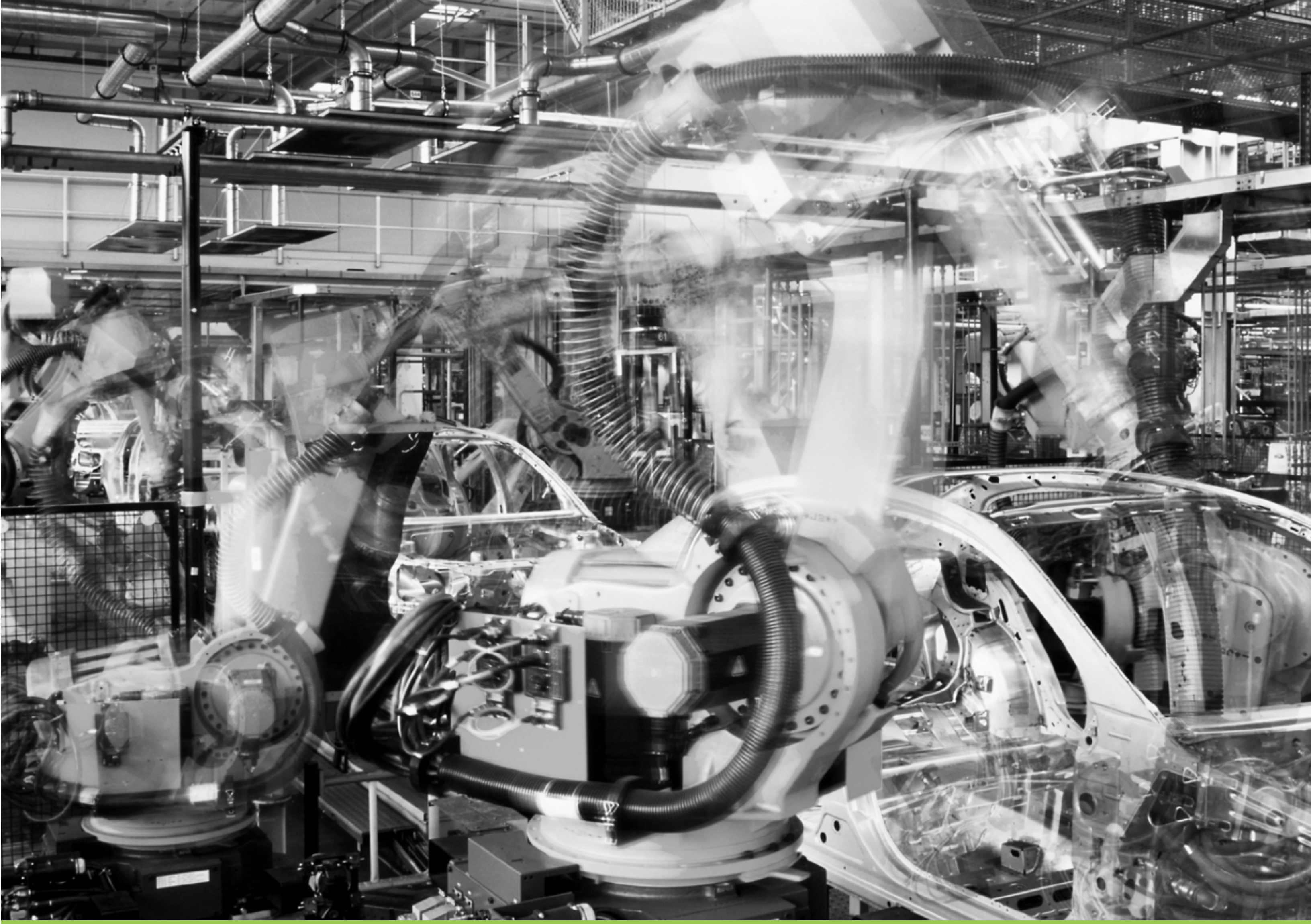

A **METAL**CUTTING TECHNICAL ARTICLE

BETTER TOGETHER:

Non Defective Bonding of Resistance Spot Welding Electrodes

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CONTENTS

INTRODUCTION

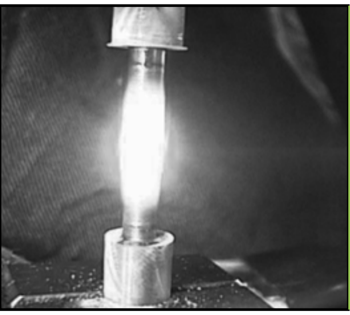
In our previous White Paper, *Selecting Resistance Spot Welding Electrode Materials,* we surveyed elemental materials for use as resistance spot welding electrodes with a focus the ideal electrode materials for welding high conductivity metals. Beyond material selection, we briefly considered conditions that can shorten electrode life which we titled the anatomy of an electrode.

