Panasonic
INDUSTRY

Production process of a plastic part

Guideline

IN Your Future

Your Committed Enabler

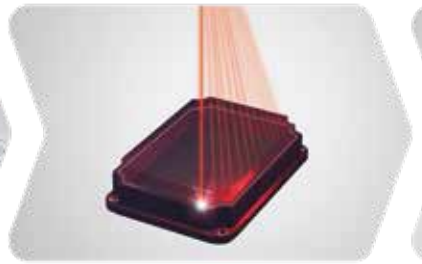
Development process of a plastic part:
From the product idea through to small-scale and serial production

Successful manufacturing and welding of plastic parts requires particular attention towards different aspects from the very beginning. We will be happy to assist you in every stage of the project – from selecting suitable materials to designing and producing joining parts and finally when laser welding the plastic parts.
During our consulting activities, we place great emphasis on the analysis of the material so that you will get optimum results. Panasonic offers a broad product portfolio for all production processes in your assembly.

Development process of a plastic part

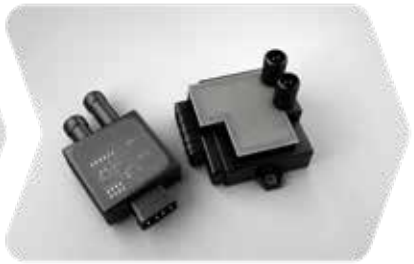
Planning

The right choice of the raw materials has far-reaching consequences and has to be planned well.



Professional tests

Our tests are performed with the same laser welding systems and components which are used later in the production process.



Result

We guarantee an exactly and neatly welded part.
The laser welding systems achieves high quality and precise plastic joining.

OVERVIEW

The different stages in the production of a plastic part

1 Material selection

Suitability tests of common materials.
Panasonic offers:
Pretests and transmission measurement

page 4

2 Part design

Integrating the welding process into the part design.
Panasonic offers:
Prototype development by check list

page 5

3 Injection molding

Considering cycle time and quality factors.
Panasonic offers:
Static discharge with ionizers

page 6

4 Storage

Protect material against environmental influences.
Panasonic offers:
Storage control via dashboard

page 7

5 Handling/ feeding

Organize safe transport and feeding of parts.
Panasonic offers:
Exact positioning by servo drives

page 8

6 Installation of single components

Planning a defect-free installation of single components.
Panasonic offers:
Inspection of assembly processes

page 9

7 Laser plastic welding

Material is welded by laser and cooled down.
Panasonic offers:
Laser welding system

page 10

8 Quality management

Debugging, leak tests, pre-set collapse measurement, and 2D code analysis.
Panasonic offers:
2D code validation

page 12

9 Laser marking

Ensure product identification and traceability.
Panasonic offers:
Laser marking systems

page 13

10 Service

Comply with maintenance periods.

Panasonic offers:
All-round service

page 14

1 MATERIAL SELECTION

Compatible materials

The key aspect of a stable plastic part is the selection of the right material: Nearly all thermoplastic synthetics and thermoplastic elastomers are well suited for laser transmission welding.
In this context the following applies: All plastics with the same chemical properties can be welded. The laser transparent material should have a laser transmittance of at least 15% to 20%, apart from the admixed additives like color, fiber content, etc. Fiber-glass-reinforced or different materials can also be welded by the laser. A selection of tested material combinations is shown in the following table.

