Wire Bond Introduction

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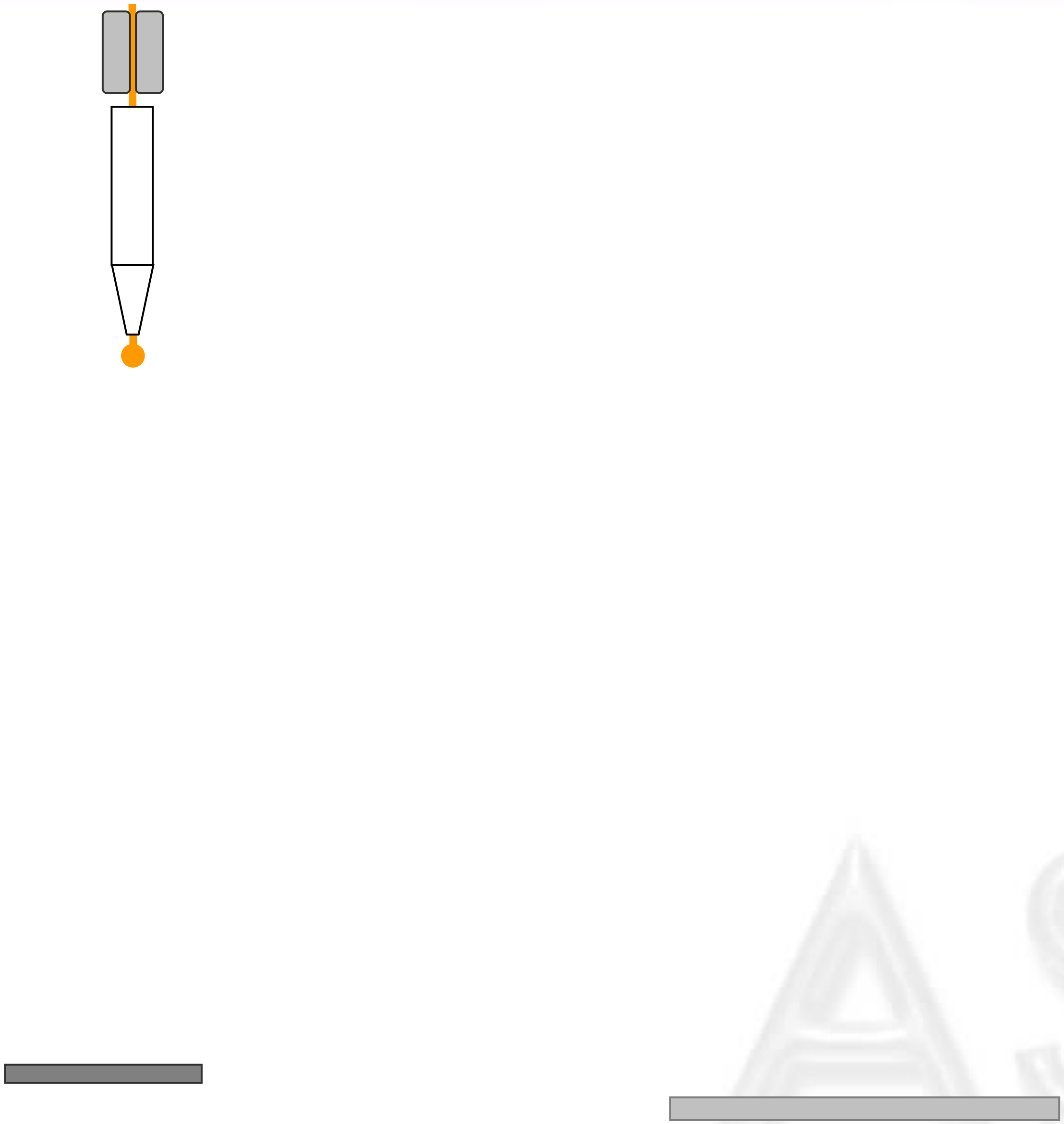
Wire Bond (Bonding Sequence)



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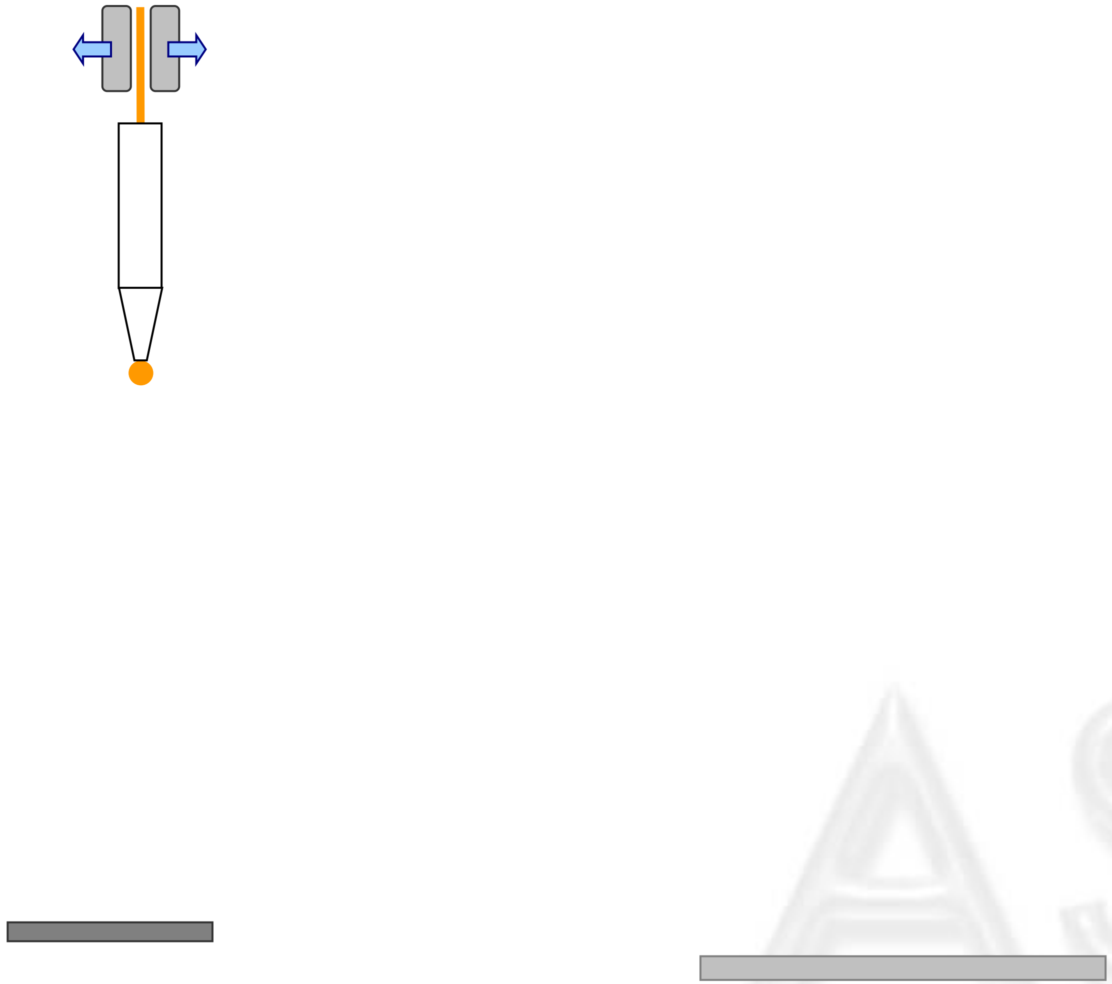

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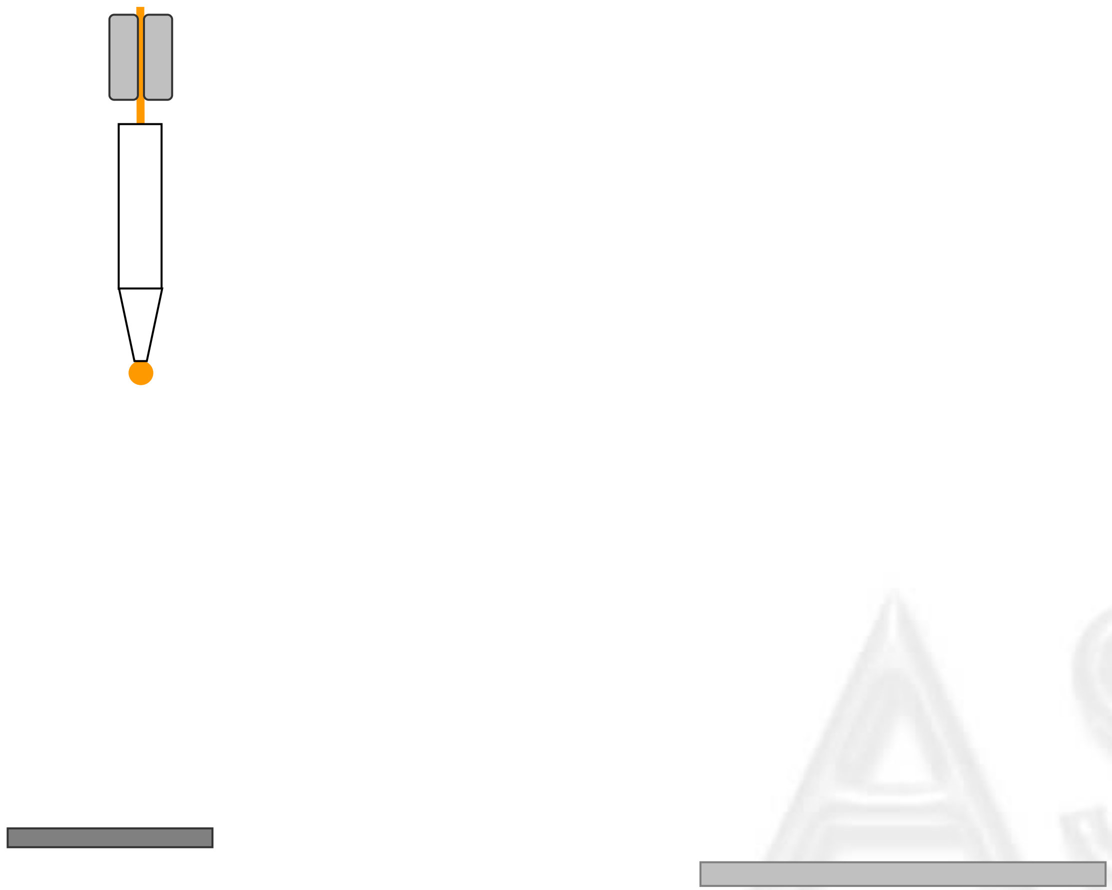

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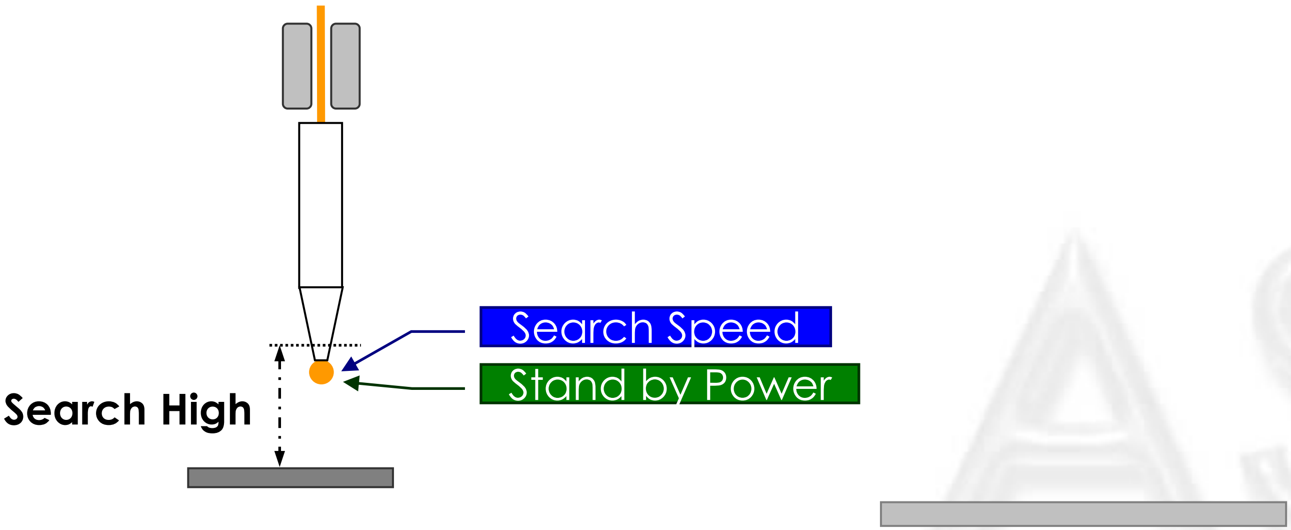

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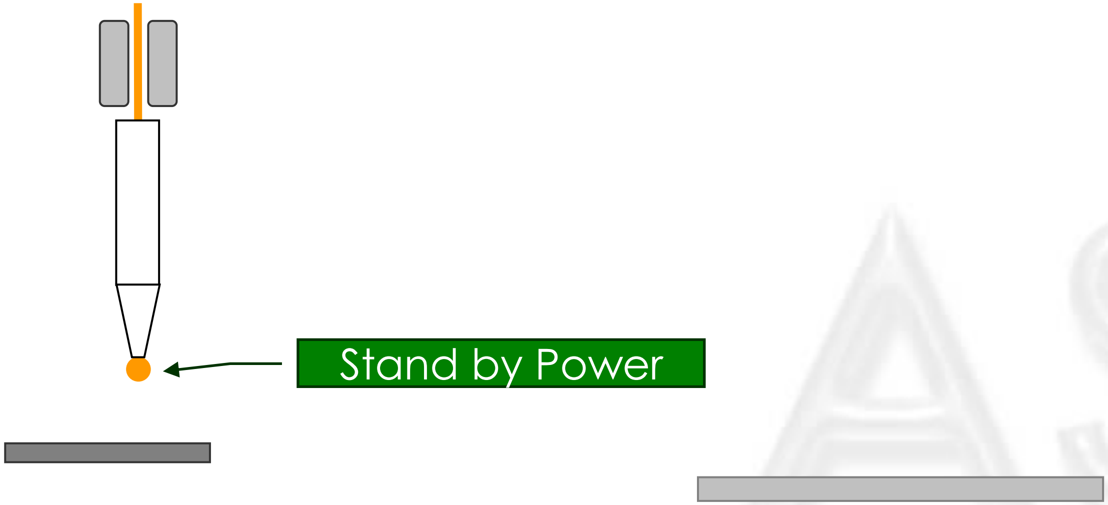

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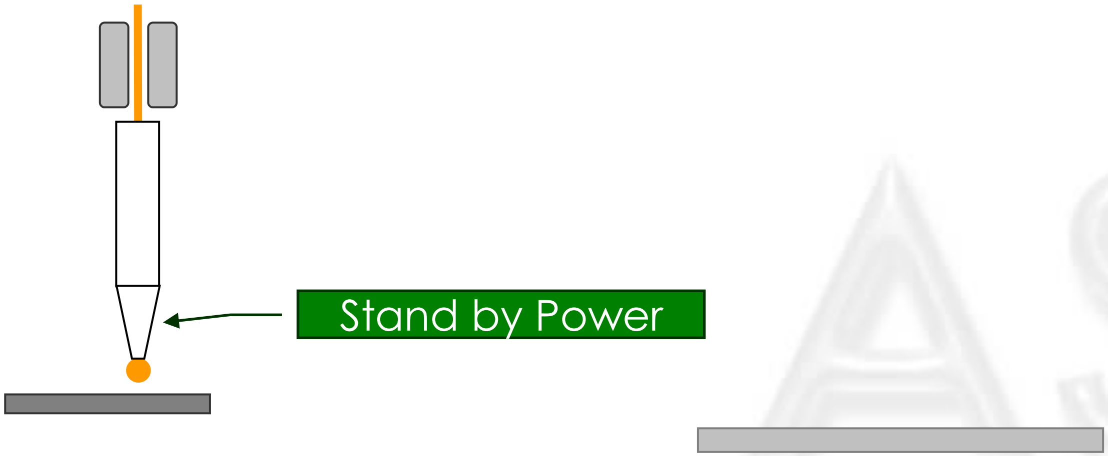

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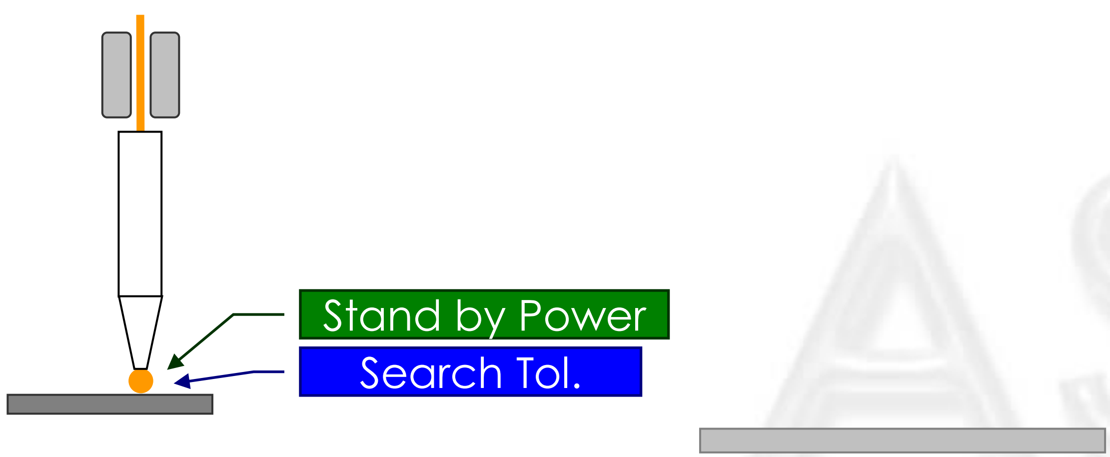

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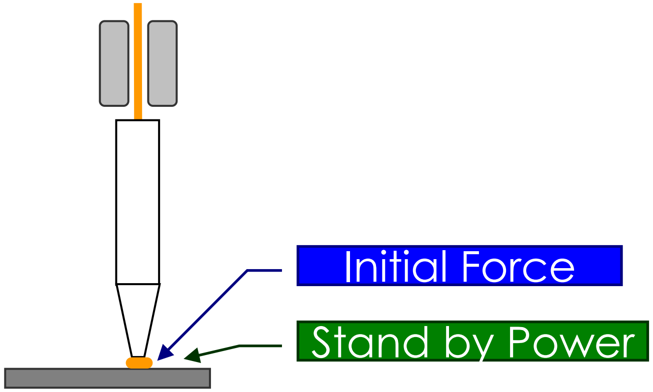

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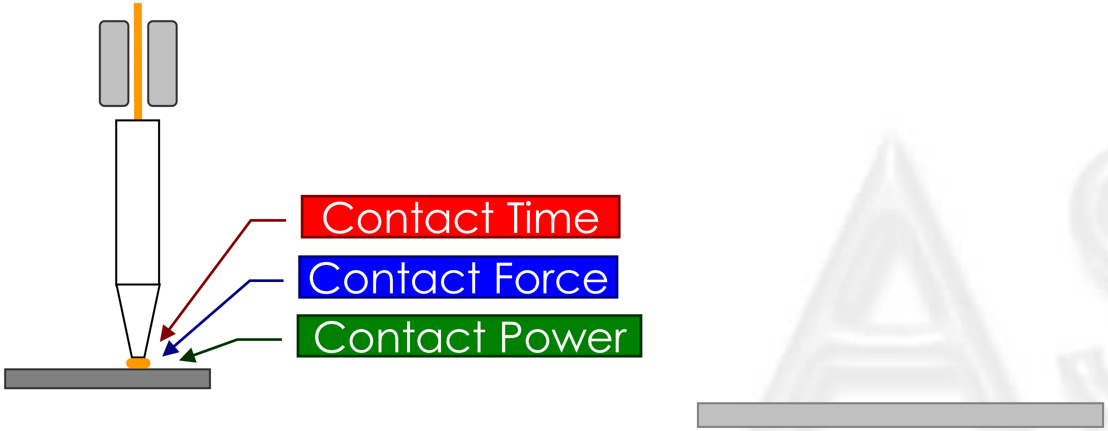