The role of a resistance welding electrode is to supply a high welding current, apply a high load voltage, and cool down the surface of the weld. To be successful, electrodes must have no deformation at high temperatures, excellent thermal conduction, sufficiently low resistivity, and minimal reactivity (to prevent chemical alloying with the work piece).

The electrode tip design should ensure a constant contact area between the tip surface and the workpiece, regardless of the electrode-to-part position. Achieving this requires three considerations:

1. Materials cannot disintegrate during use and therefore reduce the contact patch.
2. The top and the bottom electrodes must maintain their position as any misalignment or deflection will radically reduce the contact surface area.
3. Allow for a margin of error, so it is an important practice to make the electrode tip area larger than the contact tip-to-part weld area such that the waste weld heat is dissipated which also enables the electrode to operate at a lower average temperature.

Benefits include a reduction in the electrode



Proper electrode design and construction is essential to ensuring consistent weld quality, minimum electrode sticking, and maximum electrode life...

tip sticking and the maximization of the electrode life.

Proper electrode design and construction is essential to ensuring consistent weld quality, minimum electrode sticking, and maximum electrode life — requiring not only the correct materials and tip and shank profiles, but also proper bonding in the manufacture of the electrode itself. Without the right design and construction, end production can be signifcantly impacted by inefficiency, weak welds, and defective bonding between the materials that comprise the electrodes themselves.

This paper will discuss some of the causes of electrode failure and specifically introduce and focus on how patented Non-Defective Bonding (NDB) in the manufacture of welding electrodes can help increase efficiency and improve results and consistency in resistance welding operations.

TRADITIONAL METHODS OF ELECTRODE BONDING

Brazing and press fitting are joining methods commonly used to bond the electrodes that are used in resistance spot welding operations.

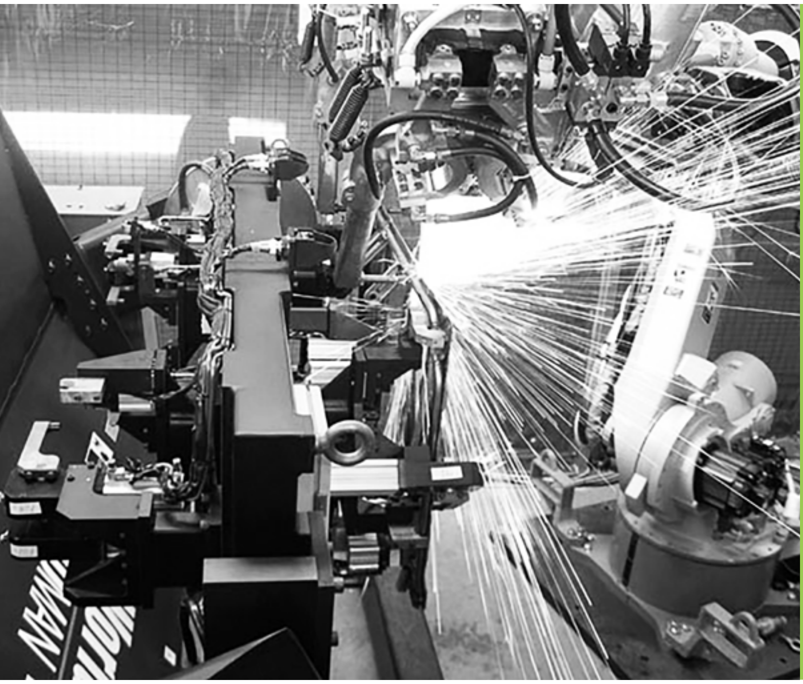
Brazing creates a metallurgical bond between a filler metal and the surfaces of the two base metals being joined, at temperatures that are lower than the melting points and welding temperatures of the bases. The filler metal is drawn through the joint by capillary action, to create the bond. The strength of the construction depends on the tensile strength of the filler metal as well as the strength of the bond between the filler and the base metals in the electrode.

A press fit is a fastening achieved by pressing two parts together, creating a force that results in extremely high friction between the parts, effectively locking the two together based on the tensile and compressive strengths of the materials from which the parts are made. In addition, thermal expansion or contraction is sometimes used in the process. The tightness of a press fit is controlled by allowance — the slight deviation in size between the mated parts — which depends on the material being used, the size of the parts, and the degree of tightness desired.

