INDUSTRIAL LASER SOLUTIONS

# Battery welding: Selecting laser, microTIG, and resistance technologies

The following is an overview of laser, resistance, and microTIG welding technologies, along with examples of battery joining applications, detailing when and where to use each technology.

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Batteries and battery packs are an integral part of everyday life due to ever-increasing demand for portable electronic devices, cordless power tools, energy storage, and hybrid and electric cars. This, in turn, drives the need to manufacture batteries and battery packs that meet the quality and production requirements for these products.

There are a number of materials joining requirements for battery manufacturing, depending on the specific type, size, and capacity of the battery. Key examples include internal terminal connections, battery can and fill plug sealing, tab-to-terminal connections, and external electrical connections.

Several joining options can be considered for these requirements, including laser, resistance, ultrasonic, and micro-tungsten inert gas (microTIG). The decision to use one or the other is generally dictated by the specific type of weld required and production requirements.

Ultrasonic welding is commonly used for the joining of the internal electrode battery materials, which are usually constructed of thin foils of aluminum and copper. The remaining joining requirements—including the connections inside the can and external terminal tab connections—are well suited to resistance, microTIG, and laser welding. For can and plug applications (seam sealing), laser welding is the joining technology of choice.

The following is an overview of laser, resistance, and microTIG welding technologies, along with examples of battery joining applications, detailing when and where to use each technology.

## Welding for battery manufacturing

Laser welding was introduced in the manufacturing marketplace in the mid-1980s and awareness of its benefits has led to it becoming an established process as another tool in the manufacturing engineer's toolbox to be used and implemented as needed.

The laser provides a high-intensity light source that can be focused down to very small diameters (0.01 in.). The concentration of light energy is sufficient to melt metals rapidly, forming an instantaneous weld nugget. The process is non-contact, has no consumables, and offers instantaneous welding once positioned at the weld point location, provides sufficient control over the process to size the weld nugget according to requirements, and provides a number of implementation methods that can be geared toward individual manufacturing requirements. Laser welding enables joining of many materials and material combinations, can weld thick parts, and has no limitation on proximity of weld spots.

There are two types of lasers that provide solutions for battery applications: pulsed Nd:YAG and fiber. Both of these lasers offer different joining characteristics that can be selected as appropriate.

Resistance welding has been used in the battery industry for almost 40 years and a steady stream of advances has given users significantly improved capabilities to control various aspects of the process. For example, the introduction of DC inverter power supplies with basic closed-loop electrical modes provides the ability to accommodate changes in the secondary circuit to specifically address part resistance. Also, polarity switching for capacitance discharge supplies enables balancing of the weld nuggets and, more recently, the addition of displacement and electrode force measurement, providing manufacturers with more tools to ensure weld quality.

Similar to resistance welding, TIG—also known as gas tungsten arc welding—has traditionally been used for the more challenging welding applications in nonferrous materials. Advances in high-frequency power supplies increased low current control and arc stability, enabling much finer welding. This process became known as microTIG, a generally non-contact process that offers excellent copper joining while offering a fairly relaxed process window, with respect to part fit-up and positioning tolerances of the electrode to the parts.

## High-speed seam and plug sealing of battery cans

Laser welding is an excellent method for seam sealing, resulting in high-speed, high-quality seams in both steel and aluminum. Laser welding offers significant advantages over mechanical clinching and adhesive methods based on joint reliability, joining speed, and ease of manufacturing. As laser welding is an extremely efficient joining process, the heat input into the battery is minimized. FIGURE 1 shows an example of seam welding of an aluminum can.