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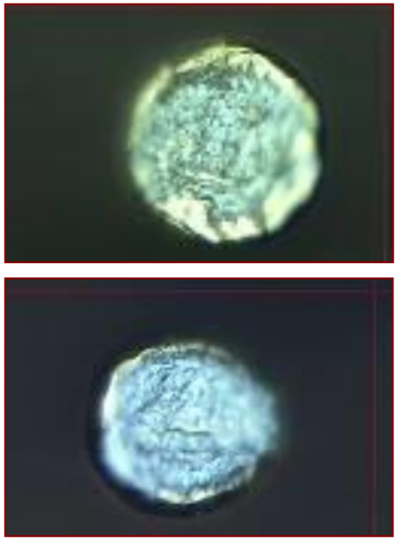

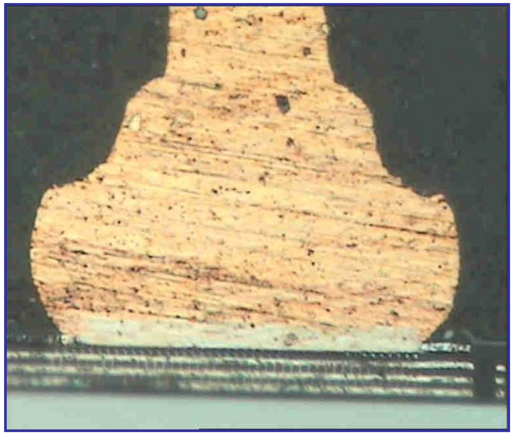

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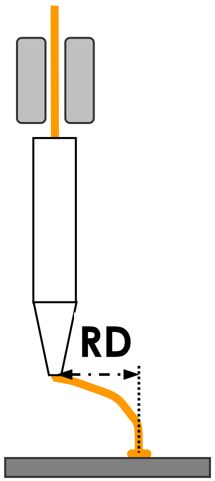

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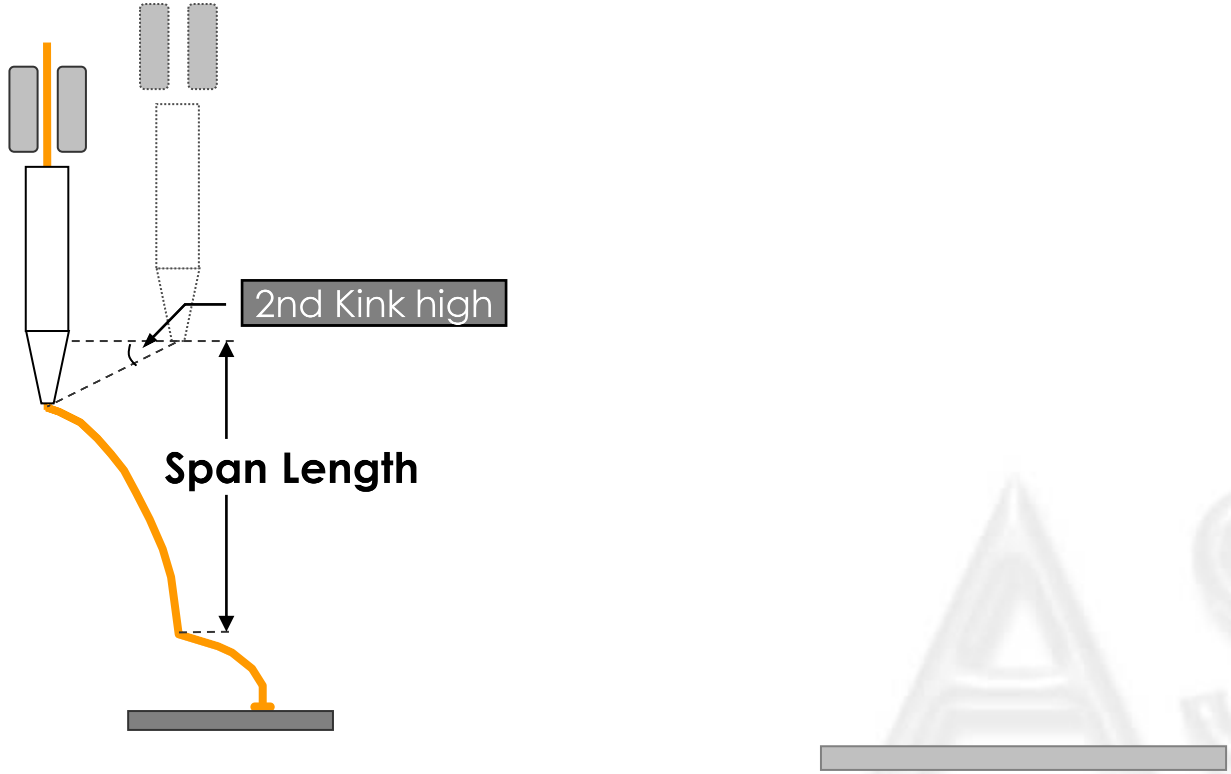

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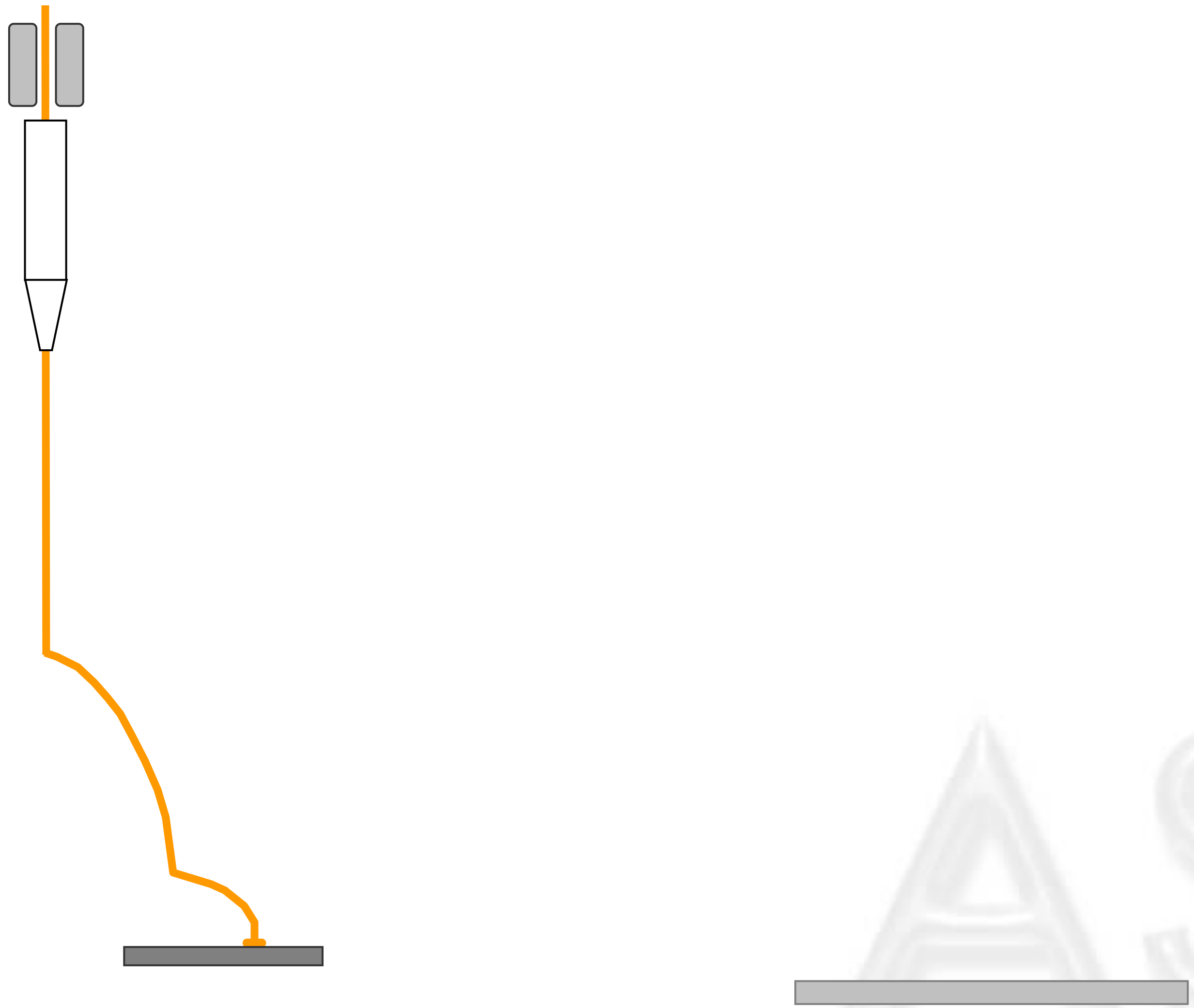

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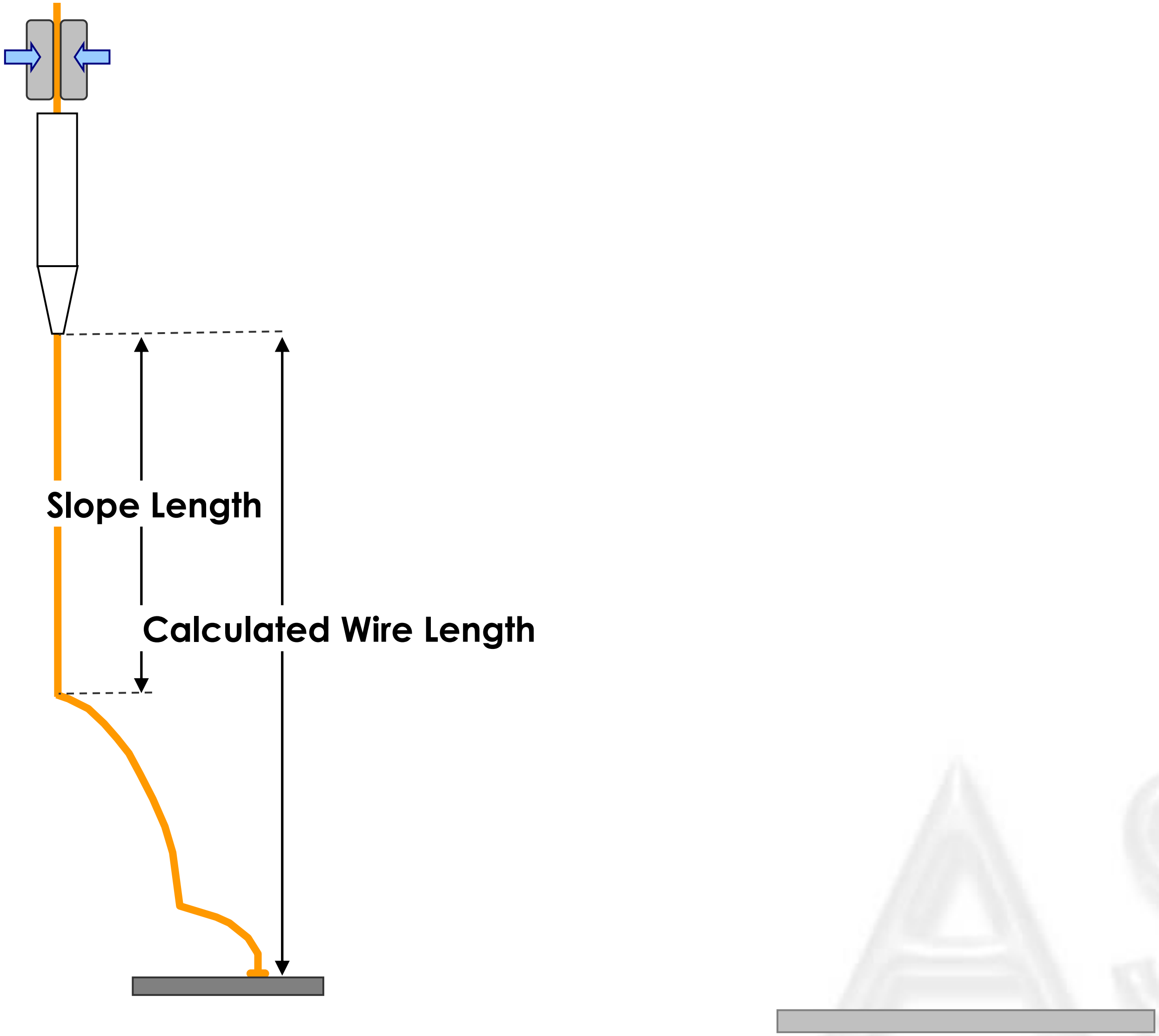

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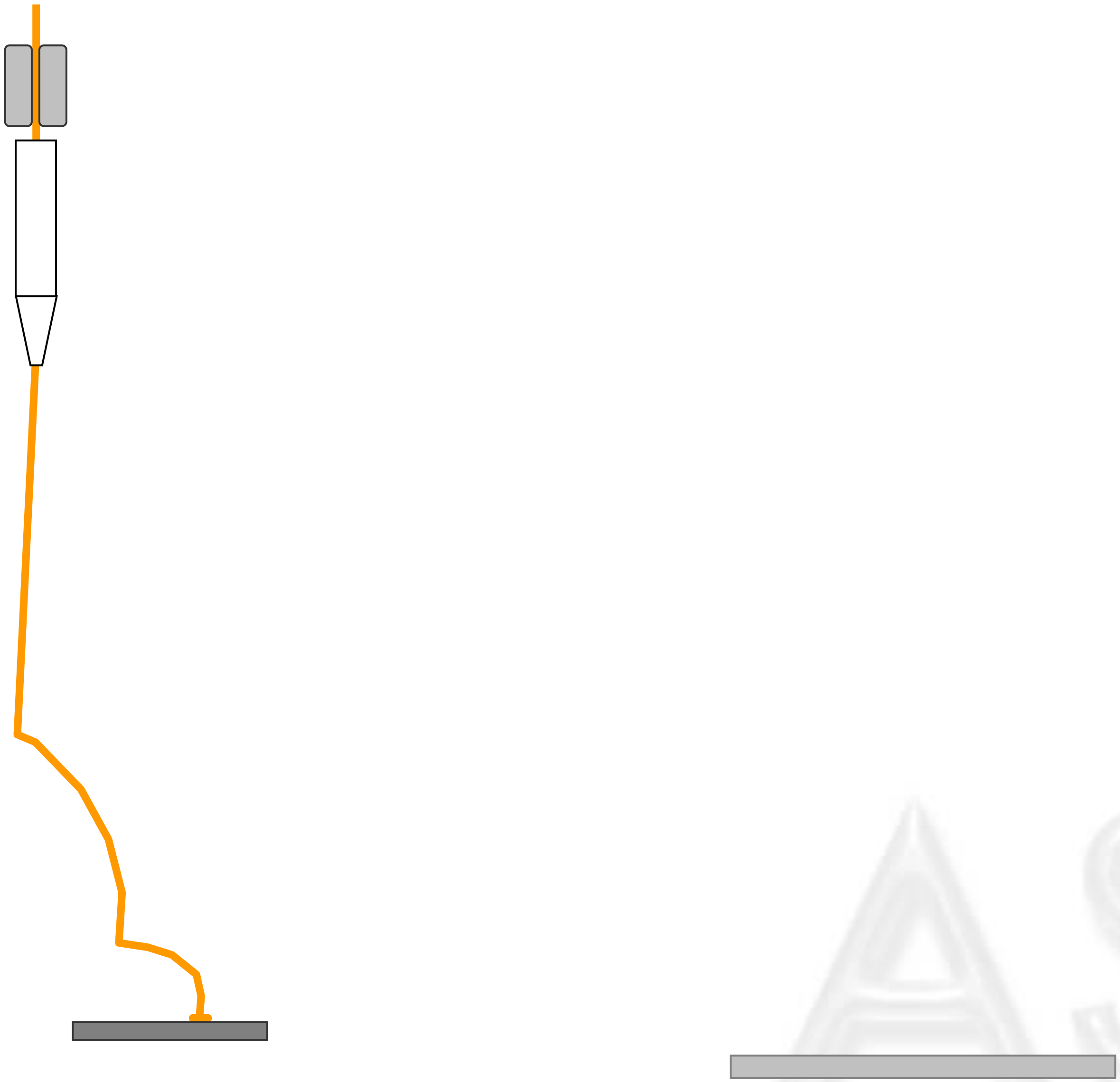

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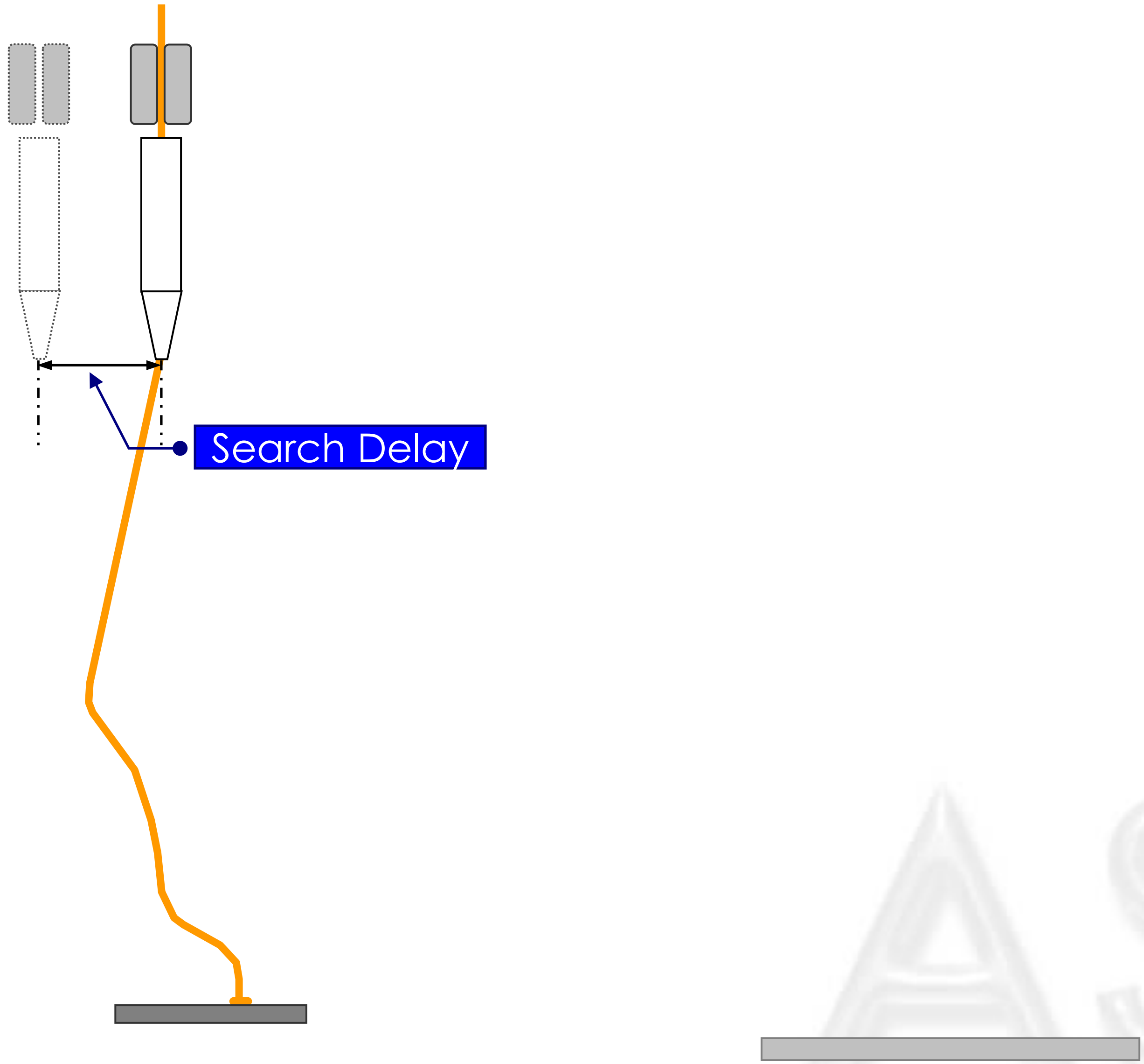

