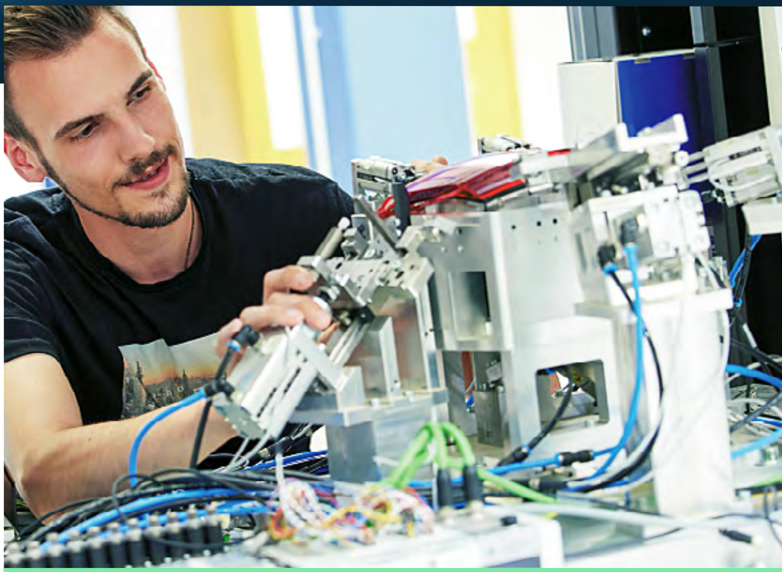
Whitepaper

LASER WELDING PPAs IN *HIGH TEMPERATURE* APPLICATIONS

In many cases, laser welding of Polyphtalamides (PPA) is not possible, and up to now laser welding of PPAs was often considered problematic.



PPAs are used in many applications needing high Tg, high temperature and chemical resistance. When it comes to the joining of PPA materials, there are many restrictions. Therefore, PPA is used mainly in combination with other welding technologies, such a Vibration– and IR–welding, while laser welding is usually not considered, but this is about to change.

Recently Envalior and LPKF Welding Equipment worked together on solutions that provide the right laser welding process in combination with the right PPA materials. Working solutions have been identified for grades using higher contents of reinforcement, halogen free flame retardancy and even in combination with materials for laser direct structuring (LDS).

Working solutions for laser welding PPAs in high temperatures

High temperature PPAs for electrical & electronics applications

JTX materials survive industrial scale lead free reflow processes

Welding highly reinforced PPAs

Laser welding of glass filled PPAs has been proven to work for ForTii® MX series

POPULARITY OF *LASER WELDING*

With the trend of integrating more functionalities into plastic parts, laser welding has become increasingly popular.

Overall, it is seen that applications like sensors, CPUs and other sensitive electronics are becoming an integral part of the design. Additionally, this most often enforces the need to seal the parts to avoid dust moisture, which would affect performance. Sealing the parts also protects and reduces outside influences on the integrated functionalities. Often weld technologies are used for this endeavor. This increased sensitivity of the parts demands more caution in these post–processing steps by which exposure to heat, vibrations, and dust particles (formation) needs to be avoided. This is where laser welding is at its best, concentrating the heat specifically at the weld area, leaving other areas unharmed. Plus, there are other advantages, such as no particles and dust, short cycle times, flexible and tweakable process, scalability, precision, etc.

As seen in Figure 1, when laser welding plastics, most often two color materials are needed—one which is transparent for the laser and the other absorbing. This creates the possibility to combine miscible plastics with very distinct melting temperatures. This way PA6 (220°C) can be combined with Stanyl® PA46 (295°C), resulting in a very good weld strength. Though most of the cases combine two colors, using two color materials of the same polymer grade has preference. In some cases, two similar colors are used, one remains laser transparent and the other absorbing, e.g., a black which appears black to the human eye. However, where the black is transparent for the laser that is then combined with parts that is colored with standard carbon black, for example.

