
3/32	.0936	.088
1/8	.1249	.118
3mm	.118	.090

Style 1016A Style 1015A



Standard groove dimensions for 1016A
FR=BR=60% Wire Diameter
B=110% Wire Diameter
GD=50% Wire Diameter
GR=45% Wire Diameter

Standard groove dimensions for 1015A
FR=BR=60% Wire Diameter
GD=30% Wire Diameter
GR=60% Wire Diameter

PART NO.				DIMENSIONS					
STYLE	Material	Shank Diameter	Tool Length	Hole Dia. H ± .0005	Foot Length FL ± .0005	Foot Width W ± .0002	Clearance C + .000 — .0005	Thickness T ± .0005	Suggested Wire Diameter
1015A-3 1016A-3	W = Tungsten Carbide TS = Tool Steel	1/16 3/32 1/8 or 3mm	S = .437 3/4 = .750 L = .828	.0045	.009	.0075	.004	.035	.003
1015A-4 1016A-4				.006	.012	.010	.004	.040	.004
1015A-5 1016A-5				.0075	.015	.0125	.004	.045	.005
1015A-6 1016A-6				.009	.018	.015	.004	.050	.006
1015A-7 1016A-7				.0105	.021	.0175	.004	.057	.007
1015A-8 1016A-8				.012	.021	.020	.004	.057	.008
1015A-10 1016A-10				.015	.021	.025	.004	.057	.010
1015A-12 1016A-12		3/32 1/8 or 3mm		.018	.030	.030	.006	.088	.012
1015A-14 1016A-14				.021	.032	.035	.006	.088	.014
1015A-16 1016A-16				.024	.032	.040	.006	.088	.016

HOW TO ORDER: STYLE — MATERIAL — SHANK DIAMETER — LENGTH. EXAMPLE: 1015A-3-W-1/16-L
FOR MODIFICATION TO STANDARD TOOLS, USE PART NO. AND SPECIFY MODIFIED DIMENSIONS.