# Fiber Lasers with Air Cool 300 W, Water Cool 500 W Single-mode and 2 kW Multi-mode for Material Processing

## 1. INTRODUCTION

Fiber lasers have an ideal performance with respect to high beam quality, to long time stability, to high reliability and to high efficiency and also make the direct fiber delivery to processing targets available. With such excellent features, the market size of fiber lasers is expanding year after year. The popularity of, especially, the fiber lasers with high output of more than 1 kW has been increasing rapidly in the field of metallic material processing where existing carbon dioxide lasers or solid-state lasers were mainly used.

We, as a pioneer amongst domestic companies, have worked early in research, in development and in mass-production manufacturing in the technologies of special fibers, optical components, pumping semiconductor lasers, fiber splicing, and also fiber amplifiers and fiber lasers using such technologies.

## 2. SINGLE-MODE FIBER LASER

The single-mode fiber laser which achieves diffraction-limited focusing property is commercialized in two types: air-cool-type with 300 W output and water-cool-type with 500 W output.

The key specifications of these single-mode fiber laser are illustrated in Table 1.

Table 1 Key specifications of single-mode fiber laser.

| Items | Specifications | Notes |
|---|---|---|
| Center wavelength | 1084 ± 5 nm | |
| Beam quality ($M^2$) | < 1.1 | |
| Modulation rate | up to 50 kHz | |
| Guide light | 660 nm | Red |

Figure 1 shows external view of the air-cool-type single-mode fiber laser with 300 W output. It has an output fiber with approx. 12 μm of mode field diameter and more than 20 m of delivery is available.


Figure 1 Air-cool-type fiber laser with 300 W output. (Upper: power supply, Lower: optical section)


Figure 2 Water-cool-type fiber laser with 500 W output.

Figure 2 shows the water-cool-type fiber laser with a 500 W output. It achieves a high processing performance for high reflecting materials such as copper, aluminum or ceramics because the beam intensity of focusing becomes over 1 x $10^8$ W/$cm^2$. Figure 3 shows the cross-section of the processing mark at the evaluation for penetration into tough pitch copper C1100 and Figure 4 shows the cutting surface of full-cut alumina.

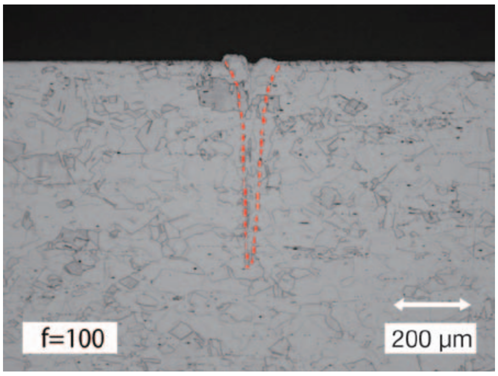


**Figure 3 Penetration into tough pitch copper. (Focusing length f = 100 mm)**

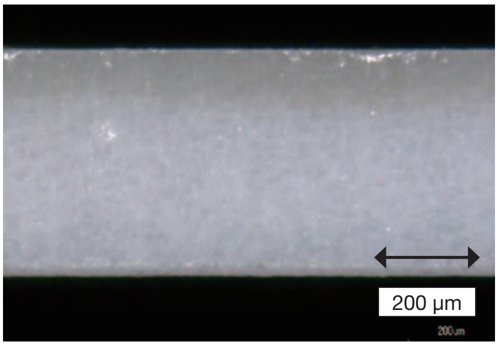


**Figure 4 Example for the cut processing on alumina. (t = 500 μm)**

## 3. kW MULTIPLEXING BY LASER COMBINER

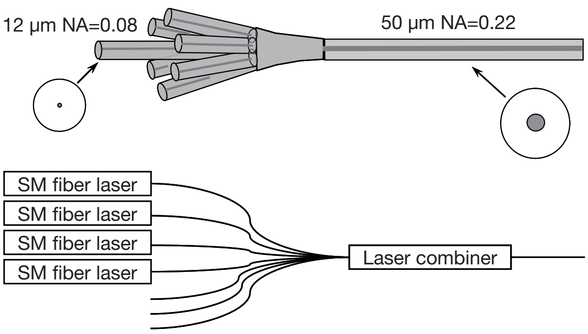


**Figure 5 Configuration of a laser combiner and a kW fiber laser.**

Similar to TFB (Taper Fiber Bundle) used to lead pumping light of the fiber laser oscillator into cladding, a laser combiner is a beam combiner which is achieved by applying fused taper technique for optical fibers. As shown in Figure 5, high efficiency of more than 95% is achieved when combining seven single-mode inputs with 12 $\mu$m core diameter and NA=0.08 into one multi-mode fiber with 50 $\mu$m core diameter and NA=0.22.

