AMADA

Hermetic Seam Sealing Microelectronic Devices

Date	Title/Topic
December 2018	Resistance Weld Monitoring for Improved Throughput and Quality
June 2019	Laser Source Selection for Micro-welding
September 2019	Hermetic Seam Sealing Microelectronic Packages
November 2019	Laser Weld Monitoring
February 2020	Resistance Spot Welding - Weld Head Selection

Contact us if you would like to get link to past webinars or a copy of the presentation.

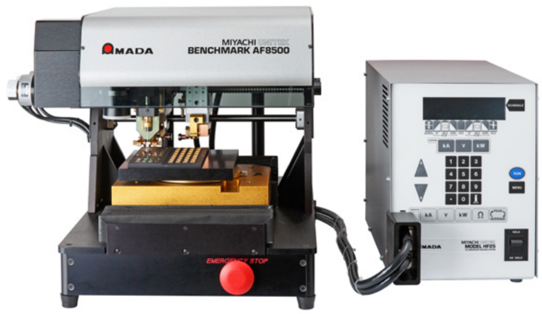
HERMETIC SEAM WELDING PROCESS SUCCESS

M MATERIAL

- Package Design
- Plating
- Material Composition
- Package Geometry

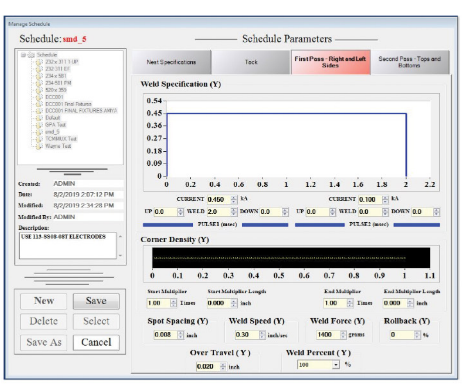
Ⓔ EQUIPMENT

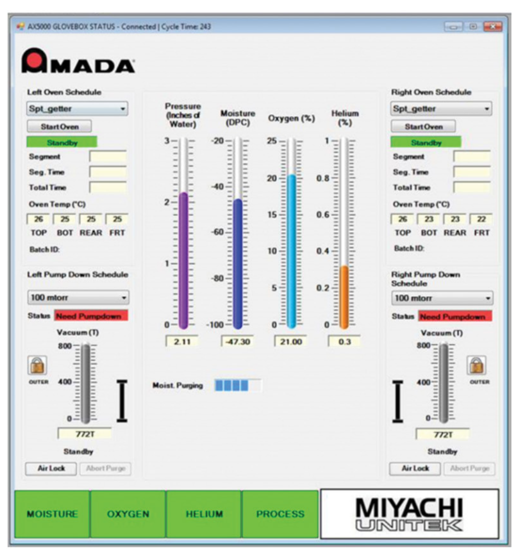
- Seam Welder
- Projection Welder
- Electrode and Fixture Design
- Welding Power Supply
- Dry Environment Glovebox



Ⓟ PROCESS

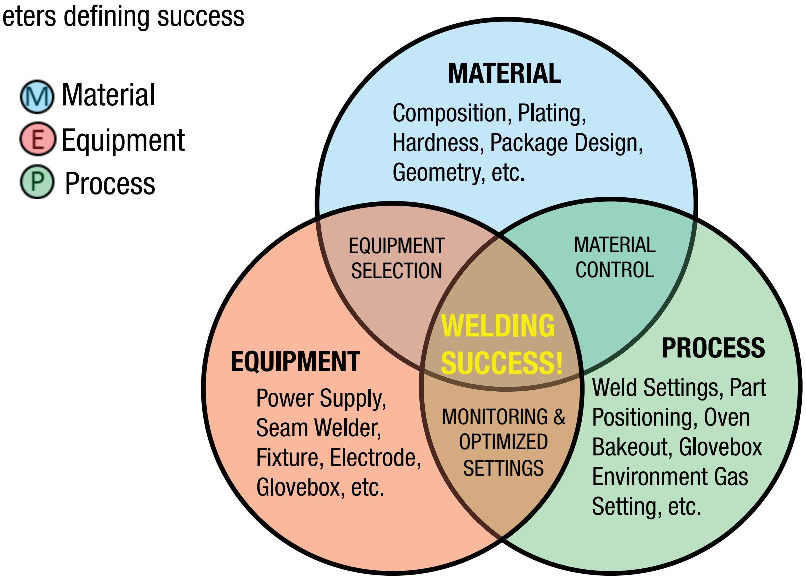
- Weld Schedule
- Oven Bakeout Schedule
- Dry Environment Schedule





HERMETIC SEAM WELDING PROCESS SUCCESS

Key parameters defining success



COMPANY OVERVIEW

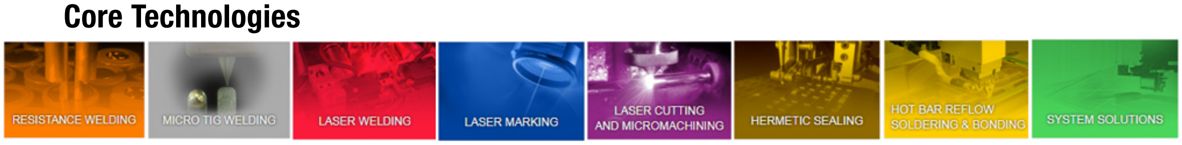
Amada Weld Tech

Established as the Weldmatic Division of Unitek Corporation in 1948. In 2001 acquired BENCHMARK International Inc. a world leader in manufacturing hermetic sealing systems. AMADA WELD TECH has been a pioneer in the design and manufacture of welding, marking, cutting, hermetic sealing and bonding systems for more than 70 years!

- A subsidiary of Amada Miyachi, Co. Ltd.
- A subsidiary of AMADA HOLDINGS CO., LTD.
- Headquartered in Monrovia, California USA
- Quality
  - Company: ISO 9001 Certified
  - Equipment: CE, CDRH, CCC, NFPA79, CSA Certified

Past Branding – Hermetic Sealing Product Lines

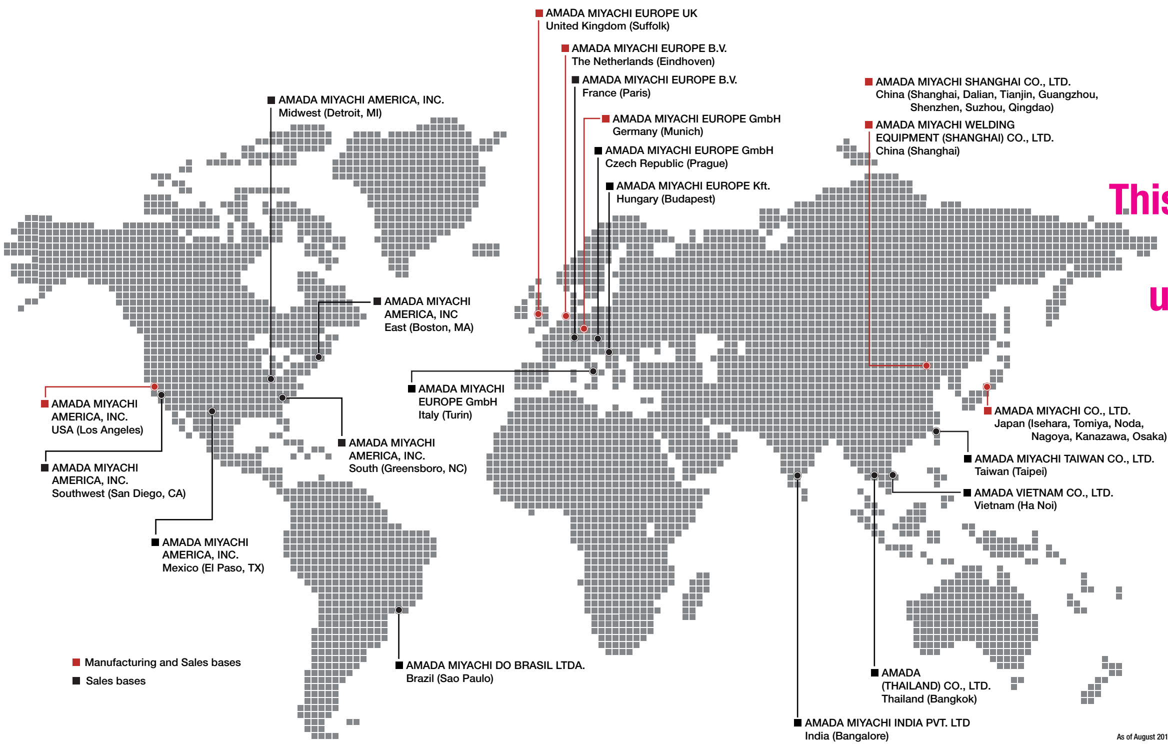
Core Technologies



Industries Served

Medical | Automotive | Battery | Electronics | Military | Aerospace | Data Communication Photonics | Life Sciences and many more!

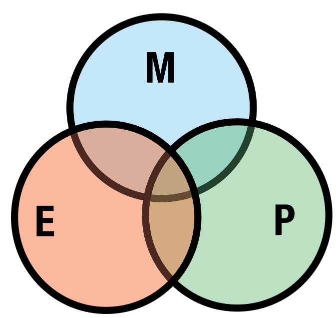
AMADA WELD TECH – GLOBAL FAMILY OF COMPANIES



This probably needs updating

HERMETIC SEAM WELDING OF MICRO ELECTRONIC PACKAGES

- Introduction - Basics
  - What is hermetic seam welding?
  - Parallel gap seam welding
  - Opposed electrode projection seam welding
- Hermetic sealing in controlled dry environment
- Hermetic seal testing
- What can go wrong with your process?
- Future of hermetic sealing products
- Summary

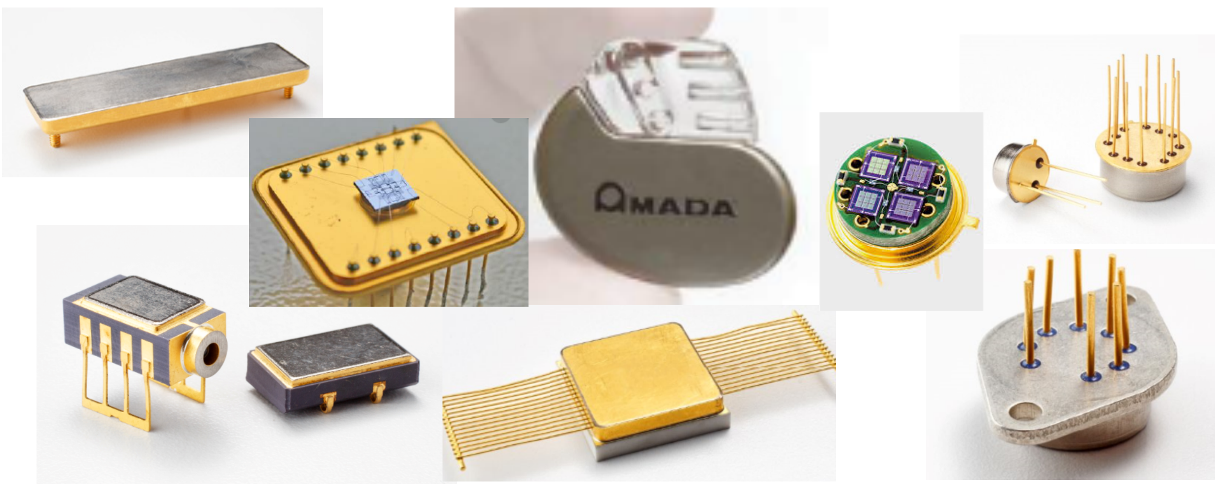


INTRODUCTION - BASICS: PRINCIPLES OF HERMETIC SEALING

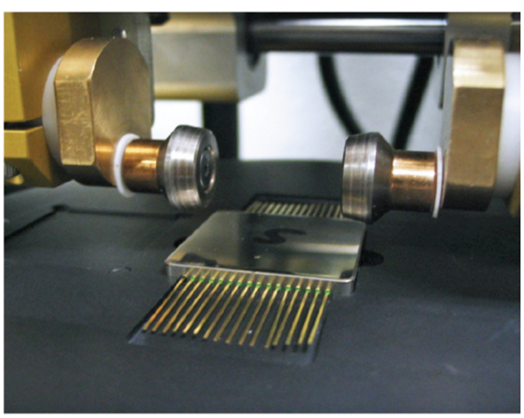
The Objective: Protecting and controlling the internal conditions of the implantable medical and sensitive electronic devices from harsh or challenging environmental conditions

The Solution: Hermetic Sealing. Encapsulation of the device into an air tight metal or ceramic housing.