Weldable plastics

	ABS	ASA	MABS	PA6	PA66	PA12	PBT	PBT/ASA	PC	PC/ABS	PE-LD	PE-HD	PEEK	PES	PET	PMMA	POM	PP	PPS	PS	PSU	PVC	SAN
ABS	■	■	■				■	▒	■	■				▒	■	■				▒	▒	■	■
ASA	■	■					■	■	■	■						■					■	■	■
MABS	■		■																				
PA6				■	■	■																	
PA66				■	■	■																	
PA12				■	■	■																	
PBT	■	■					■	■	■					▒	■	■				■	■	■	■
PBT/ASA	▒	■					■	■	■					▒							▒		
PC	■	■					■	■	■	■				■	■	■				▒	▒	■	■
PC/ABS	■	■							■	■						■							
PE-LD											■				▒	▒		■	▒	▒			
PE-HD											▒	■				▒		■					
PEEK											▒		■	■		▒					▒	▒	▒
PES	▒						▒	▒	■				■	■							■		
PET	■						■		■		▒				■							▒	▒
PMMA	■	■					■		■	■	▒	▒				■				▒	■	■	■
POM																	■						
PP											■	■						■					
PPS																			■				
PS	▒						■		▒		▒					▒				■	▒	▒	▒
PSU	▒	■					■	▒					▒	■		■				▒	■	▒	■
PVC	■	■					■		■				▒		▒	■				▒	▒	■	■
SAN	■	■					■		■				▒		▒	■				▒	■	■	■

Notice: One material component has to be laser transparent, the other component has to be laser absorbing.

■ Strong weld ▒ Weak weld □ No weld

Support of this process step

Laboratory with special application equipment

Our laboratory provides:

- Pretests for welding of laser transparent and absorbing sheet material
- Material testing:
  - Transmission measurements @1070nm
  - Tensile tests
  - Burst pressure of up to 60bar
  - Fracture analysis
  - Micro cuts
  - Microscopic analysis
- Pretest for laser marking on selected material

2 PART DESIGN

Joining partner

The technique of transmission welding has proved to be extraordinarily safe, flexible and neat. The bonding technology is particularly economical if the characteristics are taken into account already in the design phase.

Transparent part

What should be considered:

- For injection molding: The weld area has to be free from ejector and separation traces
- The injection point should be at the center of the cover
- Same circumferential thickness in weld area
- Higher stiffness with ribs
- Accessible geometry for laser beam
- The surface finish in the weld area has an impact on the final result.
- No/small outer radius (for outer clamping technology)

Absorbing part

What should be considered:

- For injection molding: The weld area has to be free from ejector and separation traces
- Injection point not close to the rib
- Clamping force during laser welding process: 2-5N/mm^2
- Support: Is a support underneath the welding seam possible?
- Flatness requirement between the parts ~0.15
- Radial welding: Is there a force fit of -0.1mm?
- Are there reference points or edges for exact position control?
- Melt collapse: 0.1 to 0.5mm during quasi-simultaneous welding.
- What is the surface finish like?

Support of this process step

Predevelopment

Our experienced team of application engineers offers support for optimum part design. A successful laser welding process starts already during design.

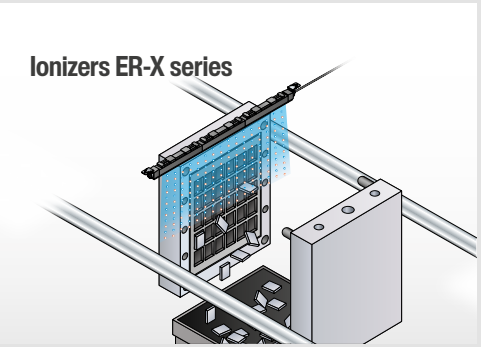
Your check list for part design	
Weldable material combination?	☐
Laser absorbing half of the molded part, absorbing @1070nm?	☐
Laser transparent half of the molded part, laser transparent @1070nm?	☐
Accessibility of laser beam ensured?	☐
Is there a bearing surface for the clamping technology?	☐
Seating of upper component possible?	☐
Seating of lower component possible?	☐
Position control of parts relative to one another ensured?	☐
Melt collapse and tolerance deviations taken into account?	☐
Enough flow space and optical coverage for melt available?	☐

3 INJECTION MOLDING

Influencing factors

Injection molding is one of the most important production processes for the processing of plastics. Above all, it is well suited for the manufacturing of complex-shaped parts in mass production. For a successful joining of plastic components via laser welding it is important to pay attention to many process parameters and different cavities. The following factors are essential for the geometric and optical properties of the later component:

- An injection point in the weld area leads to different transmission behaviors of the material
- The temperature of the injection molding tool and the cooling time of the parts have an effect on the crystallinity and hence also on the transmission of the material
- Due to a different reflection and absorption behavior, the release agent influences the processing quality
- For injection molding, the dimensional accuracy of the part and its surface finish are predetermined
  - The dimensional accuracy is important for the welding process and the thermal contact (otherwise overheating)
  - The surface finish is important for the reflection of the laser radiation
- Ejector pins in the weld area reduce the processing quality



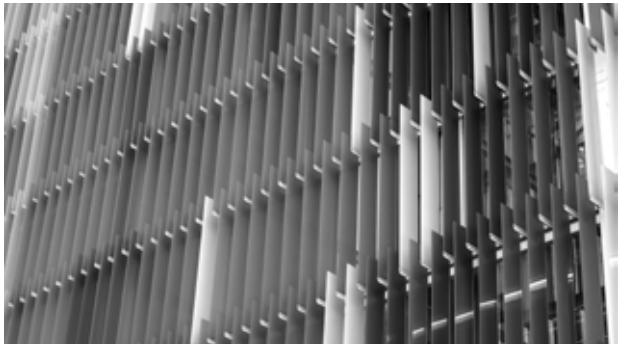
Support of this process step

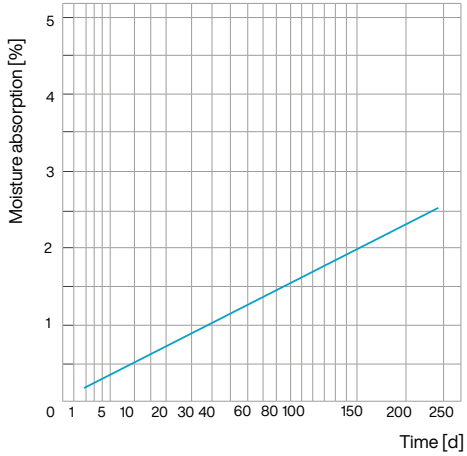
Electrostatic discharge of injection molding parts with ionizers

During the injection molding process, plastic parts are electrostatically charged. An electrostatic charge may lead to faulty forms, incomplete ejection or dust adhesion during the process. Panasonic's ionizers solve these problems quickly and directly in the flow of the process.
Features of Panasonic's ER-X series ionizers:

- Operation possible without or with compressed air for faster discharge
- Discharge frequency between 1 and 100Hz selectable
- Different lengths are available
- Automatic ionic balance
- Simple replacement of discharge needle

4 STORAGE





Appropriate storage

In terms of operation, an integrated storage strategy should be developed to keep the products under optimum conditions in a good state, also beyond the warranty period of the manufacturer (long-term storage).

To use semi-finished parts after the injection molding process for further processing steps, measurements for appropriate storage are required.

This means protecting semi-finished parts from incident sunlight (UV radiation), increased air humidity and atmospheric oxygen. Environmental influences can significantly affect the material properties. This could cause oxidation of the surfaces, swelling, warping, embrittlement, color changes and also changes in the mechanical properties. Such alterations may in turn impede the further processing of the semi-finished parts.

For laser welding primarily thermoplastic resins are used. It must be taken into account that these materials take up water from the ambient air during the whole feeding and storage period. In the process of laser welding, the absorbed water vaporizes inside the material. This may lead to blistering in the melt and/or internal foaming. The result is blistered seam structures, and hence reduced strength of the material. If blistering occurs, seal weldings are nearly impossible.
Therefore, it is mandatory to prepare materials with a high water absorption accordingly before the welding process. This means heating up the parts again to reduce the water content.

For appropriate storage of the plastic parts, closed spaces under a standard atmosphere (23°C, 50% relative humidity) are recommended. This is the only way to minimize external influences and maintain size accuracy to a large extent over an extended period of time.

