

Wykład z przedmiotu
„Montaż elektroniczny i systemy testujące”
Specjalność: Sensory i mikrosystemy

Montaż przez zgrzewanie

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Plan

- Zastosowania połączeń zgrzewanych w elektronice,
- cechy prawidłowego połączenia zgrzewanego,
- budowa nowoczesnych zgrzewarek,
- parametry zgrzewania i ich optymalizacja,
- etapy tworzenia połączeń,
- techniki montażu,
- używane materiały,
- oprzyrządowanie dodatkowe

Lectures on Electronic assembly and testing systems

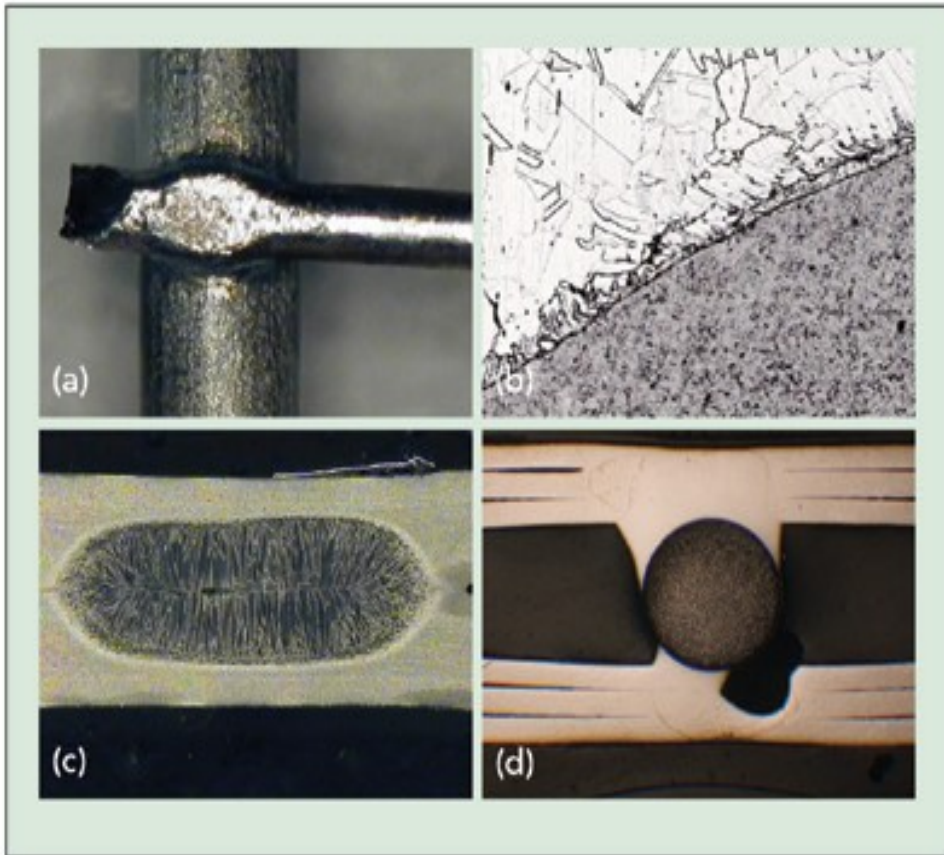
Speciality: Sensors and microsystems

Wire welding in electronic assembly

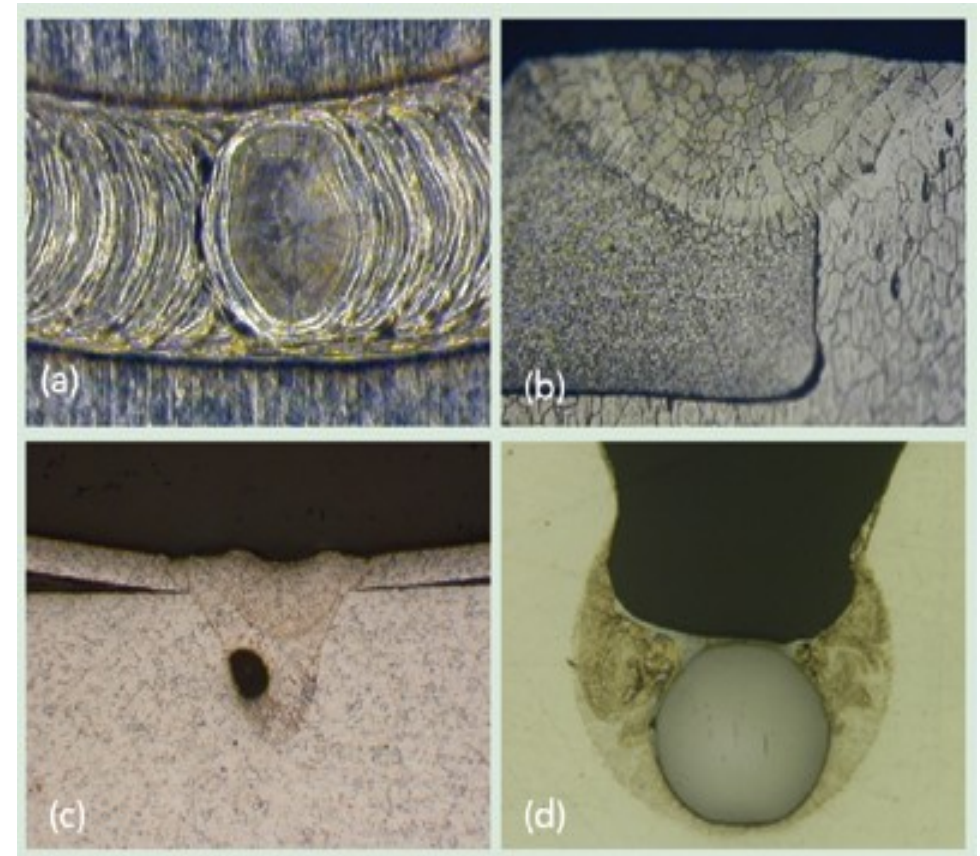
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Welding