PROBLEMS WITH TRADITIONAL BONDING METHODS

Variations in the weld quality of end products (such as weak or failed welds) and decreases in electrode life can both result from deficiencies in electrode design and bonding. For example,
electrode tip heating issues are a common problem attributed to bonding deficiencies. Passing weld current through an electrode produces heat within the electrode body, tip, tip-to-part interface, parts, and part-to-part interface. With each subsequent weld, the residual electrode tip heat increases before stabilizing at some average value determined by the welding rate and weld energy.

While residual tip heat is usually not an issue with manual welding (i.e., with a slow welding rate), it can be a big problem in automated welding environments, where the welding



Nippon Tungsten Co., Ltd., and its North American distributor, Metal Cutting Corporation, have been working with engineers and technical teams in high volume, high speed automated spot welding applications to overcome slow or inefficient production and weak or defective welds.

rate can reach one weld per second or faster. In this case, residual electrode tip heat can cause resistance welding problems such as:

- Increased part deformation
- Part cracking
- Rapid tip oxidation
- Rapid part material/plating build up on the tip
- Reduced weld strength
- Severe tip-to-part sticking
- Severe tip geometry wear
- Shorter tip life

In addition, excess weld current density can result in severe electrode sticking, tip area deformation, and tip length bending. The welding rate also impacts residual electrode tip heat. Automated welding stations utilizing molybdenum or tungsten electrode tips typically show an increase in tip temperature with each new weld, with corresponding increases in strength with succeeding welds. Unfortunately, electrode tip sticking also increases with each new weld.

Voids caused by inadequate capillary action, incorrect alignment of parts, or inadequate distribution of the filler metal in the manufacture of brazed electrodes can lower the bond strength of the electrode. In addition, surface contaminants such as oil, grease, rust/oxides, scale, or dirt can form a barrier that prevents proper brazing — resulting in the dropout of the electrode material.

ALTERNATIVE NON-DEFECTIVE BONDNG

Nippon Tungsten Co., Ltd., and its North American distributor, Metal Cutting Corporation, have been working with engineers and technical teams in high volume, high speed automated spot welding applications to overcome slow or inefficient production and weak or defective welds. The result is a patented method for non-defective bonding (NDB) of their electrodes to shanks.

Headquartered in Fukuoka, Japan, Nippon Tungsten Co., Ltd. has had powder metallurgy as its core expertise since its founding in 1931. All of its products, from tungsten and molybdenum wires and rods, electrical contacts, electrodes, magnetic read-write head substrates, and precision glass mold materials, to their premier tungsten carbide die cutters, cutting tools, wear and corrosion resistant parts all have powder metallurgy in common.

In producing materials for its resistance spot welding electrodes, Nippon Tungsten has focused on its production of the category of electrode materials best suited for welding high conductivity metals. Molybdenum (Mo), Tungsten (W), and their alloys, including copper tungsten, silver tungsten, and silver tungsten carbide as well as heavy metals are the electrodes that have benefited from their non-defective bonding.