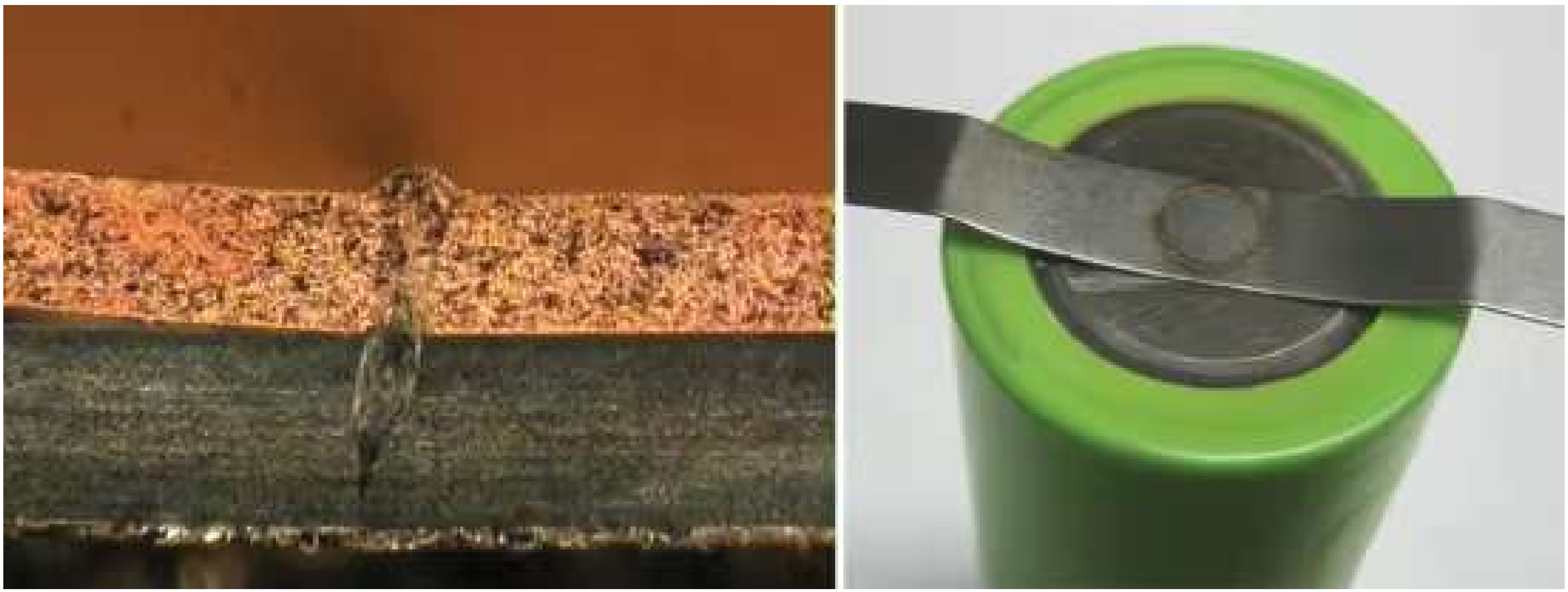
## Welding tabs to terminals and buss bars

From a welding perspective, the important aspects of tab welding are the thickness and material of both the tab and the terminal. Resistance welding is extremely well suited to welding nickel tab material up to 0.015 in. thick, and nickel- or steel-clad copper tab material to around 0.012 in. in thickness to a wide variety of terminal materials. Due to a different welding mechanism, laser welding is able to weld both thin and thick tab materials, with a capability of welding copper or aluminum tab material above and beyond 0.04 in. thick. Avoiding penetration of the can and overheating the battery are important aspects of tab-to-terminal welding.

Welding tabs or terminal connections to buss bars generally does not require as much penetration of heat input control as the tab-to-terminal welds. The materials, material thickness, and combination of materials determine the best welding technique.