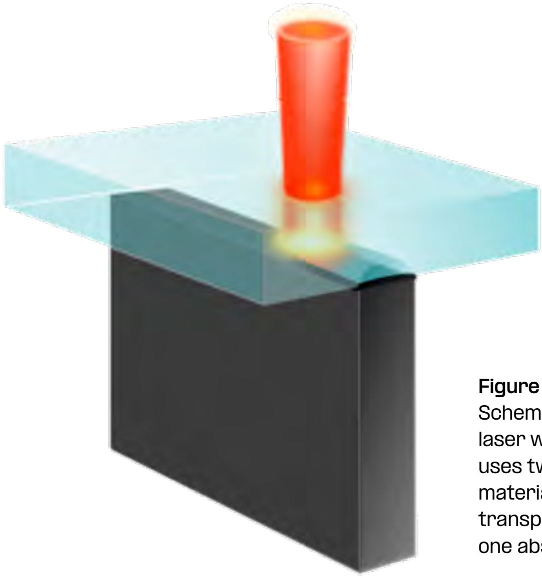
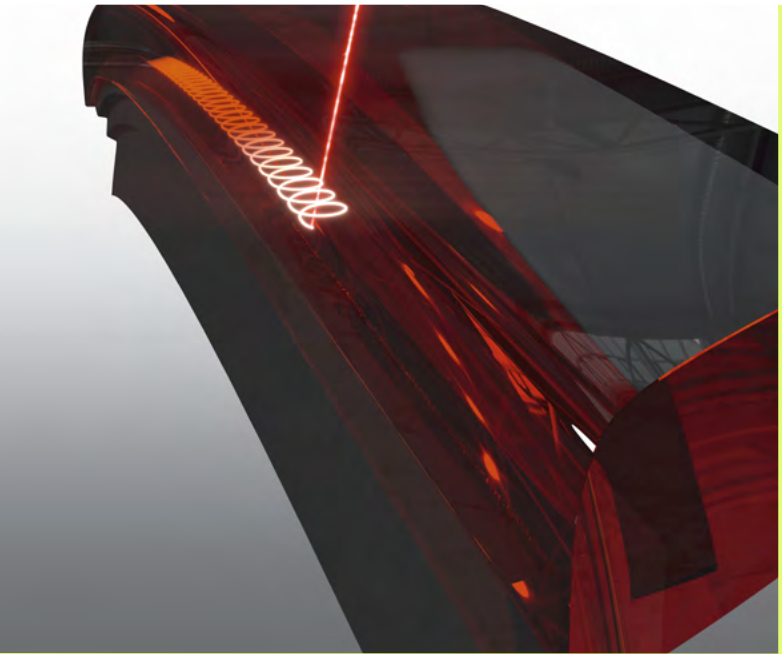


Figure 1
Schematic image of laser welding, which uses two different materials, one transparent and one absorbing.



There are other advantages, such as no particles and dust, short cycle times, flexible and tweakable process, scalability, precision, etc.

WELDING OF PPAs

Laser welding is well known for polyamides, yet for PPAs (polyphthalamides) it is less commonly used. Not all PPAs are suitable for laser welding, which often gives limitation to the welding process, though there are some PPAs that are more forgiving. This is connected to the crystalline morphology of the polymer as shown in Figure 2. This unique morphology allows for a good transmittance needed for laser welding.

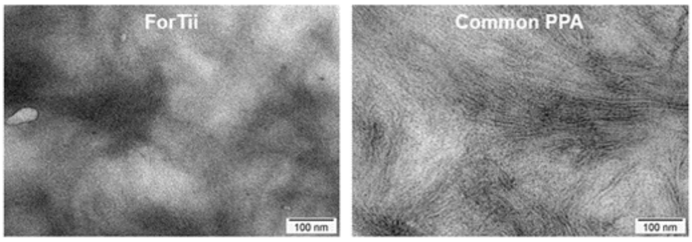


Figure 2
Transmission electron microscopy (TEM) crystalline morphology of ForTii (PPA) versus commonly used PPA crystalline morphology.

Transmittance values of ForTii allows laser welding at higher thicknesses. For the measurement method used (LPKF TMG3) the rule of thumb is that, given the right circumstances, a feasible large–scale process is possible when the transmittance is 10% or higher.