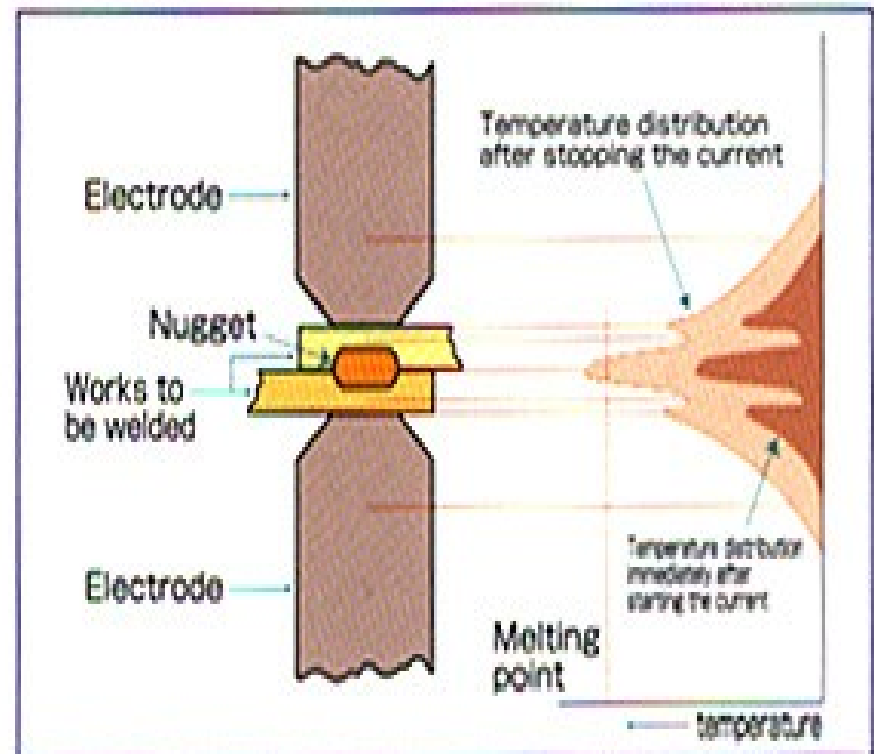
Resistance welding results



Laser welding results

What is welding?

- Resistance spot welding is a thermal process for joining two or more pieces of metal together in a specific localized area.
- The heat required to produce the welded joint is generated by the resistance of the metal being welded to the flow of electricity through it.
- Joining is accomplished either by fusing the area to be welded (**fusion welding**) or by **forge welding** the metal.
- The joining mechanism is governed by the **thermal** and **electrical** characteristics of the metals being welded.

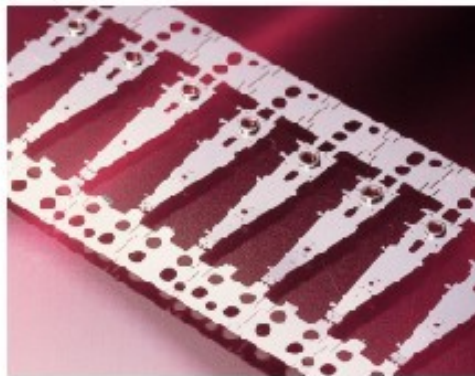
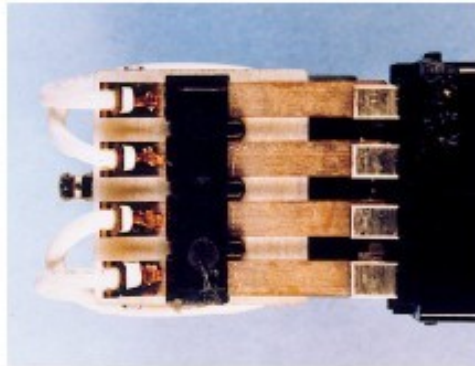


Rise of temperature in micro spot welding

Electronics applications - examples

APPLICATIONS INCLUDE:

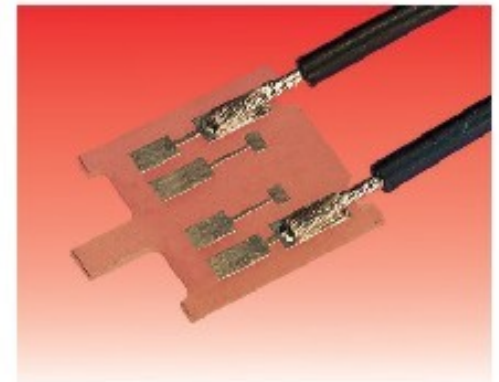
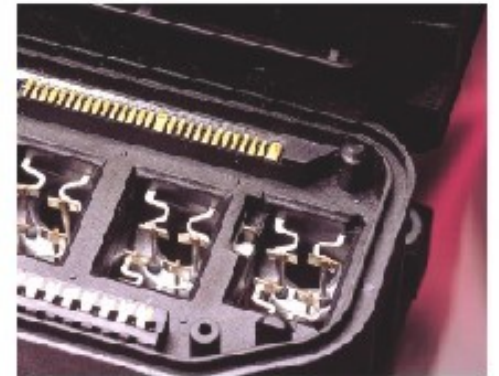
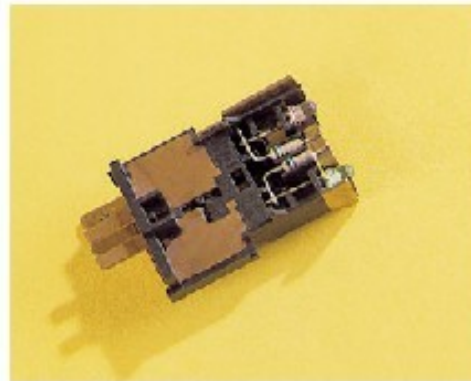
- Read / Write Armatures
- Electron Gun Assembly
- Power SCR
- Disc Drive Assemblies
- Solenoid Assembly
- Electrical Connectors
- Leadframe Assemblies
- Relay Terminal Connection



Automotive applications - examples

APPLICATIONS INCLUDE:

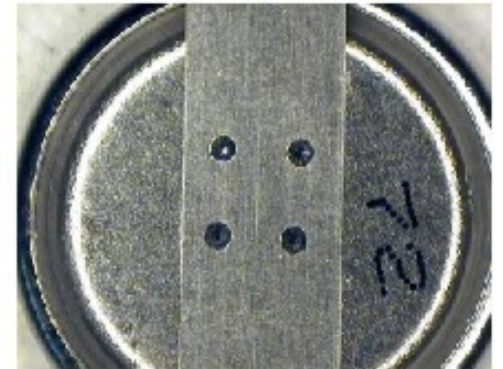
- Air Bag Assemblies
- Switch Gear Assemblies
- Motor Assemblies and Armatures
- Anti-Lock Brake Solenoids
- Ignitions Controls
- Lighting Assemblies
- Fuel Injectors
- Day / Night Switches



Battery & Battery Pack applications

APPLICATIONS INCLUDE:

- Pack Assembly
- Cell Fabrication; Coin, Prismatic and Cylindrical
- Positive and Negative tab connections
- Jelly Roll
- Leak Caps
- Hermetic Seam Sealing
- Many Weldable Sizes



Resistance welding

Four approaches:

Capacitor discharge

- recommended for spot welding all delicate materials and for most of the metal combinations found in the electronics industry. These include most copper alloys or any other highly conductive materials.

Closed loop linear DC

- recommend for micro welding applications that require greater process control and quick response times. These include both conductive and resistive materials.

Closed loop variable high frequency inverter

- used in higher power applications requiring greater process control and quick response time. Many conductive and resistive materials may be welded successfully.

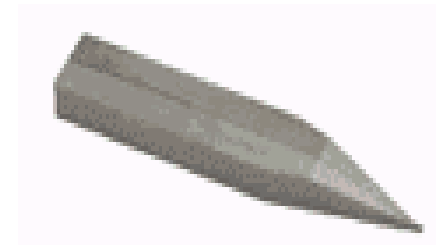
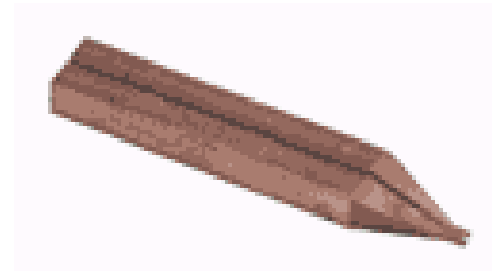
AC line type

- recommended for all seam or roll spot applications and for standard spot welding of readily weldable materials such as carbon steel, stainless steel and other metals when a long heat dwell is desired or permissible.

Micro welders and welding electrodes



RDO Induction L.L.C
<http://www.rdoinduction.com/>



Welding electrodes

Fusion welding

Fusion - the simplest and most commonly used mode of resistance spot welding.

Metal at the joint to be welded is resistance heated until it melts locally at the interface between the parts.

The pool of metal is held under pressure (compression) with the electrodes until it has solidified into a cast "nugget" that joins the pieces being welded.

Dissimilar metals can be welded as easily as similar metals provided, that the differences in their melting points, vapor pressures and other thermal and physical characteristics are not too great in most cases. Dissimilar metals that weld in this manner form alloy nuggets.