PATENTED METHOD

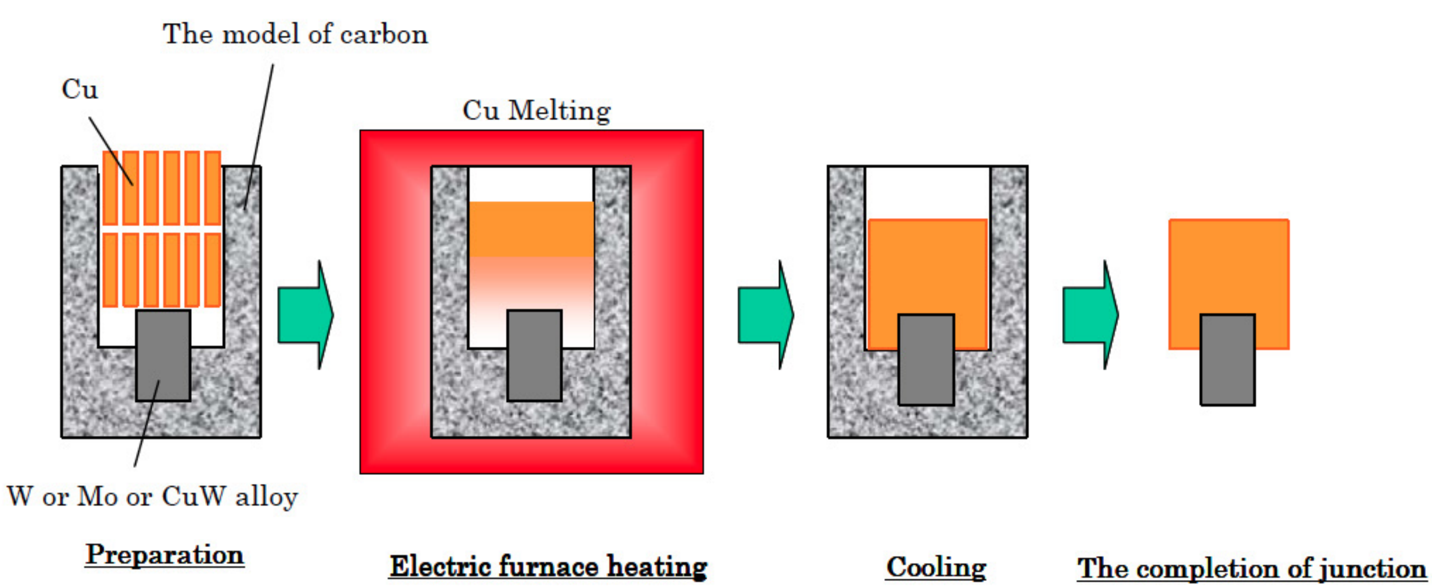
Though silver brazing and press fit techniques are often used to join an electrode to a shank, as previously mentioned, the bonding quality is a significant root cause of later problems. Serious and significant possible problems include welding quality that may vary, a decline in thermal conductivity, and hot spots in the form of increased heat generation at various junction points between the electrode and the shank. In addition, another dramatic reason for the possible shortened life of the electrode is when the electrode literally drops out of the shank.

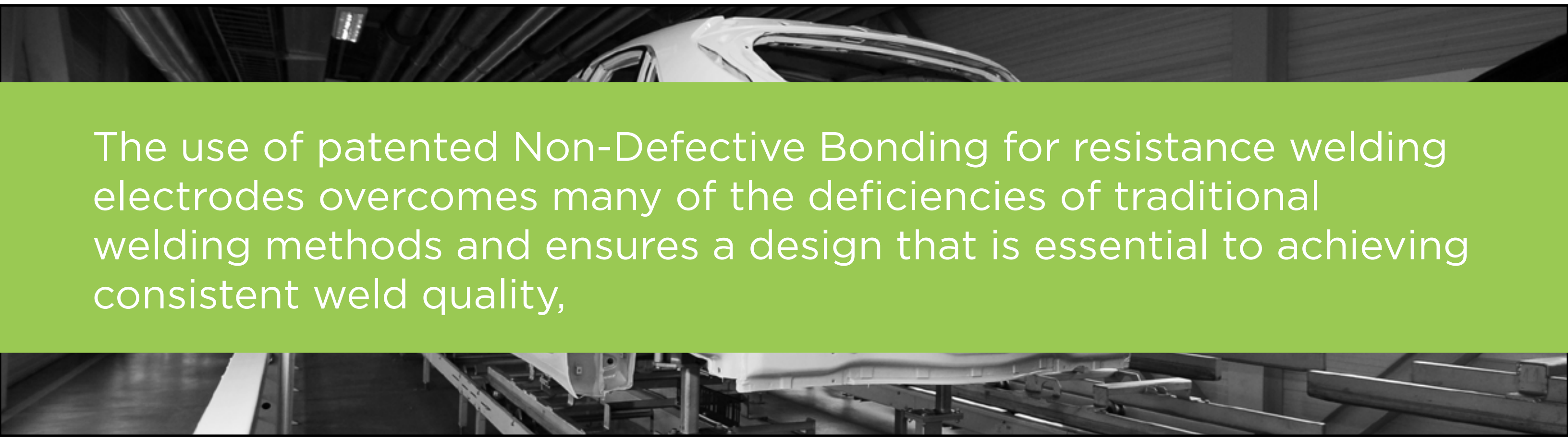
Studying the performance of electrode to shank bonding under multiple and severe welding conditions, Nippon Tungsten Co. Ltd. discovered a Non-Defective Bonding (NDB) method that improves on conventional joining of W, Mo, and their alloys as the base materials for the tips of resistance welding electrodes — providing the desired levels of thermal conductivity while reducing wear and increasing electrode life.

