1. INTRODUCTION

There are many different methods of joining plastics, with the selected process being dependant upon such variables as type of plastic, assembly requirements, and application area. These processes include welding, adhesive bonding, and mechanical fastening. Transmission laser welding involves localized heating at the interface of two pieces of plastic to be joined to produce strong, hermetically sealed welds with minimal thermal and mechanical stress, no particulates and very little flash, making it ideal for medical device applications. Cycle times can be as short as a second, and relatively light clamping pressure is required— just enough to keep the parts stationary and ensure there is no gap. Transmission laser welding can be used for rigid or flexible materials and small or large parts. Advantages are:

- Increased material choices;
- Low heat input;
- High process repeatability;
- Clean, optically clear & colourless joints;
- No visible marking or weld flash;
- No particulates;
- No adhesive cure time;
- High weld speeds;
- Low residual stress.

2. LASER-MATERIALS INTERACTION

Of all the methods for laser welding of plastics, the most flexible is spot, or contour, welding, in which the laser is focused onto a single point that is then traced along the length of the weld. This spot can be anywhere from 0.6 to 5 mm across, although 1 to 2 mm sizes are most common. It can be moved along the weld line either by fixing the workpiece to an X-Y table, by attaching the laser to a robotic arm, or a combination of the two. Using a six-axis robot to create the weld opens up the possibility of a wide range of weld contours, in contrast to fixed geometry ultrasonic- and vibration welding, in which the welded surface needs to be in or close to a single plane. It also makes for a flexible assembly system—once the weld parameters have been entered into the robotic controller, changing from one configuration to another can be done with the push of a button. In terms of the type of lasers being employed, the current trend is toward diode or fibre lasers transmitting light in the 810- to 980-nanometer wavelength range. The main advantage of these lasers is that they are compact and relatively inexpensive.

3. SEQUENCE OF THE TRANSMISSION LASER WELDING PROCESS

Figure 1 shows a schematic of the principle of laser welding. The laser light is absorbed at the surface of the lower material, which causes heat to build up at the surface of the upper layer. Intimate contact between the upper and lower absorbing surfaces is important to ensure heat transfer and bonding. On removal of heat, the material resolidifies to produce an adherent plastic weld.

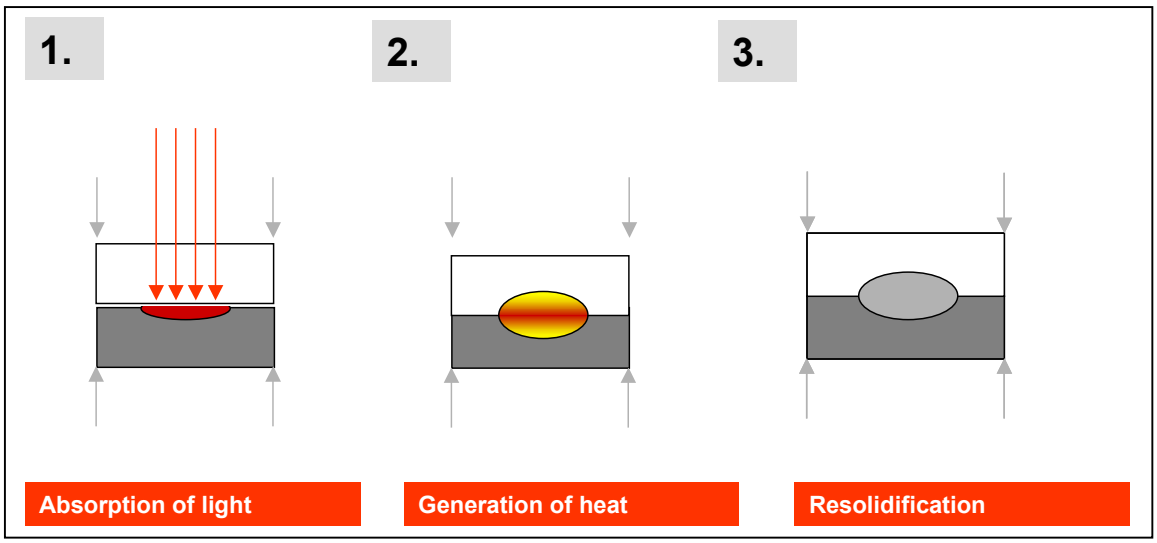

Figure 1: Sequence for transmission laser welding.

