WATT LASER LTD

IN PARTNERSHIP WITH NIPPON GOKIN SDN BHD

STAINLESS STEEL & ALUMINIUM BONDING CASE STUDY

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Abstract

Bonding between anodised aluminium & stainless steel can be challenging due to significant differences in their physical & chemical properties. The dissimilar nature of these materials presents difficulties in achieving a strong & reliable bond between them. Factors such as surface incompatibility & material reactivity contribute to the complexity of this bonding process. By employing laser surface structuring, Watt Laser can overcome these challenges.

SMT stencils are vital in the production of printed circuit board assemblies, facilitating the precise deposition of solder paste onto circuit boards with repeatability & reliability. Among the foil technologies utilised in SMT stencils, the TetraBond method, developed by Alpha & made by Nippon Gokin, employs bonding agents to secure an anodised aluminium frame to a stainless-steel foil. However, the presence of aggressive cleaning agents during the post-assembly cleaning process can lead to de-lamination issues between the anodised aluminium & stainless steel, necessitating a pre-bonding treatment.

In partnership with Nippon Gokin, Watt Laser has pioneered the implementation of laser engineering technology to introduce surface structuring on both TetraBond frames & foils, addressing the de-lamination concerns.

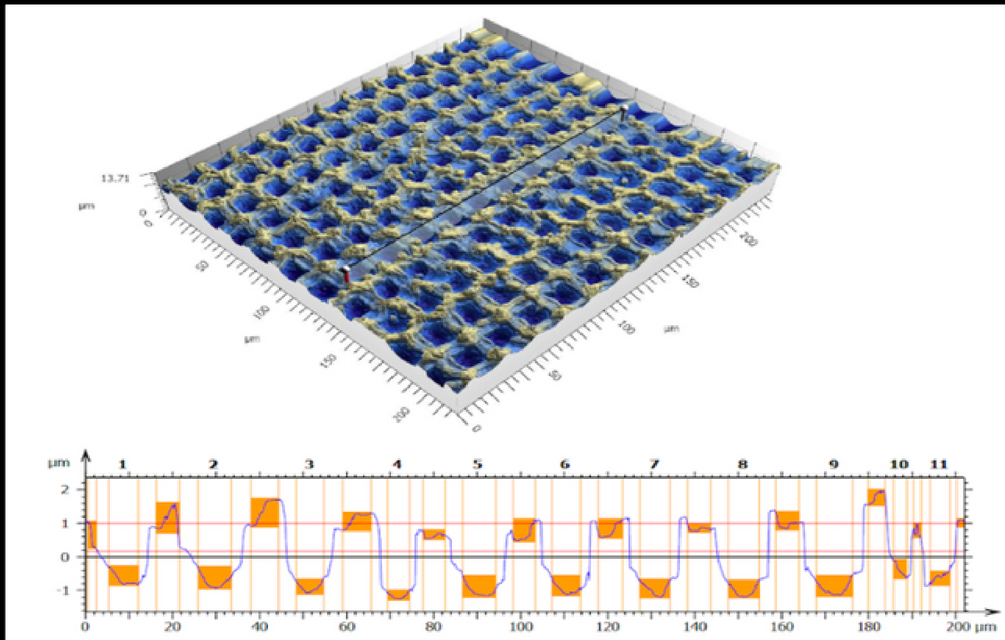
The laser structuring process utilises precise laser technology to generate microstructures on the surface of the anodised aluminium & stainless steel. These microstructures serve to significantly enhance the bonding strength, effectively mitigating the risk of delamination. Furthermore, laser structuring is employed to prepare the surface of stainless-steel foils within mesh weld frames, augmenting the adhesion in the vicinity of the bonding region. Through controlled modification of the surface characteristics, laser structuring offers a reliable & durable bond, ensuring the longevity & performance of the SMT stencil. In addition to the creation of microstructures, laser structuring effectively removes contaminants that may negatively impact the join.