For the commercialized 2 kW fiber laser, 4 pcs of single-mode fiber lasers with output of 500 W class each are connected to this laser combiner and 2 kW output with 50 $\mu$m core diameter is obtained. Also, delivery fiber length to more than 20 m is attained.

Table 2 illustrates the key specifications of a kW fiber laser and Figure 6 shows the external view of the fiber laser with 2 kW output.

**Table 2 Key specifications of kW fiber laser.**

| Items | Specifications | Notes |
|---|---|---|
| BPP | < 2.2 mm・mrad | |
| Modulation rate | up to 50 kHz | |
| Guide light | 660 nm | Red |
| Size | 1000(W) x 520(D) x 850(H) mm | Optical section |

**Figure 6 Fiber laser with 2 kW output.**

Figure 7 shows that the relationship between the driving current and the laser output characteristics of pumping a semiconductor laser, and a conversion efficiency of the optical output towards the power supplied to the diode at 2 kW output was as good as 27.3%.

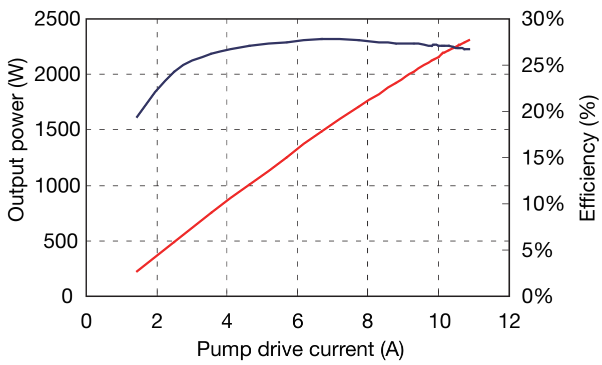


**Figure 7 Output characteristics of 2 kW fiber laser.**

As shown in Figure 8, $M^2$ of this laser is 4.66 and the emission wavelength of the laser is 1084 nm, so that the BPP (Beam Parameter Products) is calculated as 1.609 mm · mrad.

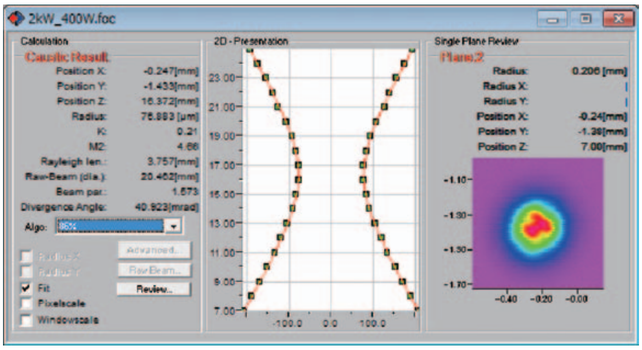


**Figure 8 Beam quality of 2 kW fiber laser.**

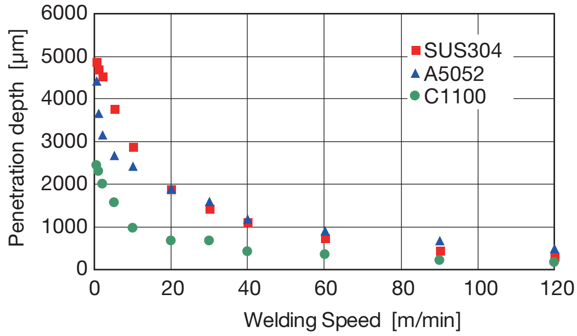


**Figure 9 Penetration characteristics into various metals. (Focusing length f = 200 mm)**

The kW output fiber laser has a multi-mode output and a power density of its focused beam which is lower than that of the single-mode fiber laser described earlier, however, since the output power becomes higher, on the other hand, the processing performance for the high reflecting materials is improved[1)]. Figure 9 shows the penetration characteristics into stainless (SUS304), aluminum (A5052) and tough pitch copper (C1100) irradiated by a condenser lens with a focusing length f = 200 mm

We have started to sell this kW fiber laser for metallic processing use such as sheet-metal cutting or welding processing.

## REFERENCES

1) Journal of JLPS Vol.19 No.1 p.7 (2012)

For more information, please contact:
Planning & Administration Department,
Telecommunications Company
Tel: +81-3-3286-3768 Fax: +81-3-3286-3708
E-mail: Fiberlaser_bsgr@furukawa.co.jp