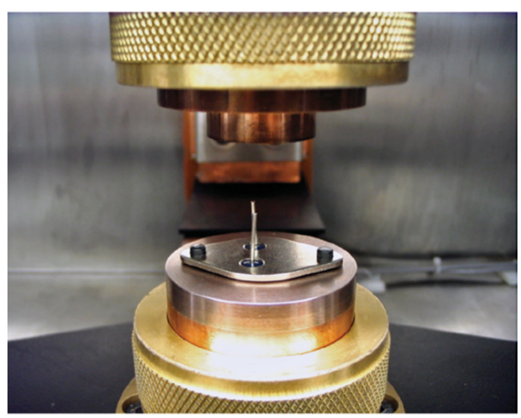
The Technology: This can be realized by joining a metal lid or cap to a metal or a ceramic base package which contains the electronic device using either parallel gap seam welding or opposed electrode projection resistance welding technologies.



Parallel gap seam welding and opposed electrode projection resistance welding technologies



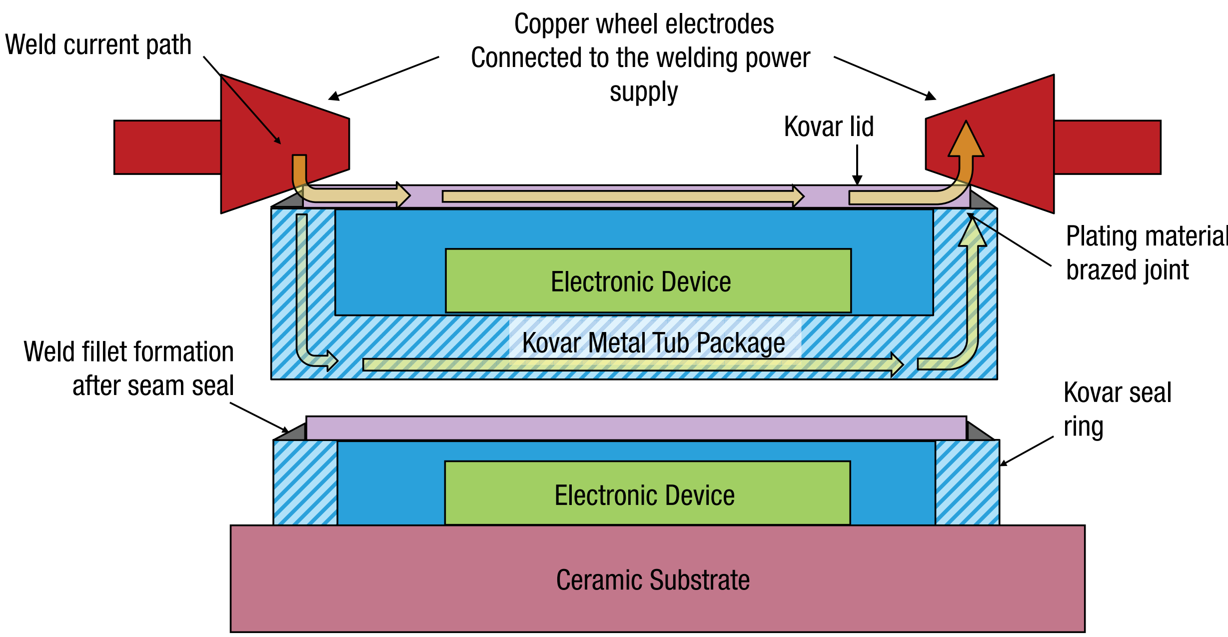
Parallel Gap Seam Welding



Opposed Electrode Projection Welding

INTRODUCTION - BASICS: PRINCIPLES OF PARALLEL GAP SEAM WELDING

A seam welder is intended to deliver multiple overlapping weld spots creating a continuous weld joining a metal lid to a metal or a ceramic package which contains an electronic device.



PARALLEL GAP SEAM WELDING

Ⓜ Materials: Part design metal tub packages and material

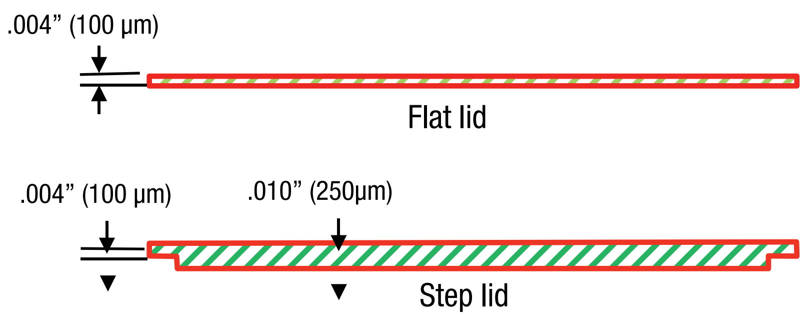
IMPORTANT: Preferred material is Kovar and maintain lid thickness at .004” (100 µm)

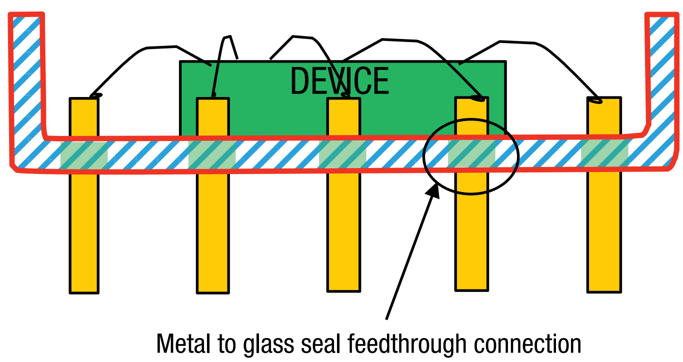
Lid Design Guidelines

Flat lid – .004" ± .001" thick (100 µm ±25 µm)

Step lid – Major thickness >= .010" (250 µm)

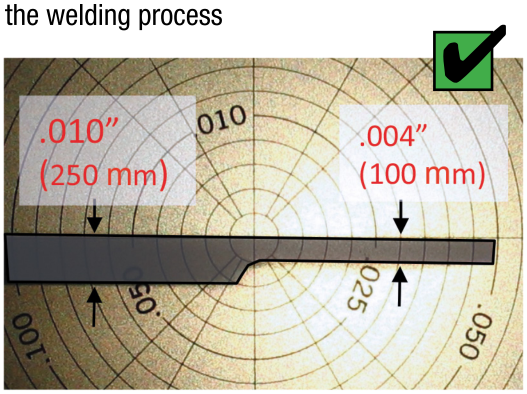
Perimeter flange thickness .004" ± .001 (100 µm ±25 µm)

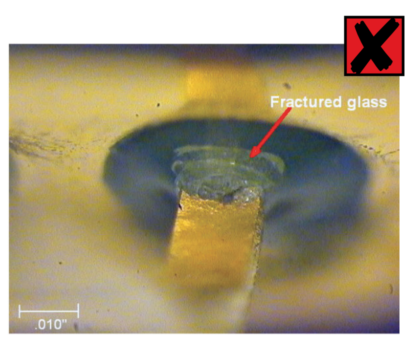




Metal tub base design guidelines

Kovar is the preferred package material having similar CTE (Coefficient of Thermal Expansion) as glass preventing metal to glass seals from leaking due material expansion from heat generated in the welding process





Hairline glass fracture due to mechanical or thermal stress

PARALLEL GAP SEAM WELDING

Ⓜ Materials: Ceramic package seal ring and lid design, plating

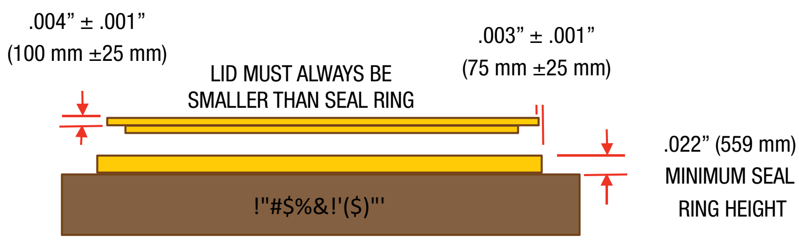
IMPORTANT: Lid should never be larger than the seal ring

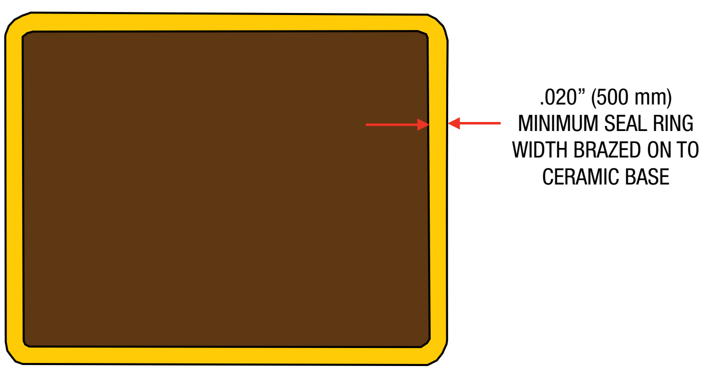
Lid Design Guidelines

Flat lid – .004" ± .001" thick (100 µm ±25 µm)

Step lid – Major thickness >= .010" (250 µm)

Perimeter flange thickness .004" ± .001 (100 µm ±25 µm)





Lid to seal ring perimeter clearance:

.003” ± .001” (75 mm ±25 mm) to prevent lids from overhanging

Lid perimeter flange thickness:

.004” ± .001 (100 µm ±25 µm)

Thin lids require low heat to weld resulting to cooler packages, minimizes thermal stress preventing the ceramic base from cracking

Seal ring minimum height: .022” (559 µm)

Seal ring minimum width: .020” (500µm)

will provide sufficient area to weld and clearance between electrode’s outer edge and top surface of the ceramic base

Typical materials:

Kovar, Nickel and Ceramic Base

Typical plating:

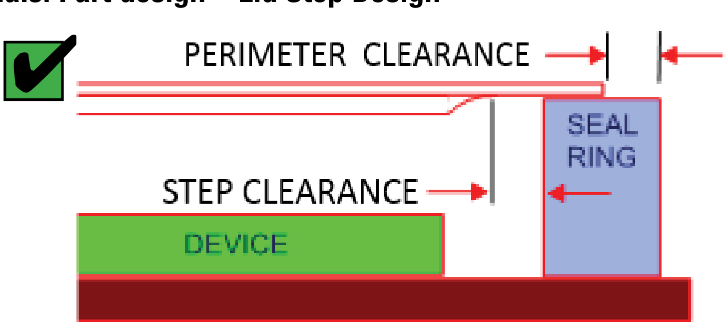
Nickel plating 50-100 µ-in (1.3 µm – 2.5 µm)

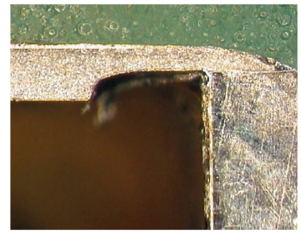
Gold plating 20 – 50 µ-in (0.5 µm – 1.3 µm)

Low to Medium Phosphorus Electroless Plating (1 – 9 %)

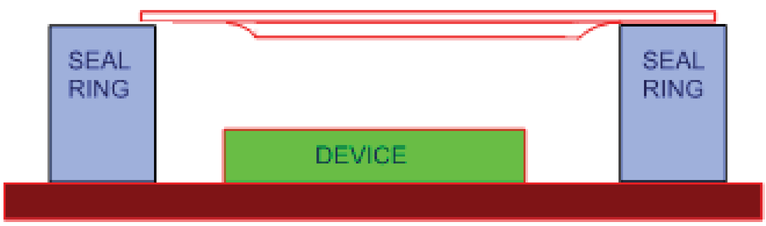
PARALLEL GAP SEAM WELDING

Materials: Part design – Lid Step Design



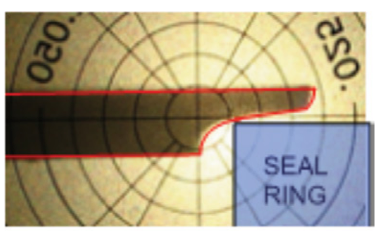


Perimeter clearance must be > or = to step clearance to prevent lid from overhanging