Source: MicroJoin – A Palomar technology Company

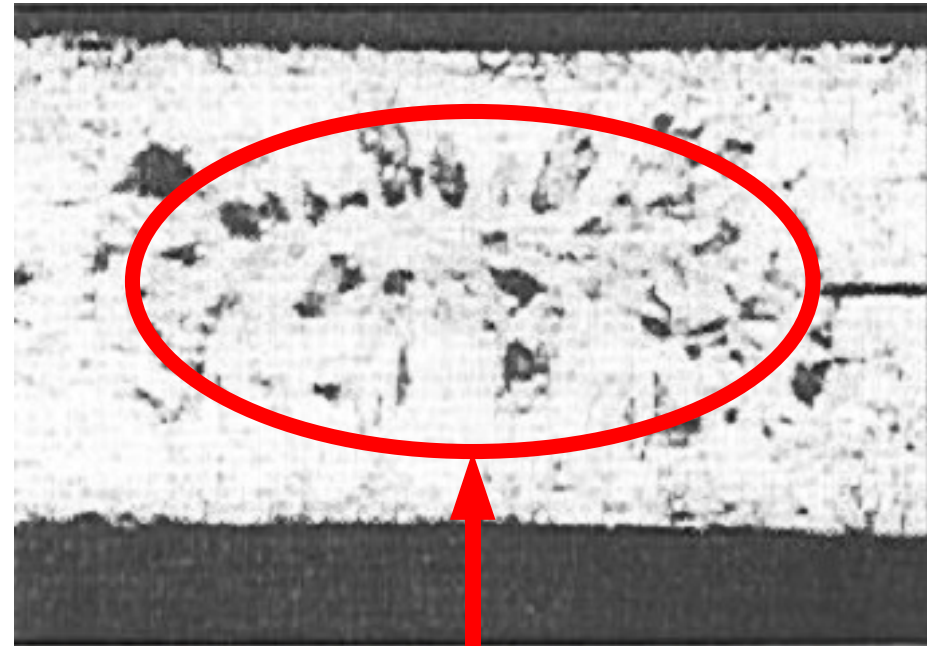


Figure 1 FUSION WELD (MAGNIFICATION 100X)

Forge welding

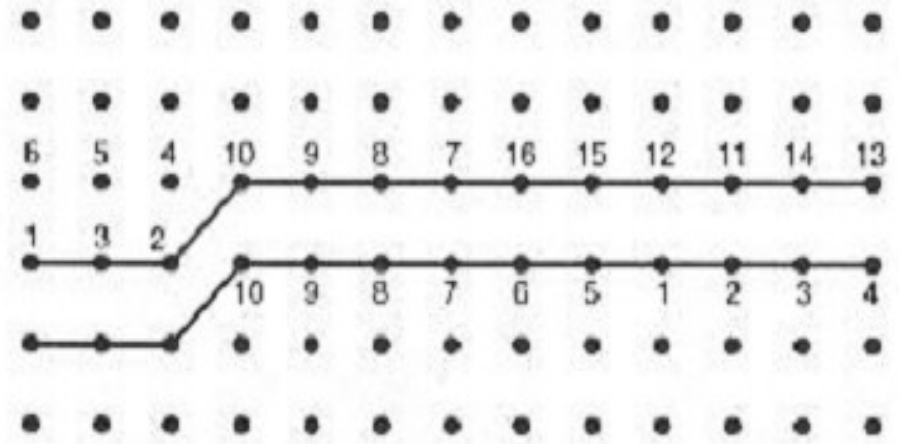
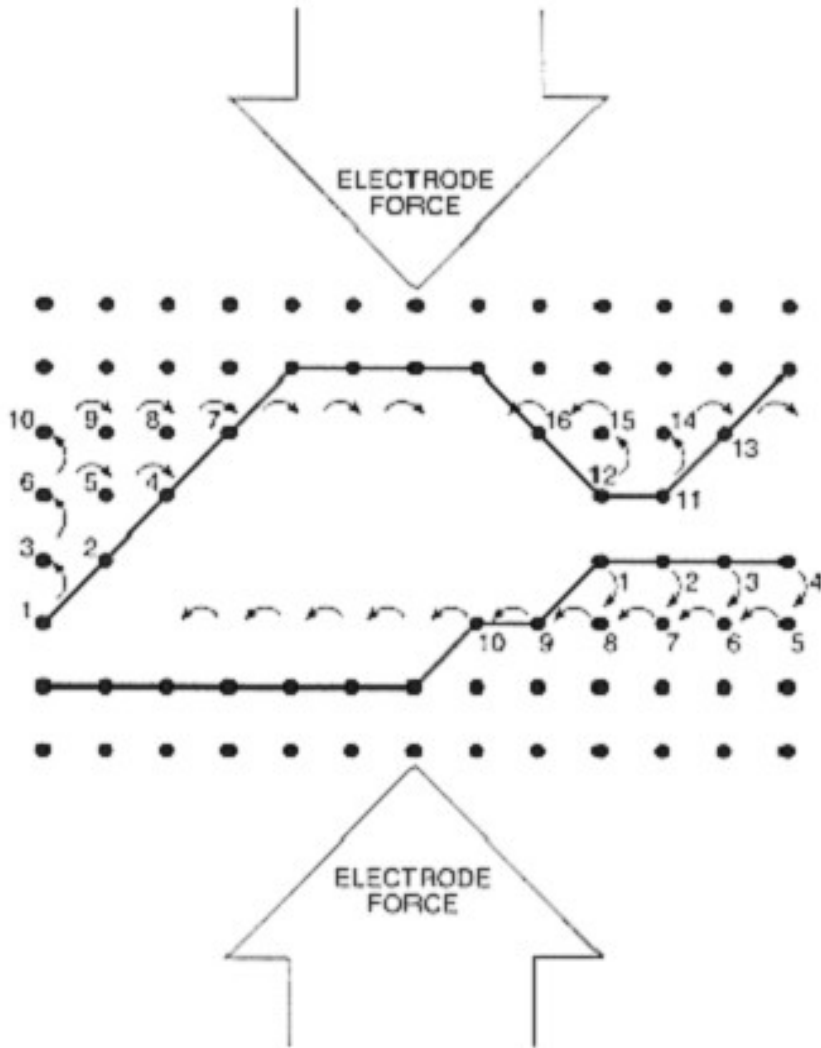
Forge welding - similar to an ancient process used by old-time blacksmiths.

