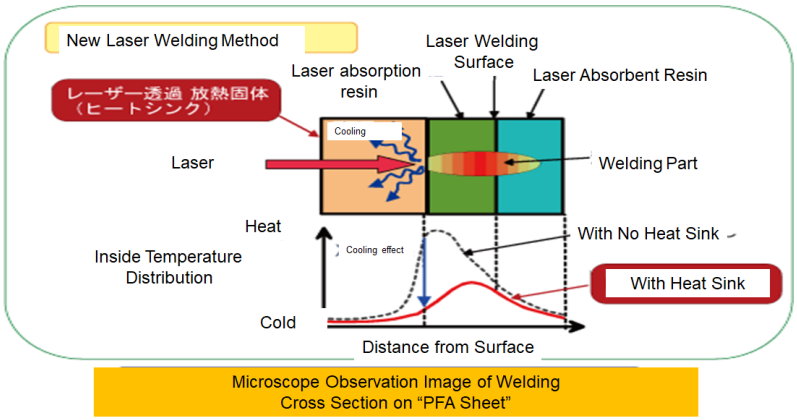
Theme Name	Surface damage-free laser welding method using infrared laser and heat sink
Organization Name	Advanced Laser Resin Welding Technology and Promotion Consortium
Technical Field	Manufacturing

Overview

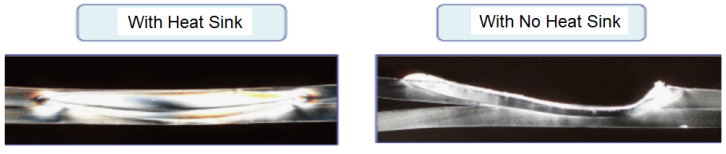
We have established a laser welding technology that combines an infrared laser and a cooling solid (heat sink) to bond the same transparent plastics together with a clean surface. This technology is applicable to many thermoplastic resins. For fluororesin, it can be applied to semiconductor manufacturing equipment parts and medical parts (catheters / tubes, etc.) and for engineering plastics, it can be applied to automotive parts and electrical parts. The Consortium is promoting activities to utilize this technology for various purposes. We welcome companies that are willing to use this technology.

Simplified Diagram

Surface damage-free laser welding method using infrared laser and heat sink
= It can bond the same transparent plastics together with a clean surface =



Microscope Observation Image of Welding Cross Section on “PFA Sheet”



With No Surface Deformation　　With Surface Deformation

Use of This Technology (Various Applications)

- Semiconductor Manufacturing Devices (Fluorine Resin)
- Medical (Fluorine Resin)
- Engine (Engineering Plastic, etc.)
- Precise Electronic Parts (Engineering Plastic, etc.)

Background

Various plastics (resins) are used for semiconductor, medical, automobile, electronic parts, etc. For many years, heaters and ultrasonic welding methods have been used to weld plastics together. In recent years, however, laser welding methods have attracted attention as a third method.

In this research, we propose a technology for welding the same transparent resins together with a clean surface without additives such as pigments.

This is the result of the NEDO University-originated business creation research and development project.