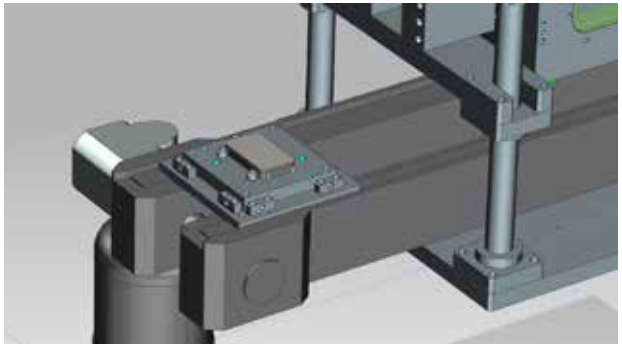
Support of this process step

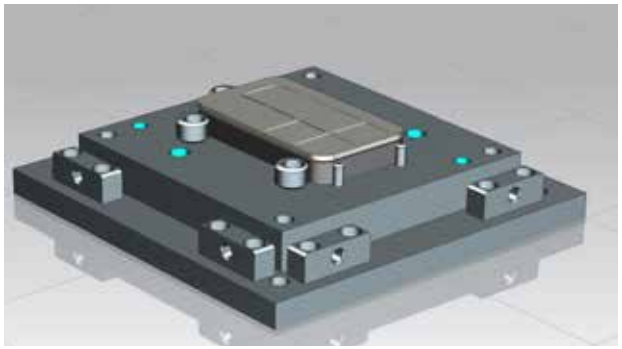
Storage monitoring and control via dashboard

- Remote maintenance & decentralization:
  Centralized synchronous maintenance and decentralized actions.
- Visualization & virtualization:
  Display complex issues simply.
  Integration of an IP camera.
- Cost reduction & real time:
  Offer services via Internet and make decisions in real time.
- Support of the service personnel and maintenance of the system.

These advantages are realized by the Control Web Creator and Panasonic's FP7 controller.

5 HANDLING AND FEEDING





Correct handling and feeding

During production, the ready molded plastic parts should be transported and treated carefully. Avoid hard hits and throwing, since these may lead to spalling, breakage damage and notches in the part. Otherwise, the surface properties and the optical behavior (absorption, transmission and reflection) will be seriously affected. The processing quality may also deteriorate.
If the surface of the transparent joining partner is contaminated, local burns may happen. The consequences are:

- Poor processing quality
- Optical disturbances

The parts should be transported carefully from one production process to the next one, i.e. with transfer or handling systems. These systems can be driven by Panasonic's servo motors with variable speeds. To realize optimum feeding of the parts into the welding process, a precisely fitting workpiece carrier is useful. This guarantees exact position of the parts and they are fixed securely. A laser welding tool consists of a lower (negative) mold and a clamping unit which during the welding process is pressed against the part. Panasonic supports you with your mold design and the construction of suitable tools for your application, thus establishing a safe transport and welding process flow.

Support of this process step

MINAS A6 servo drive

- Ultra-high response frequency: 3.2kHz bandwidth
- Pulse outputs 4 Mpps and inputs up to 8 Mpps (Mpps = mio. pulse/s)
- Enhanced real time auto-tuning during operation (transient recovery time 6ms)
- 5 notch filters: manual/automatic
- 3 damping filters: manual/automatic

The notch and damping filters of the servo drives automatically suppress vibrations caused by the resonance of the machinery. Therefore, the filters have a great impact on the quality of the welding seam.

6 INSTALLING SINGLE COMPONENTS

Assembly processes

Before welding the two joining parts and finalizing the product, in most cases many other assembly processes like locking, press-fitting, greasing, riveting, punching, tumbling, caulking and integrating the electronics, lie ahead.

During laser welding, direct contact with the integrated parts is excluded, so that the quality and functionality of the components is ensured. Especially damage due to vibrations or contamination by inclusion of fluffs or fibers do not occur with this method.