The process consists of heating the metals to be joined until they become plasticized (below the melting temperature) and then forcing them into intimate contact by applying forging pressure to the area to be welded.

The energy introduced into the system by heating and forging causes atomic movements (diffusion) at the interface between the two pieces of metal.

Basically, the atoms of the two separate pieces of metal are forced into such close proximity at the interface that atoms are actually exchanged within the crystal lattice structures of the two metals resulting in a single piece of metal.

Forge wire welding

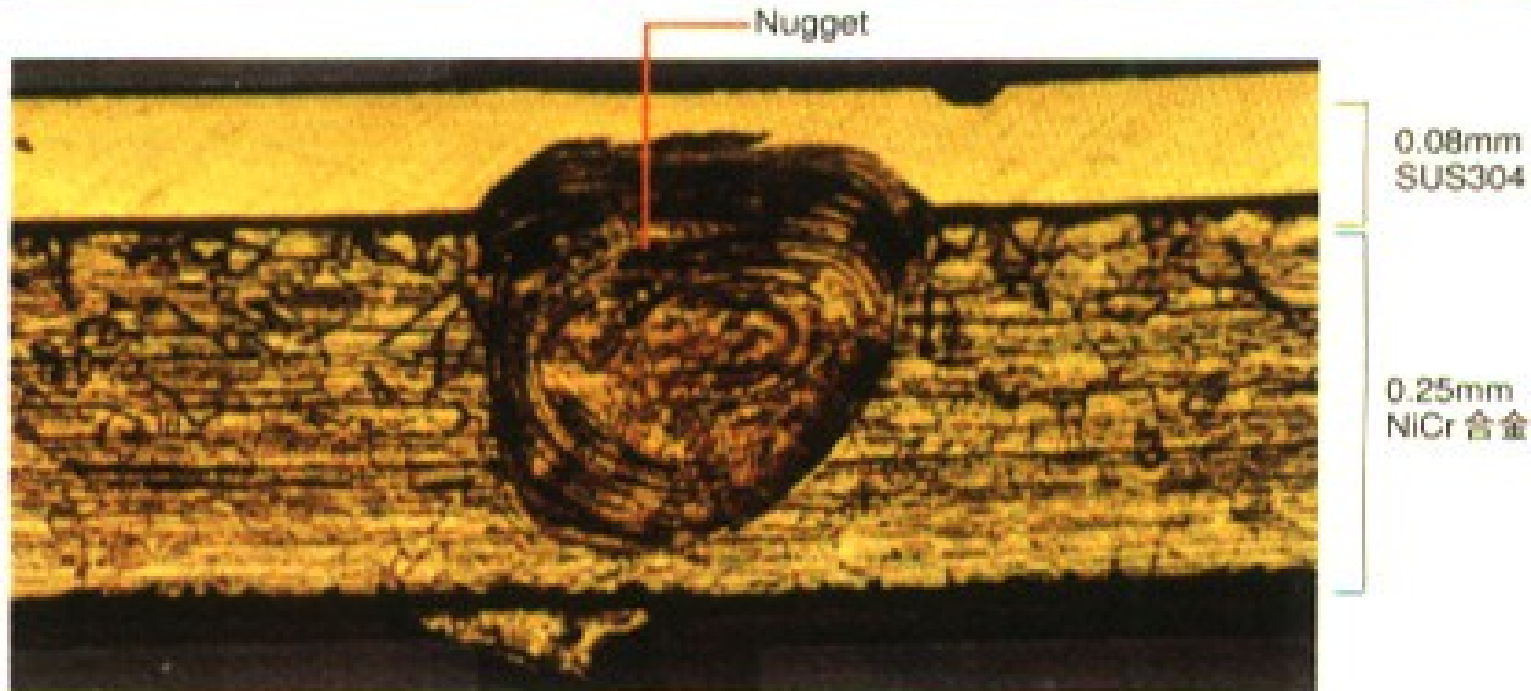


Atom locations in joint after forge welding

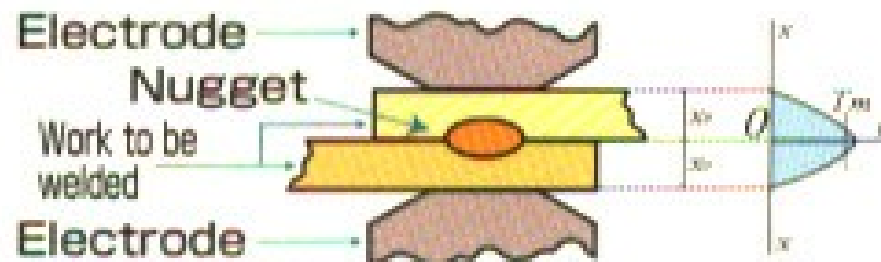
Atomic movements in forge welding

Welding result

Nugget formation with conventional resistance welding volume resistance dependant method



A longer period welding current application causes a thick nugget, resulting in a bend in the work due to contraction in the thickness of the work. Also, the nugget causes deviation in the thicker plate of the work.

