Omnisensing Photonics' Non-Invasive and Online Monitoring Solution for Industrial Ultrasonic Welding

Overview

Welding is a common manufacturing process to join metals or other materials. With the advancement of modern industrial technology, ultrasonic welding has become a popular technique versus traditional ways due to its high efficiency, ease of operation, high versatility, and suitability for assembly lines, thus now widely used for both metal and plastic welding.

Ultrasonic metal welding employs high-frequency mechanical vibration energy to join similar or dissimilar metals. This process does not require electrical currents or external heat. Under static pressure, energy by ultrasonic vibration is converted into atom level frictional work,with barely temperature rise at the joint interface, enabling a solid and clear bond among materials without melting them. This eliminates problems like splatter and oxidation of materials common in resistance welding. Furthermore, it can be precisely controlled via software.

In the automotive industry, ultrasonic welding is more and more widely used for parts that must meet the highest standards—sealing, strength, precision, and flawless appearance. It offers a fast, economical solution to complex manufacturing requirements. Similarly, in lithium battery production, ultrasonic welding also become dominating over resistance spot welding (RSW) and laser beam welding (LBW), particularly for aluminum and copper foils that are difficult to weld with traditional methods due to their low resistance or oxide layers.

Ultrasonic welding also resolves issues such as misalignment during assembly and dust-related short circuits, thereby improving product consistency. Three main welding points in lithium batteries are copper/aluminum foil to tabs, tab-to-tab, and tab to electrode lug. Among these, foil-to-tab welding is the most challenging due to the multi-layer nature of the welding and the need to bond different materials.

Challenges in Ultrasonic Welding

The effectiveness of ultrasonic welding relies on three interrelated parameters: amplitude, pressure, and time. These must be finely tuned to avoid under-welding or deformation. As battery packs grow in complexity (often 100+ layers), managing welding power output becomes increasingly critical.

Conventional PID control of ultrasonic drives cannot directly monitor the energy absorbed by the welded material. This gap in monitoring can lead to faulty connections, causing system-wide failures in serial or parallel battery configurations.Real-time, non-destructive, and independent quality monitoring is then needed, but current methods fall short.

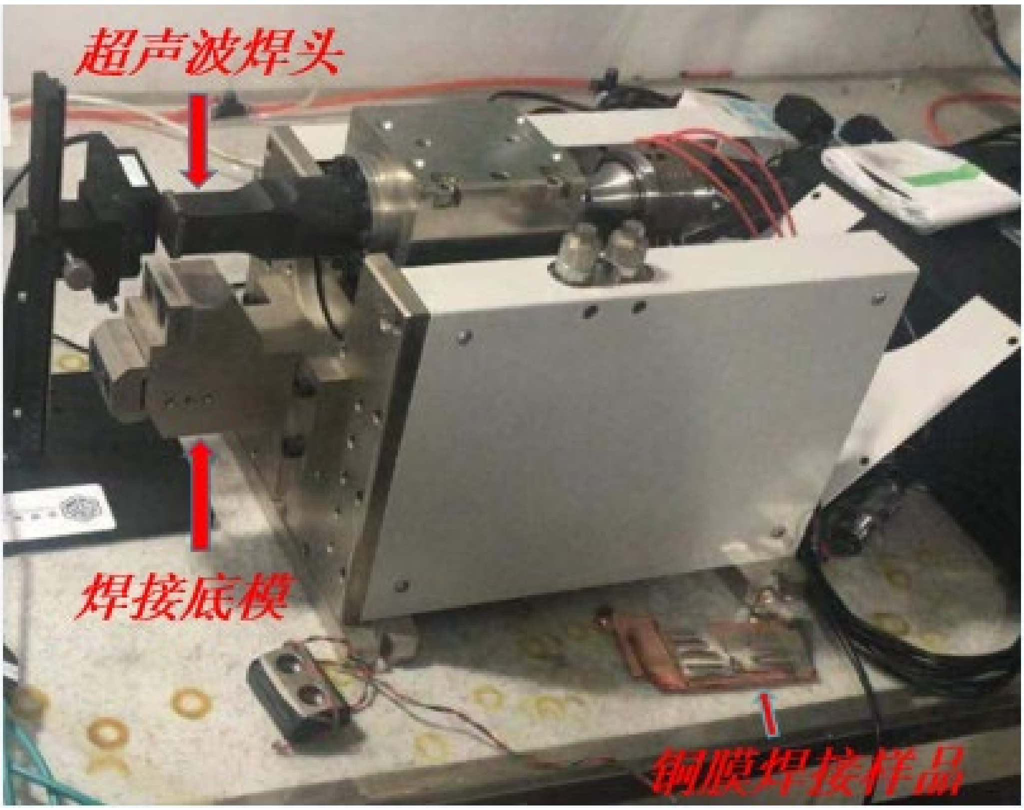
Omnisensing's Solution based on Smart Laser Doppler Vibrometry

Omnisensing Photonics has developed an innovative online, non-contact monitoring solution using its advanced smart laser Doppler vibrometry technology. At the core of this solution is a miniaturized laser vibration sensor built on a revolutionary photonic integrated chip. This compact chip integrates a laser interferometer, signal processor, battery, and communication module—all within a device no larger than a matchbox. The result is a low-power, highly compact, and cost-effective solution that significantly enhances testing efficiency and scalability.