When using W, Mo, and their alloys as electrode tip materials for resistance welding, Cu and Cr-Cu alloy are used for shanks (holders or part of the cooling holes). The patented NDB method bonds W, Mo, or their copper or tungsten alloy directly to the copper or chromium copper used for the electrode shanks (holders), without flux, filler, plating, and other issues that can cause electrode failure. This produces joints that are free from defects that reduce production time and cause welding problems, and that contribute to increased efficiency, improved weld strength, and consistent results.

The figure below reveals the NDB method — in effect, placing the W, MO, or CuW alloy materials and copper in a carbon mold and melting the copper into the alloy in a high-tempertature, non-oxidzing atmosphere electric furnace.

Since the NDB product has a good electric





The use of patented Non-Defective Bonding for resistance welding electrodes overcomes many of the deficiencies of traditional welding methods and ensures a design that is essential to achieving consistent weld quality,

conductance to the shank, the electrode can be cooled down quickly while conduction is suspended. It not only avoids electrode burnout, but also hastens the shot cycle in a way that is impossible by brazing or impregnating — contributing to improvements in productivity.

COMPETITIVE COMPARISONS

In a competitive examination of the cooling performance of an NDB manufactured electrode compared with a brazed electrode, the time to cool both electrodes from 1200°C to 500°C was measured. The brazed electrode cooled to 500°C in 1.56 second; the NDB electrode, in 1.36 seconds — a full 0.2 seconds faster.

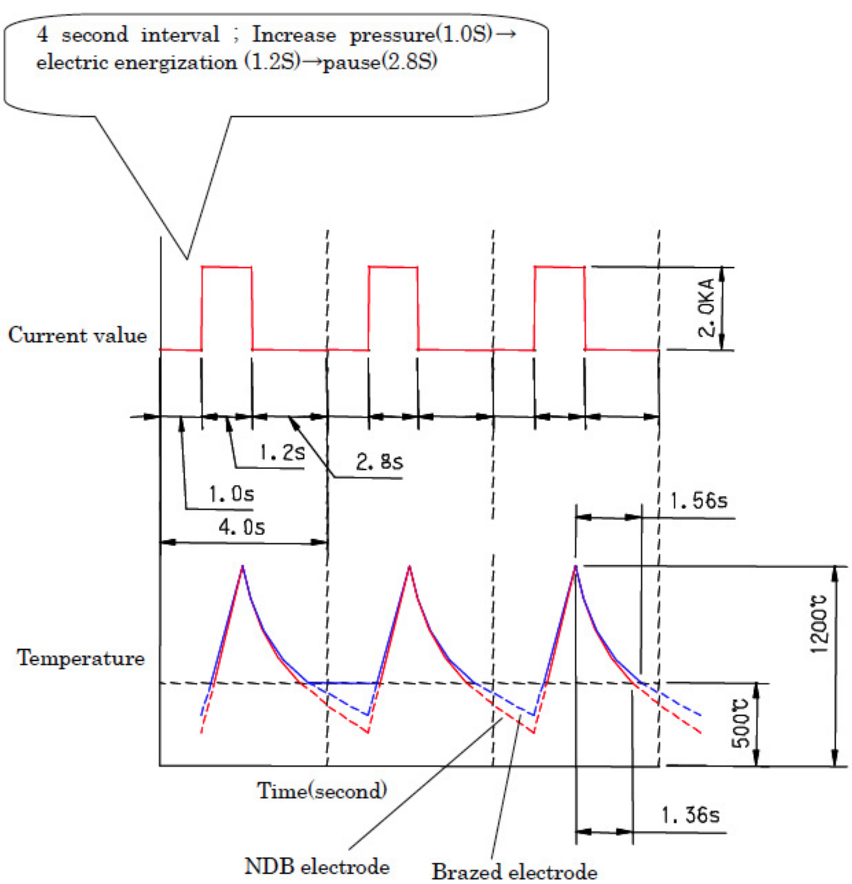


Fig.2 Result of competitive examination

Other competitive data include the following:

Electrode	Junction Area	Joint Strength	Heat Conductivity (W/m/K)	Electric Resistance (μm)
Brazed Product	60-80%	98 MPa≥	170	49.3
NDB Product	Almost 100%	127 MPa≥	210	31.8

Thus, compared with brazed and press fit electrodes, Nippon Tungsten's electrodes using the NDB method deliver:

- Better thermal conductivity
- Lower electrical resistance
- Lower electrical conductivity than copper to the junction
- Less risk of voids and other joining deficiencies
- A stronger bond, for less risk of fallout and other deficiencies

CONCLUSION

In resistance spot welding, proper electrode design and construction — including the type of bonding used in manufacture of the resistance welding electrodes — is critical to preventing failures in highly automated manufacturing environments in where downtime is extremely costly and re-work and scrap are unacceptable.