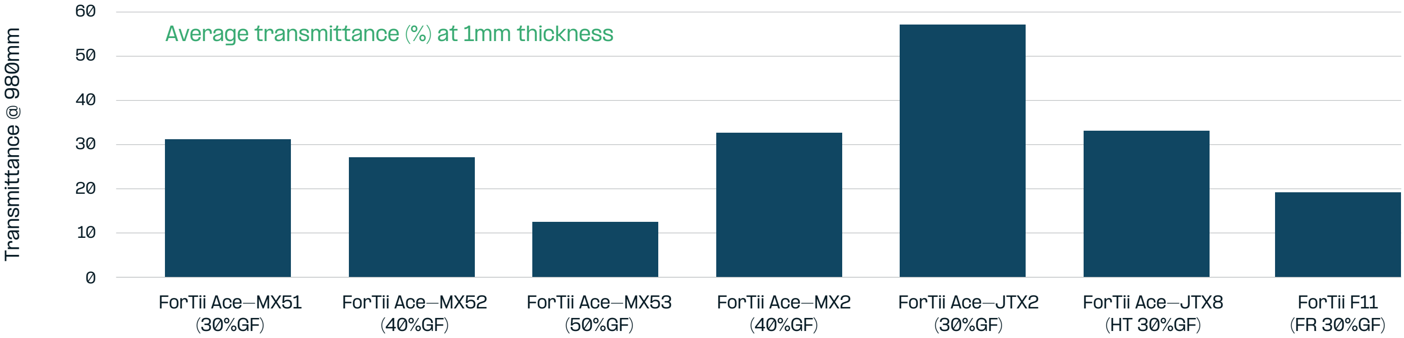


Figure 3
Transmittance of ForTii PPAs measured with the TMG3, MX series are primarily used in automotive, JTX in E&E (reflow solderable) and F11 is a halogen–free flame retarded (V0).

High temperature PPAs for electrical and electronics applications (E&E)

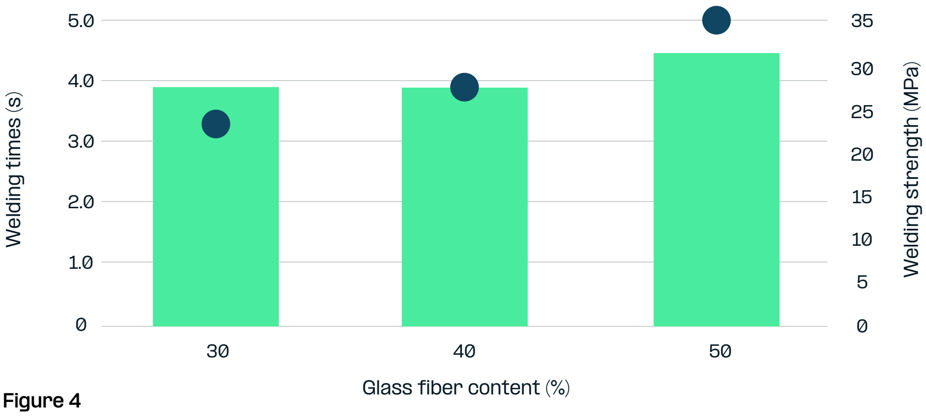
As shown in Figure 3, the JTX series (30% GF) has very good transmittance values at 980nm. These grades can be used in E&E applications needing reflow soldering. The JTX grades were developed for heavy duty auto E&E applications (connectors) and can also be used for housings of electronics. The JTX materials survive industrial scale lead free reflow processes where the ACE JTX8 is a Jedec1 capable material.

Uniquely, ACE JTX8 is one of the highest melting PPAs around with a melting point of 340°C and high glass transition of 150°C, and despite this it still shows a very good laser welding behavior with weld strength of 25–30 MPa when using the right laser welding conditions. Furthermore, this result could be achieved with a broad processing window and without observable negative influence on the welding area.

WELDING
HIGHLY REINFORCED PPAs

Laser welding of highly glass filled PPAs has been proven to work well for the ForTii® MX series. The transmittance of higher glass filled grades is sufficient, and average weld strengths up to 30 MPa are achievable.

Though higher glass fiber content puts restrictions on the thickness of the transparent cover when using the right process and welding settings, similar weld strengths can be achieved for all glass fiber contents tested even up to 50% Glass Fibers (30–50%), which expands the possibility for usage.