The Problem

In the realm of SMT stencil manufacturing, TetraBond technology is a prominent method that comprises of an anodised aluminium extrusion & a stainless-steel foil. The bonding process involves the utilisation of two distinct agents for bonding & sealing the frame and foil components. However, the presence of aggressive cleaning agents during the cleaning phase poses a significant challenge, leading to delamination issues between the stainless steel & anodised aluminium. This delamination phenomenon has been observed to occur at a failure rate of 1%, which holds substantial consequences in volume manufacturing scenarios.

The Solution

Watt Laser SE12C laser structures both the anodised aluminium extrusion & stainless steel foil before the application of the bonding agent. Laser structuring creates regularly spaced "micro-rivets" which increases the bonding region by 100% adding a micro-roughness to the boundaries of the foils, which in turn, allows for greater adhesion. The process is highly repeatable as the path, pitch & energy are determined through CNC.



Parameters	Unit	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	Step 11
Mean depth	µm	1.663	1.755	1.925	2.169	2.022	1.976	1.981	2.035	1.969	1.379	1.588

Figure 1. Structuring geometry and micro rivet depth.

By employing the SE12C laser system for laser structuring, manufacturers can effectively address the de-lamination issues encountered in the presence of aggressive cleaning agents. The enhanced bonding region & improved adhesion achieved through laser structuring significantly reduce the risk of de-lamination, ensuring a more robust & reliable bond between the foil & frame components. This advanced laser engineering solution provided by Watt Laser contributes to increased yield, improved productivity, & enhanced overall performance in the manufacturing of SMT stencils utilising TetraBond technology.

Figure 2. Structured foil (left) and structure frame (right).

Testing

To evaluate the effectiveness of the laser structuring process in enhancing the bond strength between the anodised aluminium & stainless steel components in TetraBond technology, rigorous testing was conducted by Impact Solutions. The test findings are documented in report number IMP05383, which provides comprehensive insights into the performance of the laser-engineered SMT stencil samples.

The testing methodology employed by Impact Solutions followed the 90-degree peel test as per the standards outlined in ASTM D6862.

Specimen	Maximum Load (N)	Average Load (N)	Number of troughs at average load	Number of peaks at average load
Unstructured	21	18	39	68
Structured	30	29	24	56

Table 1. 90 degree peel test results.

Based on the test results outlined in report number IMP05383, it was observed that the laser-structured samples exhibited notable improvements in bond strength compared to the non-structured samples in TetraBond technology. The findings revealed significant enhancements in various performance parameters, providing quantitative evidence of the effectiveness of laser structuring in strengthening the stainless steel-to-aluminium bond.

Firstly, the maximum load required to peel the stainless steel from the anodised aluminium was found to be 43% greater in the laser-structured samples compared to the non-structured samples. This increase in maximum load indicates a substantial improvement in the bond strength, as it signifies a higher resistance to de-lamination & a more robust connection between the foil and frame components.

Moreover, the average force required for peeling in the laser-structured samples exhibited a 61% increase compared to the non-structured samples. This significant rise in average force further highlights the enhanced bond strength achieved through laser structuring.

IIn addition to the improved load-bearing capabilities, the test results also revealed a smoother motion during the peeling process in the laser-structured samples. The presence of fewer troughs and peaks in the peel force data indicates a more uniform and controlled peeling action, suggesting a stronger and more consistent bond between the stainless steel and anodised aluminium.