Support of this process step

Verifying the dimensions

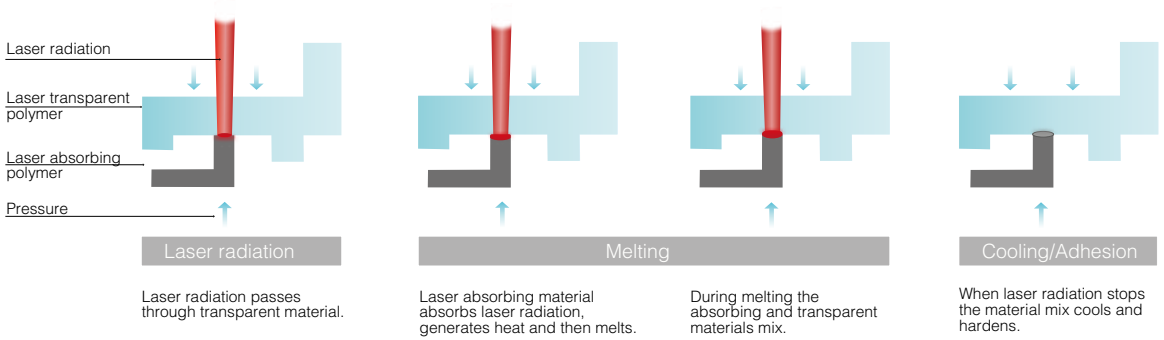
After the assembly process, the workpiece can be measured with the measurement sensors of Panasonic with high accuracy. In this way, uneven surfaces due to installation on a slant or part variations as well as the exact dimensions of the workpiece can be captured at an early stage.

Our portfolio of measurement sensors:

- Laser photoelectric sensors
- Contact-type measuring sensors
- Eddy current analog sensors

7 LASER PLASTIC WELDING

Process description



Procedure description

The new laser welding system of the VL-W1 series is based on the technology of quasi-simultaneous welding. With this method, plastic layers can be welded together by laser radiation and heat build-up at the adjacent surfaces without the need for adhesives. One of the characteristics of quasi-simultaneous welding is that the laser beam is directed very fast (quasi-simultaneously) around the component to be welded.

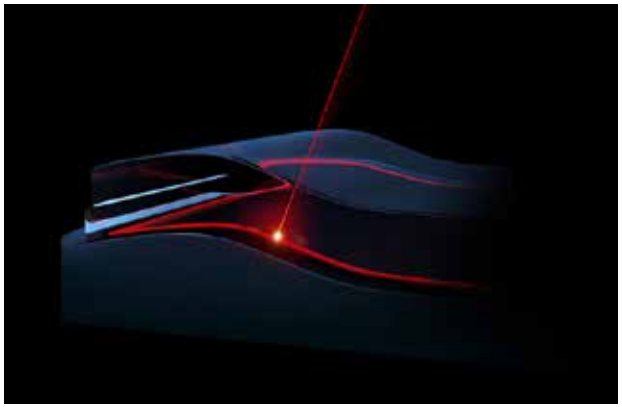
Main advantage: the component is joined together evenly so that no warping occurs. Furthermore, using the laser guarantees a high flexibility of the welding seam geometry.

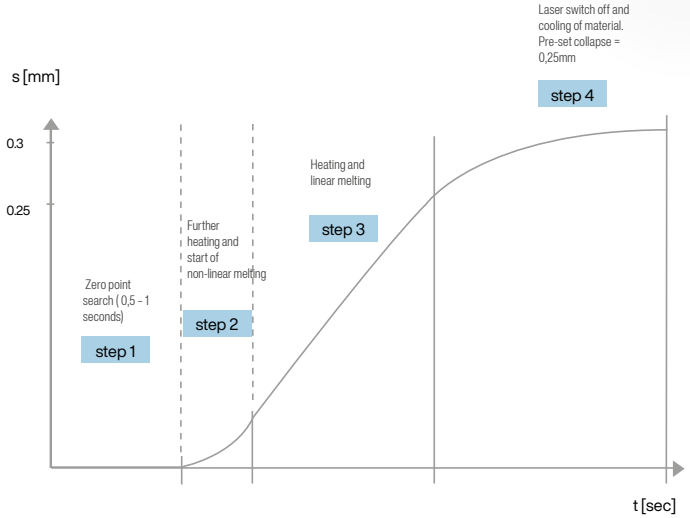
Support of this process step

VL-W1 laser welding system

- Standardized industrial system from Panasonic, in use for many years
- Clearly defined mechanical and electrical interfaces
- Software for scanner and laser
- Adjustable focus (0.7-2mm)
- Plug-and-play system
- Precise laser beam, Laser quality M2 <1.1
- Weldable 3D geometries
- Integrated power correction for curved sections
- Worldwide service concept
- Air cooling system