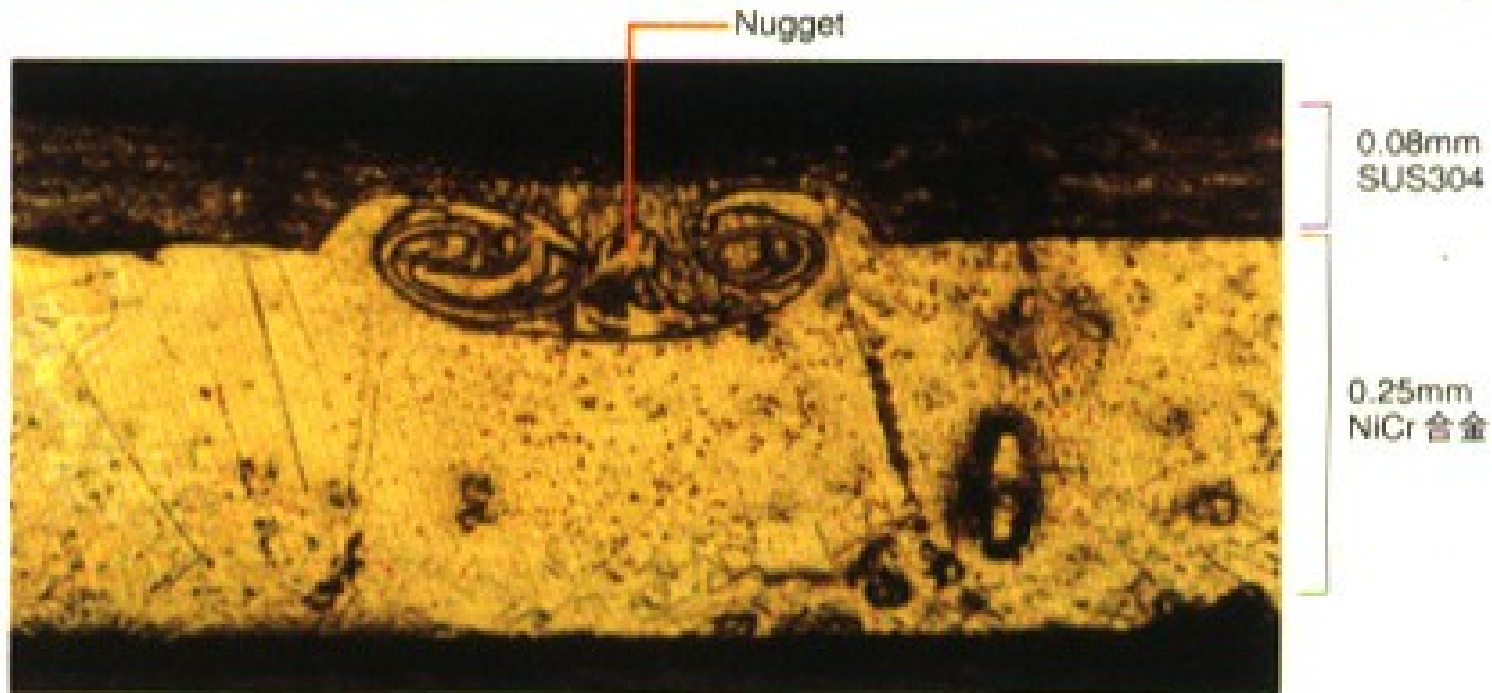


Source: M-S Cable

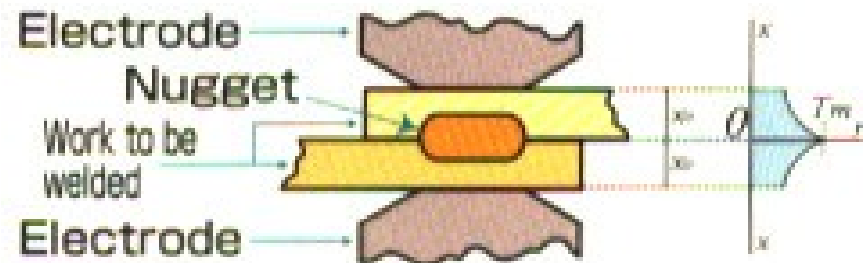
(http://www.ms-cable.com/product/resistance_welding_machine/micro_spot/micro_spot_welding.html)

Welding result

Nugget formation with micro spot welding contact resistance dependant method



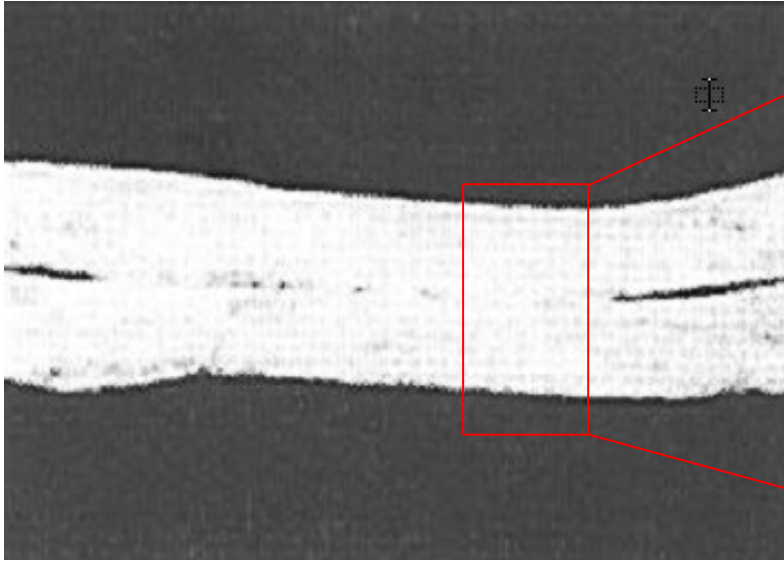
A shorter period welding current application creates a thin nugget, resulting in a smaller bend in the work. Also, the nugget is evenly distributed into both the thicker and thinner plates of the work.