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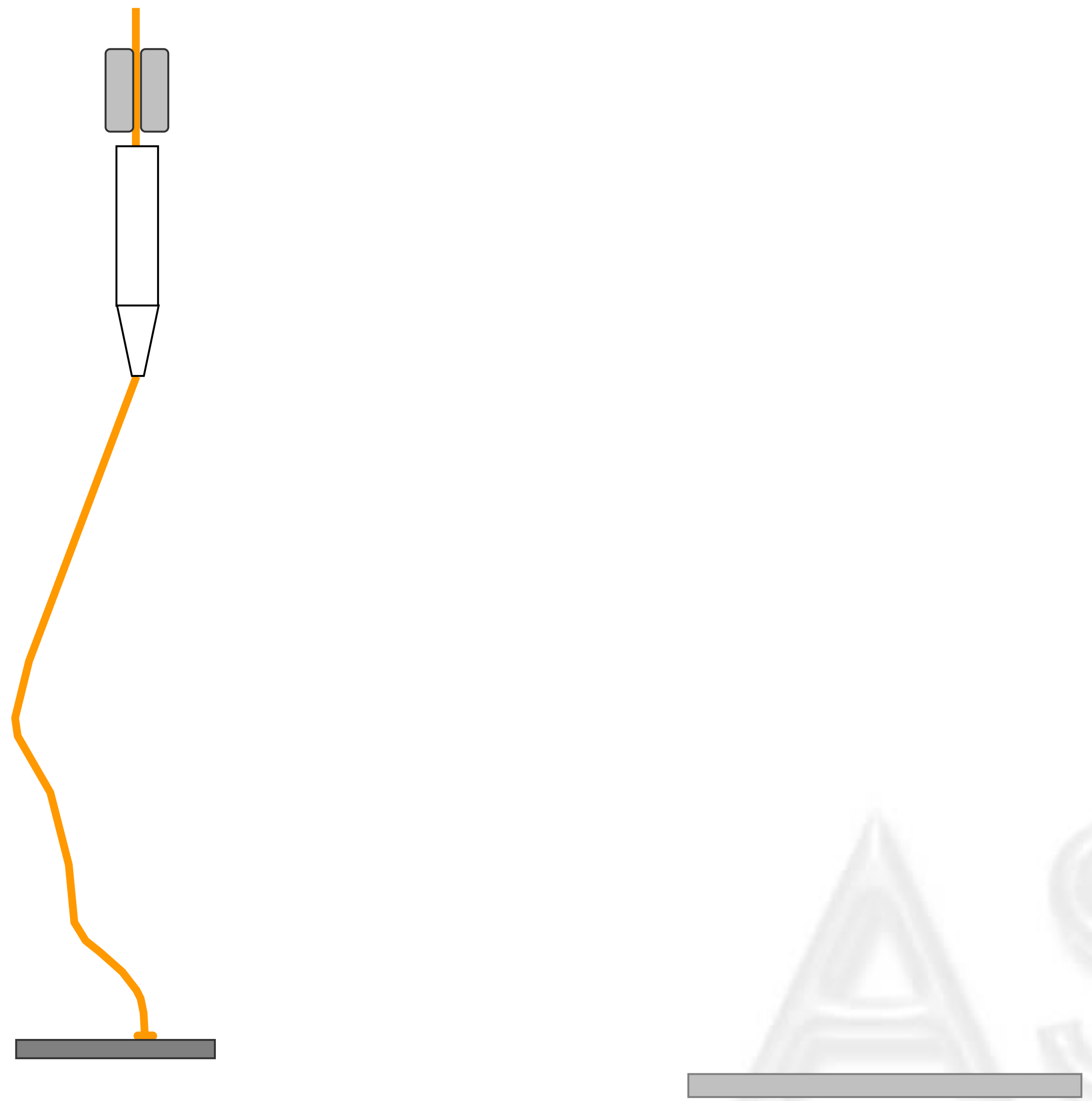

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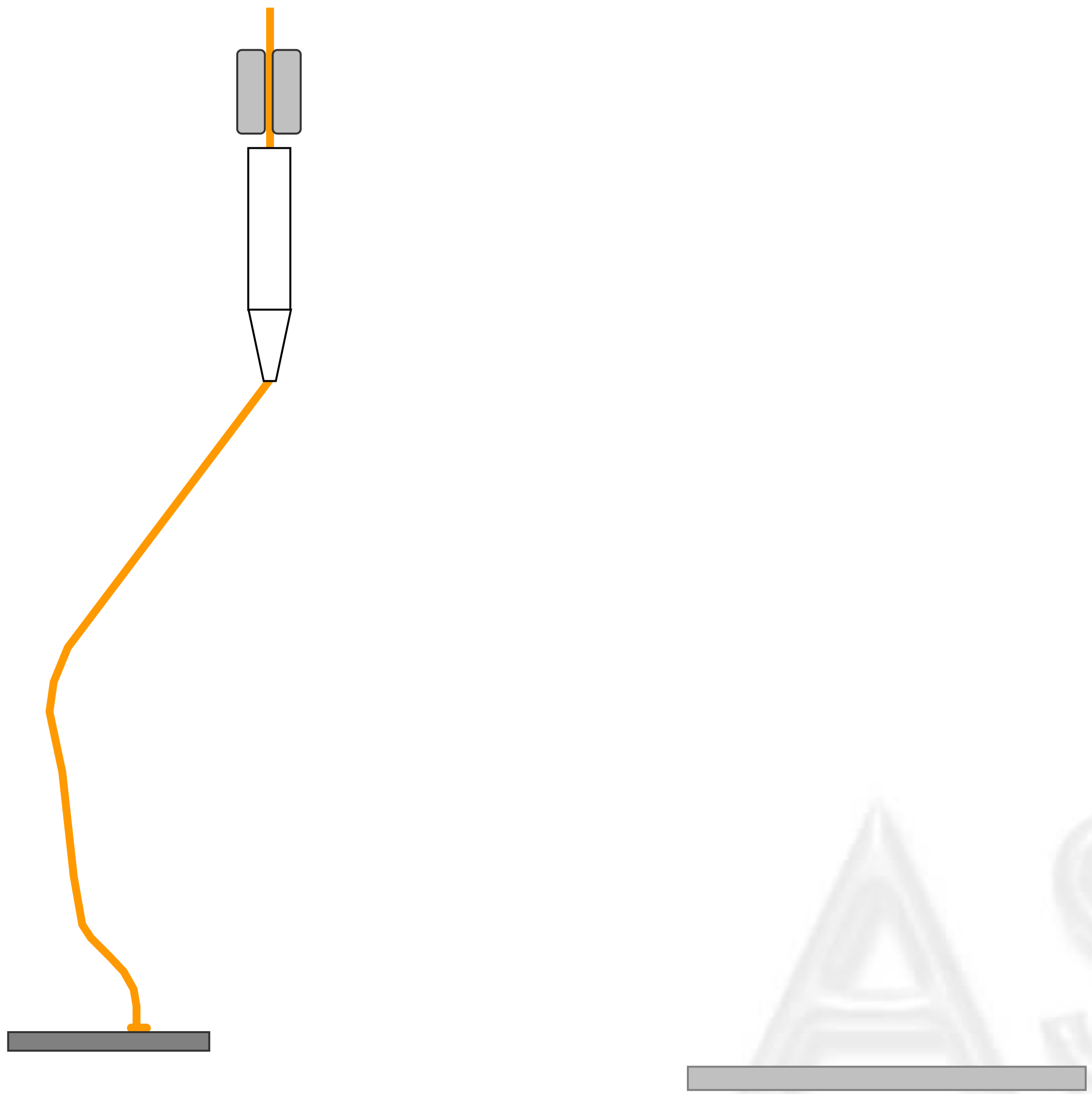

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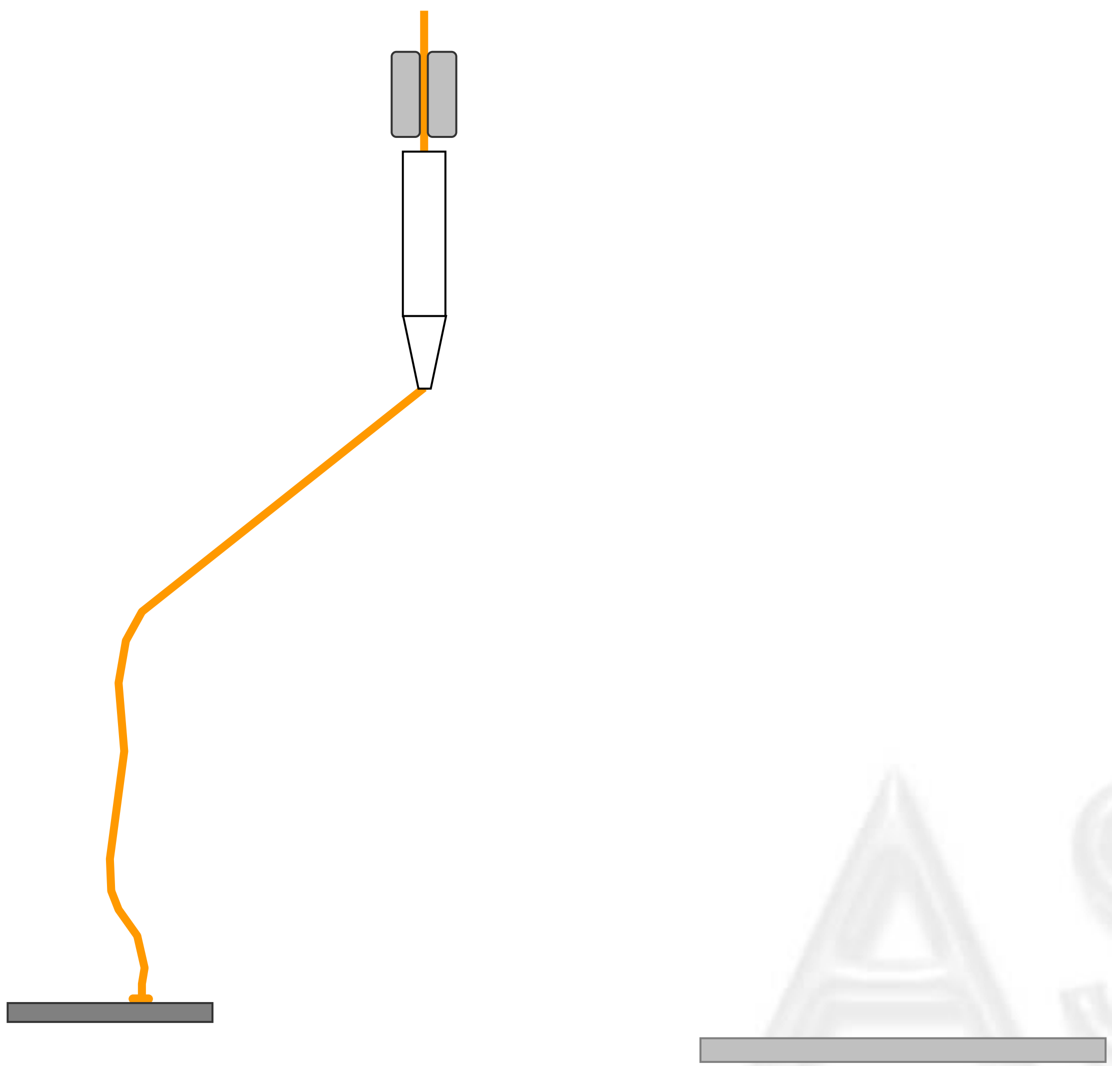

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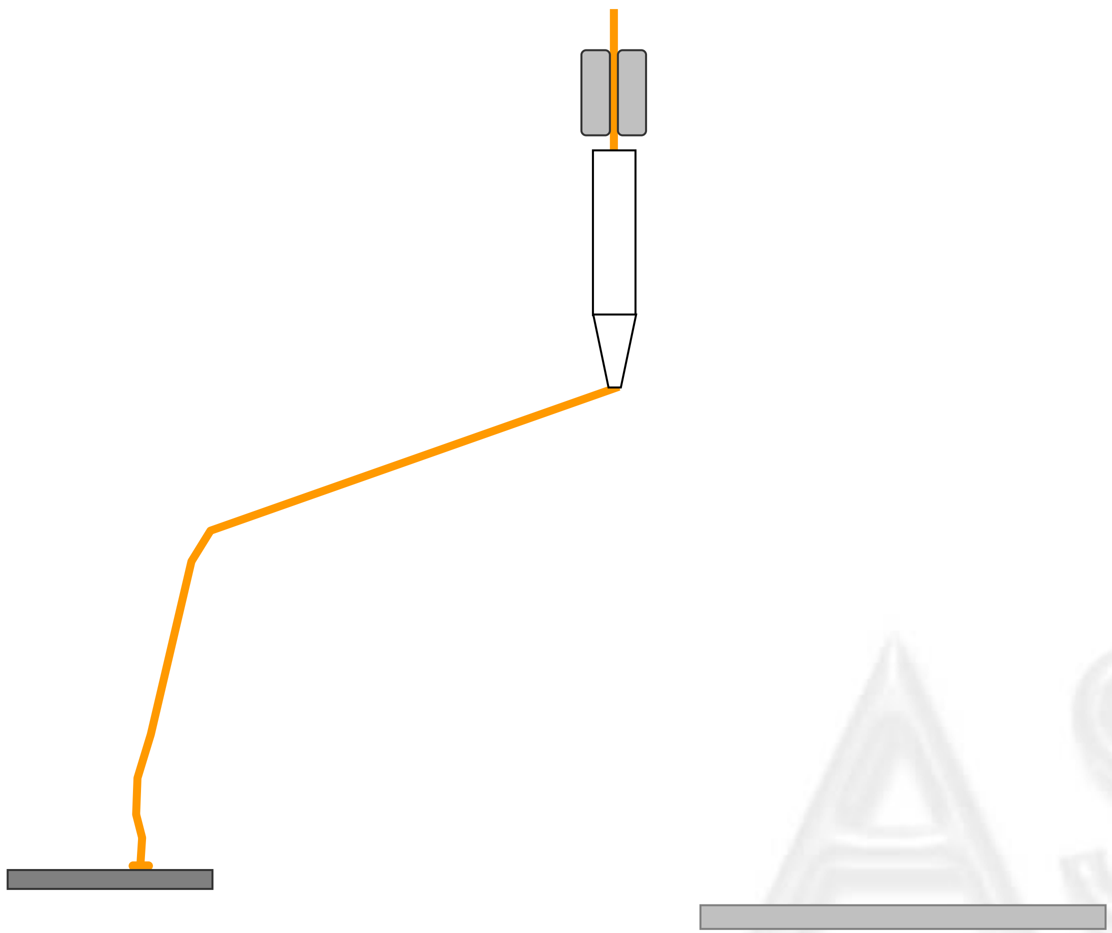

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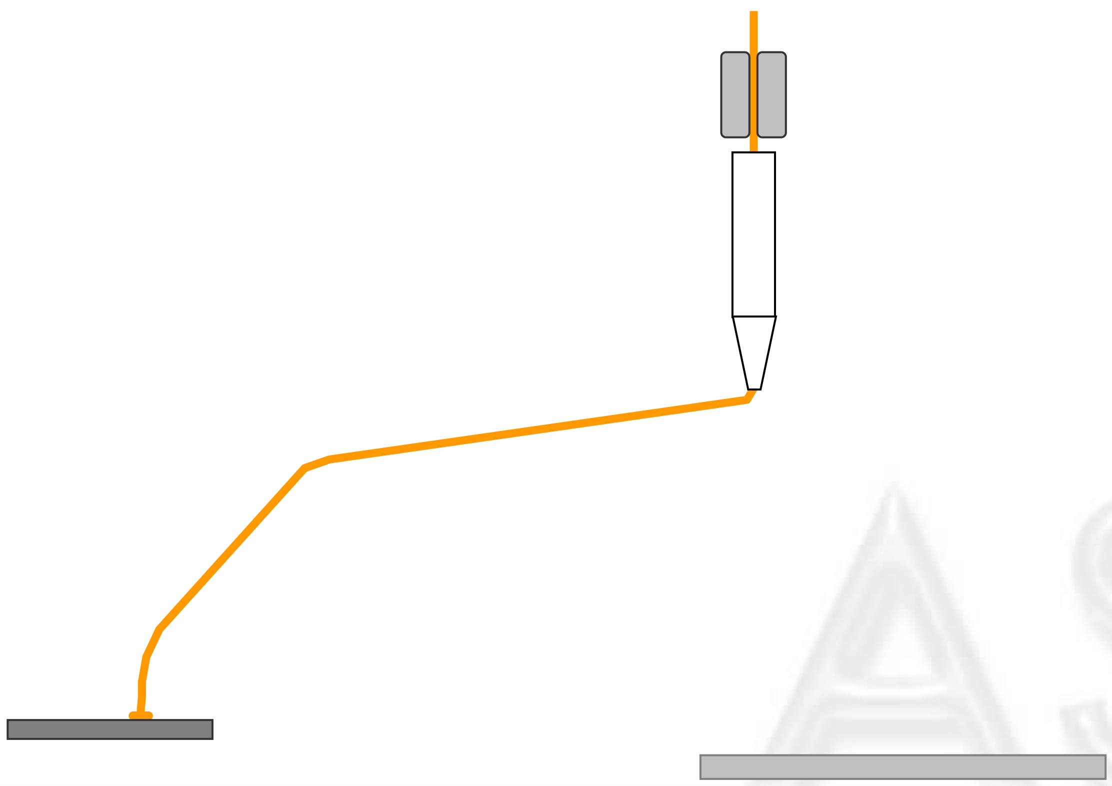