## Laser welding

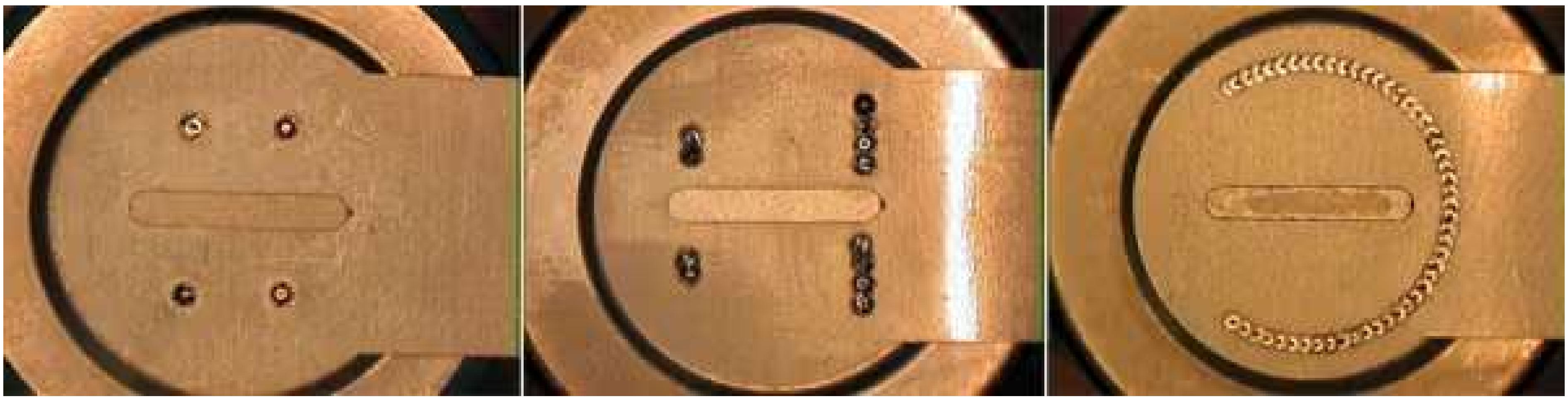
For tab and buss bar joining, laser welding offers a high degree of flexibility, welding thin and thick tab materials; copper, aluminum, steel, and nickel; and dissimilar material combinations. Two example welds are shown in FIGURE 2.



When welding a tab to a terminal, the general rule of thumb is that the tab should be thinner than the can terminal thickness. As the can thickness decreases, the tab usually must be 50 percent of the can thickness for a safe essing window that provides weld strength and conductivity without penetrating the can.

As laser welding has no limitation on the proximity of the welds, the laser can place any pattern of weld spots on the tab according to strength requirements. It is worth noting that, in nearly all cases, if the joint's weld strength is achieved, conductivity follows. For more conductive materials, the weld area required for strength can be as much as 10 times that required for conduction.

As shown in FIGURE 3, the placement of the weld spots on the tab is completely flexible, and can be tuned to the strength requirements of the pack or tab. For example, peel strength is often used as a metric for weld quality. Therefore, the welds can be positioned accordingly. The peel strength of the left-hand image is 15 lbs., while the center image is 60 lbs. The time needed to add additional weld spots is very short; sufficient tab strength can be achieved with very little impact on cycle time. Although peel strength remains an important weld test, vibration is also important. As vibration strength places an emphasis on having good weld strength in any direction, the circle of weld spots shown in the right-hand image provides the solution.