4. MATERIAL SUITABILITY

Only certain materials and combinations of materials are suitable for transmission laser welding. One of the plastics needs to be optically transparent to the laser with the other being absorbing. There are various methods of making the lower plastic absorb the laser energy. Figure 2 shows a weld of transparent to carbon impregnated material, while examples of clear to clear and clear to opaque material welds are shown in Figure 3 below.

Figure 2: Transmission laser weld of clear to carbon loaded opaque material
(Reproduced by permission TWI Ltd)

Figure 3: Clearweld® transparent to transparent polymer weld
(Reproduced by permission TWI Ltd)

Historically, the bottom layer has been opaque, incorporating small amounts of carbon black. However, in recent years, the BASF Group have commercialised a range of NIR-absorbent products, and Gentex Corp. has also created transparent NIR-absorbent pigments for transmission laser welding. Pigments have also been developed making it possible to laser weld entirely transparent through to totally opaque assemblies, as shown in Figure 4.

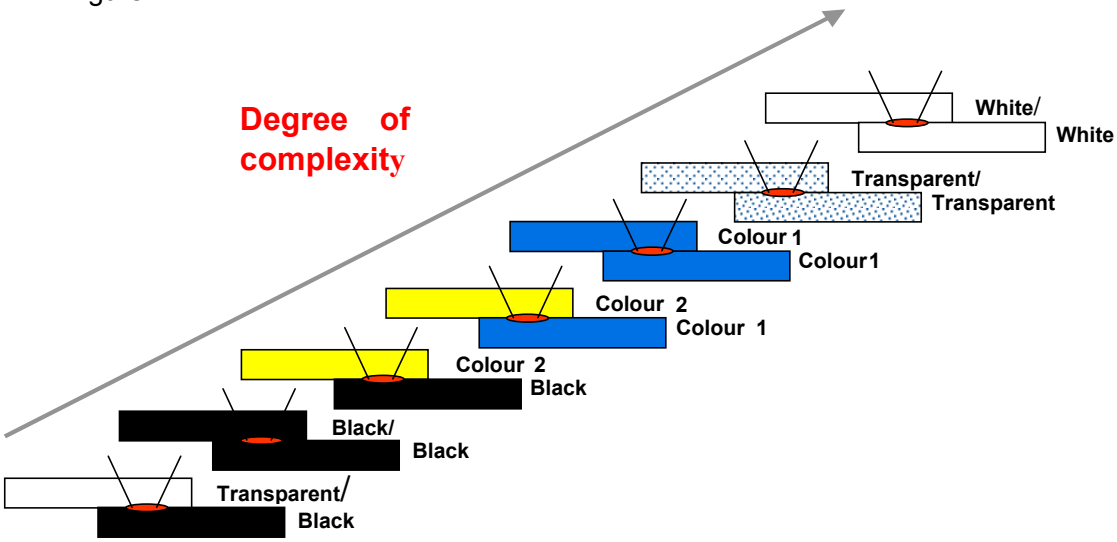

Figure 4: Polymer colour combinations for transmission laser welding as a function of degree of difficulty. Black base with transparent upper plastic is deemed to be the most desirable option. Laser joining increases in complexity with different polymer colour combinations. (Source BASF)

NIR-absorbent products are available for incorporation in the bulk material. Clearweld® additives are available in two forms: either as an additive that can be incorporated into the resin used to mould the actual part, or as a coating that is applied to the joint interface prior to welding. The latter type is available as a low-viscosity liquid that is applied via a needle tip or a solenoid dispenser. The coatings can also be sprayed for covering a wider area.

Needle tip dispensing is the most common method, because it is the least expensive. When incorporated into the parts themselves, the additives impart a slight coloration or tint to the plastic, but these can be easily compensated for with other additives to create the blue tint that is commonly found in medical products. When a coating is used, the additive is actually consumed in the course of the welding process, leaving a joint that is as clear as the plastic from which it is made.

5. JOINT DESIGNS

Many joint design permutations are possible as shown in Figure 5, and are determined by application needs.