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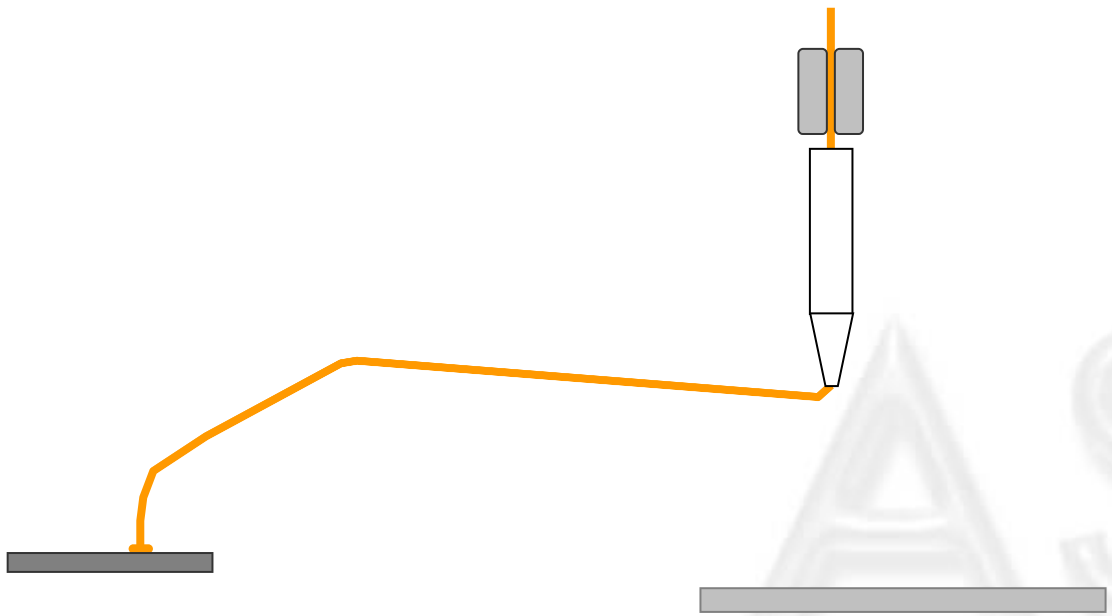

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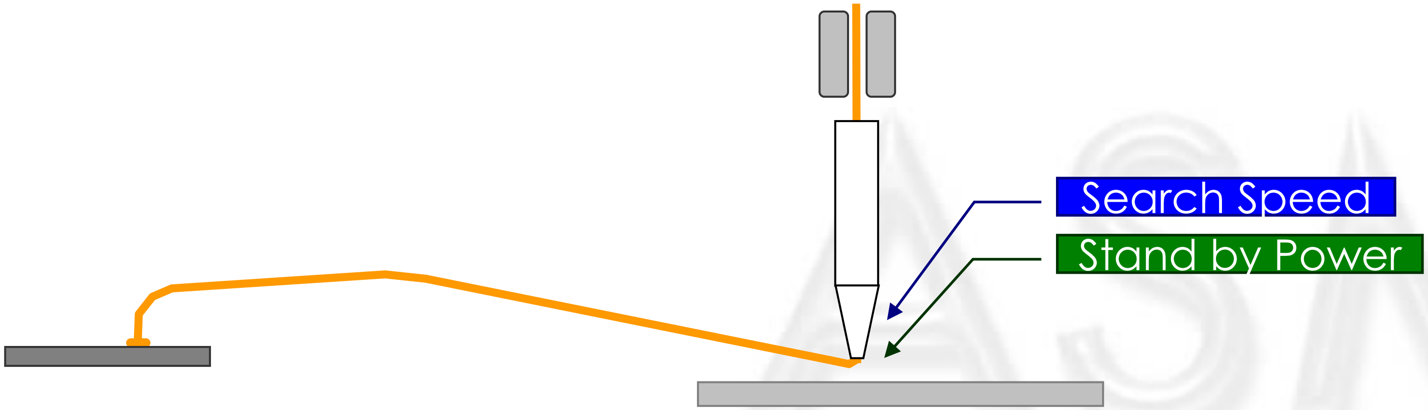

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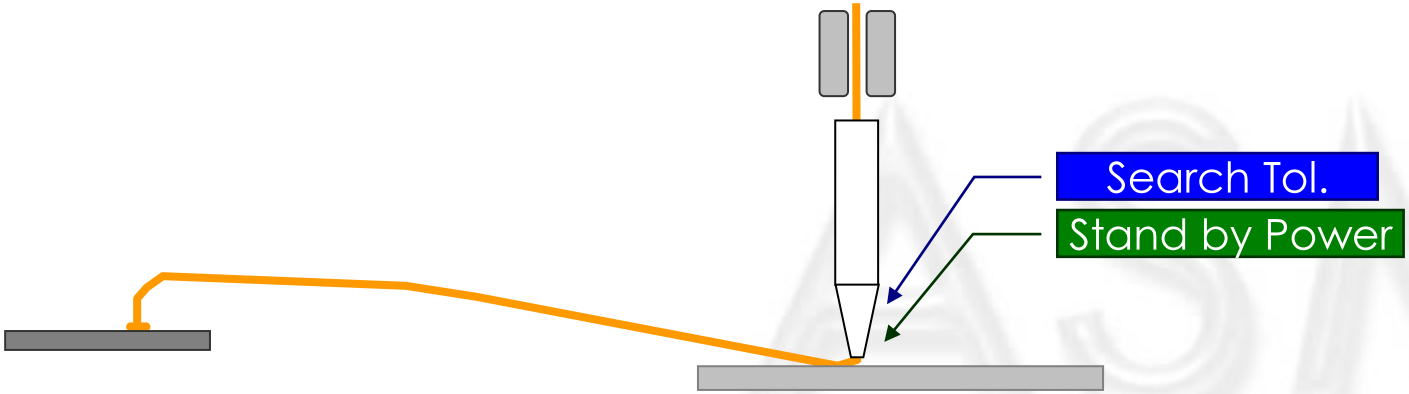

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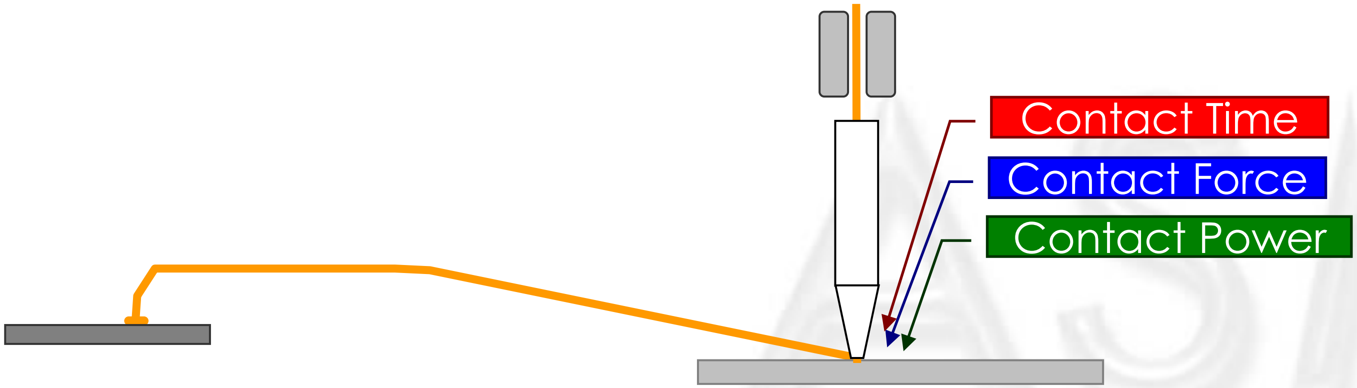

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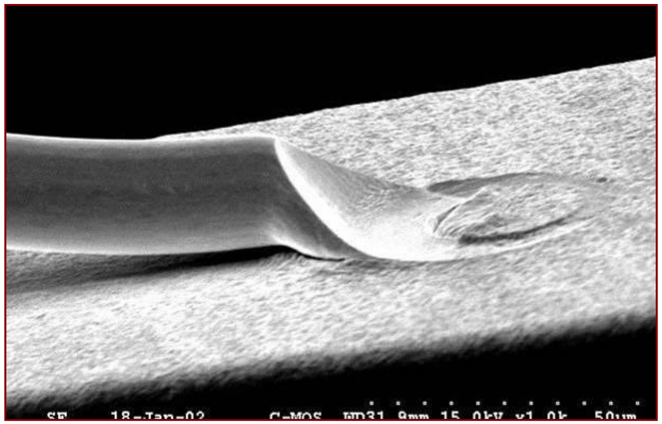

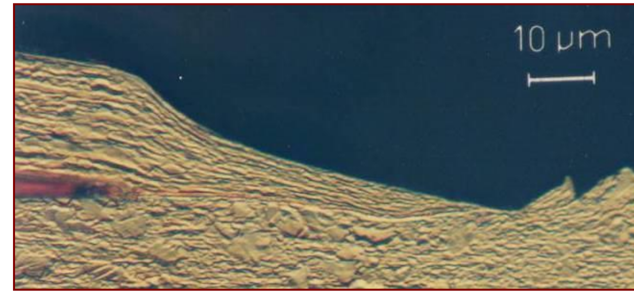

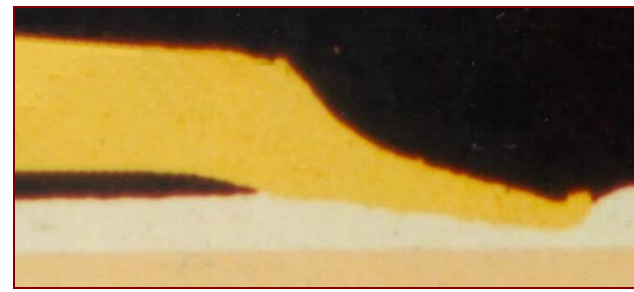

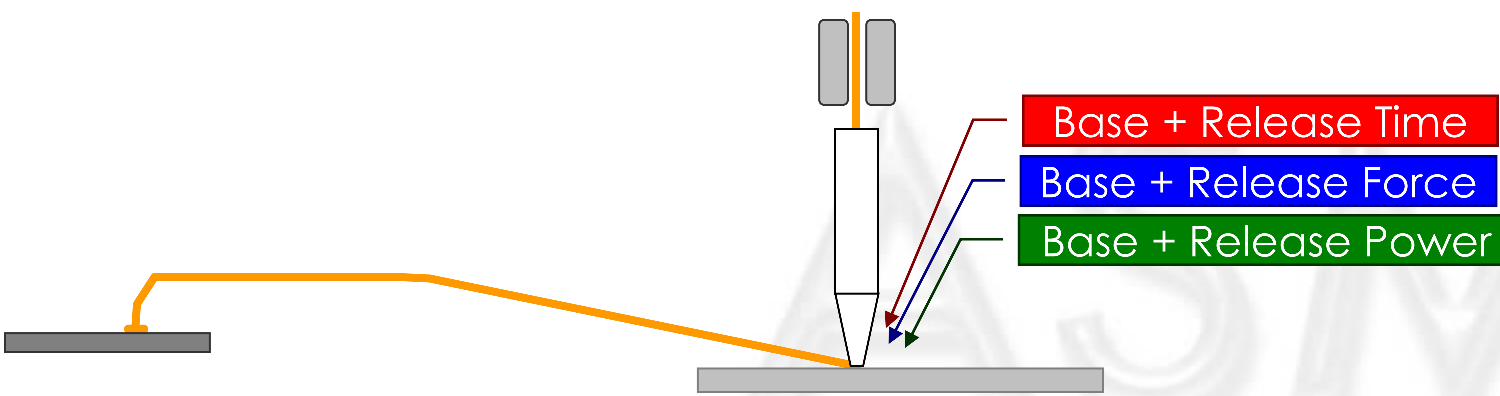

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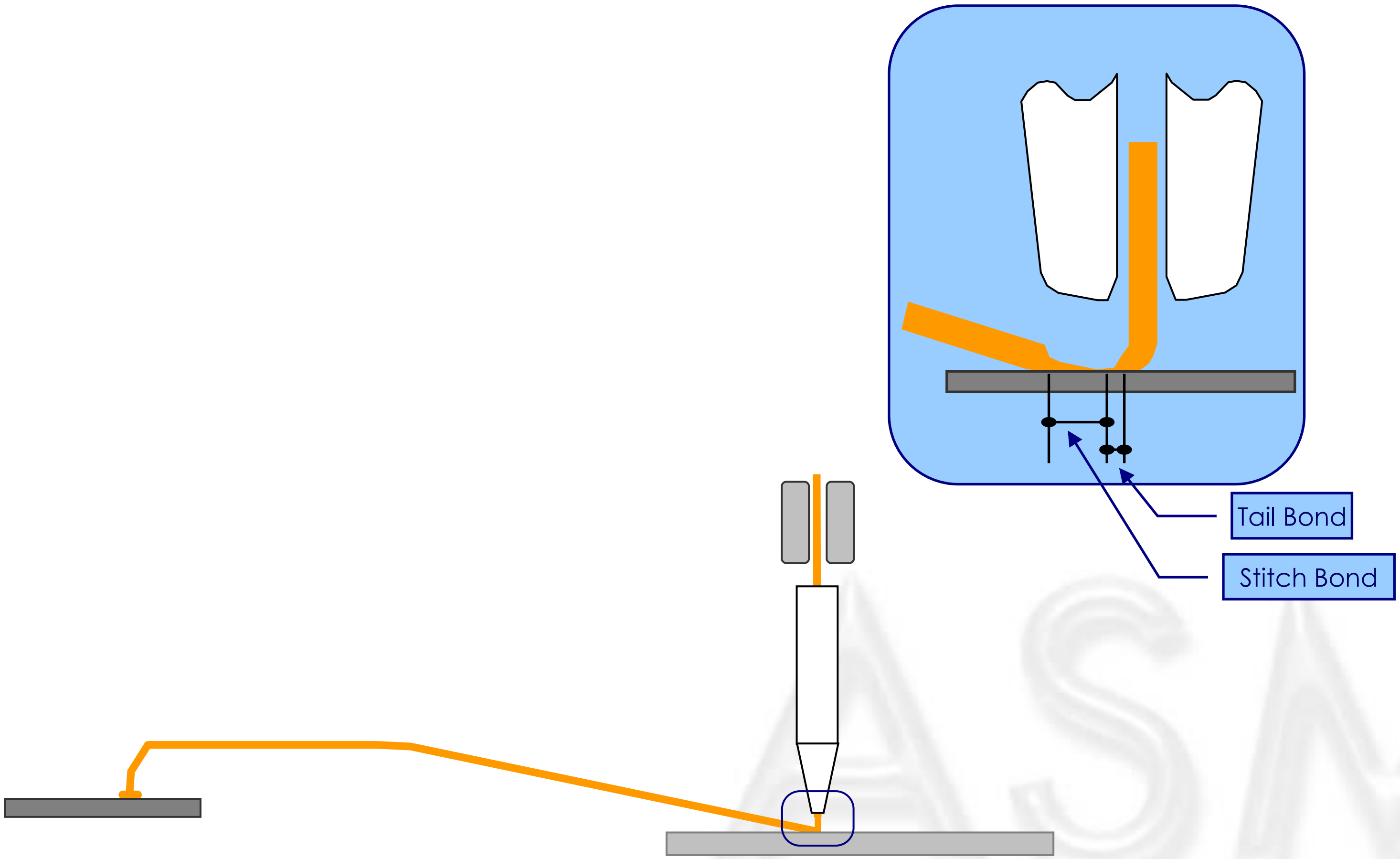

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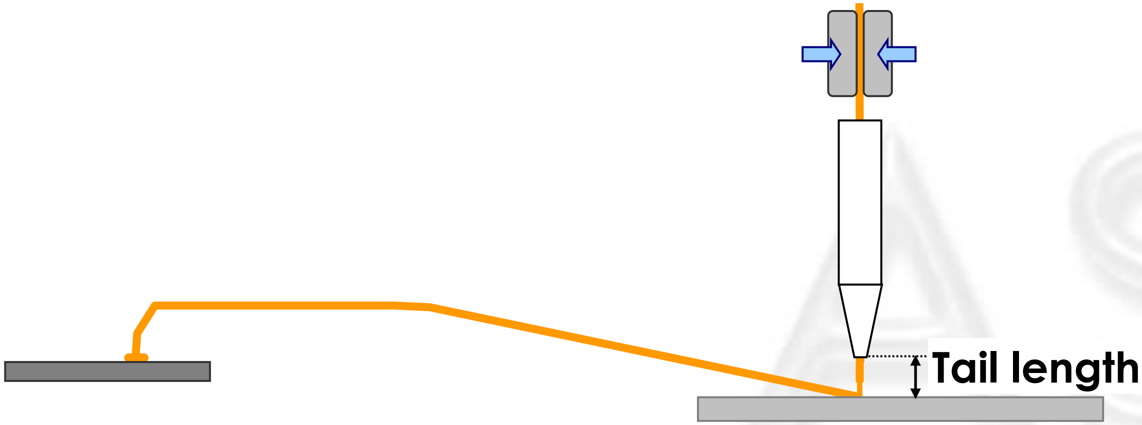

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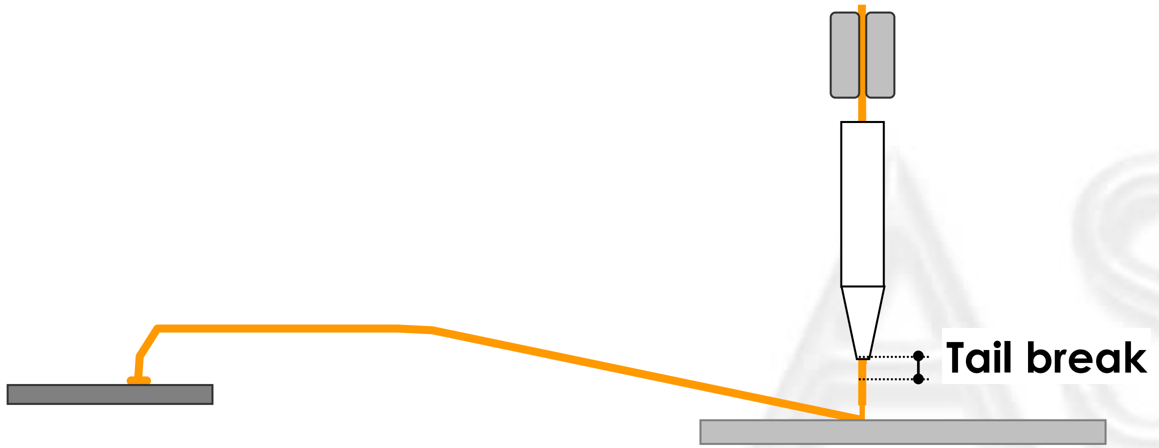

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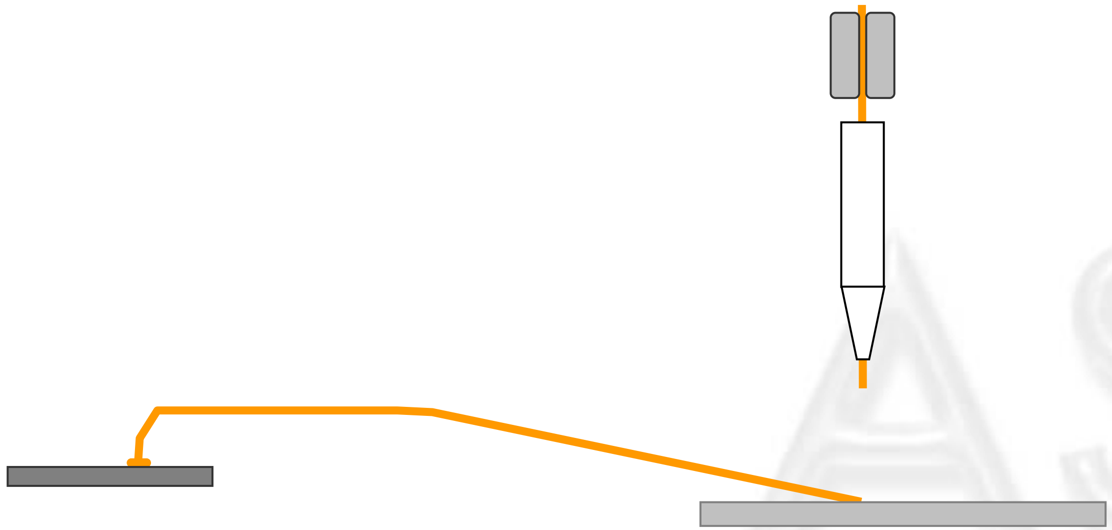