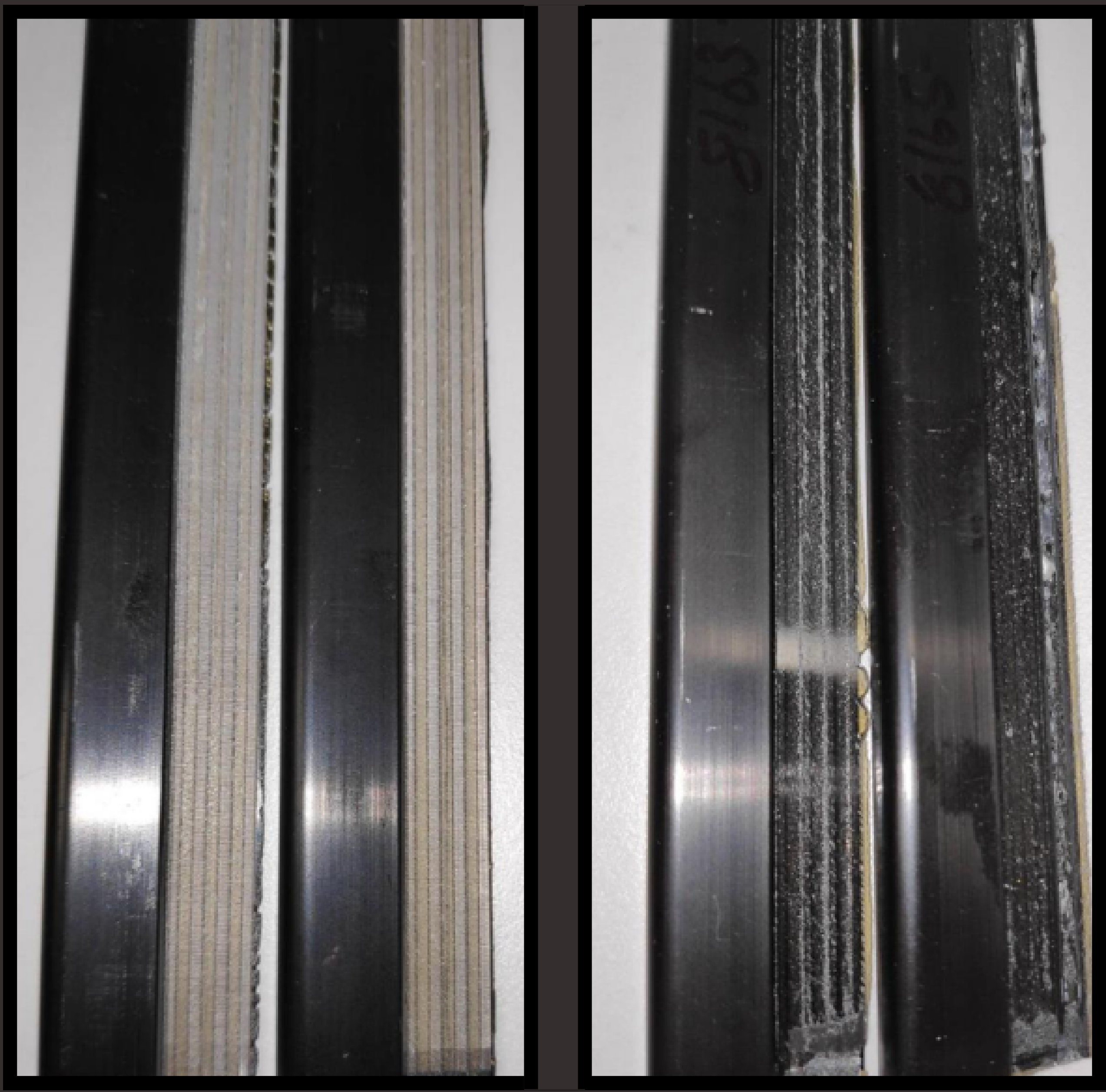


Figure 3. Structured frame (left) and unstructured frame (right).

The laser structured frame in Figure 3 displays a matted finish, with more bonding agent still adhered compared to the unstructured sample, resulting in a stronger bond.

