Blue-IR Hybrid Laser “BRACE”

1. INTRODUCTION

The development of Electrified vehicle (xEV), which are effective against climate change as no NOx (nitrogen oxide), PM (particulate matter) or CO_2 are emitted while driving, has been promoted around the world in recent years aimed toward the realization of a sustainable society. Most recently, a momentum to regulate gasoline engine vehicles by the 2030s has risen rapidly under the policies of various governments. In such circumstances, the manufacturing volumes of key components such as batteries, motors and inverters essential to xEV are expected to grow exponentially.

Various welding methods including resistance, ultrasonic and arc weldings are used to join copper parts as a conductor at plants manufacturing main components of xEV (Figure 1). The introduction of a laser welding using a fiber laser and a semiconductor laser with a stable output through their continuous waves as the processing heat source is started to be considered with the aim of further efficiency improvement, including the reduction of CO_2 emitted from plants and the process automation. In such a situation, there is a growing need to replace the conventional laser light source using a fiber laser of near-infrared light (hereinafter IR) (1070 nm wavelength band), which is difficult to process with a high quality because of its extremely high optical reflectivity against copper, with a blue laser (450 nm wavelength band), which has a good optical absorption with copper and a high-power output. We have commercialized a Blue-IR hybrid laser oscillator “BRACE”, which is the integration of a blue laser oscillator with a short wavelength and an IR fiber laser, and have started accepting orders in January 2021 (Figure 2). The high-power and high-reliability blue laser oscillator that can also be used as an industrial laser processing is equipped with a blue laser diode module jointly developed with Nichia Corporation, which has the world’s top share in blue semiconductor lasers.

2. FEATURES OF THE “BRACE”

We named the Blue-IR hybrid laser product group “BRACE” with the aim of becoming the world’s number one in the laser processing of copper using blue lasers. Each alphabet means: B: “Blue”, R: “InfraRed”, ACE: “leader, best”. In addition, BRACE that connects each of them has the meaning of “pair, one set, giving vitality”. Therefore, we have the meaning in the name that by using the “BRACE” in the manufacturing process, it will connect our company, our customers and the world, and give vitality to the world.

The Blue-IR hybrid laser is achieved with an IR fiber laser (wavelength 1070 nm band) that can perform a deep and high-speed processing for copper, and a blue laser (wavelength 450 nm band) that gives a preheating effect to copper. The light absorption rates of copper at room temperature are 4% and 65% for wavelengths of 1070 nm and 450 nm, respectively. Laser processing of copper using an IR fiber laser is difficult due to its low

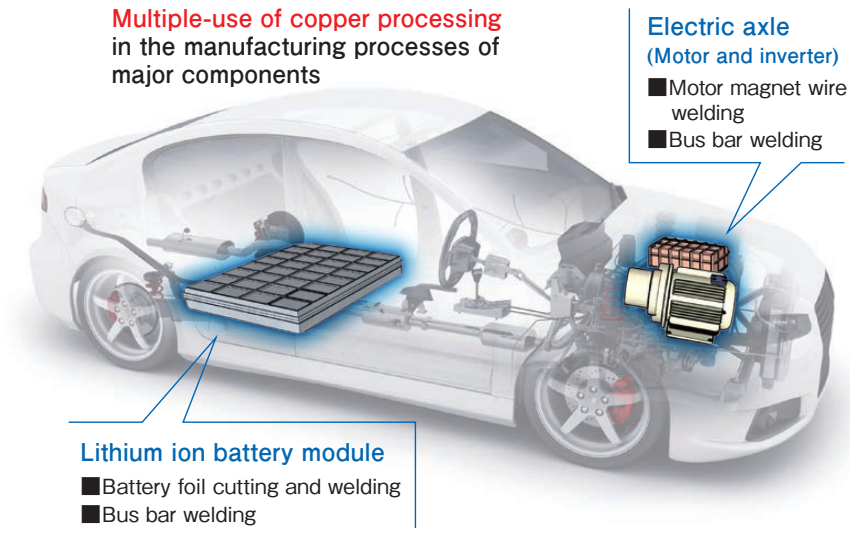

Figure 1 Main components of an xEV and the examples of copper processing.