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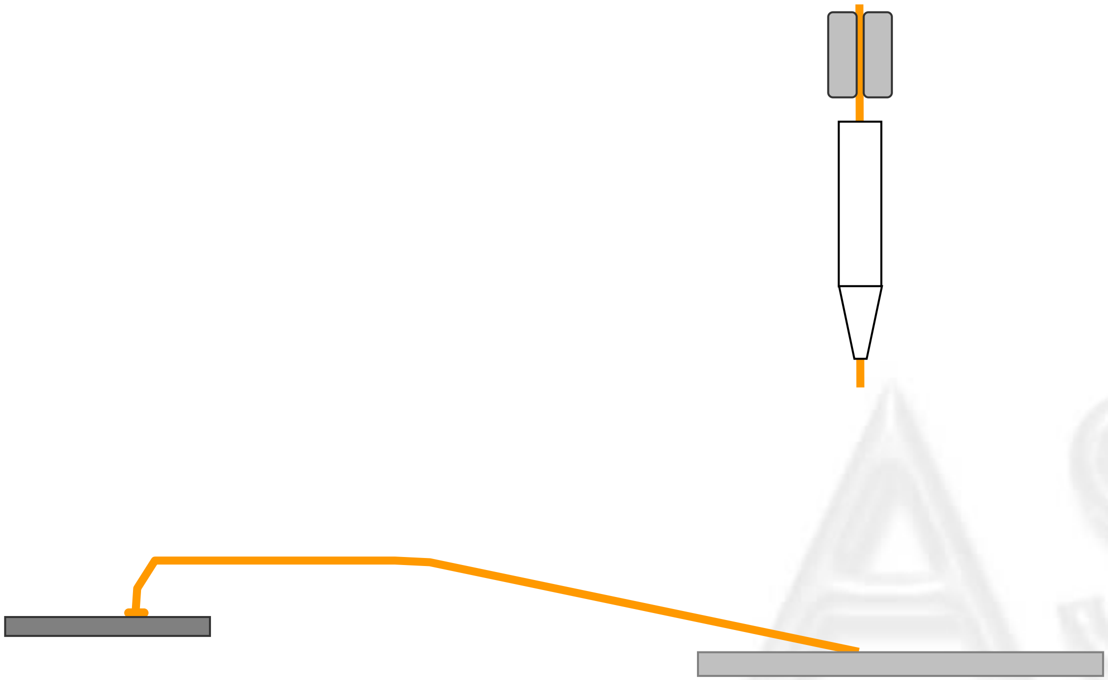

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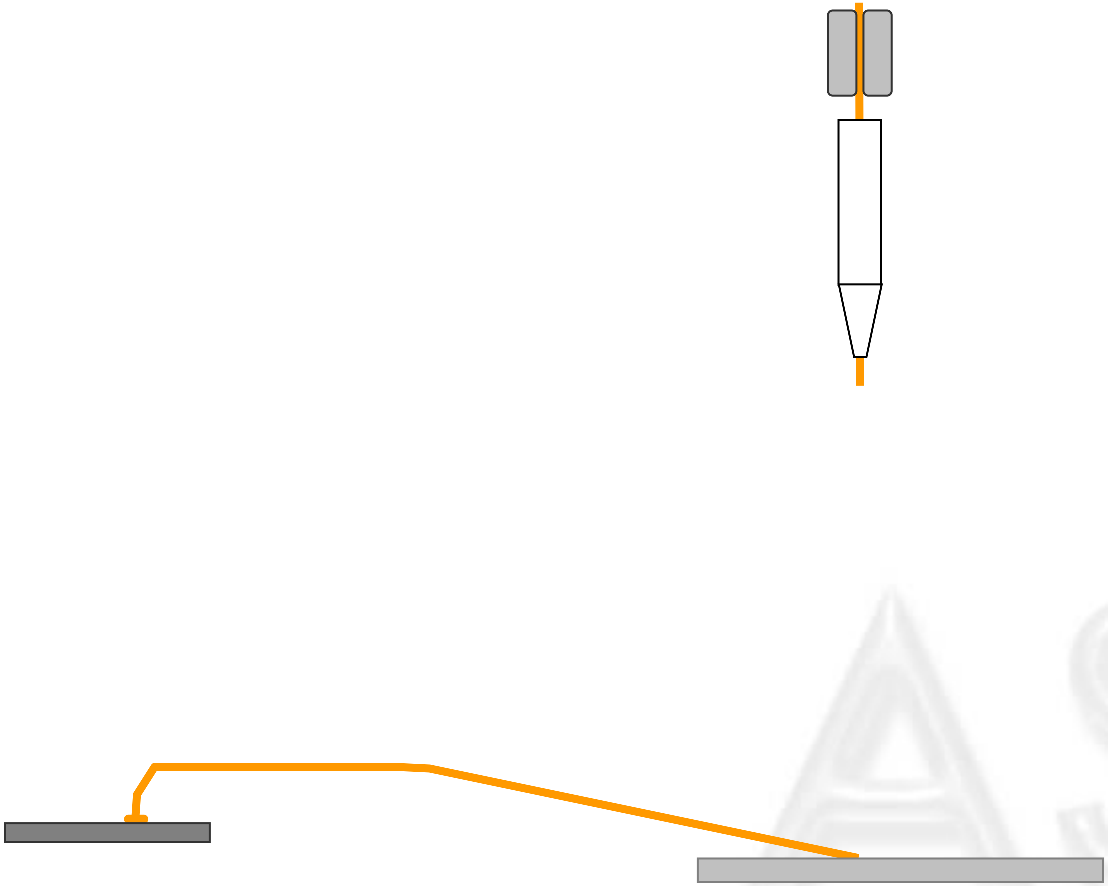

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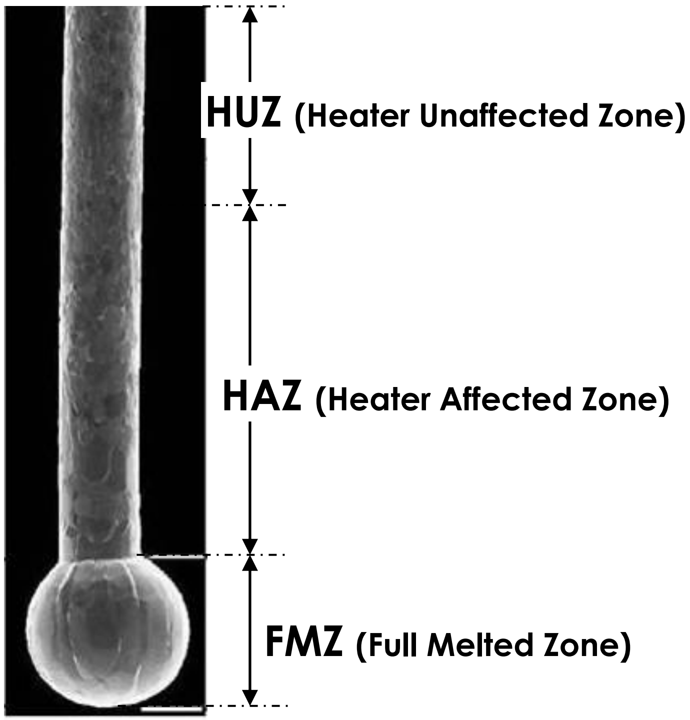
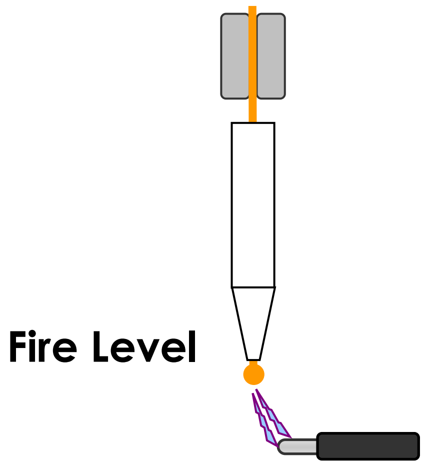
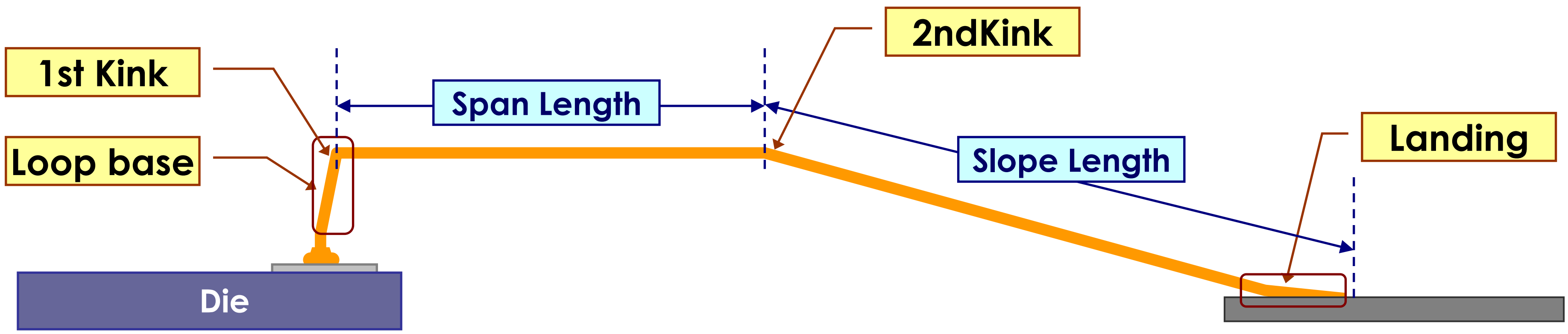
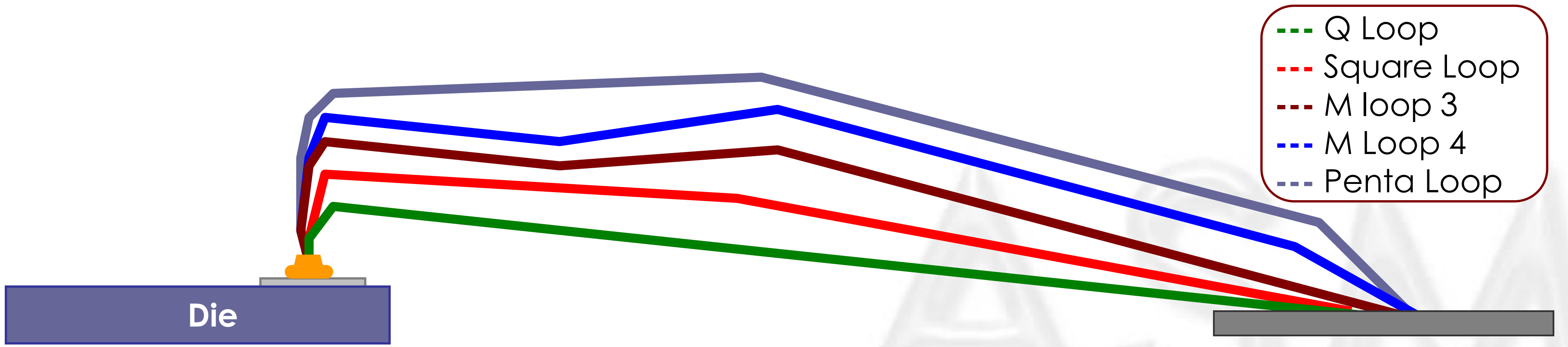




Wire Bond (Looping)

Follow bonding





Wire Bond (Loop Mode)

- **Q_loop**
  - WL: 0.05mm~1.7mm
  - High bonding speed
  - Looping strength is low

- **Penta loop**
  - WL: 1.5mm~5.5mm
  - Looping strength is middle
  - To avoid landing touch finger (Lead)
  - Span length over 70~85%

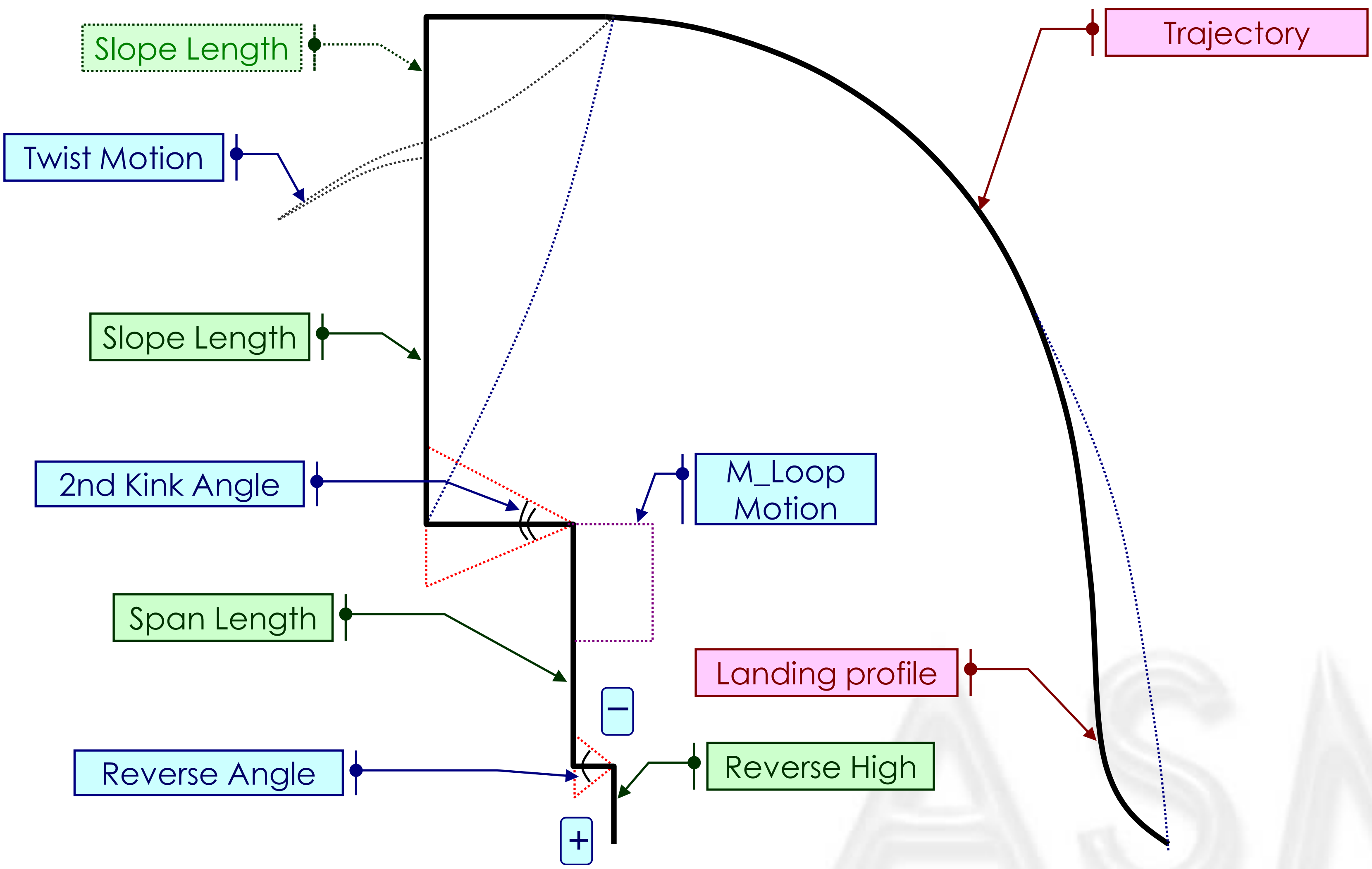
- **M_loop 3**
  - WL: 1.5mm~5.5mm
  - Looping strength is high
  - To provide stronger support on span length
  - Low loop with long wire
    - 100um loop high with 3.5mm WL

- **Square loop**
  - WL: 0.8mm~3.5mm
  - Looping strength is middle
  - To avoid touch die edge
  - Span length over 70% is limitation

- **M_loop 4**
  - WL: 1.5mm~5.5mm
  - Looping strength is high
  - To provide stronger support on span & slope length
  - Low loop with long wire
    - 120um loop high with 4.2mm WL

• Condition for WL is 0.8mil WD with 200umm loop high

Wire Bond (Loop Profile)



Wire Bond (Bonding Mode)

ASM
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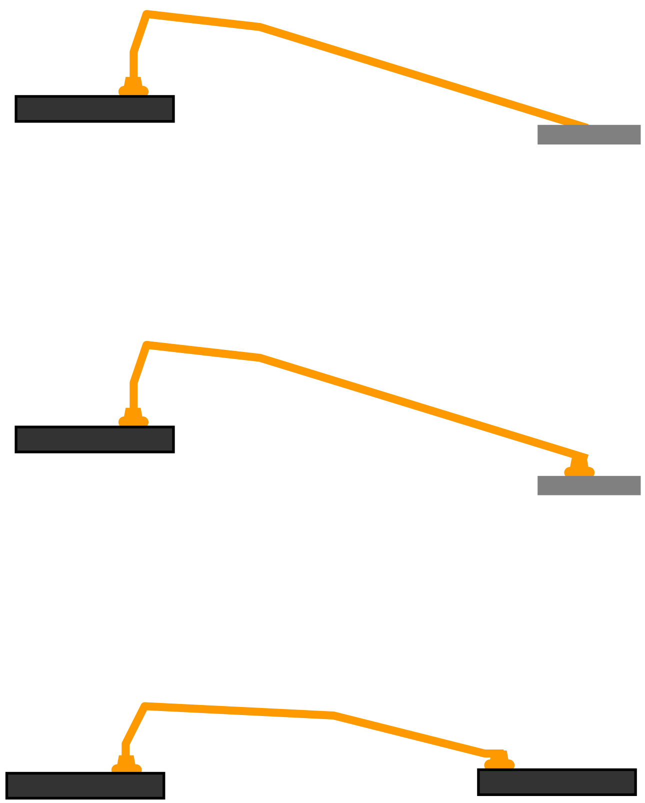
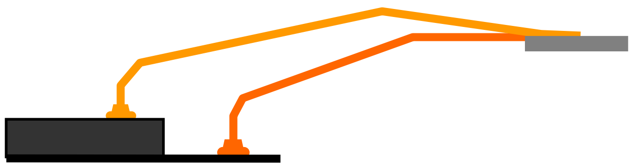
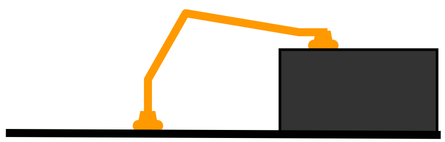


- **Follow Bonding**
  - 1st bond level is higher than (the same as) 2nd bond
    - Normal bonding
      - It is general bonding mode on wire bond
        - From die to finger
    - BSOB (Bond Stitch On Ball) Bonding
      - To cover finger contamination issue
      - Major application is for QFN with tape
      - Die to Die application

Wire Bond (Bonding Mode)