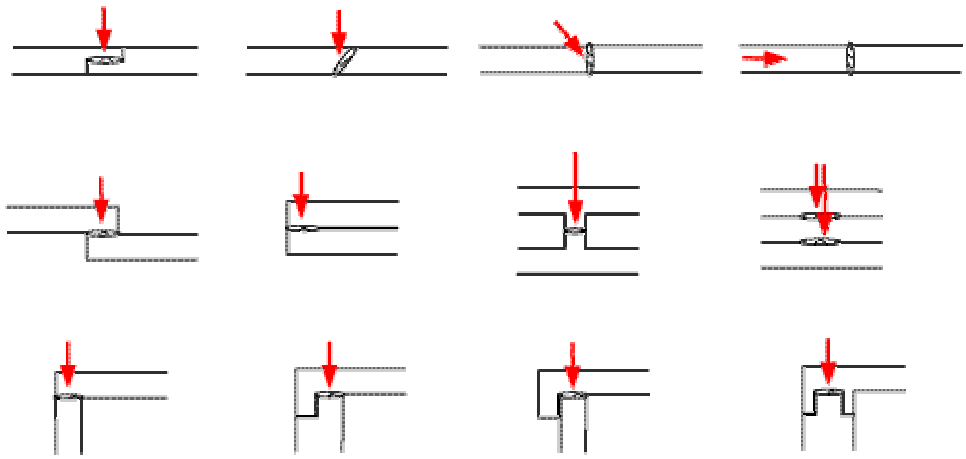

Figure 5: Possible transmission laser welded joint designs
(Reproduced by permission TWI Ltd)

6. TRANSMISSION LASER WELDING FOR MEDICAL DEVICES

The near-IR absorbents used for laser welding plastics have been shown to meet the requirements of USP Class VI testing. Application areas include medical devices such as filters, microfluidic devices, IV sets, medical packaging (blood bags). No significant effect of gamma sterilization on transmission laser welded joint strengths occurs.

7. ACKNOWLEDGEMENT

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NDNP TECHNOLOGY DIFFUSION ACTIVITY # 27	Welding Technology Institute of Australia ABN 69 003 696 526 **NATIONAL DIFFUSION NETWORKS PROJECT** **TECHNOLOGY QUESTIONNAIRE** **Medical Devices and Sensors Group** **"Transmission Laser Welding of Plastics"**	**Document No:** 9.4.7QR-0003 **Revision No:** Rev 0 **Page 1 of 2** **Date:** 24 April 2006

As part of the WTIA National Diffusion Networks Project, the Medical Devices and Sensors Industry Sector has identified the need for reliable and cost effective welding methods for the plastic components used in the manufacture of medical devices. The WTIA has prepared a Technical Guidance Note "Transmission Laser Welding of Plastics" to explain one potential joining method that is already being applied elsewhere. As a valued technology expert in this area we would like you to be part of the Technology Expert Group to review this note. Please complete this questionnaire so that we can gauge the success of meeting this need.

Objective 1: Identify potential applications for transmission laser welding of plastics

This guidance note is intended to provide the Medical Devices and Sensors Industry with key knowledge on the potential applications of transmission laser welding in the medical industry. How well does the document explain laser welding and its potential applications?

poor ☐ average ☐ good ☐ very good ☐

Comments: _____

Objective 2: Identify appropriate technology receptors in the Medical Devices and Sensors Industry

This document was written for Design and Production Engineers in the Medical Devices and Sensors Industry. Are these people the appropriate individuals we should be targeting?

yes ☐ no ☐

What other types of companies and/or personnel do you suggest we target? _____

_____

Objective 3: Identify current best practice for tack welding of reinforcement bar

The document was written to reflect current best practice for laser welding. Do you envisage opportunities for the use of this technology in the industry?

yes ☐ no ☐

If yes, what and where, if no why not? _____

_____

Objective 4: Is the information provided clear, concise and accurate?

yes ☐ no ☐

If not, why? _____

Objective 5: Broad dissemination of technology to the Medical Devices and Sensors Industry

Please indicate how best to disseminate this Technical Guidance Note to the appropriate Medical Devices and Sensors Industry Recipients

Free Website Download ☐ Poster ☐ Pocket Guide ☐ Pamphlet ☐

If poster, what size? A1 ☐ A2 ☐ A3 ☐ Laminated ☐ What selling price? $

If a pocket guide, what selling price? $

Other format? _____

Objective 6: Continuous Improvement

Please Identify areas where the document can be improved or return the document with your recommended additions/amendments. Alternatively, please use the area below to provide any additional comments.

*Respondents Name:*_____ *Company:* _____ *Phone:* _____

Fax: _____ *Email:* _____ *Date:* _____

Please Fax (02 9748 2858) or E-mail (j.baker@wtia.com.au) your response. Your prompt response is appreciated.

The WTIA has joined forces with industry and government to create a 3.5 million dollar Technology Support Centres Network. This network will assist industry to identify and exploit world's best technology and manufacturing methods to establish a vibrant Australian industry beyond 2006. Together we will be implementing a step by step process which will lead to ongoing viability and greater profitability for all concerned:

(1) Determine your technological and manufacturing needs;
(2) Identify world's best practice;
(3) Draw upon the network to implement world's best practice at your site