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Resistance Welding Dumet Wire
By David Steinmeier

Introduction
Resistance welding Dumet wire to brass or bronze terminals has always been a challenge due to the physical composition of Dumet wire. These challenges include:

- Severe wire sticking to the electrode surface
- Unexpected wire blow-out or "sparking"
- Heavy electrode grooving
- Electrode sticking and contamination from the Dumet plating

This microTip discusses several ways to mitigate the above challenges using two different heat profiles and a simple electrode tip geometry.

Dumet Wire
Dumet wire has a thermal coefficient of expansion similar to that of glass, making Dumet wire an ideal interface material for transitioning between the inside and outside of a glass package. Common applications include vacuum tube pins and all electronic components using glass to enclose the electronic elements within the glass.

A nickel-iron core covered with a copper cladding comprises Dumet wire. The nickel content is typically 42%, but can vary based on the application. The copper cladding is typically tin-plated for an easy, lead-free solder connection to a variety of electronic terminal materials. Tin/lead solder and gold are two other plating options. For a detailed description of Dumet wire construction, reference ASTM standard, F29-97 (2002).

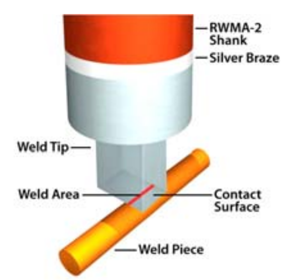
Electrode Material Selection
Dumet wire presents a dilemma in terms of electrode selection. The nickel-iron core requires an electrically conductive alloy like copper-chromium (RWMA-2, -3) or Copper-dispersed aluminum oxide (Glidcop®). The copper cladding needs an electrically resistive material such as molybdenum or tungsten to provide external weld heat.

The copper-chromium electrode may create a core-to-terminal weld in spite of the thin copper cladding, but will quickly alloy with the tin-plating on the Dumet wire, causing heavy to severe electrode sticking. In addition, the hard Dumet wire will groove the electrode tip, reducing the weld heat due to the increased electrode-to-wire contact area.
Using molybdenum (RWMA-14) or tungsten (RWMA-13) electrode material against the Dumet wire helps to heat the copper cladding, reduce the tin-plating transfer to the electrode tip, and reduce electrode tip grooving. Unfortunately, these electrode materials will severely stick to the electrically resistive nickel-iron core after the electrode tip penetrates the copper cladding.

One possible solution to the electrode material selection dilemma is to use a copper-tungsten electrode (RWMA-11) material as a compromise between the electrical conductivity of the RWMA-2 and RWMA-13 or RWMA-14 materials. RWMA-11 is also harder than RWMA-2.

Electrode Tip Geometry
To ensure consistent weld heat, the electrode tip design should provide constant weld current density to the parts. There are two methods to achieve this goal when welding a round wire to a flat terminal.

If the Dumet wire-to-terminal position is not stable, use a rectangular electrode tip oriented as shown in the adjacent diagram. If the wire-to-terminal position is tightly controlled, consider using a rectangular tip, but add a notch to captivate the wire. The electrode life of the notched tip will be greater than the simple rectangular tip.



Weld Heat Profile Selection
There are three possible weld heat profiles for welding Dumet wire using a feedback controlled inverter or linear power supply. The simplest profile is Upslope/Weld, followed in complexity by Dual Pulse and Pulsation. Use the Design of Experiment (DoE) process to determine which heat profile is best for your Dumet wire application. In addition to shear or peel strength for your DoE responses, include a qualitative response for the degree of electrode sticking. Achieving the highest shear strength has no meaning if the electrodes severely stick to your parts.

Real World Example

The author conducted a series of Design of Experiments (DoE's) to determine which heat profile produced the highest, most consistent 90º peel strength with minimal electrode tip sticking to the Dumet wire. Here are the key test conditions:

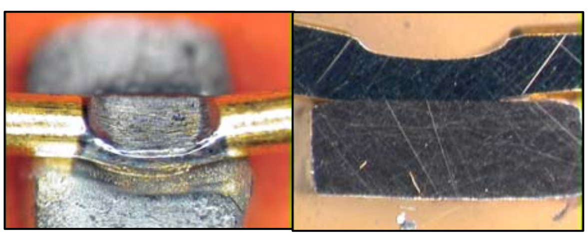
Item	Description
Dumet Wire	0.64 dia.-mm
Terminal	C51000, 0.77 thick x 2.30 wide-mm
Electrode, Top	RWMA-11, 1.2 deep x 2.36 wide x 1.2 high-mm
Electrode, Bottom	RWMA-11, 2.36 dia.-mm
Power Supply	Miyachi Unitek, HF2/230
Weld Transformer	Miyachi Unitek, X11/4000A
Weld Head	Miyachi Unitek, 84A/EZ

Upslope DoE Results

The L9 Taguchi DoE regression and ANOVA DoE results revealed that the weld current magnitude was responsible for 80% of the peel strength. Upslope time, weld time, and weld force did not affect the peel strength within the range of the DoE input factors. However, the degree of electrode sticking was affected by all four input factors.

Ten samples were welded and peel tested using the DoE optimized weld schedule listed in the table. The average peel strength was 60-N, with very little to no electrode sticking. The weld is a solid-state bond.

Upslope (ms)	8	Current (KA)	1.90
Weld (ms)	10	Force (N)	110

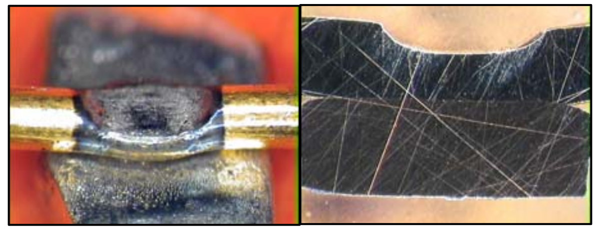


Pulsation DoE Results

The L18 Taguchi DoE regression and ANOVA results revealed that the most important input factors in descending order were: weld time, force, cool time, weld current, and number of pulses.

Ten samples were welded and peel tested using the DoE optimized weld schedule listed in the table. The average peel strength was 114-N, with very little to no electrode sticking. The weld is a solid-state bond.

Weld (ms)	12	Current (KA)	1.70
Cool (ms)	20	Force (N)	60
Pulses	4	---	---



Pulsation produced an average peel strength almost double that of the Upslope schedule. However, the pulsation terminal was much hotter and showed a larger tin-plating melting area compared to Upslope heating. The higher terminal temperature might damage the component's glass-to-metal seal. Reducing the total pulse count from four to three dropped the average peel strength to 52-N. This is slightly less than the 60-N average produced by the optimized Upslope weld schedule.

Dual Pulse Results

Adding a conditioning pulse to the optimized Upslope profile required increasing the weld current to 2.20 KA to produce the same average peel strength created by the Upslope schedule. For this application, Dual Pulse did not provide any significant improvement over a single Upslope heat profile and may shorten electrode life due to the higher weld current.

Conclusions:

1. Both Upslope and Pulsation weld heat profiles can be used to successfully resistance weld Dumet wire to a conductive, tin-plated terminal.
2. Dumet wire electrode sticking is extremely sensitive to electrode polarity. To minimize electrode sticking, the Dumet wire electrode must be negative. Reversing the polarity causes the wire to actually weld to the RWMA-11 electrode.
3. Sticking is also function of electrode tip geometry. Increasing the electrode width from 2.36-mm to 4 or 6-mm eliminates sticking by reducing the average tip temperature.

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