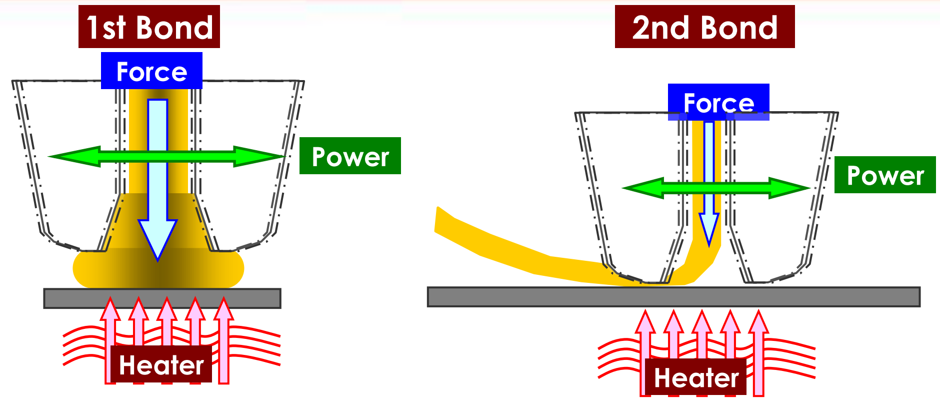
- **Reverse Bonding**
  - 1st bond level is lower than 2nd bond
    - Normal bonding
      - Form die to lead/ from GND to lead
    - BSOB (Bond Stitch On Ball) Bonding
  - From GND (lead) to Die

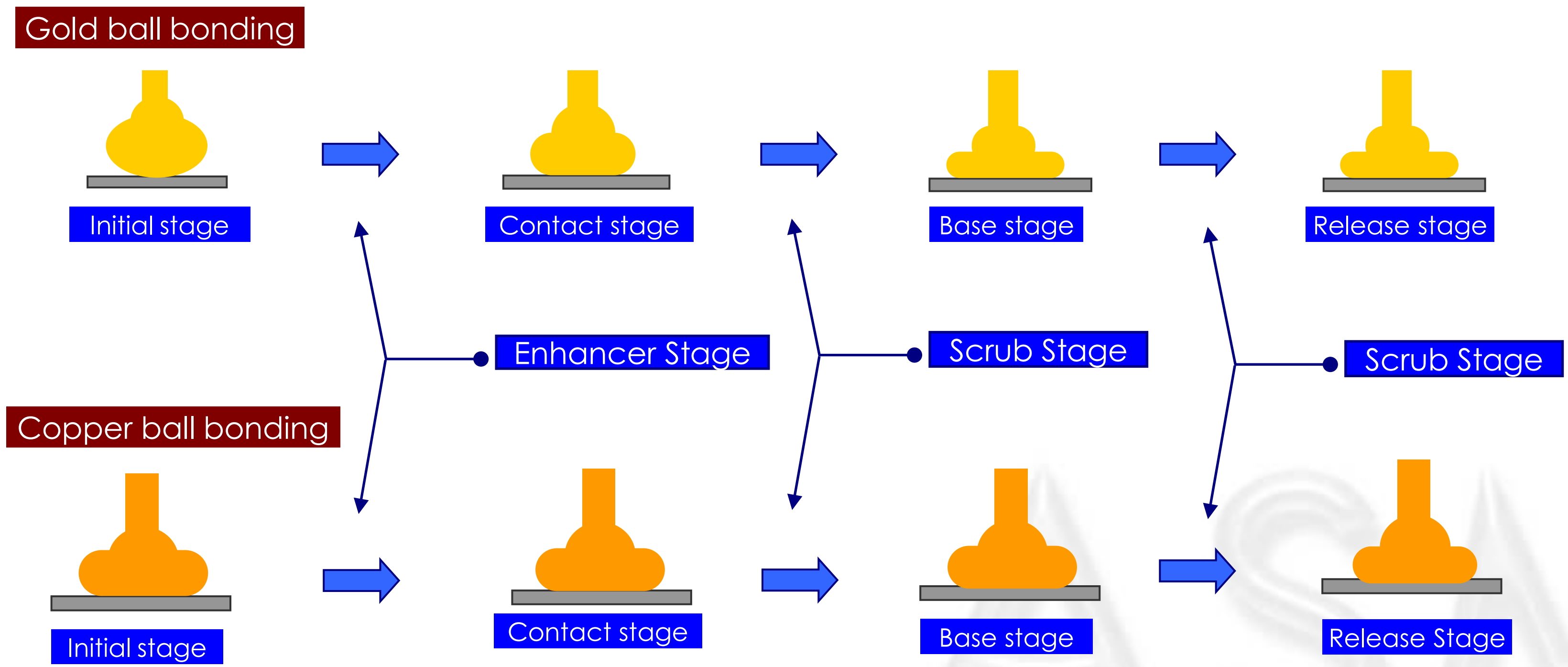
- **BBOS (Bond Ball On Stitch)**
  - Enhance stitch pull
  - Reduce the risk to cause wire sweep/ NSOL/ short tail
    - Due to the platform of standoff ball is unevenness

- **BSOS (Bond Stitch On Stitch)**
  - Enhance stitch pull
  - Reduce wire usage amount

Bonding

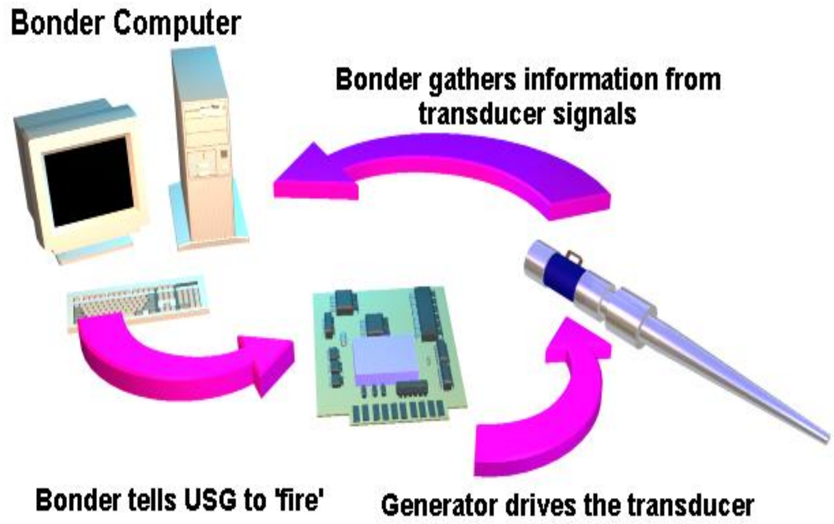
- **Bonding condition**
  - Pressure (Force)
  - Ultrasonic energy (Power)
  - Bonding time (time)
  - Heater (Temp.)

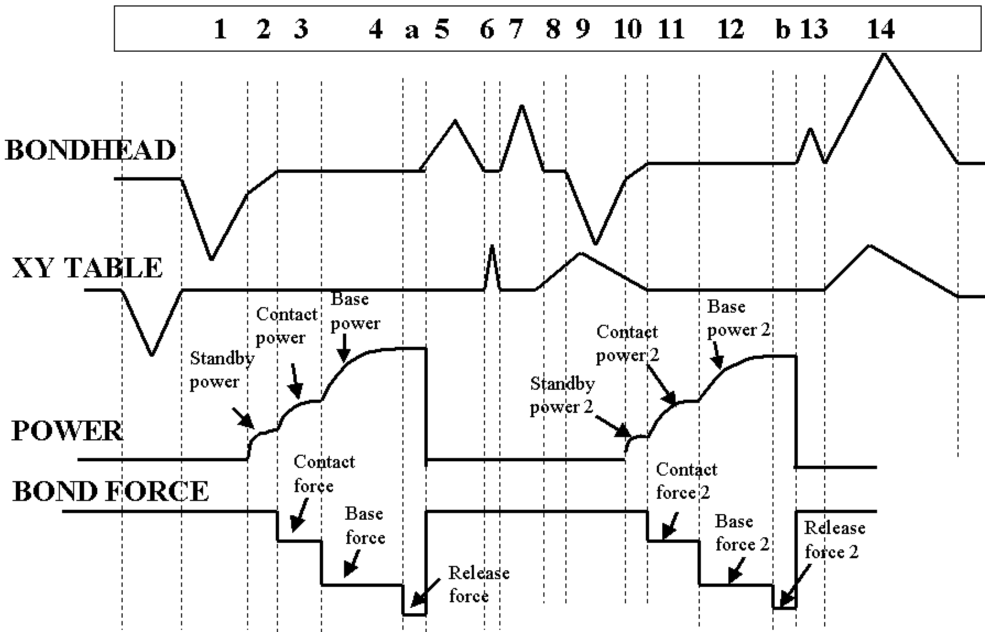


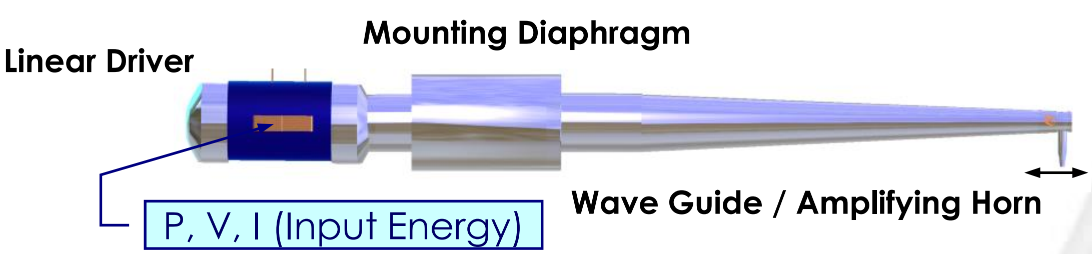


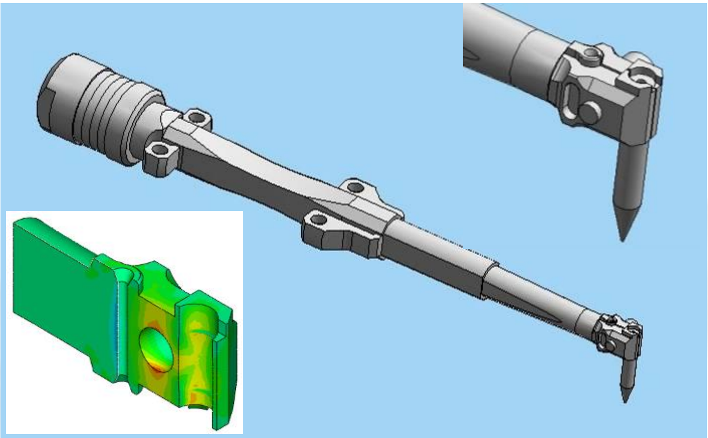
Bonding (Ultrasonic)

- **Transducer**
  - Quartz/ PZT





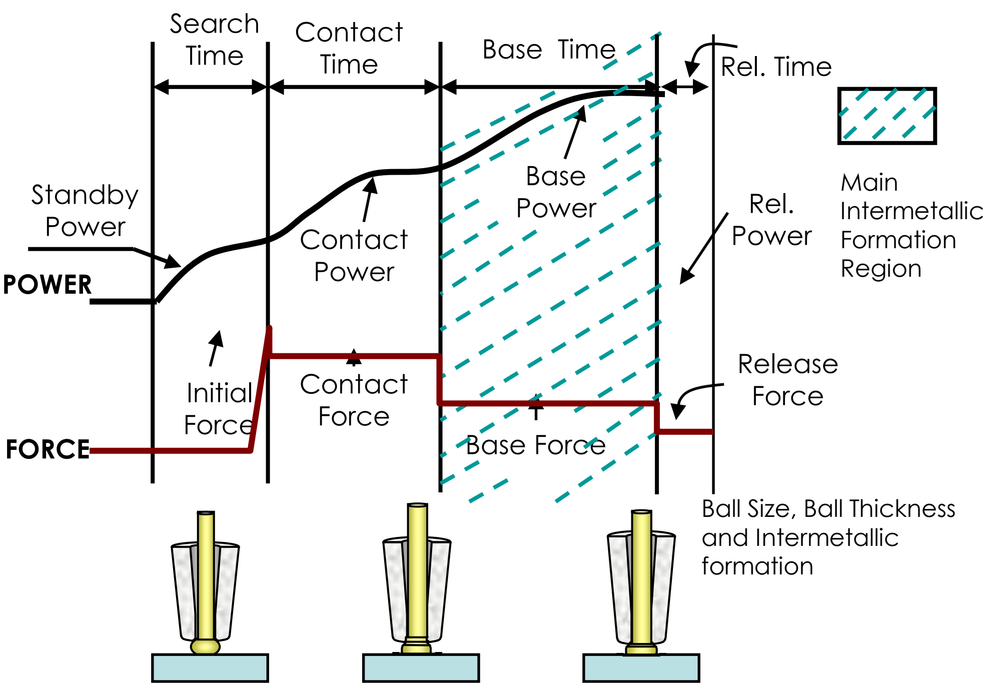


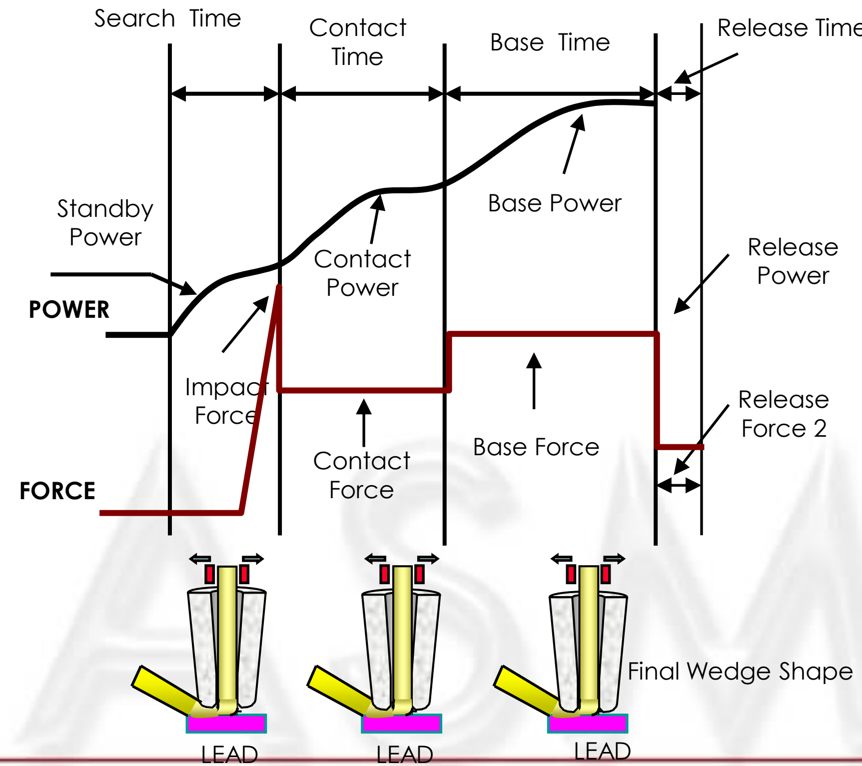


Bonding (Ultrasonic)

Application & Capability

- Best flexibility for difference application
- Provide "Real Time" Bond Quality Monitoring (BQM)
- Selectable for 1st and 2nd bond
- Provide multiple control modes
  - Constant Voltage/Current/Power mode

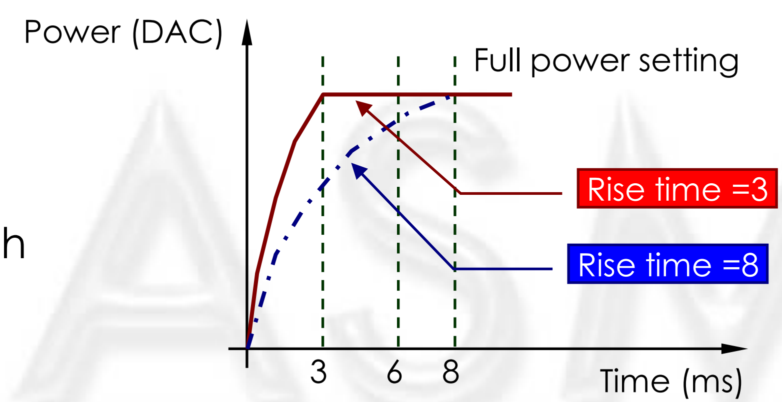




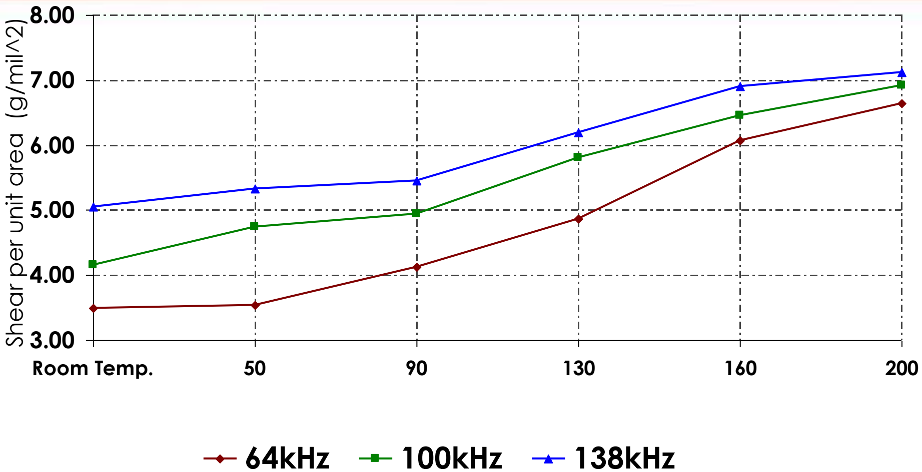
Ultrasonic (Control Mode)

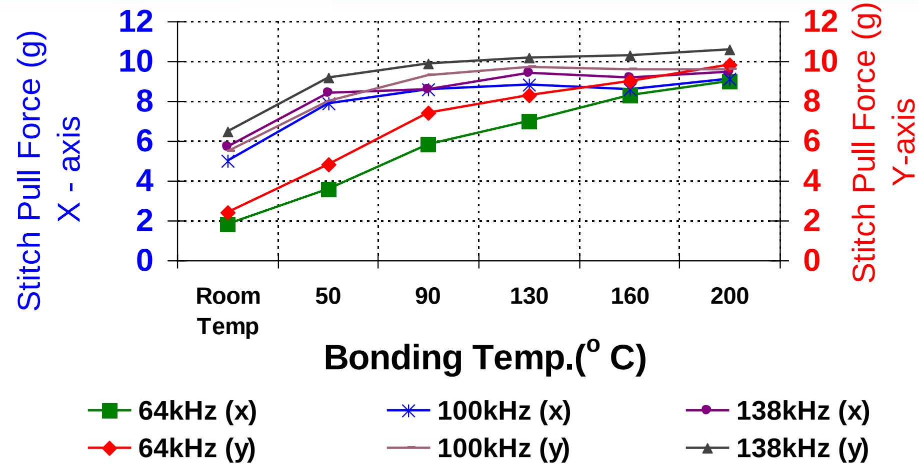
- **C_I (Constant Current)**
  - P = (I^2)*R, when "I" = constant
  - Impedance "Z" increase so output power "P" increase to maintain the <u>C</u>onstant current <u>**I**</u>
- **C_V (Constant Voltage)**
  - P = I*V and I = V/Z, so P = V^2/Z, when "V" = constant
  - Impedance "Z" increase so output power "P" decrease to maintain the <u>C</u>onstant <u>V</u>oltage
- **C_P (Constant Power)**
  - P = I*V and I = V/Z, so P = V^2/Z, when "P" = constant
  - Impedance "Z" increase so voltage "V" increase to maintain the <u>C</u>onstant <u>P</u>ower