7 LASER PLASTIC WELDING





The 10 most important process steps for joining plastics

1. Part detection and scanning of CMC code.
2. Clamping unit moves to operating position and transfers force to part.
3. Zero-point search (0.5 – 1 second).
4. Laser is turned on and the material starts to heat up.
5. Further heating and non-linear melting starts.
6. Heating and linear melting.
7. Laser turns off and material cools down. Pre-set collapse = 0.25mm.
8. Cooling completed. Melt collapse = 0.3mm.
9. Clamping system moves to base position.
10. Transfer of the melt collapse and melting time values into quality control/MES.

Support of this process step

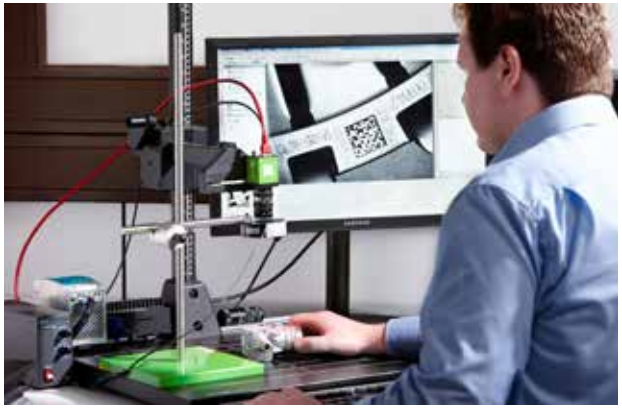
Workstation for laser welding

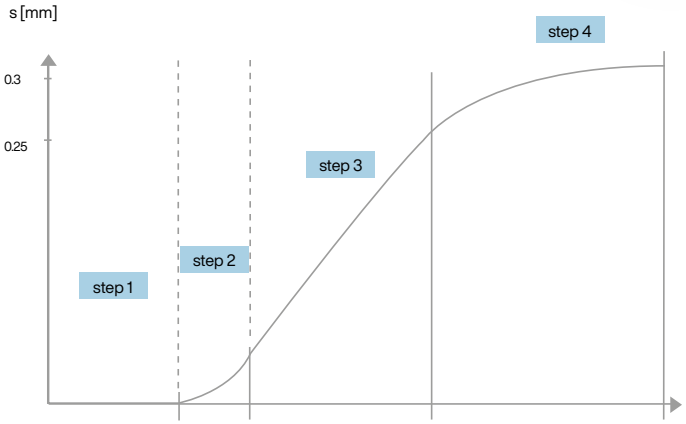
Panasonic currently offers complete systems for manual low volume production.
For extensive serial production we offer support for concepts and designs to reach a successful series launch together with your plant constructors and machine builders.

Advantages of the workstation:

- Compact laser welding cell
- 400x400mm processing field
- 300-4000N
- Clamping unit with servo motor
- Quick-change system for setting up new processes

8 QUALITY MANAGEMENT





Pre-set collapse chart

Suitable test methods

Before the finished product is packed and further transported, it has to pass quality management. Early detection of faulty parts in the production process can save costs which arise during the production and after the delivery of the products. There are different methods to avoid claims or recall operations as well as the associated loss of reputation. It is important to choose the correct test method and the correct test criteria. The control of the test processes and the documentation of the results also affect sustainability. For example, the following test methods are available:

Leak test

To test the workpieces regarding their tightness, flow sensors can monitor the air flow. Pressure sensors can reliably detect a pressure drop in a test lead.

Pre-set collapse measurement

The process sequence described in process stage 7 generates a melt collapse value which can be used for the quality control. When setting up the process, reasonable upper and lower limits can be defined which will then be controlled by the machine during the process sequence. If the limit values are passed, i.e. due to transparency fluctuations, an NOK identification marking is executed and the relevant part is removed from the process.