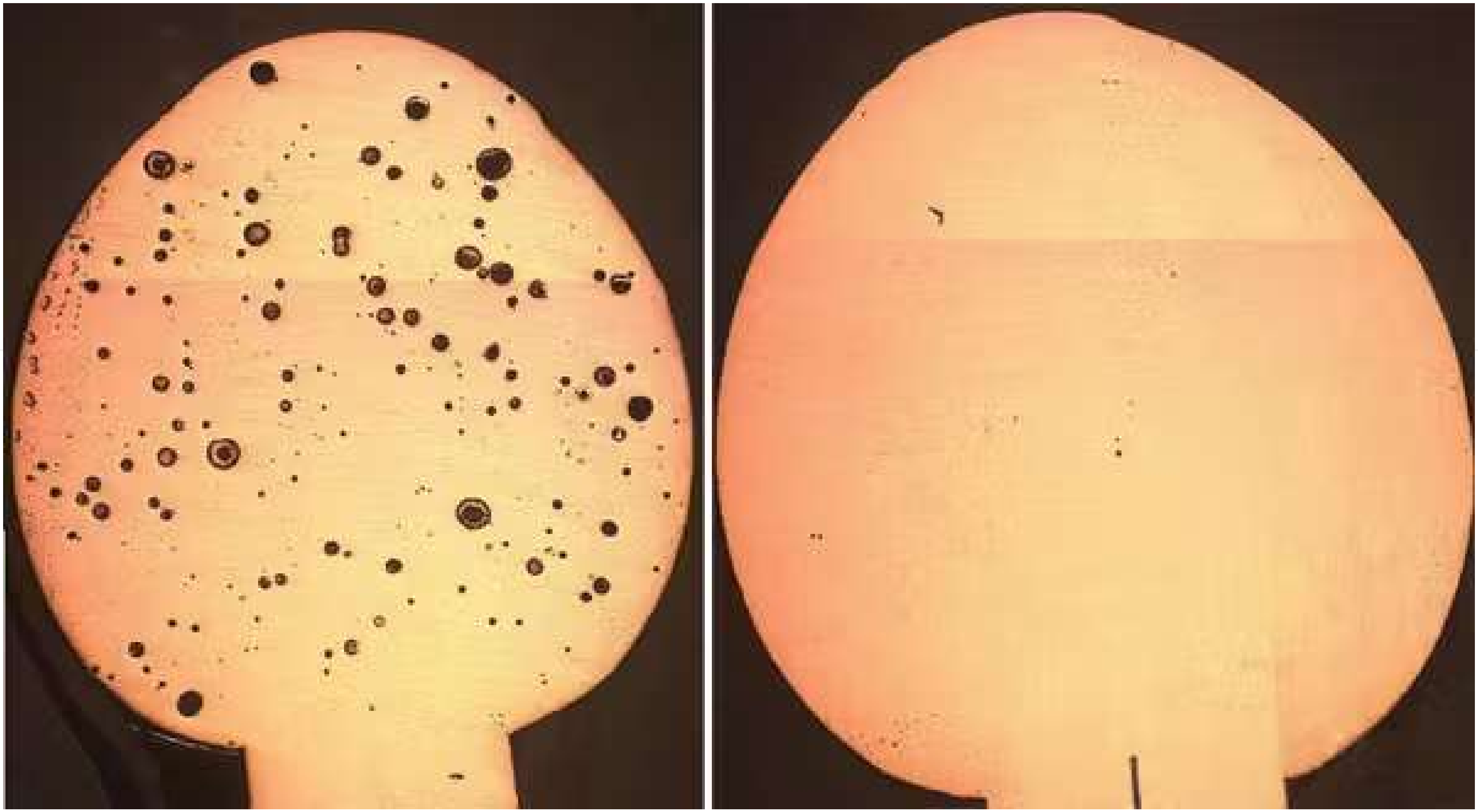
## Resistance welding

Resistance is the most cost-effective method for joining tabs on a wide range of battery types and sizes, using both inverter closed-loop and capacitor discharge power supplies. With fast rise times, closed-loop feedback control, polarity switching, and options for displacement and force sensing, the process can be finely tuned and monitored to ensure both high quality and yield.

For nickel tab thicknesses up to 0.0070 in., the tab can be welded without modification. Beyond this thickness and to prevent electrical shunting and excessive electrode wear, a slot and projections are placed in the tab as part of the stamping process. The projections act not only as energy concentrators for the weld, but also greatly increase electrode lifetimes. FIGURE 4 shows several examples of the wide range of resistance tab welding applications.


**MicroTIG**

MicroTIG offers excellent welding of copper and presents a good solution for buss bar welding that would require a brazing material for resistance welding or a large-power laser welder. Butt, fillet, and lap welds are possible in copper measuring 0.02 in. thick and beyond. When welding copper using microTIG, it is extremely important to use a pulsation function that creates the weld without porosity (FIGURE 5).



## ery pack manufacturing systems

The two main production options available are continuous flow in-line or offline systems. It should be noted that the manufacturing flow can have an impact on the welding technology selected and this should be factored in at the technology selection stage. A consideration of materials, joint geometry, weld access, cycle time, and budget will normally point in the direction of the required joining technology.

## Production volume driven by consumer demand

The production volume of batteries continues to be driven by the demands of consumer electronics and electric vehicles. Likewise, the manufacturing and joining needs of these batteries are also pushed by capacity, size, materials, and usage. Laser, resistance, and microTIG technologies have specific features that align well to these joining needs. A clear understanding of the technologies and applications is needed to implement an efficient and reliable production welding system.