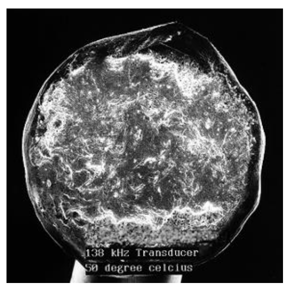
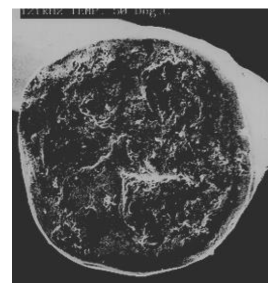
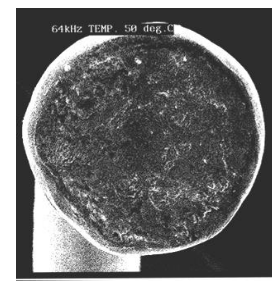
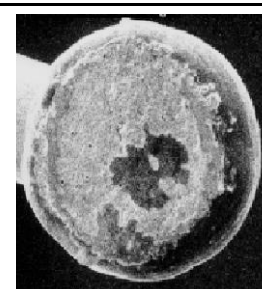
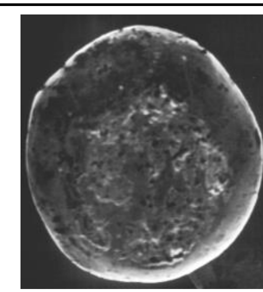
- **Rise Time**
  - Is the time to reach the max power output
    - If the rise time set to 8 ms and base time is 6ms, the power will never reach max value



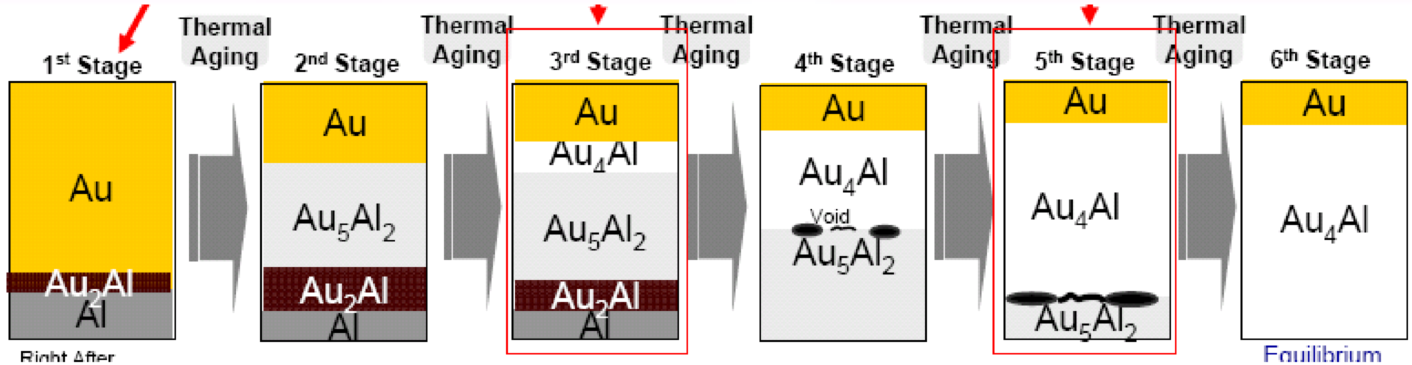
Ultrasonic (Frequency)

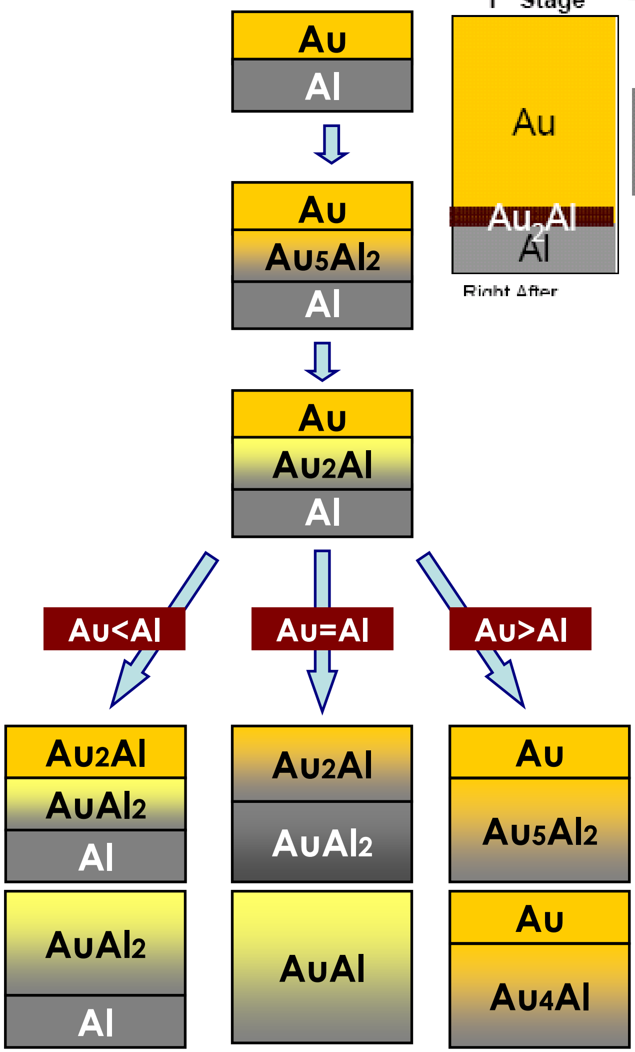




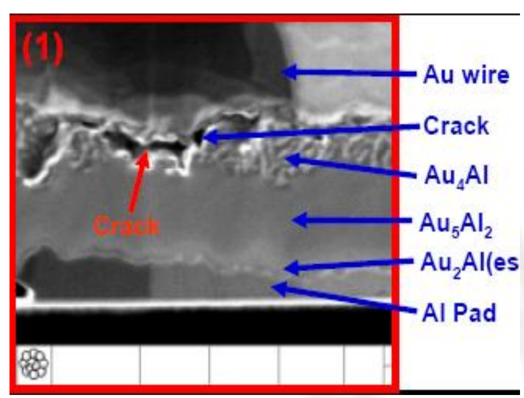
	138kHz	121kHz	64kHz
Room Temp.			
200deg			

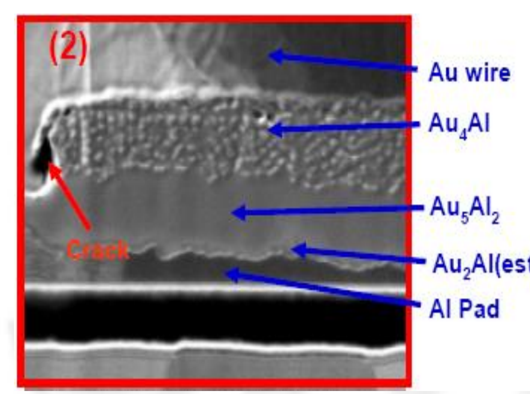
Bonding (Inter-Metallic Compound)





AuAl2	紫色，是1種良導體，熔點為1060℃。
Au2Al	白色，是1種很脆的絕緣體，熔點只有624℃。
Au4Al	白斑” **Au4Al** 的危害更大，更具脆性，所以對焊點的可靠性危害更大。
Au5Al2	長成速度快且硬，電阻率高





Bonding (Inter-Metallic Compound)

- **Au/Al vs Cu/Al IMC growth rate comparison.**
  - 電負度Cu(1.9)和Al(1.6)差別小，而電負度Au(2.5)和Al(1.6)差別大，電負度差別越大反應力就越大，所以金和鋁的反應力大於銅與鋁
    - 電負度又稱陰電性,為判斷原子拉電子的強度大小
    - 常用的元素電負度大小
      - F(4)>O(3.5)>N,Cl(3.0)>Br(2.8)>I(2.6)>C,S(2.5)>H(1)

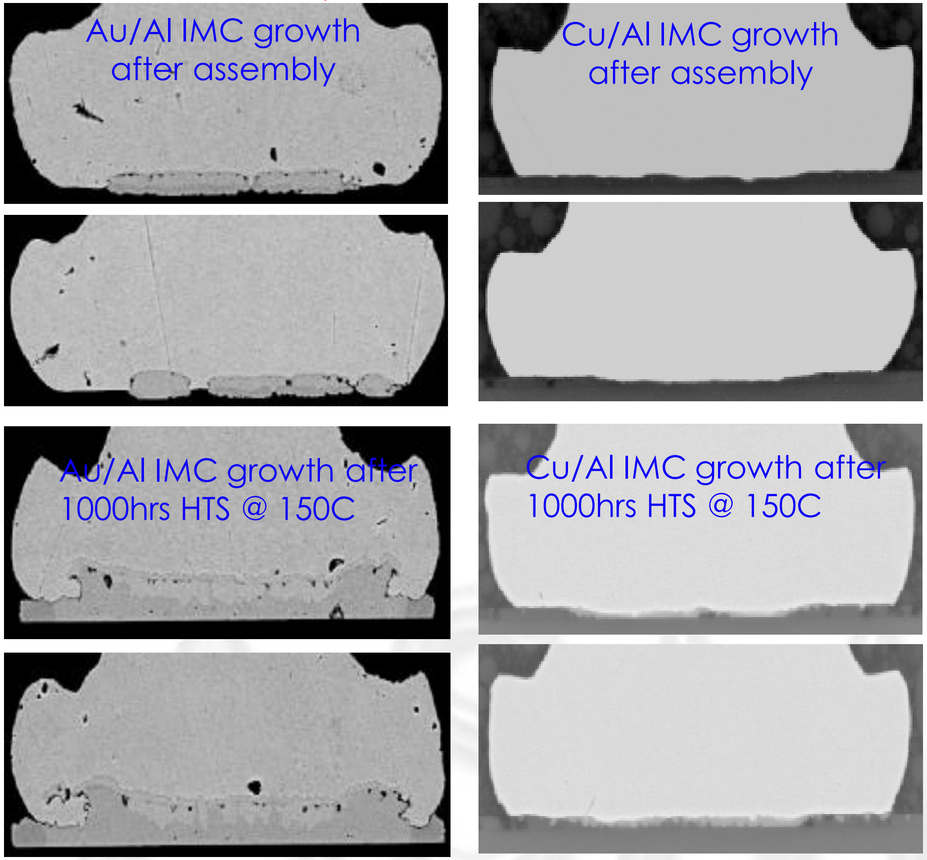
Au/Al IMC長成速率明顯比Cu/Al快

Temperature (deg C)	Cu/Al, K (cm^2/s)	Au/Al, K (cm^2/s)
150	1.878×10^{-16}	1.1×10^{-14}
280	2.645×10^{-13}	2.4×10^{-11}
350	3.747×10^{-12}	3.9×10^{-10}

X=Kt^1/2

"X" is the intermetallic layer thick

"t" is the time



Bonding (Plasma Process)

- **Plasma Mode**
  - DC (Direct current)
    - Balzers
  - RF (Radio Frequency)
    - March, E&R
  - MW (Microwave)
    - Tepla

- **Gas process**
  - H·+ Metal O → Metal + O2 (還原)
    - Weak bombardment effect
  - O·+ Metal → Metal O -- (氧化)
    - Moderate bombardment effect
  - Ar+ → high energy ions– (撞擊)
    - Strong bombardment effect

	L/F base	Chip contamination	Substrate base	Substrate contamination
Plasma Type	March (RF)	E&R (RF) March (RF)	E&R (RF) Balzers	E&R (RF)
Gas	Ar	Ar	Ar + H2 Ar + O2	1st : O2 2nd: Ar+H2
Key process	解離	解離	活化+解離	活化燃燒+解離

Bonding (Wire Selection)

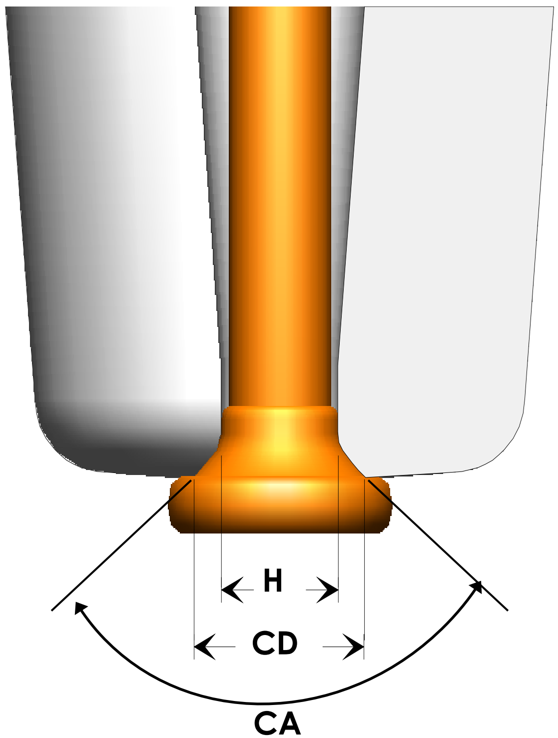
Process Focus

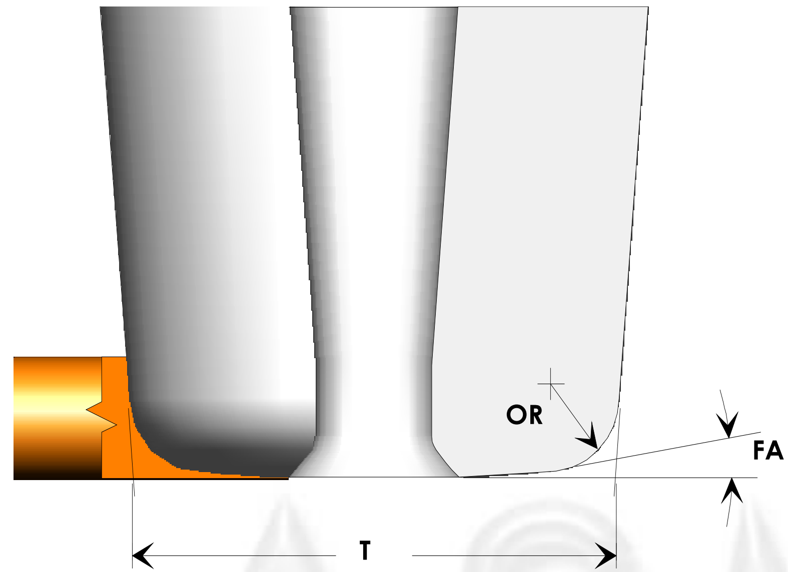
- FAB (Free Air Ball) Hardness
  - Soft wire (4N) for weak bond pad structure
  - Hard wire (AuPd/ 2N) for small BPP application
- Break load/ Elongation
  - Good for looping form &molding wire sweep by high "BL"
  - Good performance for stitch pull by low" BL" with high "EL"
  - Reduce cap. growth up by low "BL"
- Reliability
  - Good for reliability by AuPd wire
    - Intermatecillic growth is slow

BPP (um)	BPO (um)	Max. Wire Length	Wire size	Finger Pitch
B.P.P.≧ 80	B.P.O.≧ 70	5334 um (210mil) <= MWL < 5588 um (220mil)	**30um**	---
		5080 um (200mil) <= MWL< 5334 um (210mil)	**30um**	145 um min.
		MWL < 5080 um (200mil)	**25um**	140 um min.
70≦B.P.P.＜80	60≦B.P.O.＜70	5080 um (200mil) <= MWL< 5334 um (210mil)	**25um**	145 um min.
		MWL < 5080 um (200mil)	**25um**	140 um min.
60≦B.P.P.＜70	50≦B.P.O.＜60	4572 um (180mil) <= MWL< 5080 um (200mil)	**23um**	140 um min.
		MWL< 4572 um (180mil)	**23um**	135 um min.
55≦B.P.P.＜60	45≦B.P.O.＜50	4064 um (160mil) <=MWL< 4572 um (180mil)	**20um**	135 um min.
		MWL< 4064 um (160mil)	**20um**	130 um min.
50≦B.P.P.＜55	40≦B.P.O.＜45	3556um (140mil) <= MWL< 4064um (160mil)	**18um**	130 um min.
		MWL< 3556um (140mil)	**18um**	130 um min.

Bonding (Cap. Selection)

- **Process Affect on 1st bond**
  - Hole (**H**)/ Chamfer Diameter (**CD**)/ Inner Chamfer Angle (**ICA**)
- **Process Affect on 2nd Bond**
  - Tip (**T**)/ Outside Radius (**OR**)/ Face Angle (**FA**)/ Chamfer Diameter (**CD**)

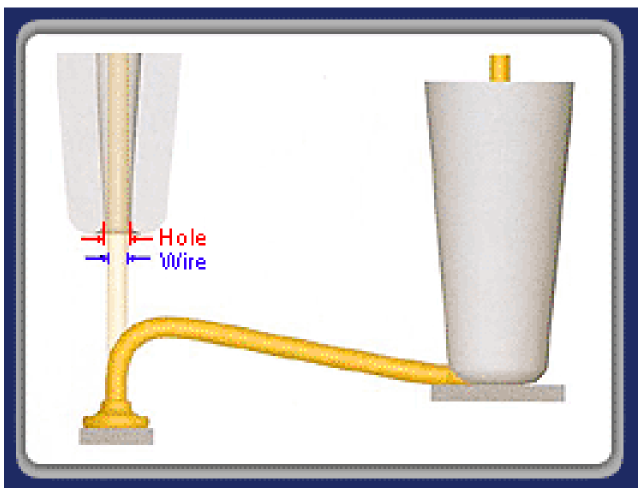


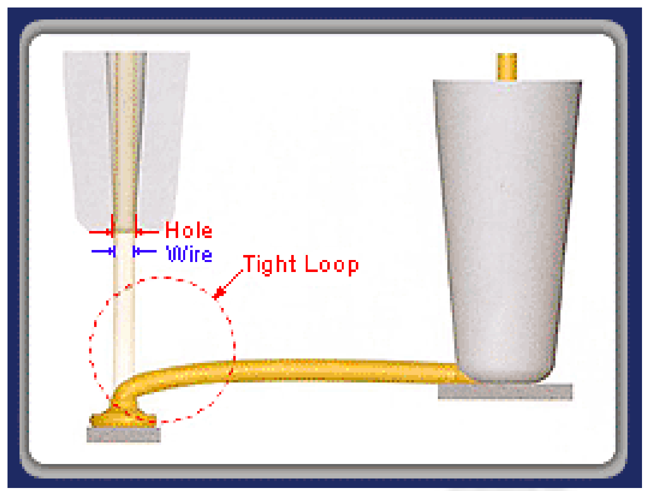


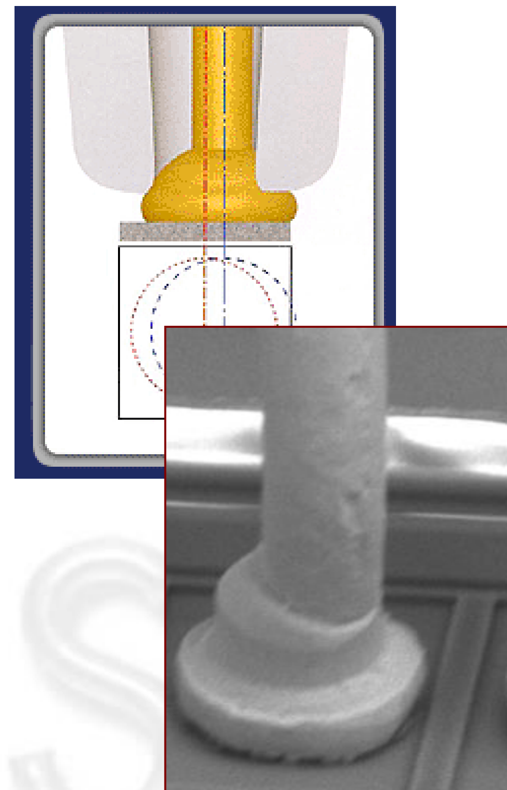
Bonding (Cap. Selection)

Hole Diameter (HD)