2D code analysis

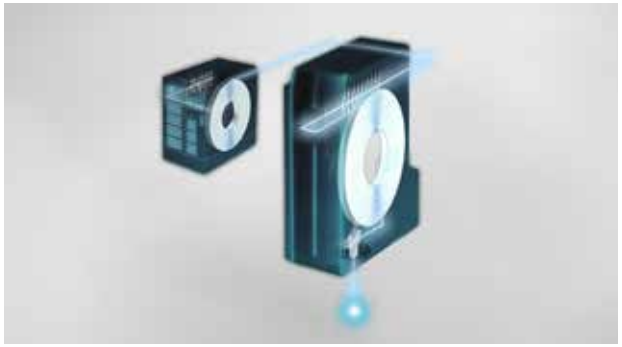
Laser markings that mark the 2D codes directly on the product are well suited for ensuring the traceability of the product. Afterwards the code is read by a 2D code reader. The combination of direct marking by laser and control by a 2D code reader establishes a new method of identification and optimizes your quality management.

Support of this process step

2D Code Reader LP-ABR10

- Illumination:
  very bright LED with light variations
- High resolution:
  1.2 megapixel image sensor
- Image processing:
  Proprietary algorithm for DPM code

9 LASER MARKING



Laser marking on a finished part

Laser marking ensures quality and traceability throughout the entire product life cycle. At the end of all process steps, the finished part can be denoted by a laser marking system with serial number, production date or a 2D code.
This ensures quality and traceability in case of consequential damages. It is recommended to apply identification markings on all products. Doing so by a laser is very effective, because the markings withstand external influences very well. Laser markings are resistant to abrasion, temperature, light and lubricants.

Your advantages

- Your product can be identified and is retraceable during all following steps
- A laser marking lasts for the whole service life
- The high contrast of the identification marking offers very good readability for reliable traceability and is perfectly suited for error-free readout of the code contents

Support of this process step

Fiber laser marking system for high quality marking of plastics

- High pulse peak power of a short-pulse laser with low heating effect
- High-contrast color change of plastics
- Integrated pre- and master oscillator
- On-the-fly marking
- Power range: 13W, 25W, 50W und 100W
- 3D marking

Panasonic Support

All the way, from the idea for a product right up to serial production of the finished component.

More information on www.industry.panasonic.eu

10 PANASONIC SERVICE

Customer assistance

Panasonic provides experience with product design and know how with product launch, thereby ensuring exact welding.

Feasibility study

Selection of laser settings: which laser is best suited for your application? Depending on the specifications, we test the welding results for tensile strength and airtightness, and execute microscopy analyses.

Project consulting

Our team of consultants, application engineers, and technical support will be available from the very start of your project. Panasonic supports customers all the way, from the idea for a product right up to serial production of the finished component.

Installation

You can utilize Panasonic's laser welding systems as manual manufacturing workplaces or implement them into your production line. During the installation of a laser welding system, we pay particular attention to the existing facilities and conditions in the production environment of our customers.

Training

On site in your company or in the Panasonic laser laboratory, you and your employees will become acquainted with the laser welding system. Your employees will get intensive training and will learn all functions and required parameters for trouble-free and autonomous handling of the system.

Maintenance

Every laser welding system sold establishes a long-term relationship between you and Panasonic. On request, our Service Center will undertake all maintenance work and other services for your laser welding system. This way, a continuous and smooth operation of your laser welding systems can be guaranteed.

Support

For us, quick and flexible support is a matter of course and normal practice. Our technical support is performed by highly qualified and certified service technicians. They offer competent assistance for all laser welding systems and accessories.

Delivery/Storage

We want our customers to be able to fully concentrate on their core business. We want to ensure your production processes and therefore offer different service packages with maintenance and spare part delivery options.

Panasonic
INDUSTRY

We are dedicated to the highest standards of global sustainability as **Your Committed Enabler**. Find out more on our website.

Panasonic Industry Europe GmbH

Caroline-Herschel-Strasse 100
85521 Ottobrunn
Tel. 49 89 45354-1000
info.pieu@eu.panasonic.com
industry.panasonic.eu

3242 euen 01/23