Figure 2 Picture and logo of the “BRACE”, Blue-IR hybrid laser (The device is the BRACE-I of the specifications of IR: 1 kW, Blue: 150 W).

light absorption rate, and even if keyholes are formed and copper melts, the molten pool is unstable. As a result, a large amount of spatter is scattered and welding defects are formed (Figure 3). In particular, when vertical light enters, an IR fiber laser oscillator may be damaged by the return light due to its high light reflectance.

On the other hand, a blue laser has a high light absorption rate of 65% at room temperature for copper. However, a blue laser is a laser achieved by spatially coupling multiple blue semiconductor laser beams with an optical system. Compared to fiber lasers, the brightness is lower by an order of magnitude or more, and the numerical aperture (NA) of the laser beam is large. When a single visible light laser including a blue laser is high-powered and irradiated to copper, it provides a welding form called a heat conduction type because of the low brightness of the light. In this case, since a melting phenomenon occurs due to the heat conduction to copper, the depth becomes shallow and the speed cannot be increased, so that the work is easily affected by the heat, and it generates a demerit that welding of copper materials with a thickness of 1 mm order cannot be performed well (Figure 4).

The Blue-IR hybrid laser “BRACE” was developed to make up for this disadvantage. The blue laser is used as a preheat source for copper. The light absorption rate of copper in the 1070 nm wavelength band tends to increase as the temperature rises. By performing this preheating with a blue laser, a thermal conductivity type cavity is created on the copper surface. And the IR fiber laser achieves keyhole-type high-aspect melting. The heat conduction type cavity by the blue laser is a technology that stabilizes the copper molten pool even for the keyhole formation and is also effective in reducing the welding defects such as spatters and blowholes (Figure 4). As shown in Figure 3, increasing the light output of the blue laser can significantly improve the molten state and obtain extremely good molten bead marks.