Using the patented NDB method, we are able to offer an electrode that has good electric conductance to the shank, so the electrode can be cooled down quickly. This not only avoids electrode burnout and heat deformation, but also hastens the shot cycle and thus improves productivity over what can be accomplished using a brazed or press fit electrode.

The use of patented Non-Defective Bonding for resistance welding electrodes overcomes many of the deficiencies of traditional welding methods and ensures a design that is essential to achieving consistent weld quality, minimum electrode sticking, and maximum electrode life — improving both efficiency and weld quality.

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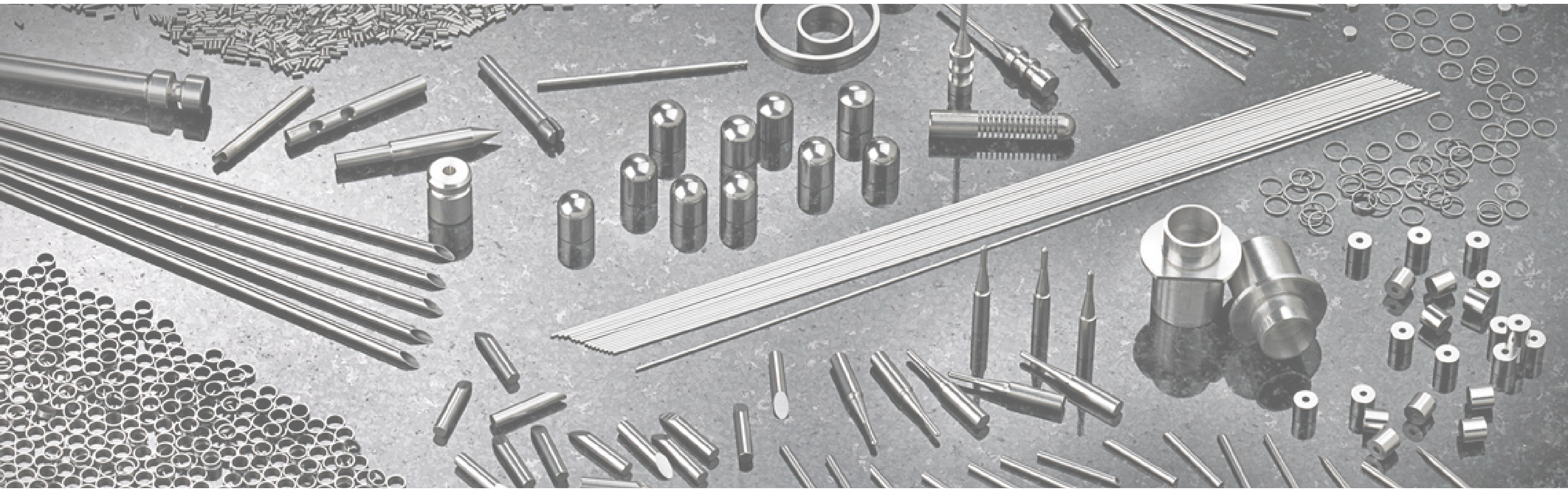

ABOUT **METAL**CUTTING **CORP**

Metal Cutting Corporation manufactures burr-free tight tolerance parts from all metals. We provide the precision required by medical device, automotive, electronic, biotechnology, semiconductor, aerospace, fiber-optic, electrical and many other diverse industries.

We are specialists with over 45 years cutting, grinding, lapping, polishing and machining metal parts. And now, Metal Cutting offers specialty refractory metal electrodes.

Our electrode materials expertise is in Tungsten, molybdenum and their alloys, including copper Tungsten and silver Tungsten as well as carbide compositions and heavy metal electrodes. Our electrodes are used in high speed large volume automated resistance spot welding manufacturing environments and are also excellent for die sinker EDM.

Questions? Call Metal Cutting today.

We hope you've found this guide to useful as a reference as you evaluate electrode providers.

We invite you to call us for a quote. We think you'll agree that hearing what we have to say will be one of the best decisions you make in researching CuW electrodes. Reach a Metal Cutting specialist today at 973-239-1100 or email sales@metalcutting.com.

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