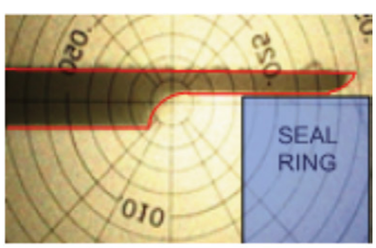


A misaligned lid is still within the seal ring

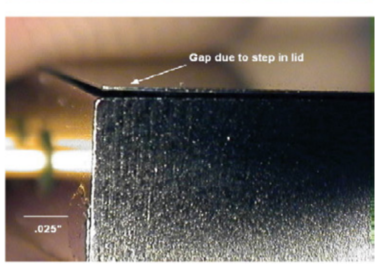
Lid overhanging



Gap between lid and seal ring caused by insufficient step clearance, the lid's step fillet radius is resting on top of the seal ring



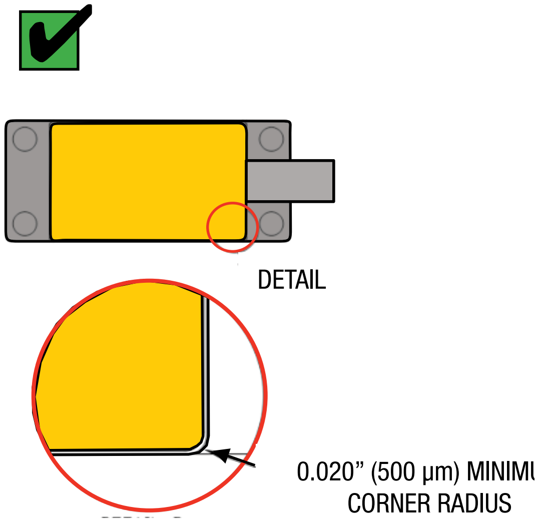
Lid tip has a radius

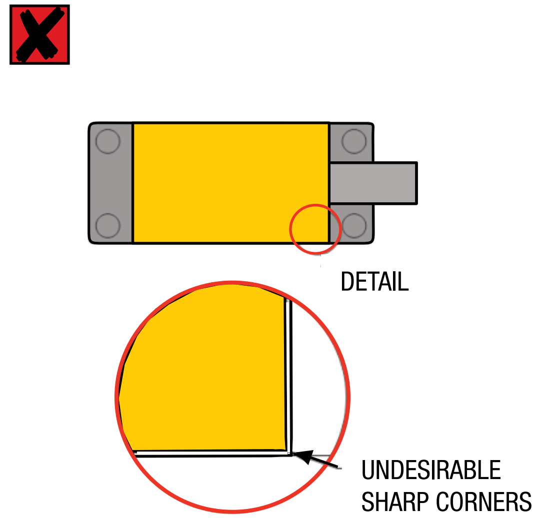


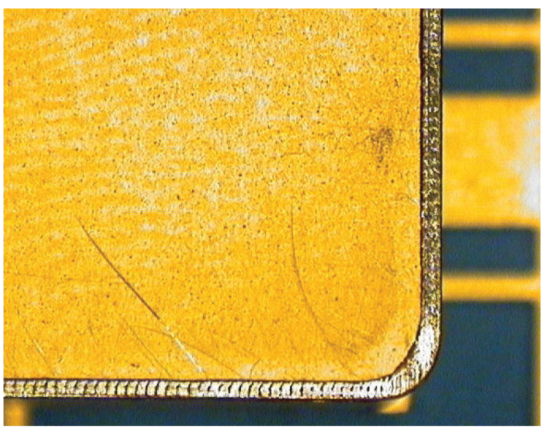
Gap between lid and seal ring

PARALLEL GAP SEAM WELDING

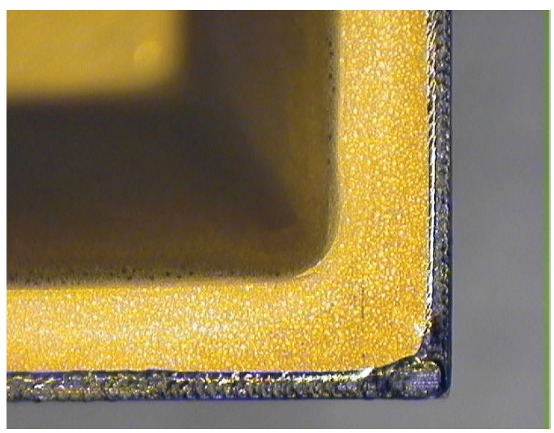
Materials: Part design corner radius







Detail
Packages with a corner radius will cosmetically look better, no overheated corners and less chances of arcing



Detail
Sharp corners will may cause arcing and over heated corners

PARALLEL GAP SEAM WELDING

Ⓟ Process: Basic principles of resistance welding

The key objective in resistance welding to efficiently generate heat while directing it to a specific predetermined location

General heat generation formula for resistance welding

Heat = I^2 x R x t - K

Where:

I = Weld current (Amperes)

R = Resistance (Ohms)

t = Weld time (seconds)

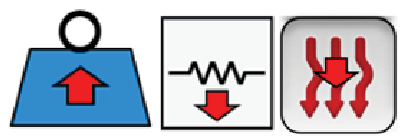
K= thermal factor due to: weld force, material properties, efficiency of current path, fixturing, heat sinking

Relation between welding force, weld current, area of contact, contact resistance, weld time, material properties, plating properties and heat generated during a welding process.

- Low welding force
- Small contact area
- Resistive materials
- Higher weld current
- Longer weld time
- More weld spots delivered at a faster rate

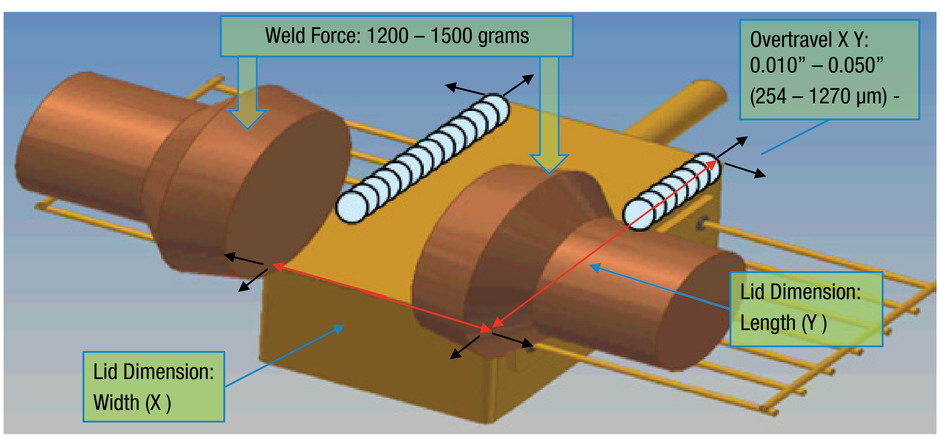
More material mass

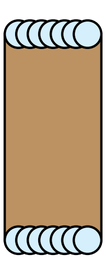
- More heat sinking
- Thicker and more conductive plating
- More force = Less resistance = Less heat



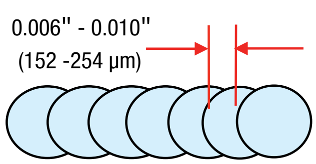
Ⓟ Process: Process – Weld schedule key parameters

• Lid Dimension • Weld Force • Spot Spacing • Overtravel • Weld Current • Weld Speed





Spot Spacing:



Cooler packages and no overheated corners are realized using slow speed position based firing and less weld spots at the corners of the package

Typical weld settings for .004” (100 µm) lids

Weld Current: 0.30 – 0.45 kA

Weld Pulse: 2 – 4 msec

Weld Speed: 0.1 - 0.5 ips (2.5 – 12.7 mm/s)

Spot Spacing: .008” (200 µm)

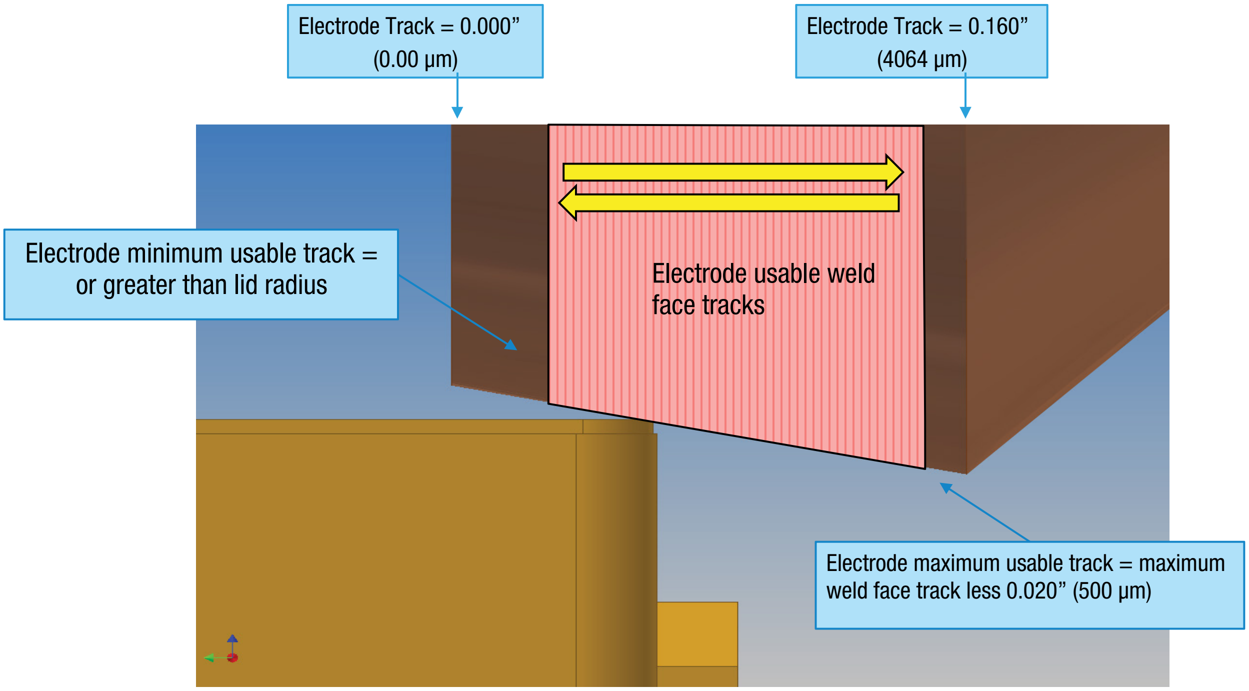
Overtravel: .020” (500 µm)

Weld Force: 1400 grams

PARALLEL GAP SEAM WELDING

P Process: Weld electrode tracking

AUTO-TRACK FEATURE : Seam welder automatically increments 0.001”(25.4 μm) every weld pass



Electrode tracking prolongs life and even wear of electrode weld face

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E Equipment: BASIC and ADVANCED

When do you choose one over the other?