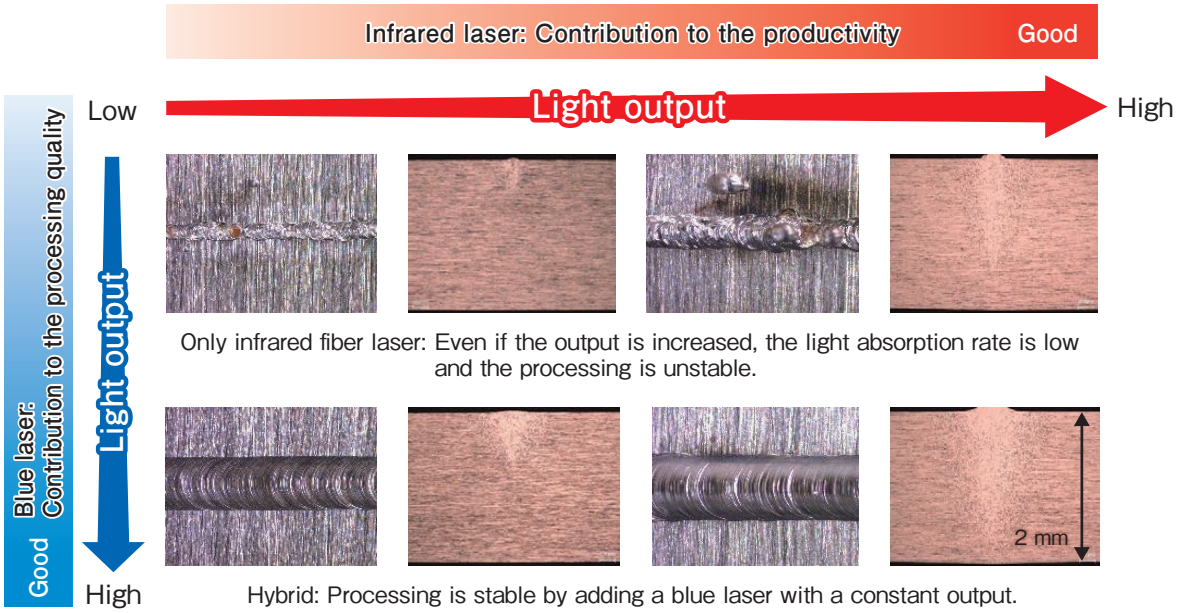

Figure 3 Changes in the surface and the cross section of copper plates (thickness 2 mm) when the light outputs of an IR fiber laser and a Blue laser are increased, respectively.

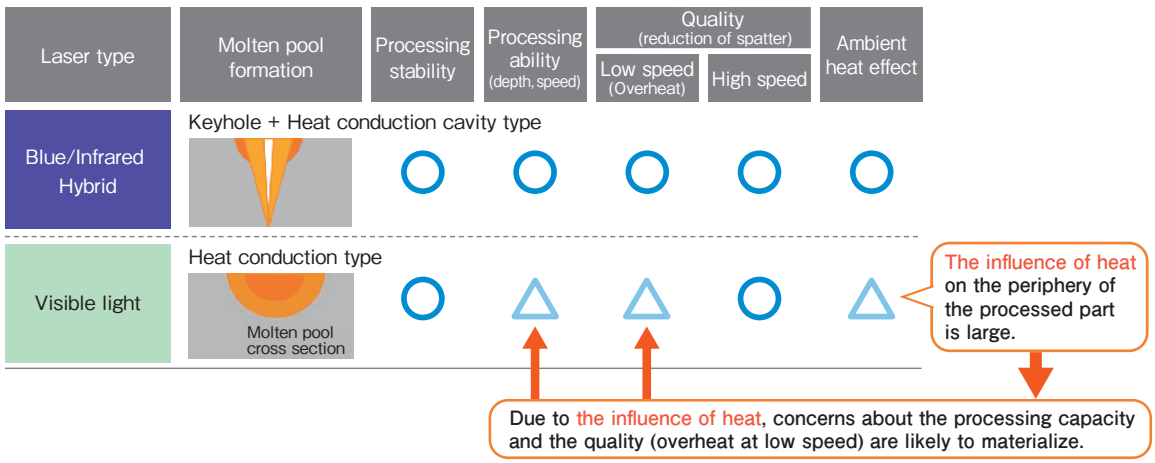

Figure 4 Comparison between a Blue-IR hybrid laser and a visible light laser of single color.

3. PRODUCT SPECIFICATIONS

Table 1 shows the product specifications of the BRACE-I.

The BRACE-I is equipped with a blue laser oscillator with an optical output of 150 W and an IR fiber laser oscillator with an optical output of 1 kW operating in a single mode. This laser is optimal for the laser processing of copper approximately up to 1 mm thickness. Due to the good quality of the beam of the blue laser, laser processing using a hybrid type galvanometer scanner is also possible.

Table 1 Specifications of the BRACE-I (FBHY150/1000S-5 model).

Model	FBHY150/1000S-5	
	Blue laser	Fiber laser (IR)
Rated output (W)	150	1000
Beam mode	Multimode	Single mode
Construction	Oscillator / power supply integrated type	
Wavelength (nm)	465	1070
Output adjustable range (%)	10 to 100 each	
Modulation frequency (kHz)	Up to 5	
Cooling method / Oscillator, power supply, cable	Water cooling	
Cooling water temperature (℃)	25	
Optical output cable end connector	QBH	
Standard cable length (m)	5	5
Fiber core diameter (μm)	110	14
Beam quality M^2 (typical value)	—	＜1.1
Beam quality BPP (typical value) (mm·mrad)	12	—
Power supply (V)	Three-phase AC 200-240	
Frequency (Hz)	50/60 ± 5 %	
Body size (mm)	W 700 × D 1000 × H 800	
Body weight (kg)	About 300	

4. FUTURE ROADMAP

Figure 5 shows the commercialization roadmap for the “BRACE”, a Blue-IR hybrid laser. We plan to commercialize the new BRACE-II and the BRACE-X in January 2022.