Key features of the solution include:

- Online and Non-invasive monitoring
- Nanometer-level precision
- Excellent dynamic response
- Compact form factor and low power consumption
- Easy integration via Ethernet or Modbus into industrial systems

As shown in Figure 1, the sensor is installed near the DUT (Device Under Test) on the anvil. During welding, high-frequency vibration is transmitted from the horn to the top metal layer, generating frictional heat that welds the contact surfaces within milliseconds. Omnisensing's sensor then measures the actual response on the DUT. Upon weld completion, results are transmitted in real-time to a control console or production line PLC for independent quality assessment.



Figures 2–4 show sets of measurement results from field testing. Examples of under-welding, over-welding, and proper welding are shown respectively. With 105 labeled samples, machine learning models effectively distinguished between faulty and acceptable welds, as shown in Figure 5. The results confirm the sensor's ability to identify structural defects like micro-holes or inconsistencies due to subjective human judgment.

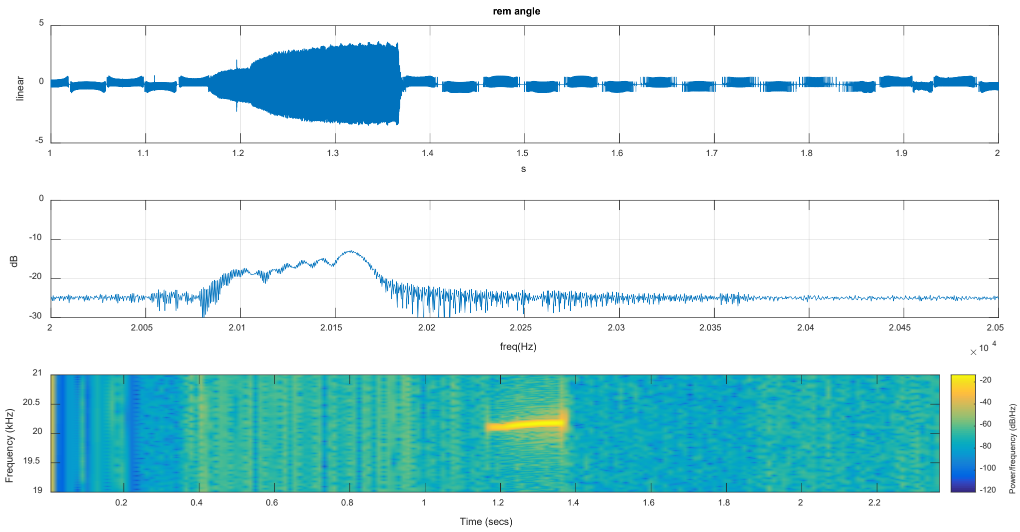


图 2：under welding example

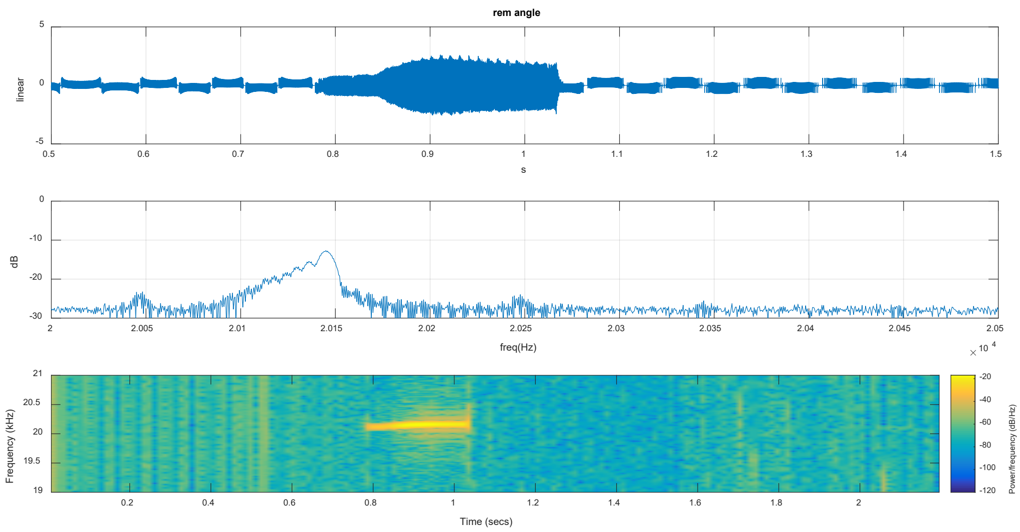


Figure 3：over welding example

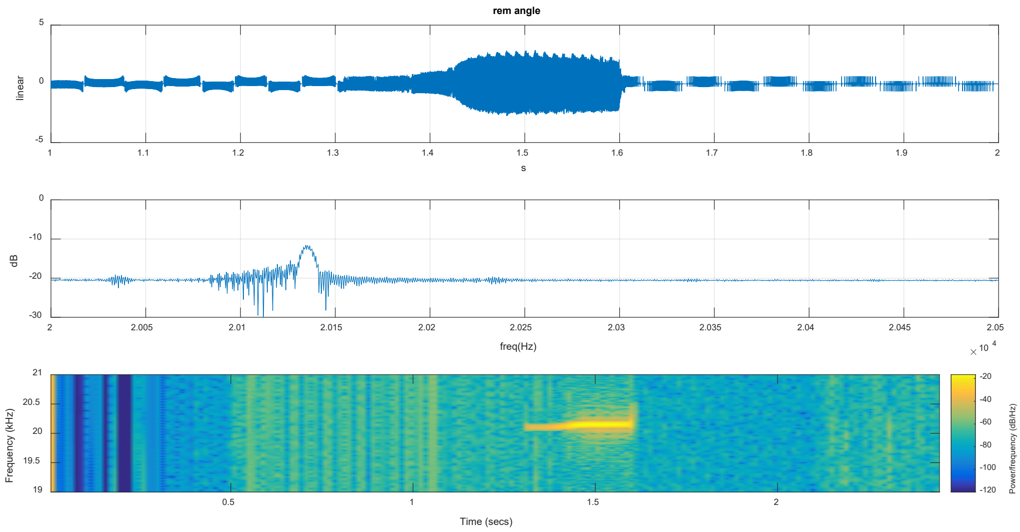


Figure 4： proper welding example

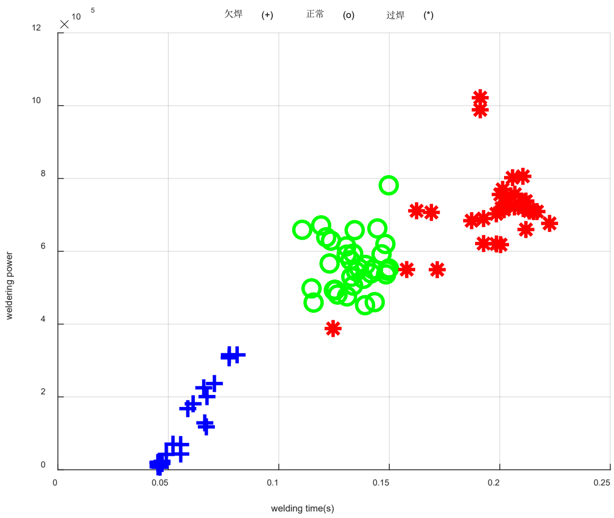


Figure 5： ML models to qualitatively categorize welding quality

Product Comparison

In Figure 9, a direct comparison is presented between Omnisensing Photonics’ MV-series sensor and the industry-standard VibroGo device developed by Polytec. The MV-series sensor is more than 40 times smaller in physical size, reflecting Omnisensing’s leadership in miniaturization through photonic integrated chip technology. Despite its significantly reduced footprint, the MV-series not only maintains but exceeds key performance benchmarks compared to global competitors. This combination of compact design and superior performance underscores the advantages of Omnisensing’s approach in delivering next-generation LDV solutions optimized for portability, integration, and scalability across diverse application environments.