Source: M-S Cable

(http://www.ms-cable.com/product/resistance_welding_machine/micro_spot/micro_spot_welding.html)

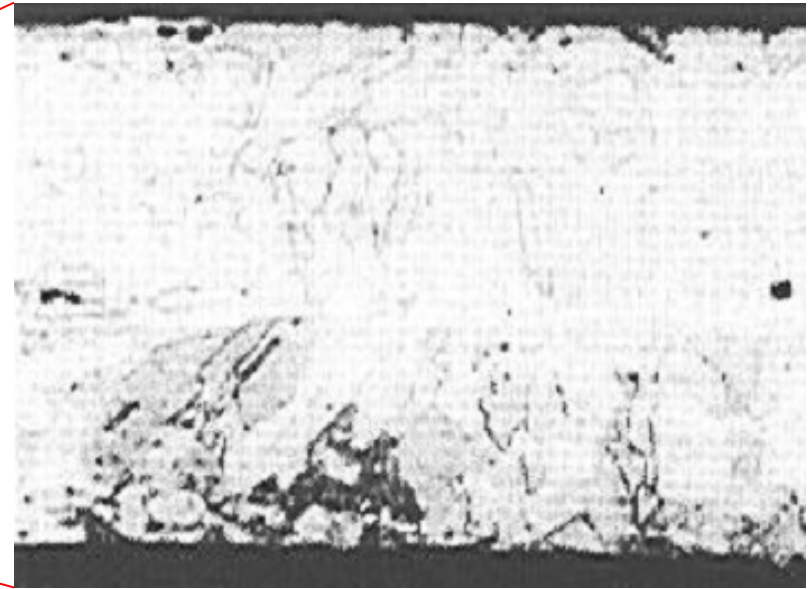
Forge welded joint - examples



SPOT WELD (MAGNIFICATION 200X)

Cross section of a typical spot welded joint formed by forge welding.

Notice that, although the joint line disappears completely in the area welded, the grain structure was not significantly changed.



SPOT WELD (MAGNIFICATION 400X)

Higher magnification reveals that the metals recrystallized across the joint interface, eliminating any joint line.

Factors influencing resistance welding

Melting temperature of metals being welded - pure metals melt at constant, well-defined temperatures, alloys melt over ranges of temperatures determined by reference to the appropriate phase diagrams.

The **plastic range**, or **hot working temperature** of metals and alloys, is more difficult to define.

At this temperature metal can be mechanically deformed or altered without increasing its hardness or inducing residual stresses into the part that has been wrought.

HOT WORKING TEMPERATURES OF SOME COMMON METALS			
METAL	HOT WORKING TEMPERATURE (°C)	MELTING POINT (°C)	HOT WORKING TEMP/MELTING POINT X 100 (%)
Magnesium	427	649	66
Aluminum	510	650	78
Copper	843	1066	79
Nickel	1205	1455	83
Iron	1232	1538	80

Welding process

A certain amount of heat generated in resistance welding is lost by conduction to the electrodes and to cooler areas of the pieces being welded. This heat loss is determined by each material's thermal conductivity. Another small and indeterminate fraction of the heat generated is dissipated by radiation. These heat losses must be added to the heat required for welding.

$$Q = I^2 Rt$$

where:

Q - quantity of heat (Ws), I – current (A), R - resistance in the circuit (Ω), t- time (s)

The most important physical properties of metals governing their weldability are:

- melting point (hot working temperature),
- resistivity,
- thermal conductivity.

Physical properties of certain metals

These properties determine:

- the amount of welding heat required,
- how easily the heat can be generated,
- and how readily it can be confined to the required area for spot welding.

GROUPING AND PHYSICAL PROPERTIES OF CERTAIN METALS									
	METAL	ATOMIC NUMBER	ATOMIC WEIGHT	DENSITY	MELTING POINT	SPECIFIC HEAT	THERMAL CONDUCTIVITY	THERMAL EXPANSION	RESISTIVITY
FERROUS METAL	iron	26	55.85	7.87	1539	.011	0.18	11.7	9.71
	cobalt	27	58.94	8.9	1495	0.099	0.165	12.3	6.24
	nickel	28	58.69	8.90	1455	0.105	0.22	13.3	6.84
LIGHT METALS	Aluminum	13	26.97	2.699	660	0.215	0.53	23.9	2.655
	Magnesium	12	24.31	1.74	650	0.25	0.38	26.0	4.46
CONDUCTIVE AND NOBLE METALS	copper	29	63.54	8.96	1083	0.092	0.94	16.5	1.673
	silver	47	107.88	10.49	960	0.056	1.0	19.7	1.59
	gold	79	197.2	19.32	1063	0.031	0.71	14.2	2.19
	platinum	78	195.23	21.45	1773	0.032	0.17	8.9	9.83
	palladium	46	106.7	12.0	1554	0.058	0.17	11.8	10.8
REFRACTORY METALS	Molybdenum	42	95.95	10.2	2625	0.061	0.35	4.9	5.17
	Tungsten	74	183.92	19.3	3410	0.032	0.48	4.3	5.5
	Tantalum	73	180.88	16.6	2996	0.036	0.13	6.5	12.4