Technical content

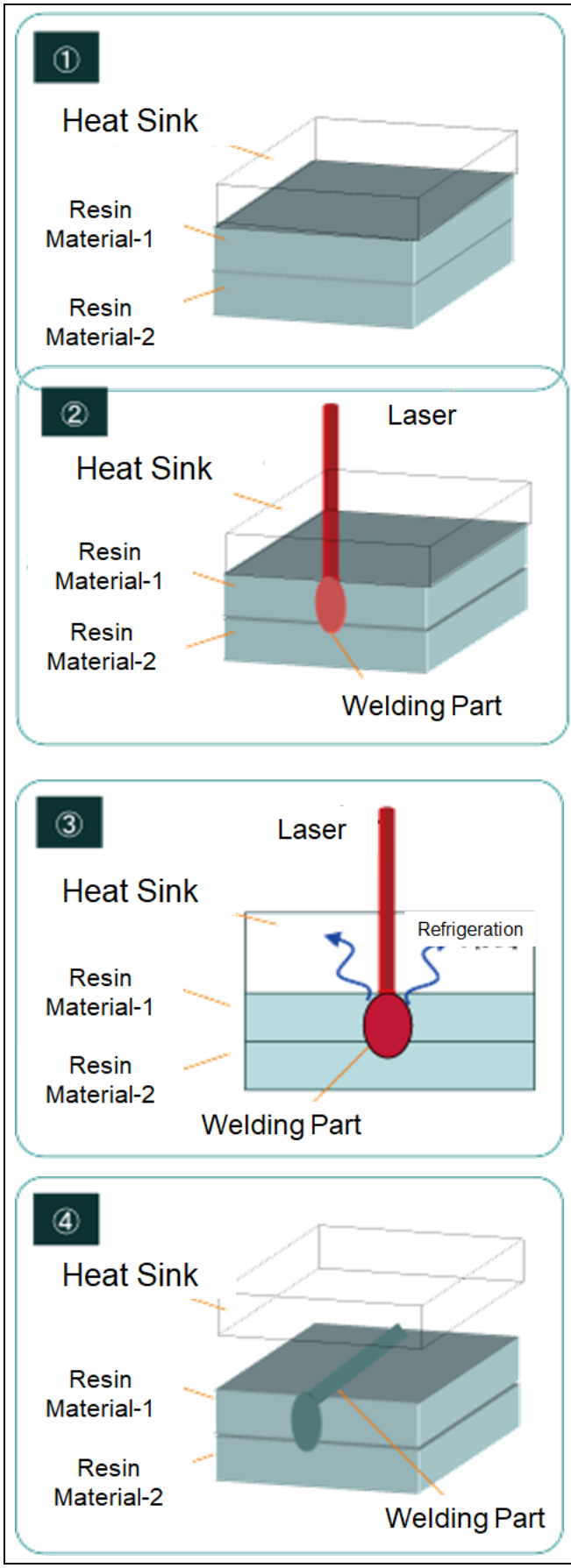
This is a new laser processing method that combines with lasers of various wavelengths (CO 2 laser, fiber laser, CO laser, Er. Yag laser, etc.).

1) Superpose resins that indicate absorption in the infrared range.

2) Install the heat-radiating solid object (heat sink) that penetrates the laser on the surface of the resin irradiated with the laser.

3) Beam laser from the top of the heat sink.Although, the resin absorbing laser generates heat by converting the laser beam into heat, the heat sink radiates heat from resin surface. Therefore, the resin surface does not cause thermal deformation, and only the junction becomes hot and welded.

4) High-speed welding is possible by scanning the focused point of laser.


①
Heat Sink
Resin Material-1
Resin Material-2
②
Laser
Heat Sink
Resin Material-1
Resin Material-2
Welding Part
③
Laser
Heat Sink
Refrigeration
Resin Material-1
Resin Material-2
Welding Part
④
Heat Sink
Resin Material-1
Resin Material-2
Welding Part

Strengths of technology and know-how (innovation, superiority, utility)

The comparison with the conventional technology is as follows.

(1) Hot plate and hot air welding dryer

- Welding with hot plate or hot air dryer. The disadvantage is deformation of the surface.

(2) Vibration welding / ultrasonic welding

- Since it is difficult to weld resins with low friction coefficients and they vibrate, it is not suitable for fine and precise jointing of electronic parts.

(3) Direct laser radiation

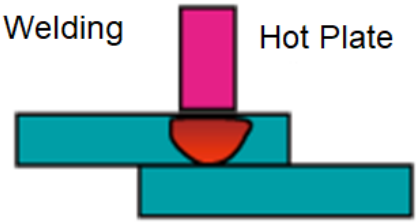
- Superposes light-absorbing resins and radiate laser from one side. It is suitable for focused welding, but the disadvantage is that it thermally deforms because heat is concentrated on the surface like a hot plate.

(4) Laser Penetration Welding

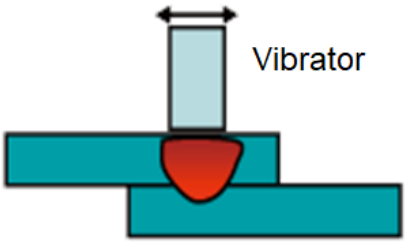
- This is a technology superposing light-penetrating resins and light-absorbing resins and radiating laser from the light-resins side.
  Since heat is concentrated on the interface between the resins, the surfaces can be welded together with a clean surface, but cannot be applied to the same resins.
- There is also a method to execute laser welding by superposing the same transparent resins together and putting dyes between the interfaces. However, this method requires a lot of time and cost, and the use of dyes, carbon black and adhesives bond tend to be avoided in medical applications.
- When the conventional laser penetrating welding method (using CO 2 laser) is applied to fluorine materials, harmful decomposition gas is generated due to thermal damage of the resin surface. If this method is used, workers must wear a gas mask.
  Also, there is no effective adhesive bond for jointing fluorosis or olefin resins.