BASIC Seam Welder

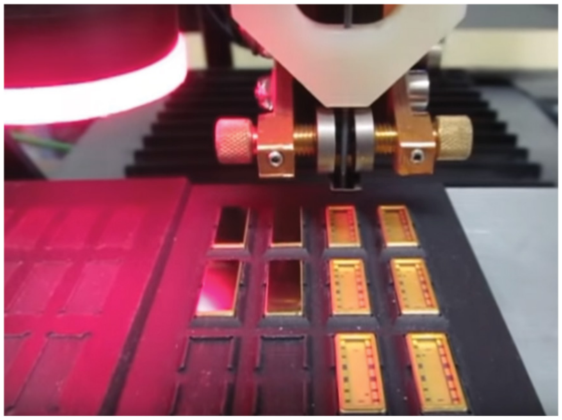
- R & D and **Low volume** production 50 – 60 UPH (data from 10 mm^2 packages)
- **Single part** welding operation
- **Rectangular and circular** sealing applications
- **Manual** lid placement operation

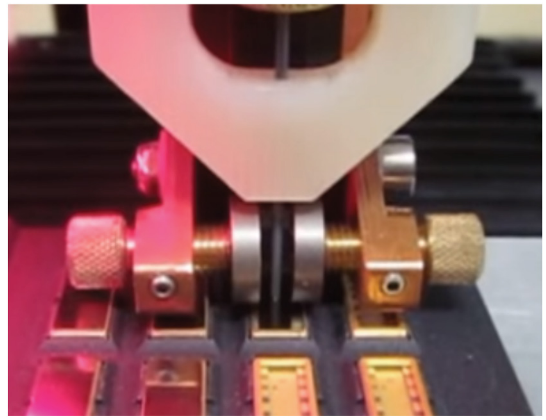
ADVANCED Seam Welder

- **High volume** production, 150 to 180 UPH (data from 10 mm^2 packages)
- **Multiple parts** welding operation
- **Rectangular** sealing applications
- **Automatic** Vision assisted pick and place, tacking and seam sealing operation

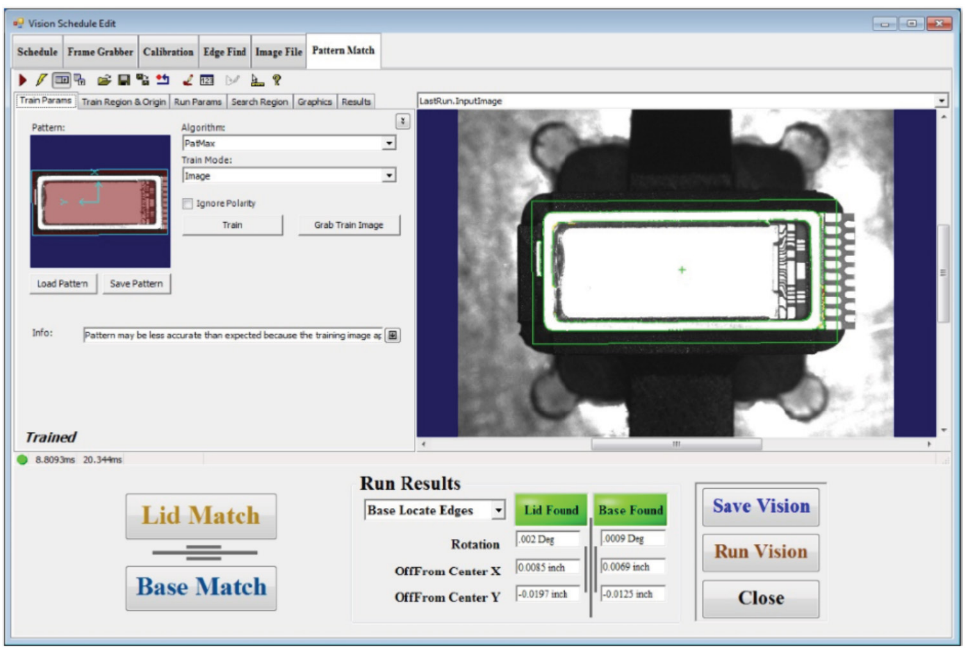
PARALLEL GAP SEAM WELDING

E **ADVANCED –** Automatic pick place, tack and seam seal welding system





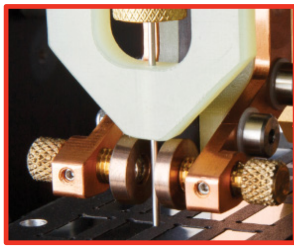
Vision assisted automatic pick and place and tacking



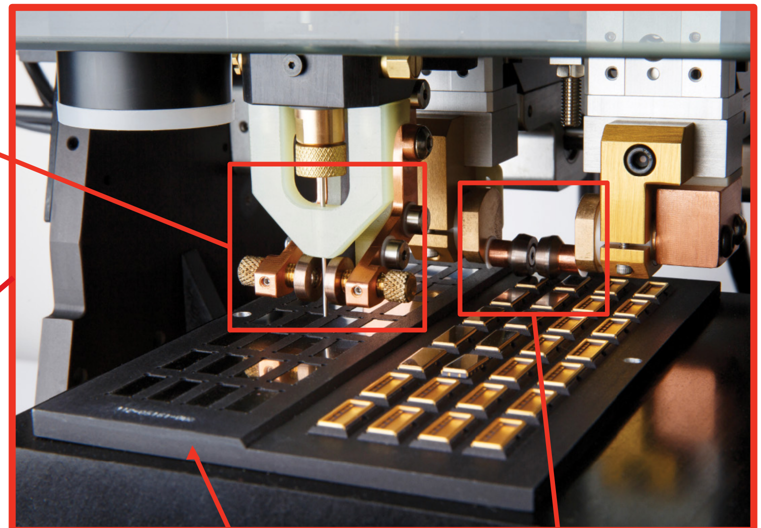
Pattern match using vision tool solves locating hard to find edges and a gold seal ring on gold background images by masking undesired background images

PARALLEL GAP SEAM WELDING

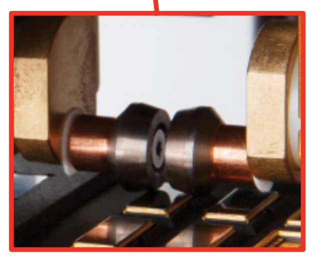
(E) Equipment: Seam welder, HF welding power supply, electrodes and fixture design



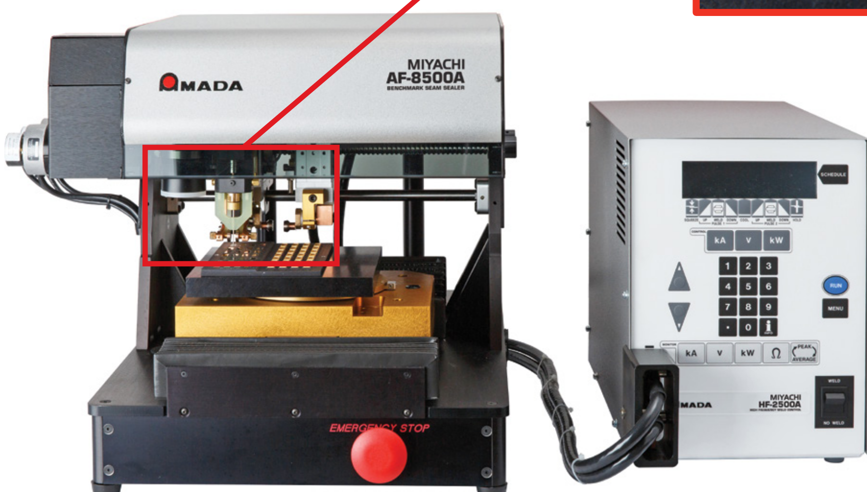
Lid pick-up tube and tack electrodes



Welding fixture nesting lids and bases



Seam weld electrodes



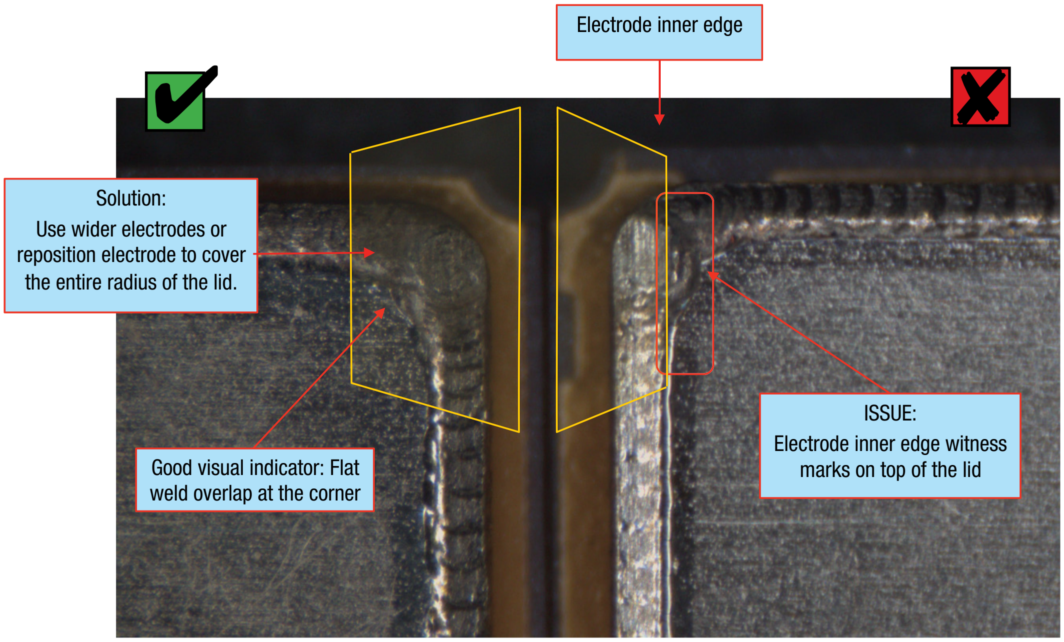
Seam welder

HF welding power supply

PARALLEL GAP SEAM WELDING

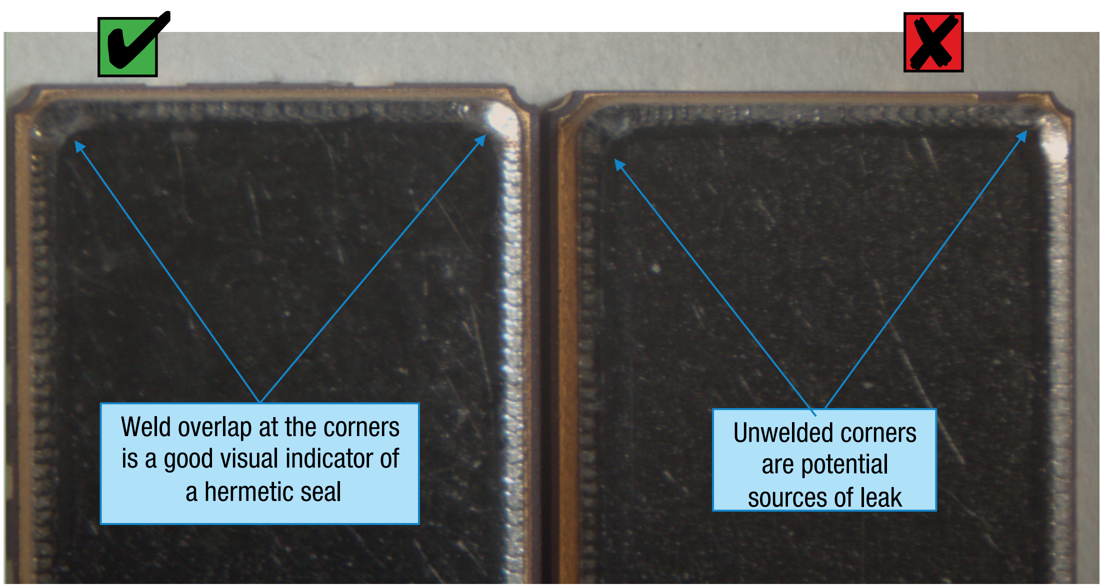
Process: What can go wrong?

Electrode inner edge witness marks at the corner of the package



Process: What can go wrong?