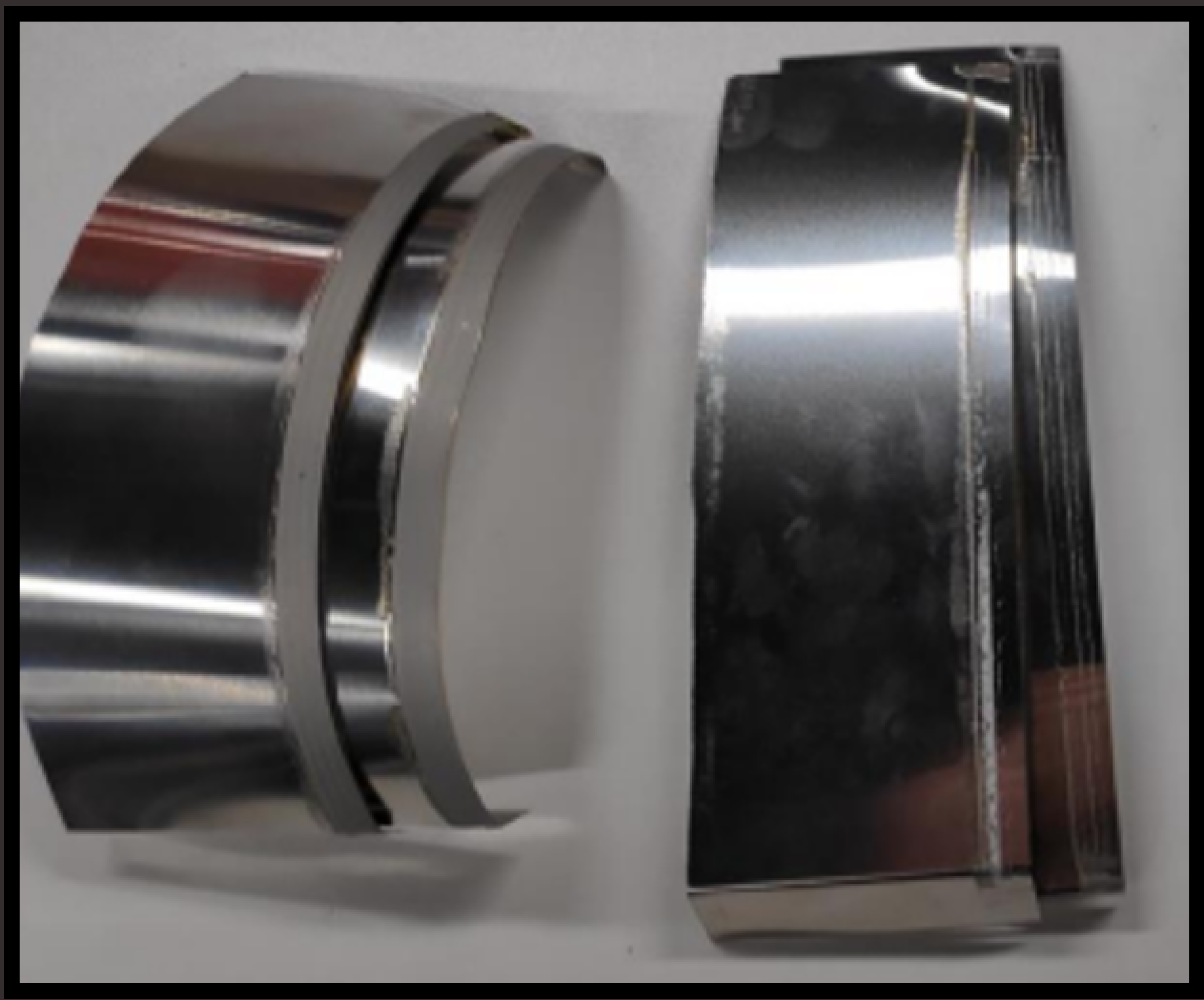


Figure 4. Structured foil (left) and structured (right).

Figure 4 illustrates compelling evidence regarding the enhanced bond strength and resilience to de-lamination achieved through laser structuring in the TetraBond samples. The structured sample, compared to the sample on the right, exhibited greater deformation and more residual adhesive, indicating a higher force was necessary to separate the bond.

Key Benefits

- Increased surface area & micro-roughness, producing a stronger adhesive bond between the substrate & bonding agent to eliminate de-lamination in TetraBond frames.
- Superior adhesion in mesh welded frames.
- Removal of contaminants & oxides from the substrate surface.
- High repeatability & semi-automated laser structuring process.