Conventional Welding Method

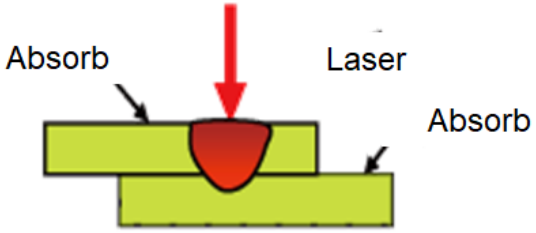
（1）Hot Plate / Hot Air Welding



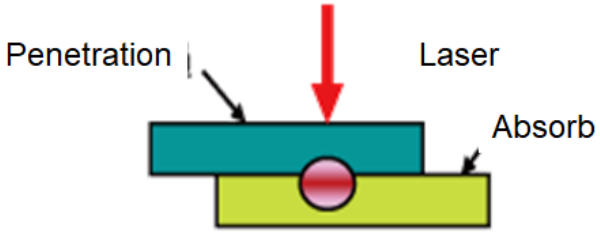
（2）Vibration Welding



（3）Direct Laser Radiation



（4）Laser Penetrating Welding



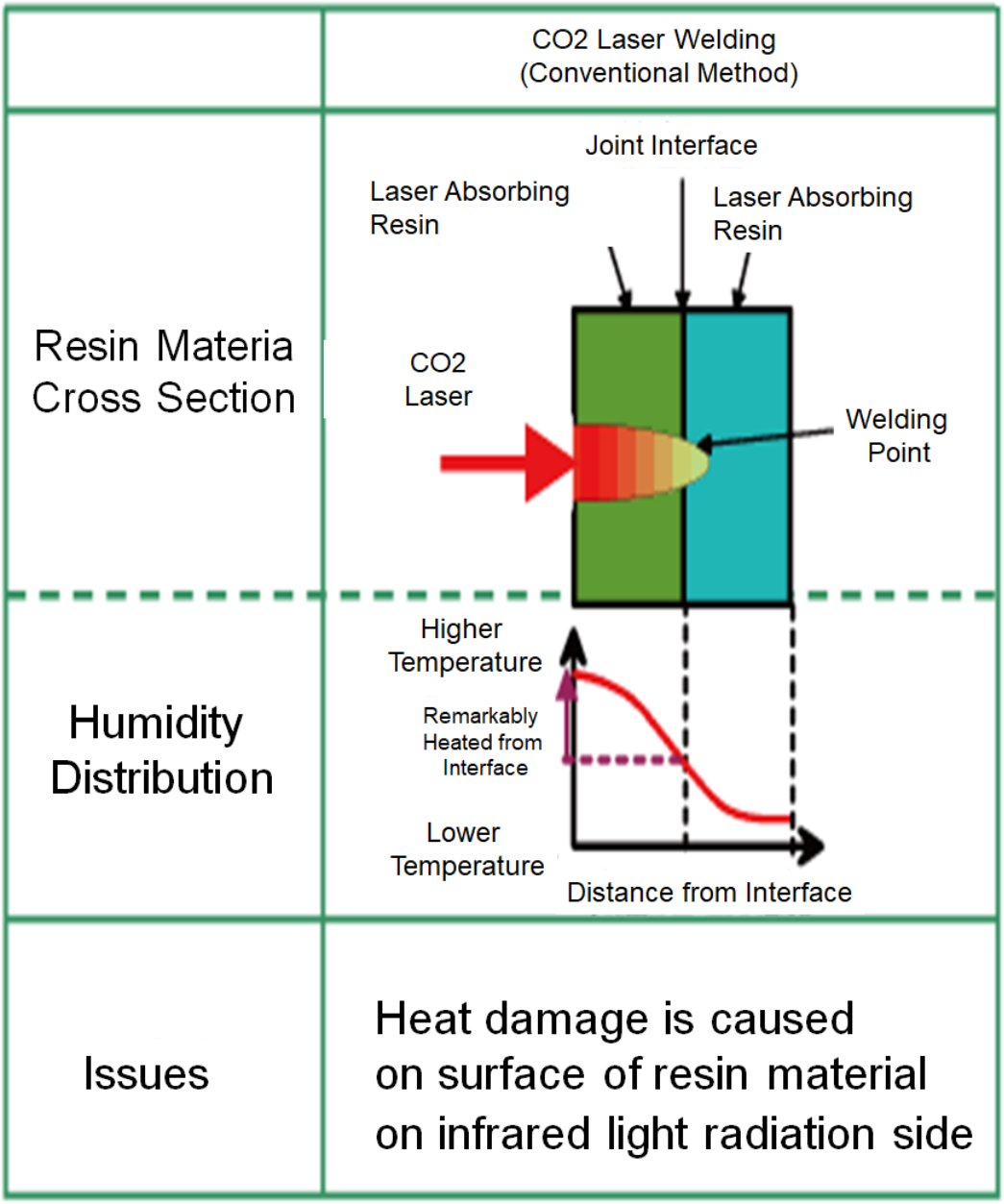


Image of Allied Company

We welcome companies that wish to use this technology.

For example, we can propose to the following companies.

1) Enterprises with the need to weld transparent plastics together with clean surfaces.

- Fluorine resin parts, engineering plastics, etc.

(PFA, modified PTFE, PC, PMMA, POM, etc.)

2) Medical parts manufacturers

- Companies that have the need to weld fluororesin such as catheters and medical

tubes.

3) Semiconductor component manufacturers

- Especially companies that have a need for fluororesin welding.

4) Automobile manufacturers

- Companies particularly with engineering plastic welding needs.

5) Other companies willing to use this technology.

Utilization of technology and know-how (image)

This technology can be applied to various plastic processing such as acrylic processing, fluorine processing, Teflon processing, etc.

1） Application to parts for semiconductor manufacturing equipment

- Due to the chemical resistance required for parts of semiconductor manufacturing equipment, fluororesin (PFA / modified PTFE, etc.) is often used. It can be applied to chemical containers, chemical tanks / tanks, piping, pipe fittings, valves / pumps, wafer carriers, and other molded products.
  Welding methods using heaters and screw fitting methods can be used for jointing parts together, but there are many problems. This technology can be applied, and the optical system and heat sink can be customized according to the shape of the junction.