With the BRACE-X, the processing of copper materials approximately up to 3 mm in thickness can be performed with the development of a blue laser oscillator with an optical output of 1 kW and the installation of a multimode IR fiber laser with an optical output of 3 kW. As a result, for example, in motor magnet wire welding, it will be possible to achieve a welding time in the 0.1 sec/point range, which is equal to or less than one-third of the conventional method. In battery foil welding and bus bar welding, the BRACE-II application achieves twice the processing performance of the BRACE-I. From the above, we will contribute in improving our customers' production efficiency of key components for xEV.

5. CONCLUSION

We have introduced our new Blue-IR hybrid laser, the “BRACE”.

We have built application laboratories at our Chiba Works and Nichia’s Yokohama Research Center, and can perform demo welding using the BRACE-I and a hybrid galvanometer scanner. Please contact us for details.

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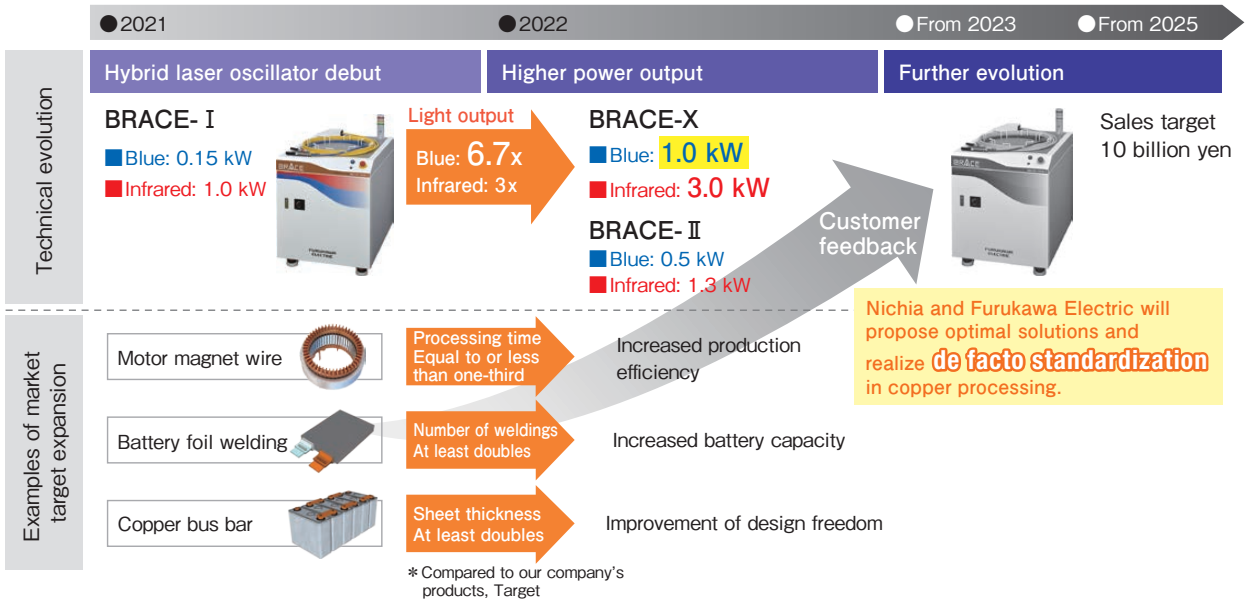

Figure 5 Roadmap for the commercialization of the BRACE, Blue-IR hybrid laser.