Unwelded corners due to insufficient weld travel

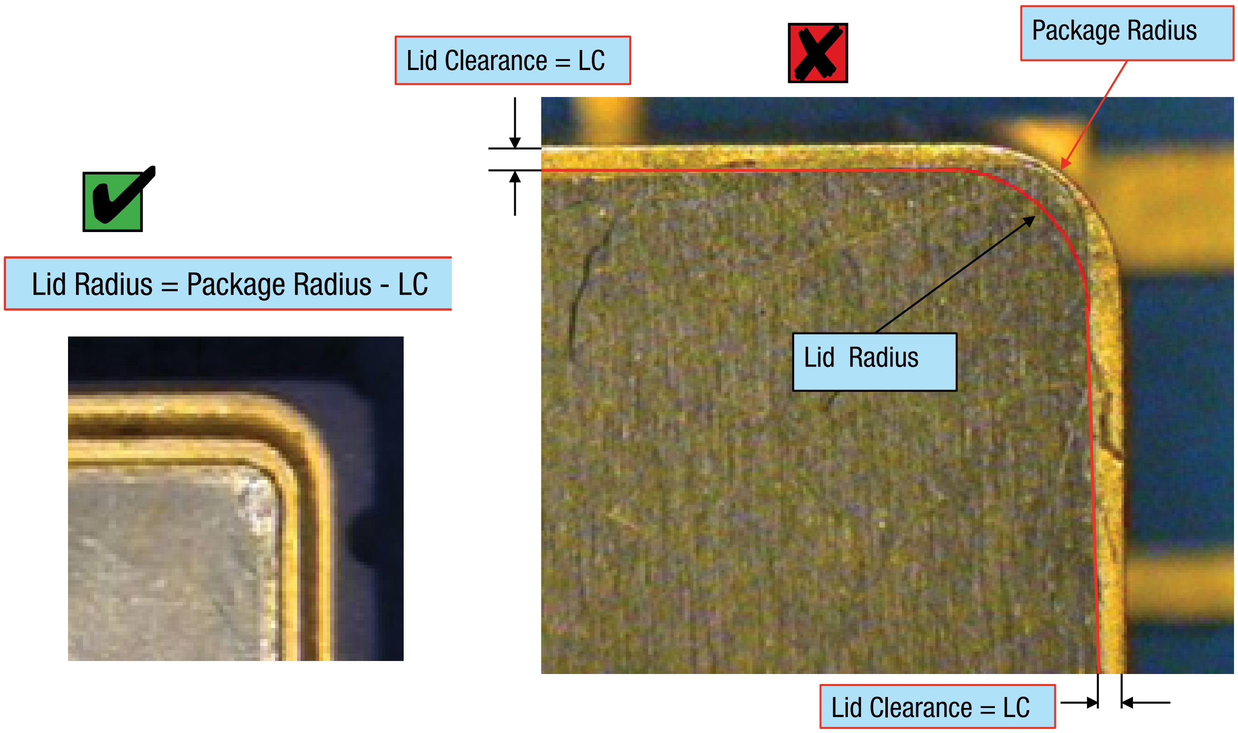


This can be resolved by welding beyond the lid size resulting to a weld overlap at the corners of the package

PARALLEL GAP SEAM WELDING

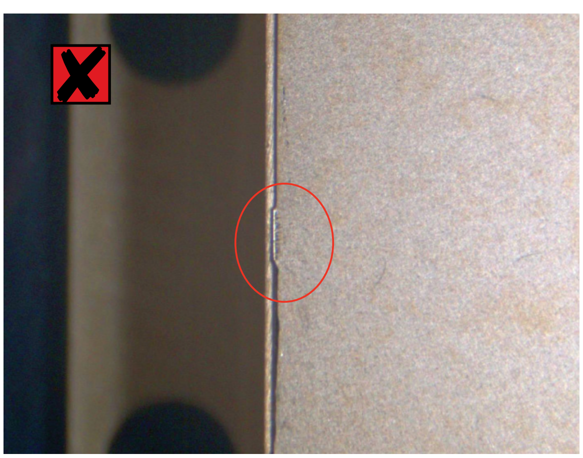
Ⓜ Material: What can go wrong?

Lid to package corner radius mismatched design

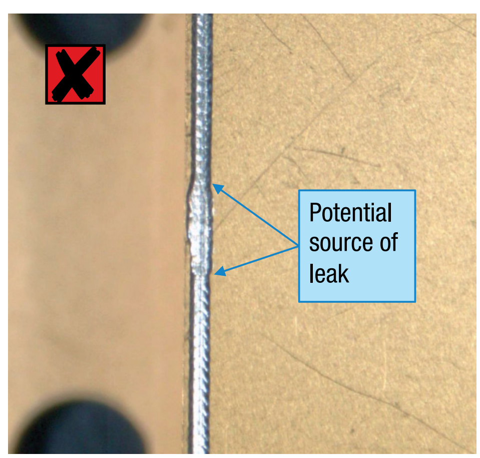


Ⓜ Material: What can go wrong?

Tab protrusions at the lid perimeter edge



Before Seam Sealing

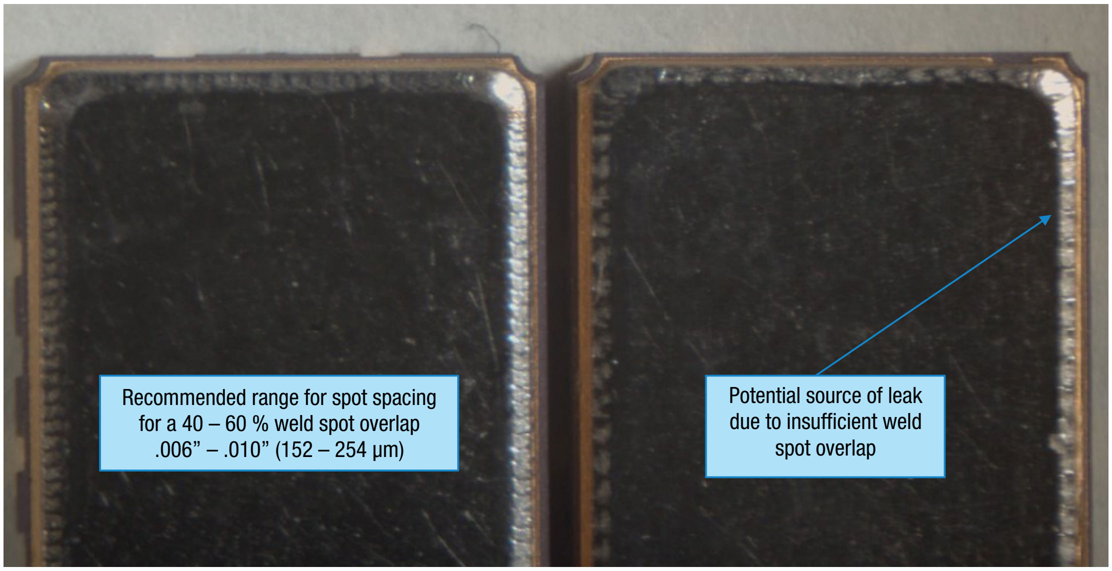


After Seam Sealing

PARALLEL GAP SEAM WELDING

Process: What can go wrong?

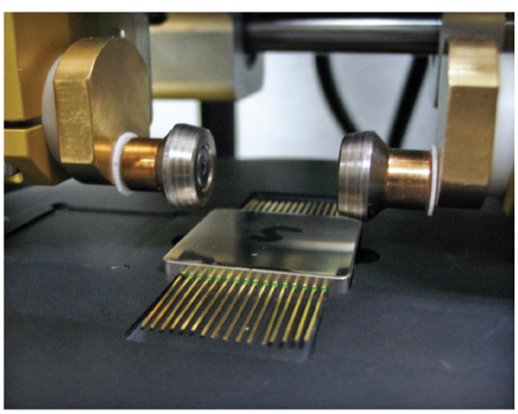
Insufficient weld spot overlap



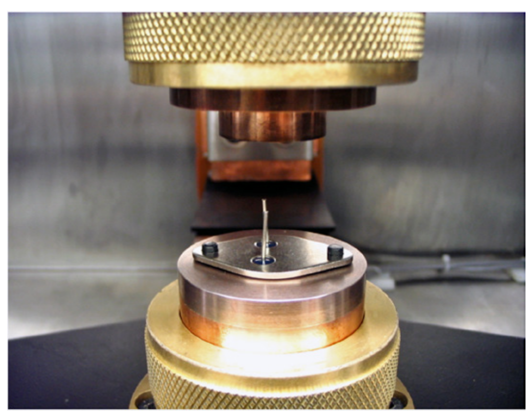
INTRODUCTION - BASICS:

Principles of Hermetic Sealing –

Parallel gap seam welding and opposed electrode projection welding technologies



Parallel gap seam welding



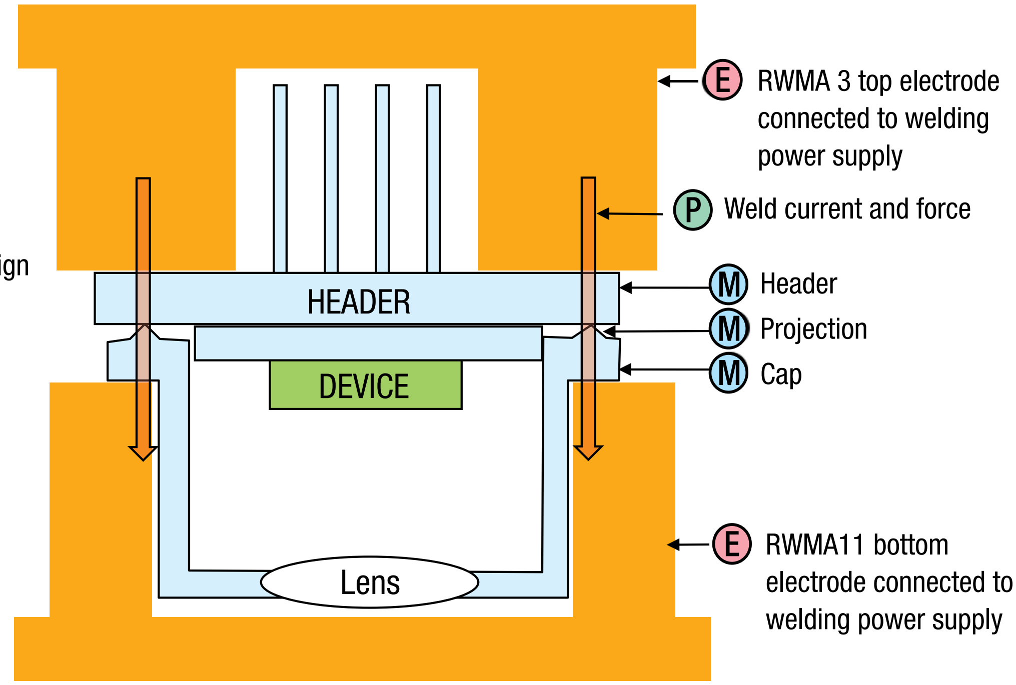
Opposed electrode projection welding

OPPOSED ELECTRODE PROJECTION SEAM WELDING

This technology utilizes opposing electrodes joining a header containing the electronic device and covering it with a cap.

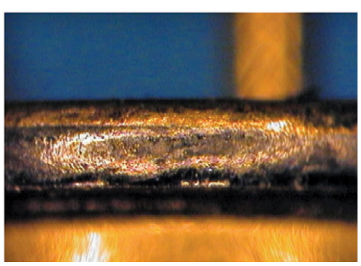
Key Elements:

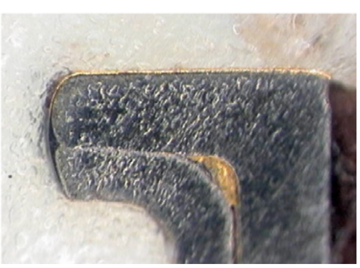
- P - Clamping speed
- P - Weld force
- E - Weld electrode design
- P - Weld energy
- M - Part design.