Category	Polytec VGO-200	Omnisensing MotionGo
Signal Frequency Range	DC–100 kHz	DC–1 MHz (Sps= 5M sps)
Operation Distance	0.355–30 m	0.06–40 m*
Max Vibration Speed	2 m/s	Max 20 m/s*
Velocity Resolution	10 nm/s/√Hz	5 nm/s/√Hz
Trigger	None	Trigger IN/OUT
Dimensions	344×124×87 mm	80×50×22 mm
Weight	3.1 kg	0.25 kg
Temp. Range	5°C–40°C	0°C–50°C
Power	25W (12V)	3W (12–24V)
Protection	IP64	IP65/67*
Laser Class	Class 2	Class 1
Wavelength	633 nm	1310 nm
Interface	Ethernet/Wi-Fi	Ethernet
Software	Vibsoft	GUI & DLL

* Depend on Model PN and Lens System

About Omnisensing Photonics

Omnisensing Photonics is a globally recognized leader in the development and manufacturing of Laser Doppler Vibrometers (LDVs). Distinct from conventional LDV solutions, Omnisensing's systems are built on proprietary photonic integrated chip technology. This innovation enables the company to deliver low-power, ultra-compact, and highly cost-effective LDV solutions that dramatically improve testing efficiency and scalability across applications.

Omnisensing's LDV systems are trusted and widely deployed in a range of sectors, including industrial manufacturing, medical diagnostics, and scientific research. The versatility and precision of their technology make it suitable for both routine and advanced vibration measurement tasks. Over the past several years, Omnisensing has successfully delivered thousands of LDV units to customers worldwide, demonstrating its reliability, scalability, and strong market adoption.

For more information, visit https://ospmotiongo.com/ or contact Globalsales@osphotonics.com.

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