- Rule of thump
  - Hole Diameter = wire diameter + 0.2mil
    - Larger hole is better working for smoother wire stream ,but may fail to finely adjust the bond placement on the right place causing off-center on pad

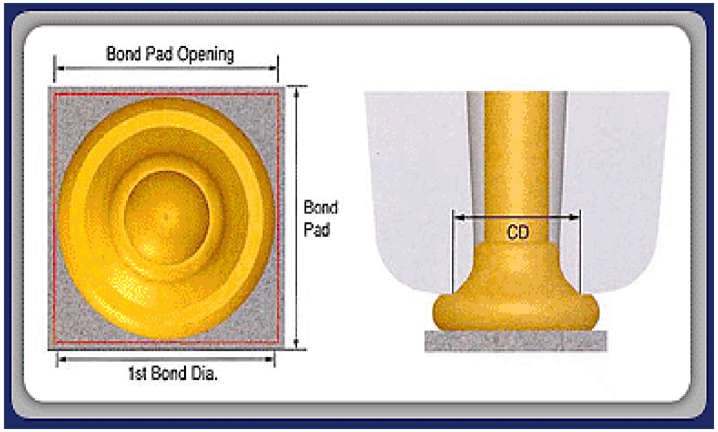


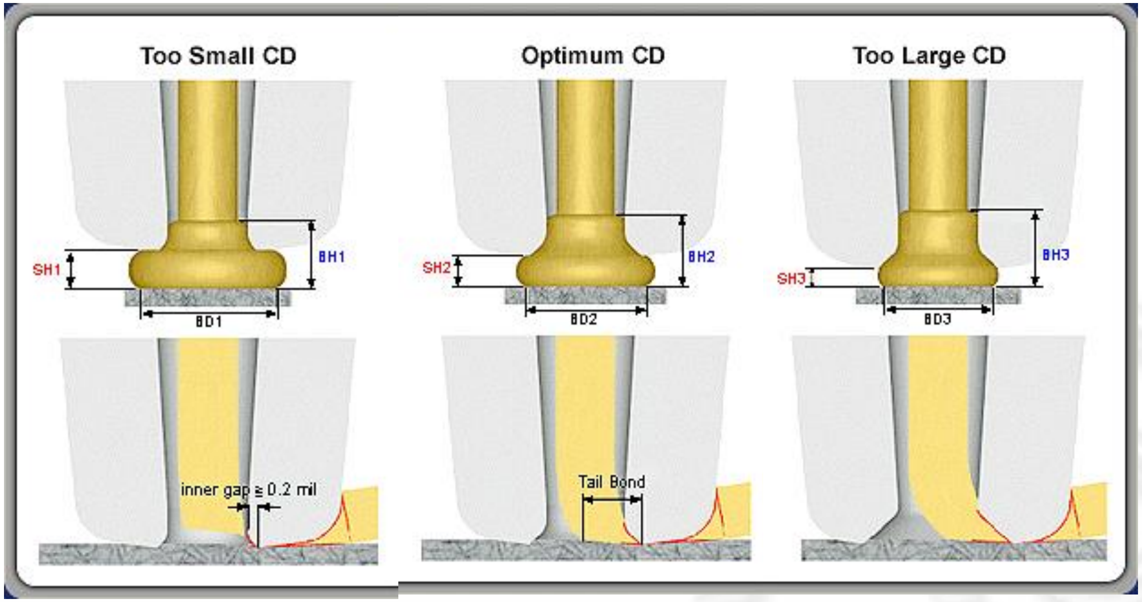




Bonding (Cap. Selection)

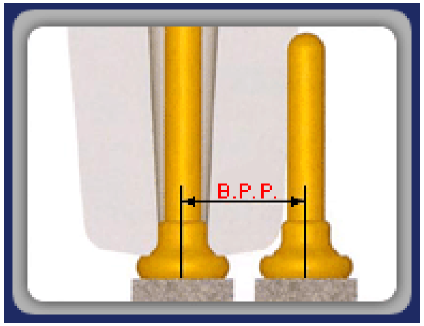
- **Chamfer Diameter (CD)**
  - Rule of thump
    - Chamfer Diameter = Ball size – 6~8µm
    - Effect on 1st Bond
      - Affect 1st bond ball deformation
    - Effect on 2nd Bond
      - CD too small cause short tail
      - Improve stitch strength, increase CD reduce hole diameter

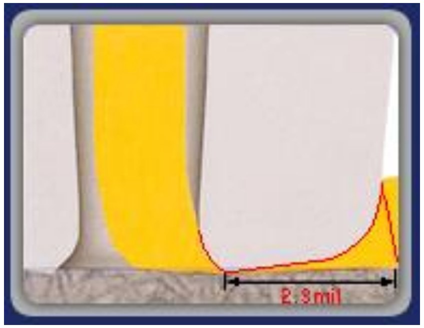




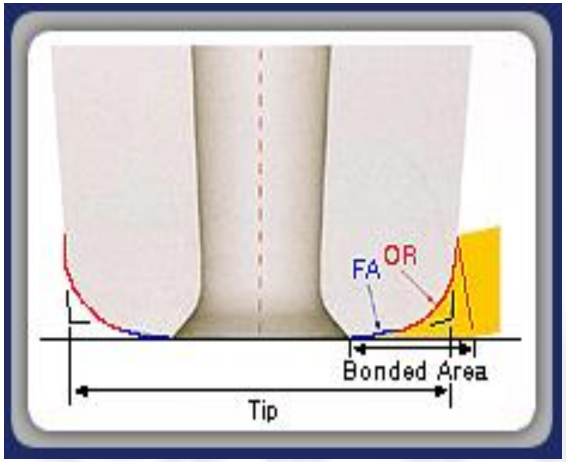
Bonding (Cap. Selection)

- **Tip (T)**
  - Rule of thump
    - Tip Diameter = BPP *1.3
      - Small TD: 2nd bond may be weak
      - Large TD: Can see the cap interference with 1st bond & looping

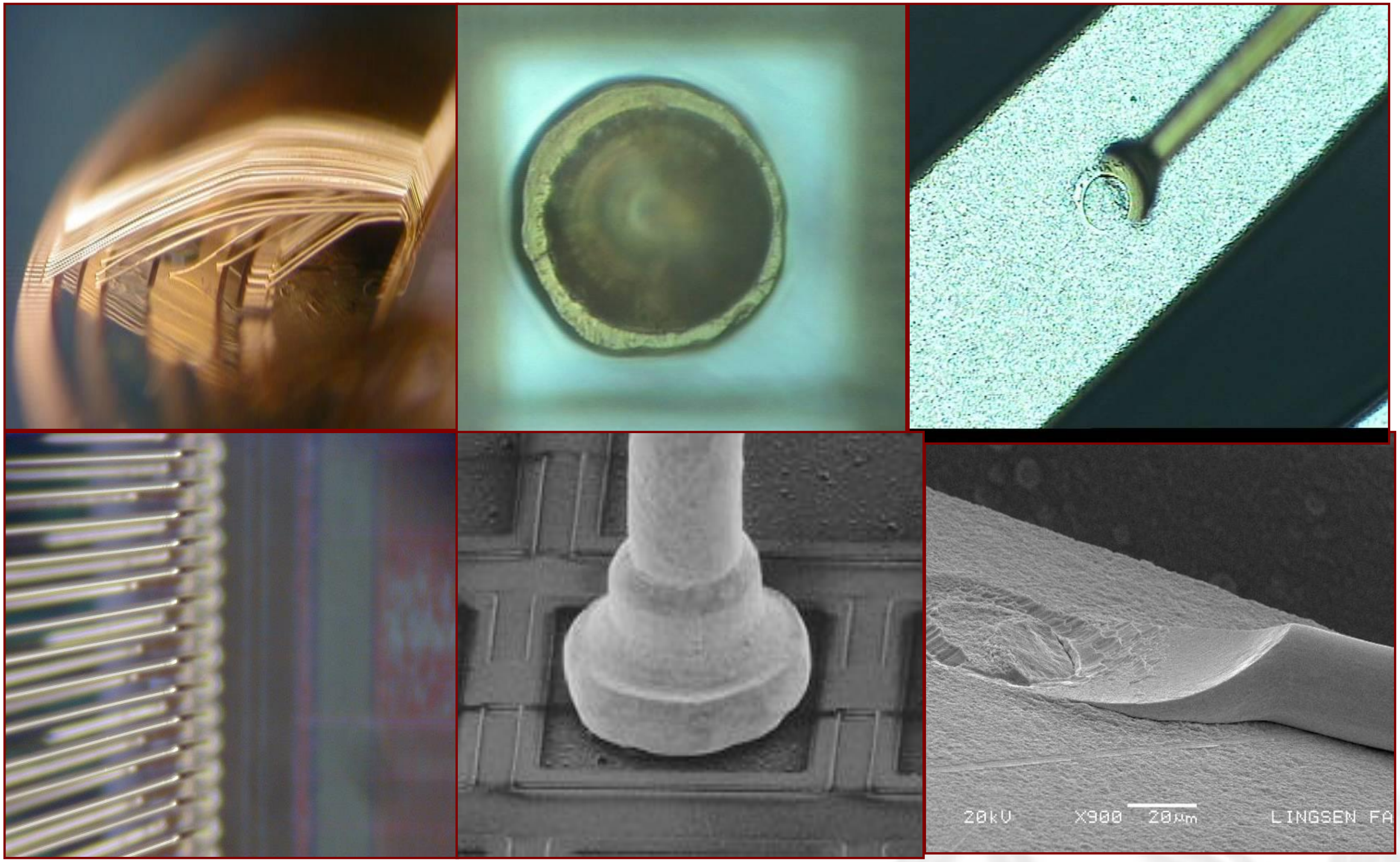




- **Face Angle (FA)/ Outside Radius (OR)**
  - Control the wedge width and wedge thickness
  - Small FA will result in sharp corners
    - Cause heel crack on wedge
      - Higher FA and smaller OR leads to optimum wedge width
  - Recommend OR: 3~ 5um , FA: 8~11 degree

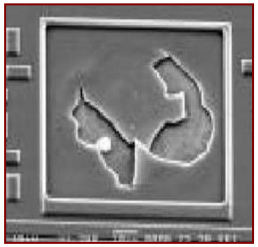


Quality (Normal)



Quality (1st Bond)

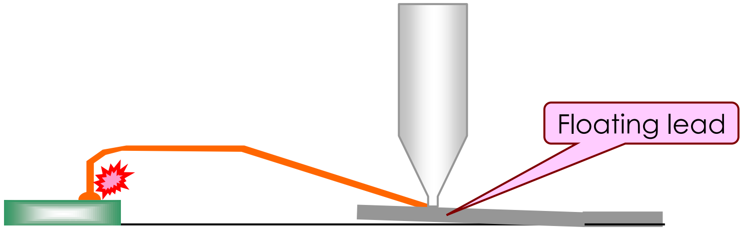
- **AL Peeling**
  - Process
    - Reduce bond power, and increase bond force
    - Increase ball size
    - Reduce Cap. CD
    - Reduce impact on bond pad (reduce search speed)
    - Al coating process (review with wafer house)
  - Hardware
    - Review if die floating

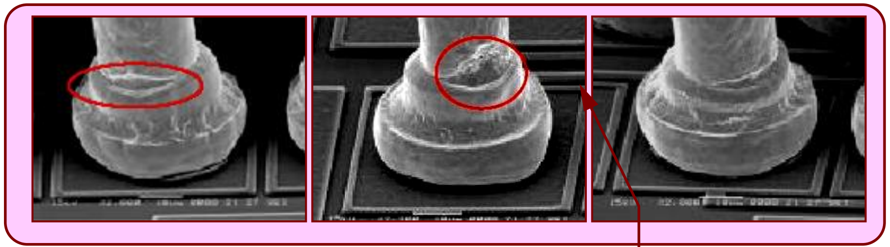


It is easy to cause NSOP when reduce bond power

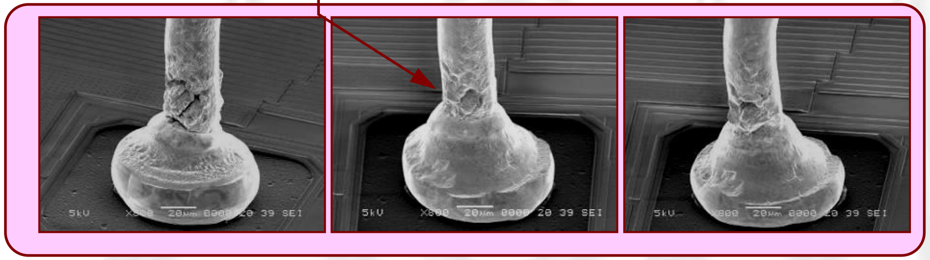
Quality (1st Bond)

- **Neck crack**
  - Hardware
    - To check lead (finger) if floating
    - Wire clamp opening too small
  - Process
    - Larger reverse motion on looping
      - Reduce RD/ RDA, raise RH
    - 2nd power too large to cause neck crack
      - Reduce 2nd power/ increase bond force
    - EFO current too large





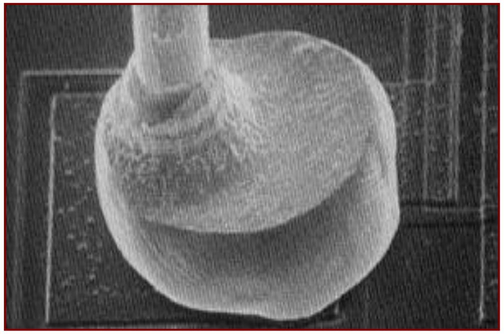
Due to unsuitable loop motion



Due to lead (finger) floating

Quality (1st Bond)

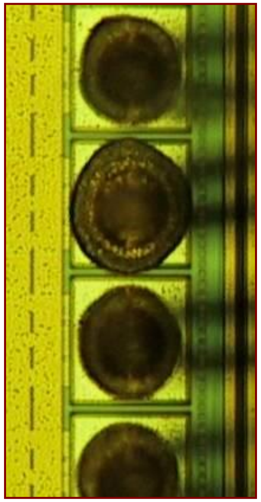
- **Golf Ball/ Abnormal ball size/ Miss ball**
  - Hardware
    - Clean wire spool/ wire path/ air tensioner (Cause wire contamination)
    - Clean/ calibration wire clamp due to unstable wire clamp motion open/ close
    - E-torch damage to cause abnormal sparking
    - Tail bond unstable to cause tail bent
      - Finger contamination/ floating
    - Check "fire level" if with in STD setting
    - EFO box or cable connection problem

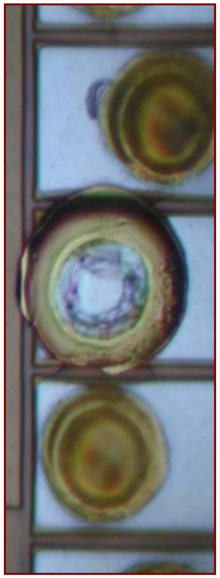


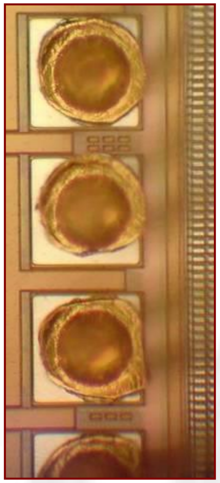
  - Process
    - 1st bond power too larger
    - Raise EFO current
      - It is 35mA for 0.8mil WD for 38um ball size
    - 1st bond search high too low
    - Cap. hole size too larger
    - Tail too short
    - Tip of tail length swing away from E-torch

Quality (1st Bond)

- **Smash Ball**
  - Solution (Hardware)
    - Check bond force sensor (Z driver BD) if damage
    - Calibration / Check wire clamp due to noise
    - Check if die floating
    - Check FAB size if too small
    - EFO Torch tip setting no good
    - BQM board not calibrated.
    - Dirty Torch Tip
    - Inconsistent Die Thickness / Die Height
    - EFO Box Problem
    - Air diffuser too large
  - Process
    - Raise search high/ reduce search speed
    - Unsuitable search parameter ("LW" too small)
    - Initial force too larger
    - To raise power "raise time"
    - 2~3 ms power delay on 1st bond
    - Reduce base power

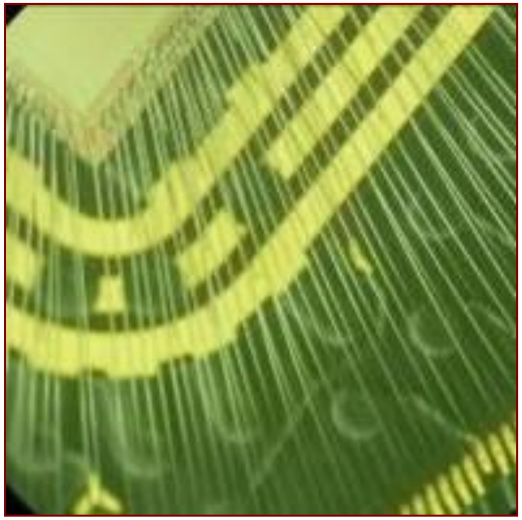




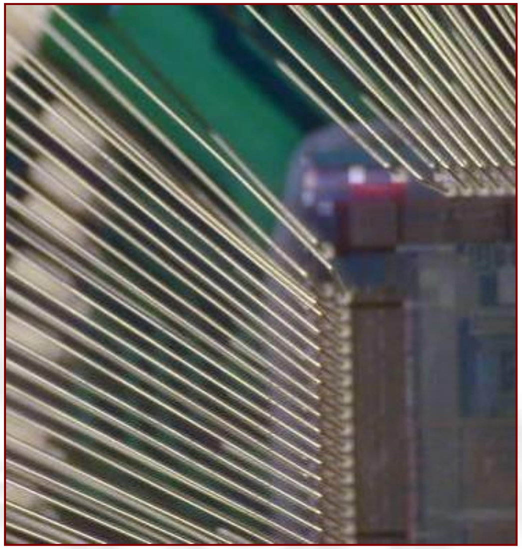


Quality (Looping)

- **Wire sweep/ sagging**
  - Solution (Hardware)
    - Check wire path if smooth
    - Check/ calibration wire clamp
    - Check if index to cause wire sweep/ sagging
  - Solution (Process)
    - Reduce 2nd bond power
    - Fine tune loop parameter "LC"
    - More reverse on 1st kink

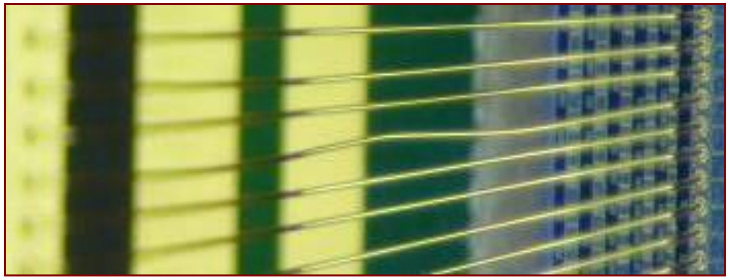


- **Loop base bent**
  - Solution (Hardware)
    - Check wire clamp
    - Check/ calibration wire clamp
  - Solution (Process)
    - Fine tune loop parameter
      - Reduce RDA (negative is better)
    - Check if unsuitable cap tip size
    - Check if unsuitable "EL" on wire



Quality (Looping)

- **Snake wire**
  - Solution (Hardware)
    - Check/ calibration wire clamp force
  - Solution (Process)
    - Add scrub/ bond smooth motion on 2nd bond
    - Check wire clamp profile if with in STD setting
    - Enable "Tail break motion"
    - Increase Tail power
    - Provide tail power in advance stage
    - Reduce the speed for "tail to fire level"



~End~