2） Medical applications

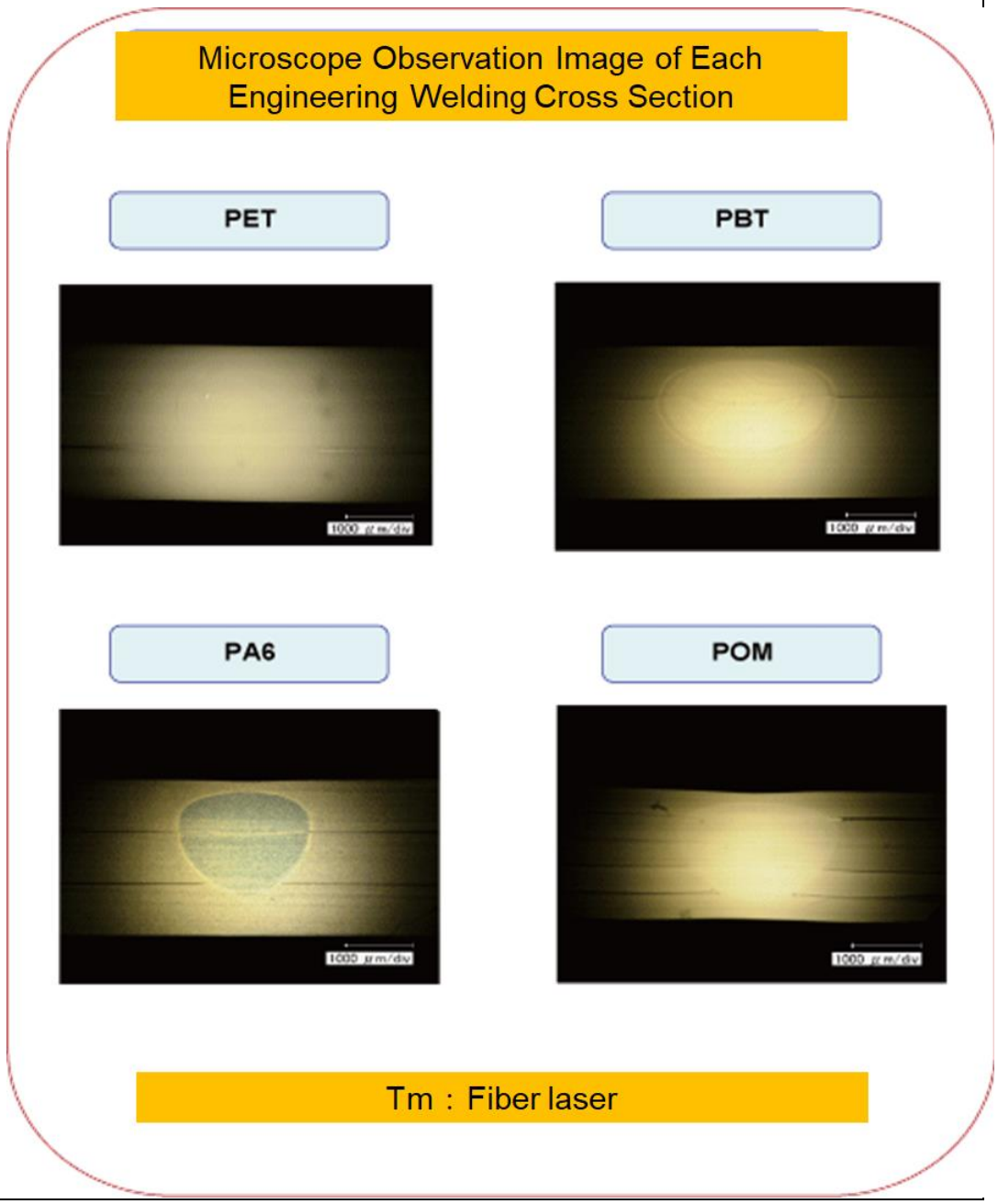
- Fluororesin is used because it requires chemical resistance like semiconductor manufacturing equipment parts. Ultrasonic welders are used in syringes (syringes and plastic needles) and infusion packs, but there is a problem of dust during processing. In addition, since the catheter and tube connections are microscopic, laser local welding is suitable, but the use of dyes, carbon black, and adhesives poses a hygienic problem.
  This technology does not require these additives and is clean, therefore, it is suitable for medical applications.

3） Application to automotive parts

- Currently, plastic of around 8 to 10% vs total weigh is used for automobiles, so weight is reduced.Engineering plastics are attracting attention in terms of their durability needs. For example, engineering plastics such as PC are used on the body shell to resist the heat generated during painting. In addition, the use of PP has been increasing as a means of reducing weight.

4） Applications in the electrical machinery field

- Electronic devices such as printed circuit boards and smartphones are required to be small, light, highly functional, heat-resistant, and robust against external shocks, and the demand for lightweight and highly functional engineering plastics is increasing rapidly. Transparent resins such as PC are used for optical components. This method can be used for laser welding of "contamination free, solvent free, and general purpose" in the assembly of these components. Also, since this is a precision instrument, it is possible to take advantage of the features of this technology when problems occur with ultrasonic welding machines that generate dust and mechanical vibrations.



* Examples of welding to engineering plastics

Utilization Process of New Technology and Know-How

The basic method has already been established, and demonstration machines have been installed in the University of Electro-Communications. We will explain the details of the technology after your inquiry.

Explanation of technical terms

[Infrared laser]

Infrared lasers are CO 2 laser, fiber laser, CO laser, Er. Yag laser, etc. When semiconductor lasers are used, transparent plastic does not generate heat because it penetrates light and makes welding difficult. In these lasers, even transparent plastic absorbs light and generates heat.

Since the absorption spectrum differs depending on the resin, a relevant laser is selected and used in accordance with the resin and welding conditions.

[Heat sink]

Heat sink is a solid object that penetrates light and releases heat from the surface. Without a heat sink, the surface would be deformed, so it is the basic material of this technology.

[Fluororesin]

Fluororesin has excellent chemical resistance and is used in a wide range of applications, including medical parts and semiconductor manufacturing equipment parts and so on. The disadvantages are no suitable adhesive bond and toxic gas generated when the surface is decomposed by heat.

[Engineering plastic]

Engineering plastic is an industrial plastic material with excellent strength, impact resistance, heat resistance, hardness and aging resistance.

Generally, those with tensile strength of 500 kg / cm 2 or more are called engineering plastic.