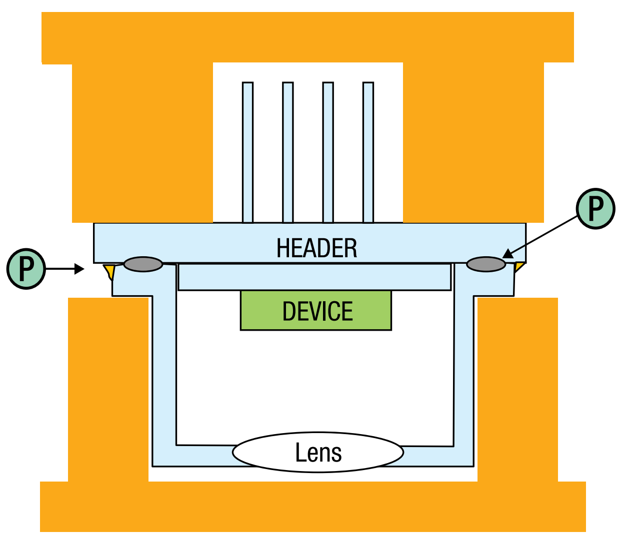


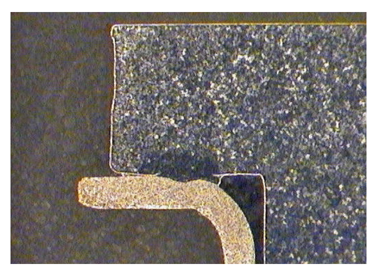
P Visual indicators of a successful weld

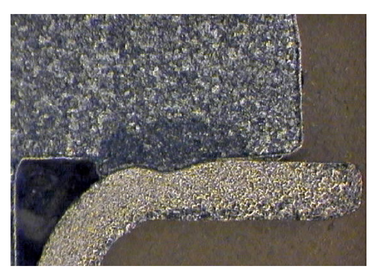
Weld fillet formation (typically seen when neither cap or header has a ring projection)
At least 50 – 90% projection collapse (a liner displacement can be added to the weld head)









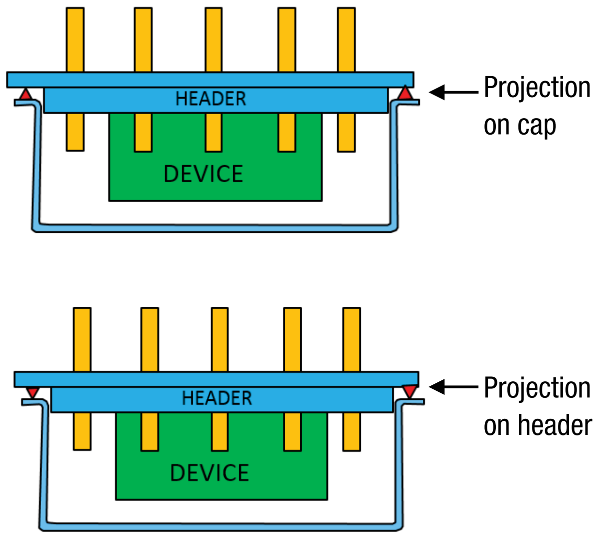


Fillet formation along the perimeter of the cap and header can be uses a visual indicator of a hermetic seal

Projection will collapse and will form a weld nugget or a solid state bond

OPPOSED ELECTRODE PROJECTION SEAM WELDING

M Materials: Part design metal packages, electrodes and plating



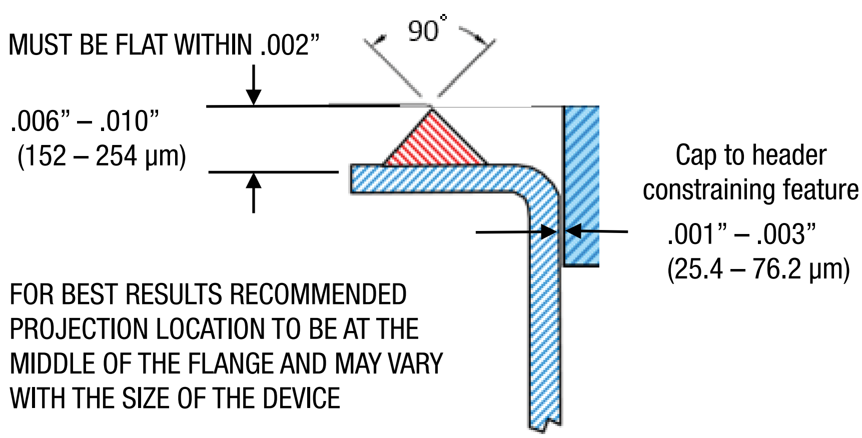
DESIGN FEATURES:

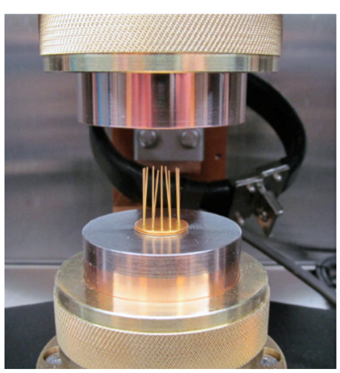
Projection located on either cap or header

- Cap position is constrained by the header within .001" - .003" (25.4 – 76.2 µm)
- Preferred material: Kovar
- Others materials: Nickel, Low carbon stainless steel, cold rolled steel

Typical Plating:

- Nickel 50-100 µ-in (1.3 - 2.5 µm)
- Gold 20 – 50 µ-in (0.5 – 1.3 µm)



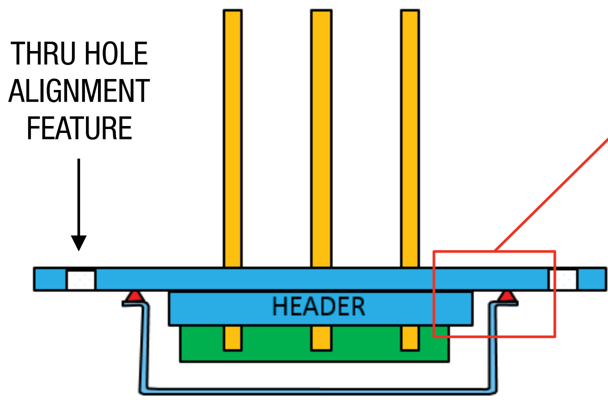


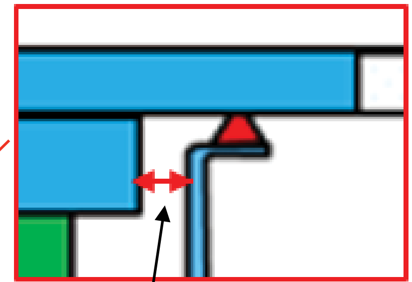
E WELDING APPROACH:

Both cap and header are loaded at the bottom electrode

OPPOSED ELECTRODE PROJECTION SEAM WELDING

M Materials: Part design metal packages, electrodes and plating





M ISSUE: No Constraining feature between cap and header

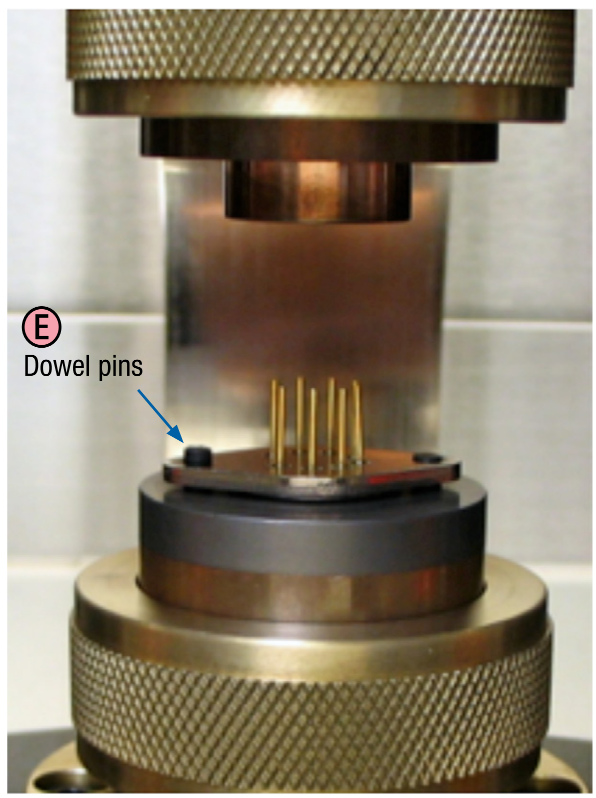
DESIGN FEATURES:

- E SOLUTION: Since the cap and header does not have a constraining feature with each other lower electrode design must have a feature to align the parts together using non-conductive dowel pins
- M Ring projection is on the cap
- M Typical cap and header material:

  Kovar, nickel, cold rolled steel, low carbon stainless steel
- M Typical Plating:

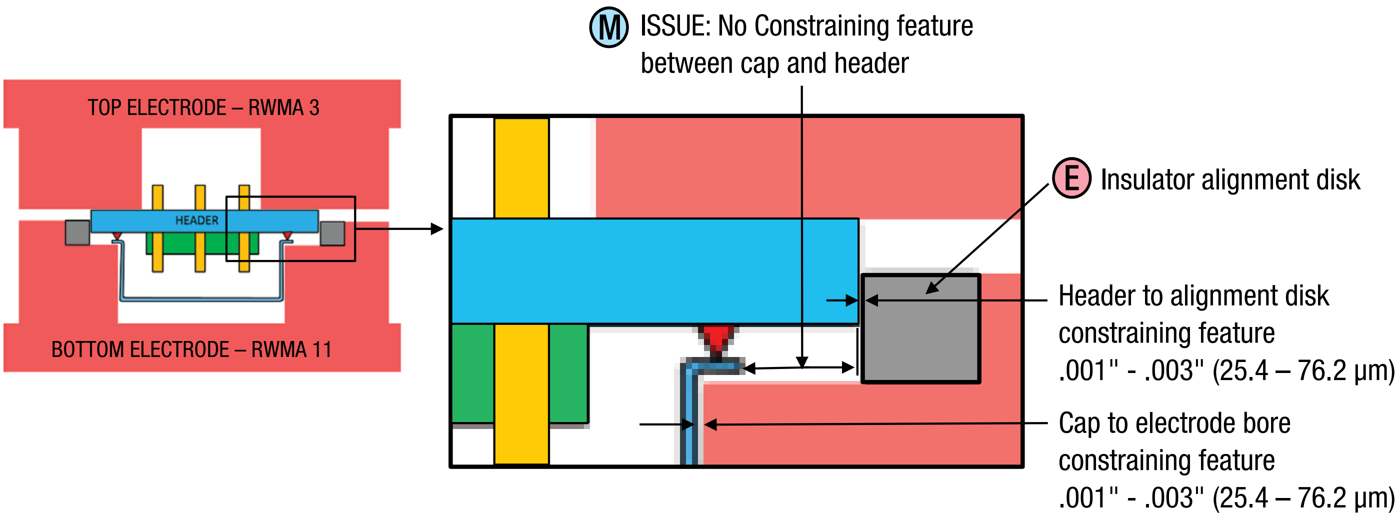
  Nickel 50-100 μ-in (1.3 - 2.5 μm)

  Gold 20 – 50 μ-in (0.5 – 1.3 μm)



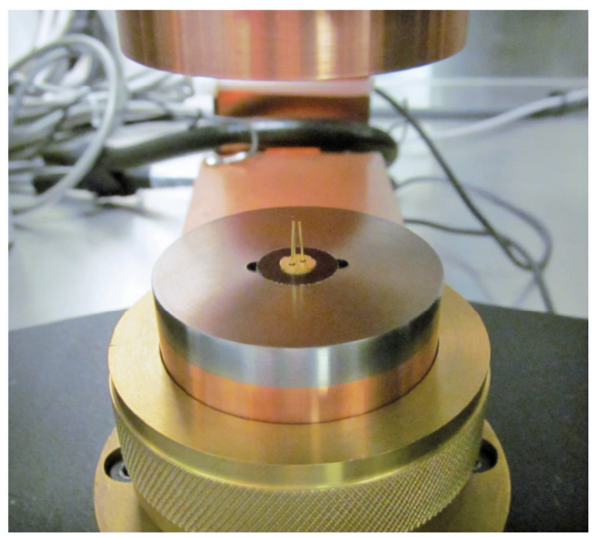
OPPOSED ELECTRODE PROJECTION SEAM WELDING

Ⓜ Materials: Part design metal packages, electrodes and plating



DESIGN FEATURES:

- Ⓔ SOLUTION: Since the cap and header does not have a constraining feature with each other lower electrode design must have a feature to align the parts together using non-conductive alignment disk
- Ⓜ Typical cap and header material:
  Kovar, nickel, cold rolled steel, low carbon stainless steel
- Ⓜ Plating:
  Nickel 50-100 µ-in (1.3 - 2.5 µm)
  Gold 20 – 50 µ-in (0.5 – 1.3 µm)



OPPOSED ELECTRODE PROJECTION SEAM WELDING

(P) Process – Weld Schedule Development

TYPICAL ELECTRONIC DEVICES AND CAPACITOR DISCHARGE POWER SUPPLIES IN THE MARKET													
DEVICE TYPE	TO-56	TO-18	TO-46	TO-5	TO-39	TO-37	TO-8	TO-66	TO-3	14 DIP	24 DIP	RELAYS	HYBRIDS
PROJECTION LINEAR LENGTH (mm)	0.49” (12.5)	0.7” (17.8)	0.7” (17.8)	1” (25.4)	1” (25.4)	1.1” (27.2)	1.6” (40.6)	1.9” (48.3)	2.8” (71.1)	2.4” (61.0)	3.3” (83.8)	4” (101.6)	5” (127.0)
CD POWER SUPPLY MAXIMUM OUTPUT													
1000 JOULES	X	X	X	X	X	X							
3000 JOULES		X	X	X	X	X	X	X					
6000 JOULES			X	X	X	X	X	X	X	X			
9000 JOULES				X	X	X	X	X	X	X	X	X	
12000 JOULES				X	X	X	X	X	X	X	X	X	X

LEGEND: “X” - WELDABLE

(P) BASELINE SETTINGS

Clamping Speed:
Slowest approach speed to prevent top electrode from damaging on to the device

Weld Force:
Round caps - 400 lb-F / inch (7.2 kg-F/mm) of projection

Rectangular caps – 700 lb-F / inch (12.5 kg-F/mm) of projection

Weld energy:
Round caps: 600 Joules/ inch (23.6 Joules/mm) of projection

Rectangular caps: 1000Joules / inch (39.4 joules/mm) of projection

Note: Recommended baseline setting will need further optimization.