Weldability

Weldability can be expressed in relation to resistivity, thermal conductivity and melting point:

$$W = R/FK_t$$

where: W – weldability, R – resistivity, F - melting point, K_t - thermal conductivity

WELDABILITY INDICES OF BASIC MATERIALS					
CATEGORY	METAL	RESISTIVITY	MELTING POINT (C)	THERMAL CONDUCTIVITY	WELDABILITY
FERROUS METALS	Iron	9.71	1539	0.18	3.51
	Cobalt	6.24	1495	0.165	2.46
	Nickel	6.84	1455	.22	2.15
LIGHT METALS	Aluminum	2.655	660	0.53	0.76
	Magnesium	4.46	650	0.38	1.80
CONDUCTIVE AND NOBLE METALS	Copper	1.673	1083	0.94	0.16
	Silver	1.59	960	1.0	0.17
	Gold	2.19	1063	0.71	0.29
	Platinum	9.83	1773	0.17	3.26
			10.8	1554	0.17
REFRACTORY METALS	Molybdenum	5.17	2625	0.35	0.56
	Tungsten	5.5	3410	0.48	0.34
	Tantalum	12.4	2996	0.13	3.19

very readily spot welded

reasonably easy to spot weld

notoriously difficult to spot weld, except of gold

weldable using special practices



(all properties stated in cgs units)

A higher value of weldability = more weldable material.

Resistance welding

Use of very high welding currents for extremely short discharge intervals.

These quick discharge times allow welding heat to be developed only in the weld area.

Advantages to not developing high heats in other sections of the materials being welded:

- no metallurgical change other than in the weld area
- minimum deformation
- little possibility of annealing effects
- no electrode burn-off (and no water cooling required)
- minimum discoloration
- welds can be made adjacent to heat-sensitive items without damage
- extremely low inertia design of the welding heads

Welding process – steps...

- Select the proper electrode material or materials recommended for the particular metals to be welded
- Set the **force indicator** (middle position on the scale)
- Set the **timing** or duration of the weld pulse (start from lower times)
- Set the **energy control** to minimum (welder turned on)
- Place the materials between the electrodes and depress the head
- Check carefully to see that proper contact is being made and that the effects of the force alone are not too great or too slight
- If material deformation or pinching --> reduce the force until the condition is corrected.
- Make a few trial welds. If these are not satisfactory, increase the energy gradually until you have a satisfactory weld.
- Do not attempt to change both energy and force at the same time.
This results in loss of time by causing confusion in determining which of the two variables requires changing.
- Test each weld for the strength or conductivity required for your particular application

Setting the force - prescriptions

Welding force:

- is continuously adjustable over a wide range
- must be sufficient to hold the materials together in good contact
- should be high enough: surface resistance should be essentially the same from piece to piece

Increase the welding force:

- for thicker materials
- for harder materials
- for better contact between materials (to flatten uneven materials so they touch at the point to be welded)
- to reduce sticking of materials to electrodes
- to correct blowing holes or excessive metal splattering

Decrease the welding force:

- for thinner materials
- for softer materials
- to correct excessive material deformation
- to correct excessively pinched wires in cross-welding
- to correct inability to form a weld

Setting the energy - prescriptions

The energy:

- power supplies offer precise control of weld energy
- needed precision in setting and resetting the exact heat required
- should be high enough: surface resistance should be essentially the same from piece to piece

Increase the energy (higher number of watt-seconds):

- for thicker materials
- for materials having higher electrical conductivity, such as copper
- for materials having lower surface resistance
- to correct a setup that fails to produce a weld
- to correct weak welds or welds that do not "pull a slug"
- for softer materials

Decrease the energy:

- for thinner materials
- for materials having lower electrical conductivity
- for materials having higher surface resistance
- to correct welds that blow a hole through the material
- to correct excessive material deformation
- to correct excessive material discoloration
- for materials that stick to the electrodes

Testing the weld

The most reliable test of the quality of a weld is its strength compared with the strength of the material joined.

Sensitive machines that perform such tests are not always available or necessary.

Simple and practical tests:

The "Peel Test"

After joining two pieces of sheet metal with one spot weld, peel them apart. If one of the two pieces has a hole in it, the weld has a generally satisfactory unit shear strength. If the hole has a diameter at least twice the thickness of the thinner sheet of the two metals, the weld is probably as strong as it can be.

Appearance of the weld

Microscope is helpful when inspecting weldments:
check whether material discoloration or excessive deformation exist.

Leading Suppliers of Equipment and Systems for Resistance Welding, Laser Welding

Miyachi Unitek: <http://www.miyachiunitek.com/>

Microwelder: <http://www.microwelder.com/>

RDO Induction L.L.C <http://www.rdoinduction.com/>