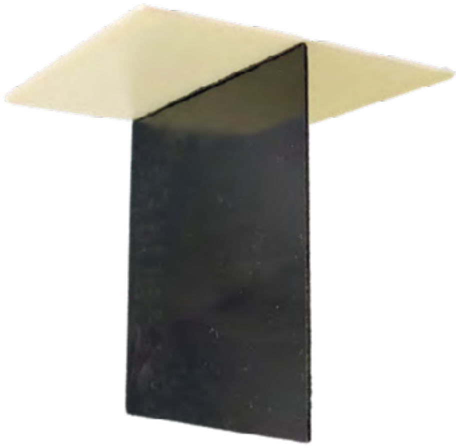
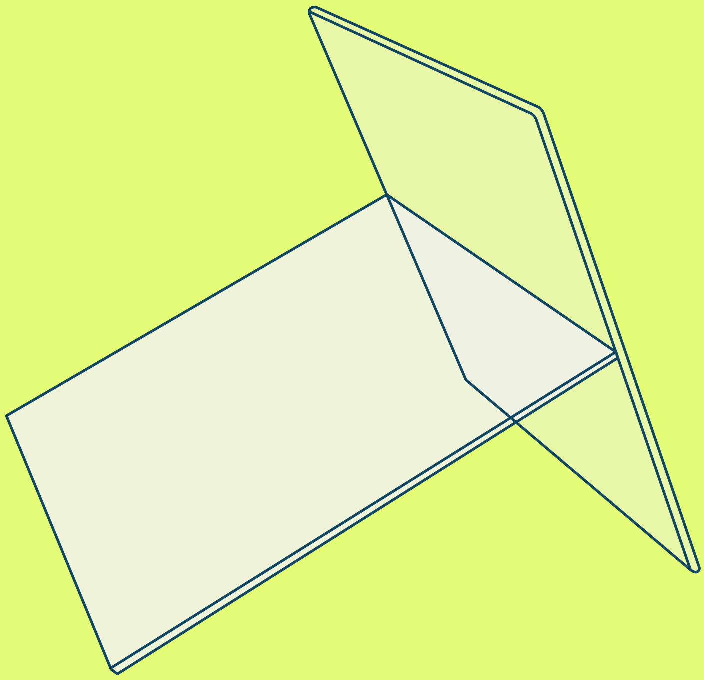


Figure 4
Example of welding times (dots) and welding strengths (bars) for laser welded T–joints of ForTii with three different glass–fiber contents (left) and T–joint (right). Reference measurements were extrapolated for 250mm contour length and 1mm thickness.

WELDING HALOGEN FREE
FLAME RETARDANT PPAs

For ForTii materials like F11, which is 30% Glass filled, V0 halogen free flame retarded laser welding is possible. Understandably the laser welding processing window for flame retardant materials is somewhat narrower, though very well possible with acceptable welding times, sufficiently high weld strengths (16–17MPa) and without observable defects.

Observations suggest welding that covers up to 1.5 mm thick should be possible. Next to F11, experiments were performed on ForTii T11, which is also 30% glass filled, Halogen Free Flame retarded V0 targeting automotive FR applications. Feasibility tests on ForTii T11 in a radar enclosure application displayed initial results like the F11. The F11 and T11 materials are both reflow solderable (lead free) materials. The combination between Flame retardant ForTii and laser welding opens new possibilities, such as the flexible production needed for modular connectors, and electronics and inverter housings, micro actuators and junction boxes.



LASER DIRECT STRUCTURING (LDS)

Laser welding is also possible when using an LDS grade as an absorbing part as shown in Figure 5. For the cover any ForTii grade, such as JTX2 and MX2, in natural or other laser transparent colors with sufficient transmission could be used. This opens even more possibilities to integrate more functionalities (3D trace structures, antennas, switches, connectors, and sensors) into a part that can be sealed after processing and assembled using laser welding. This opens substantial new opportunities for component design miniaturization, weight reduction, low startup cost–threshold, scalability, high pressure resistance and vacuum tight protection of sensitive elements. ForTii LDS85B has a track record in applications using fine–line resolution of electrical tracks. Even 3D weld joints will be possible.

Laser welding of PPAs is now an option

A variety of applications using PPAs in combination with laser welding grades are now a possibility thanks to the expertise of Envalior and LPFK, despite the perception that laser welding PPA materials is problematic. Envalior and LPKF has shown that by combining material knowledge with the right welding equipment and state of the art process knowledge, laser welding can be applied successfully to all ForTii material grades.

Figure 5
ForTii LDS85B, laser activated, plated, assembled, reflow soldered and laser welded with a PPA cover.

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To learn more, contact us via Envalior.com.