WELD FORCE	WELD POWER	WELD TIME	CONTACT AREA	MATERIAL CONDUCTIVITY	CONTACT RESISTANCE	HEAT GENERATED
⇧					⬇	⬇
	⇧					⬆
		⇧				⬆
			⇧		⬇	⬇
				⇧		⬇
					⇧	⬆

LEGEND: ⇧ - CAUSE ⬇ - EFFECT

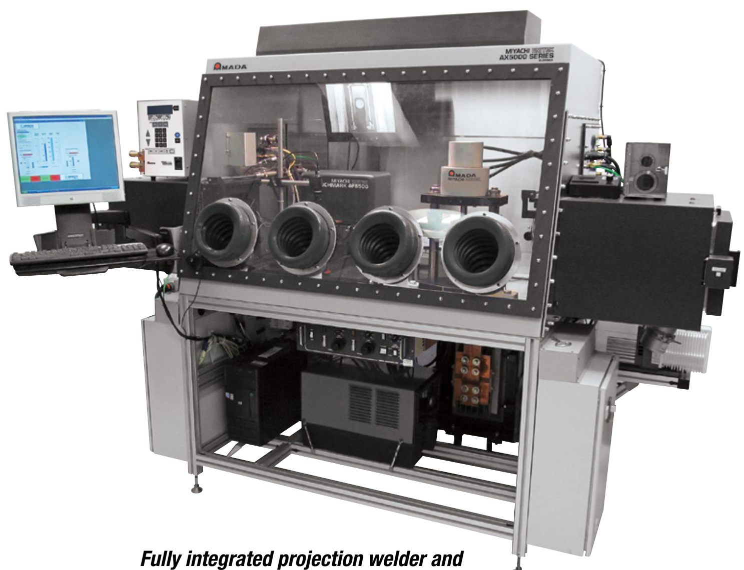
OPPOSED ELECTRODE SEAM WELDING

E Equipment: Projection Welding Systems

Projection Welding Systems
200 – 4000 lb-F
(90.7 – 1,814 kg-F)

Projection welder with vacuum – backfill feature

Desktop projection welder with weld monitor



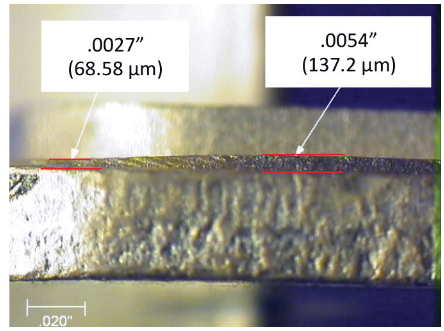
Fully integrated projection welder and seam sealer glovebox system

OPPOSED ELECTRODE SEAM WELDING

Ⓜ Materials – What can go wrong?

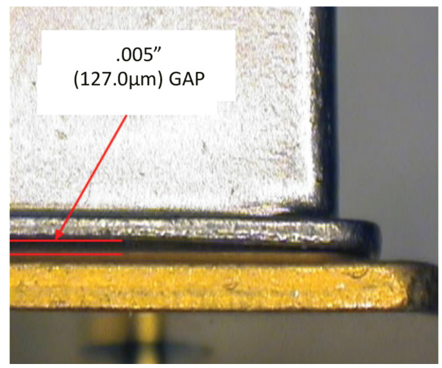
Projection Flatness issue will cause over welded joint at the high point of the projection and leaks at the low section of the projection.

Projection Flatness must be less than .002" (50µm)

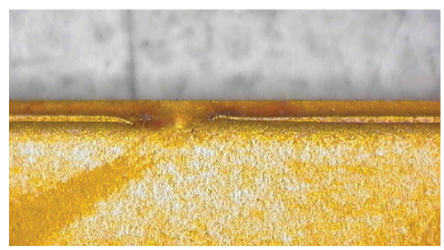


Bowed cap flange will have the same welding issue with materials having a projection flatness issue. Overheated weld joint or material expulsion will be seen at the contact point of the cap to the header and leaks at sections with a gap.

Cap flange Flatness must be less than .002" (50µm)



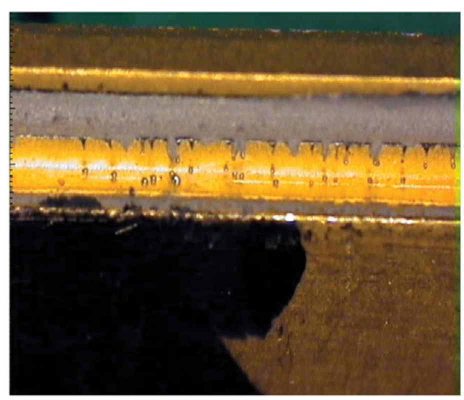
Non-continuous projections will cause unwelded gaps resulting to a non-hermetic weld joint



Ⓜ Materials – What can go wrong? PIND Failure

Material Expulsion inside or outside the perimeter of the weld joint is a visual indicator of materials which have flatness issues, insufficient welding force, or excessive weld energy.

If expelled material is trapped in the package this will cause Particle Impact Noise Detection **(PIND) test failure.**



OPPOSED ELECTRODE PROJECTION SEAM WELDING

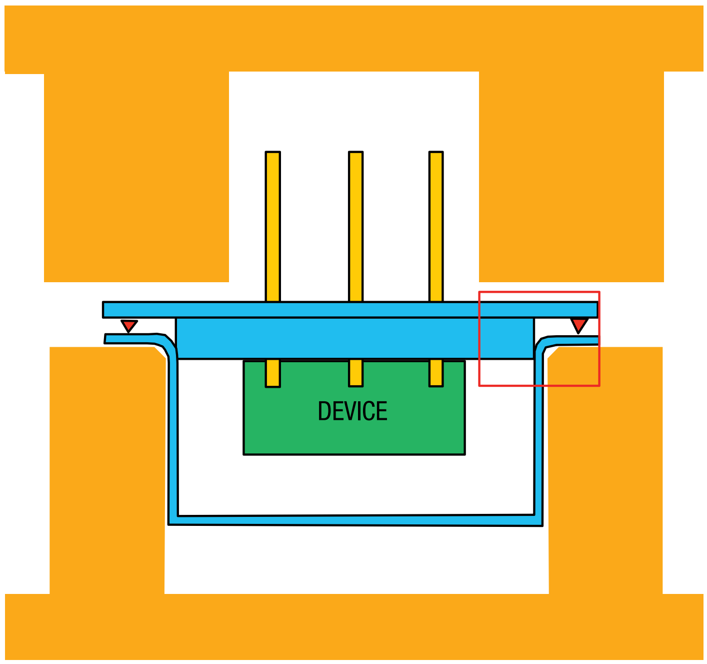
E

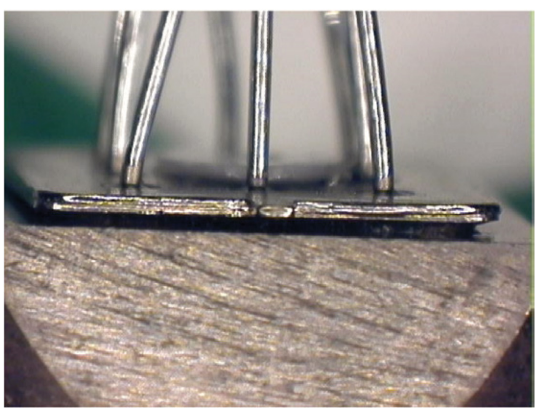
Equipment – What can go wrong?

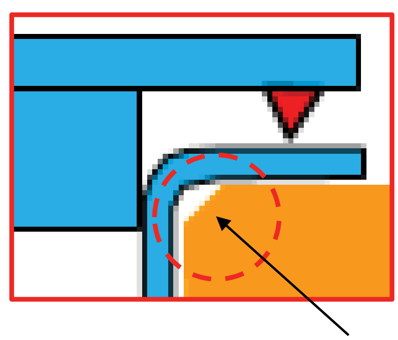
Electrode design issue

Issue: Cap flange not seated flat in the lower electrode

Solution: Add a chamfer at the bottom electrode





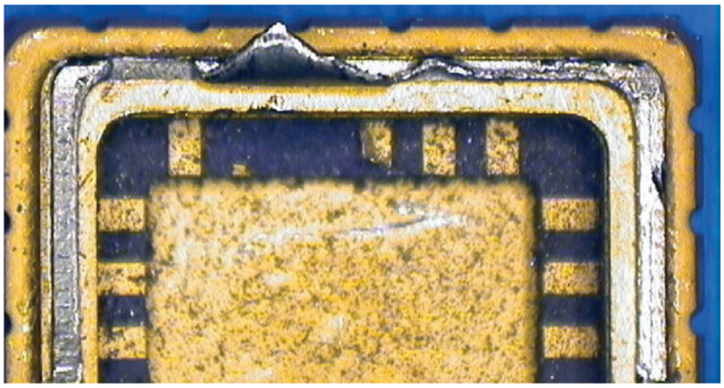


RELIABILITY TESTING

Ⓟ Process – Weld strength destructive testing

Objective - Mechanically separating welded lid or cap from base material

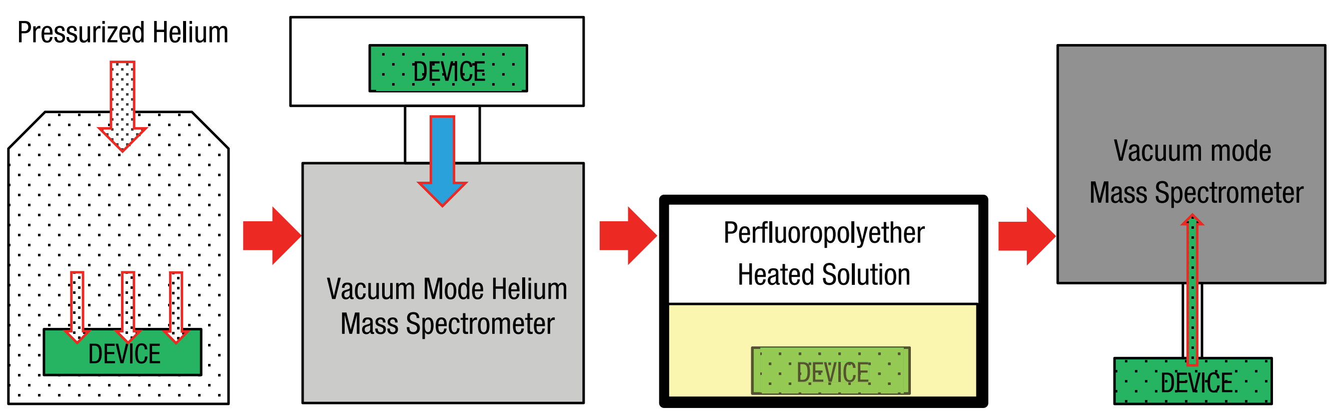
Visual indicators of a strong weld: 75 – 100% of the weld joint is still intact after mechanically separating the 2 welded parts



Testing weld strength – peel test

Mechanically separating cap from header

Ⓟ Process – Weld strength destructive testing



Helium bombing chamber

(Not required if package is seal with 10-15 % helium tracer gas)

Helium fine leak testing chamber or *Optical Fine Leak Detector

Gross leak testing submersion tank Bubble testing

Residual Gas Analysis / Internal Vapor Gas Analysis

Other Test:

- Particle Impact Noise Detection
- Temperature cycling
- Accelerated aging test

Note: Refer to MIL-STD 883 for more details

*Helium bombing not required

HERMETIC SEALING CONTROLLED DRY ENVIRONMENT:

(E) Equipment – What is a glovebox purpose:

Enclosure:

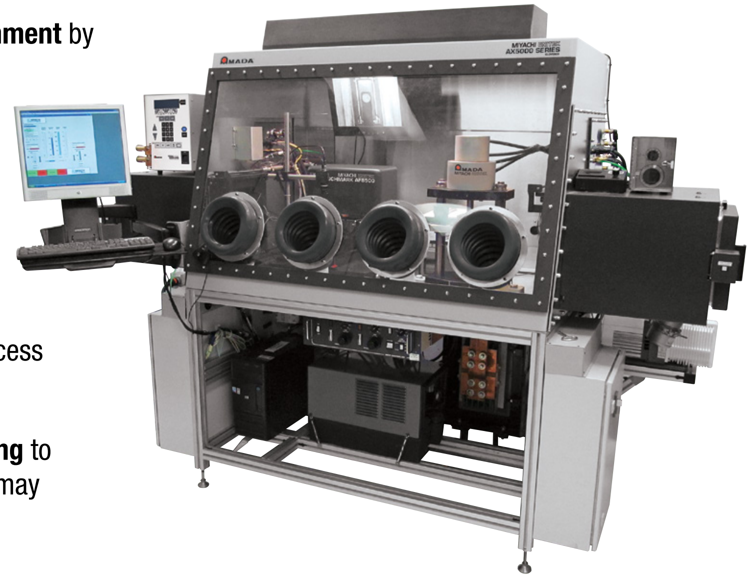
- **Maintains a controlled dry environment** by monitoring desired moisture levels.

Antechamber:

- **Door interlocking feature** to prevent enclosure from being exposed to ambient atmosphere
- Removes ambient atmosphere's moisture from items entering the enclosure by purging or vacuum process

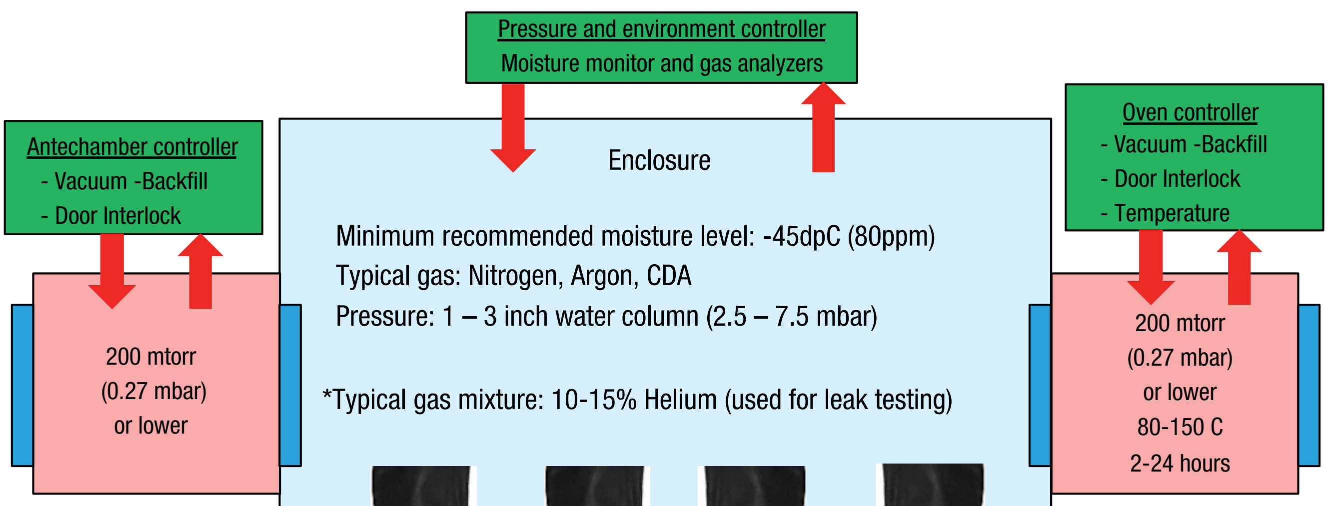
Desiccation Ovens:

- Subjects parts to **Vacuum and baking** to remove undissolved solvents which may outgas prior to seam welding



HERMETIC SEALING CONTROLLED DRY ENVIRONMENT:

(E) Equipment – What is a glovebox purpose:



- Welding with helium tracer gas will shorten process time by skipping the helium bombing process and proceed with fine leak testing immediately after welding

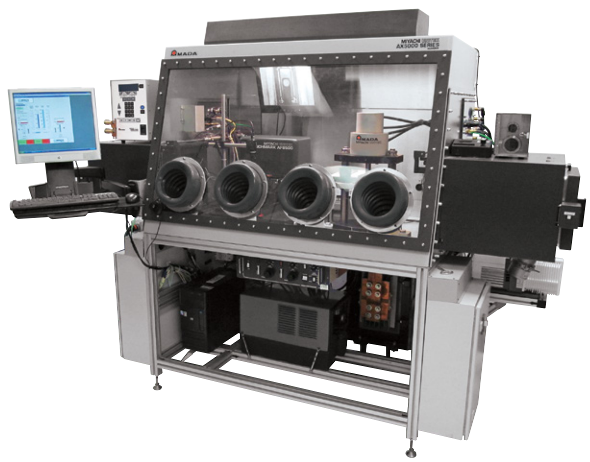
HERMETIC SEALING CONTROLLED DRY ENVIRONMENT:

(E) Equipment – Glovebox Images and Configurations

Compact enclosure with projection welder with gas purification system

Compact enclosure with seam welder

Modular glovebox with standalone gas analyzers and seam welder

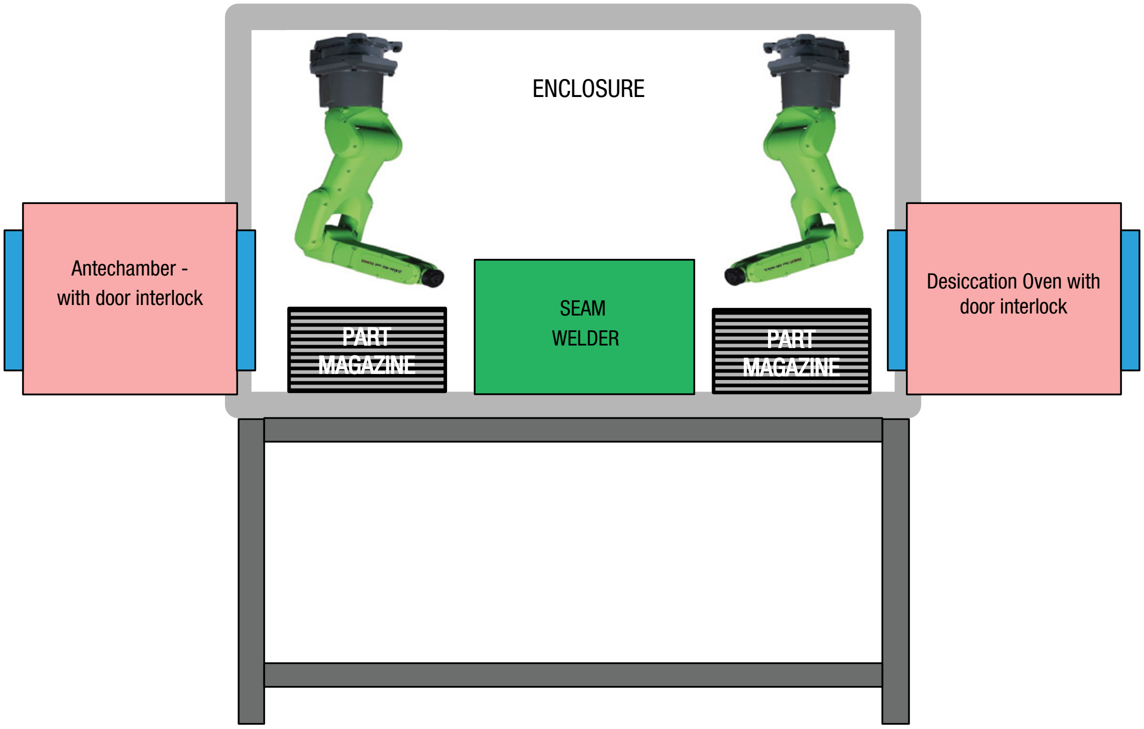


Advanced glovebox with close looped analytical gas analyzers and unlimited oven bake schedules seam sealer and projection welder

Advanced glovebox with close looped analytical gas analyzers, unlimited oven bake schedules with multiple oven add-on module and seam welder

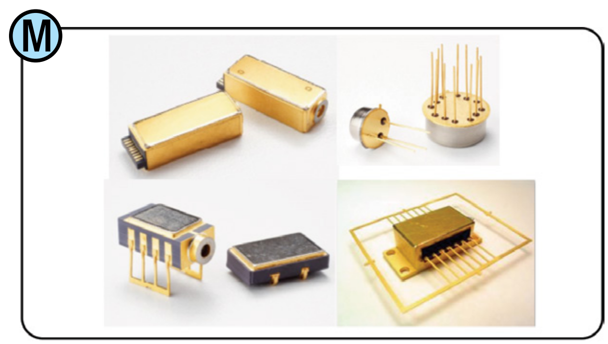
FUTURE OF HERMETIC SEALING PRODUCTS:

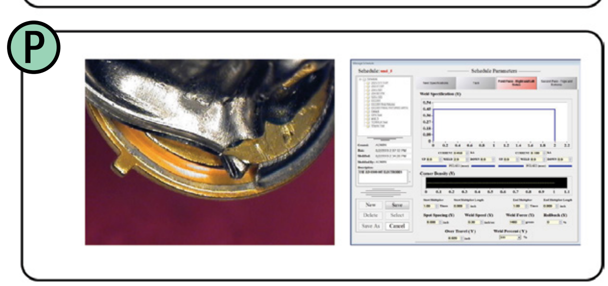
Robot assisted seam sealing pick and place systems



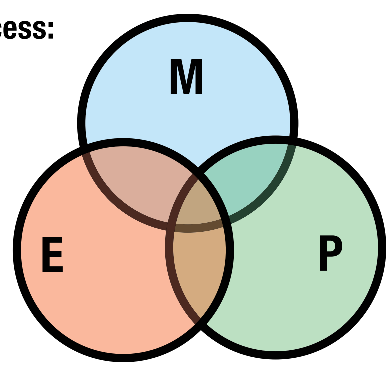
SUMMARY

- Hermetic seam sealing of electronic packages
  - Parallel gap seam welding
  - Opposed electrode projection seam welding
- Hermetic seal testing
- What can go wrong with your process?
- Future of hermetic sealing products





Success:



Amada Weld Tech – Webinars

Date	Title/Topic
December 2018	Resistance Weld Monitoring for Improved Throughput and Quality
June 2019	Laser Source Selection for Micro-welding
September 2019	Hermetic Seam Sealing Microelectronic Packages
November 2019	Laser Weld Monitoring
February 2020	Resistance Spot Welding - Weld Head Selection

Contact us if you would like to get link to past webinars or a copy of the presentation.