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Ariel

High Power Industrial Laser Measurement

User Manual

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Safety Procedures and Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT
Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY
Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning		**The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.**
Caution		**The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.**
Note		**The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.**

Chapter 1: Overview

Features

- Measures up to 8000W
- No Water Cooling
- Self-Contained, built in Display, Battery, Bluetooth, USB
- Very Compact
- Dust proof, splash proof
- Supported by PC and Android applications

Figure 1: The Ariel isometric view

The Ariel measures high power industrial lasers of up to 8kW by measuring the energy of a short exposure to this power. The laser is set to deliver a pulse of from 0.05 to several seconds. The Ariel then measures the energy and duration of the laser pulse and calculates the power. The Ariel is designed to work without water cooling.

The Ariel is versatile and durable with a dust sealed enclosure and detachable antireflection coated protective window. It also comes with a detachable diffuser for measuring very high power density beams.

The Ariel is compact, wireless, and self-contained with its own display and battery, making it ideal for usage in tight spaces such as an additive manufacturing chambers as well as for production process quality control and R&D.

Chapter 2: Specifications

Version: 3 (12/26/2020)

<table>
<tr><td>**Note**</td><td>☝</td><td>**See our website www.ophiropt.com for latest specifications.**</td></tr>
</table>

Model	Ariel
Use	High power laser measurement by short exposure
Absorber Type	LP2, absorption >95%
Power Range	200mW – 8,000W
Exposure Time (see table below)	Pulsed Mode: 0.05 – 2s. [a] CW mode: 10s to continuous depending on power level
Wavelength	Window: 440-550nm, 900 – 1100nm [b] Diffuser:440-550nm, 940-1100nm [b] Without window or diffuser: 2.94µm [c], 10.6µm [c]
Aperture	Ø32mm. Maximum beam diameter for Gaussian beam 21mm. With diffuser Maximum beam diameter for Gaussian beam 10mm.
Calibration Uncertainty	±1.9%
Power Accuracy	±3% (900-1100nm, 2.94µm, 10.6µm), ±3.5% (440-550nm) [a] [b]
Minimum Power for Pulse Width Measurement	440 – 800nm, >20W; 800 – 1100nm, >10W; >1100nm, not available [c]
Maximum Beam Incidence Angle	Without diffuser: ±30 degrees for <12mm Gaussian beam, With diffuser: ±25 degrees for <10mm Gaussian beam [d]
Reproducibility	±1%
Power Range vs. Irradiation Time	200mW – 30W: CW, 500W: up to 20s; 1,000W – 8,000W: 0.05 – 1s.
Linearity	±1.5%
Time to Reading	3s after end of exposure
Waiting Time for Next Measurement	12s
Maximum Energy for Single Pulse	2.4kJ
Maximum Exposure Before Cooling Down is Necessary	Maximum operating temperature of 60ºC will be reached after exposure to 14kJ (e.g. 10 shots at 2,000W, 0.7s). Cooling down time before another 14kJ series of shots is ~10 minutes [e].
Over Temperature Warning	Flashing display
Cooling	Convection [e]
Battery	Rechargeable, 1100mAh, lifetime >15 hours
Interface	128x64 pixel LCD Display, Bluetooth 5.1 (compatible with Bluetooth 4 and above), USB-C
Dimensions (L x W x H)	70 x 70 x 79 mm (see drawing)
Weight	0.8kg
Operating Temperature	10-60ºC
Ingress Protection	IP62

Compatible Client Applications	StarLab (PC, USB), StarViewer (Android, Bluetooth)			
Recommended Exposure Times and 1/e² Gaussian Beam Diameters	Laser Power W	Recommended Exposure s	Min 1/e² beam dia. mm	Min 1/e² beam dia. with diffuser (max dia. is 10mm) mm
Continuous Power Measurement	30	Continuous (e)	1	0.3
	500	20 (e)	4	2
Power Measurement from Short Exposure	500	2	4	2
	1000	1	5	1
	2000	0.7	10	1.5
	4000	0.5	16	3.5
	8000	0.3	22	N.A.
Compliance	CE, UKCA, China RoHS			
Version				
Part number	7Z02798			

Notes: (a) The power is calculated by measuring the pulse energy and exposure time. A rectangular pulse is assumed for this calculation.

(b) May be used at 550-900nm with decreased accuracy and higher reflection (up to 10%).

(c) Use without window or diffuser. The sensor does not measure pulse width above 1100nm. For pulsed power measurement at >1100nm, a short pulse with known duration should be applied. A pulse energy measurement is performed and divided by the known pulse width to obtain the power. When working without window and without diffuser, the sensor is not sealed against dust or water.

(d) With diffuser, reading will be up to 10% lower than vertical beam and beam should be offset from center in opposite direction to beam incidence by ~10mm.

(e) Faster cooling can be achieved by attaching the Ariel to a heat sink using the mounting threads at the bottom.
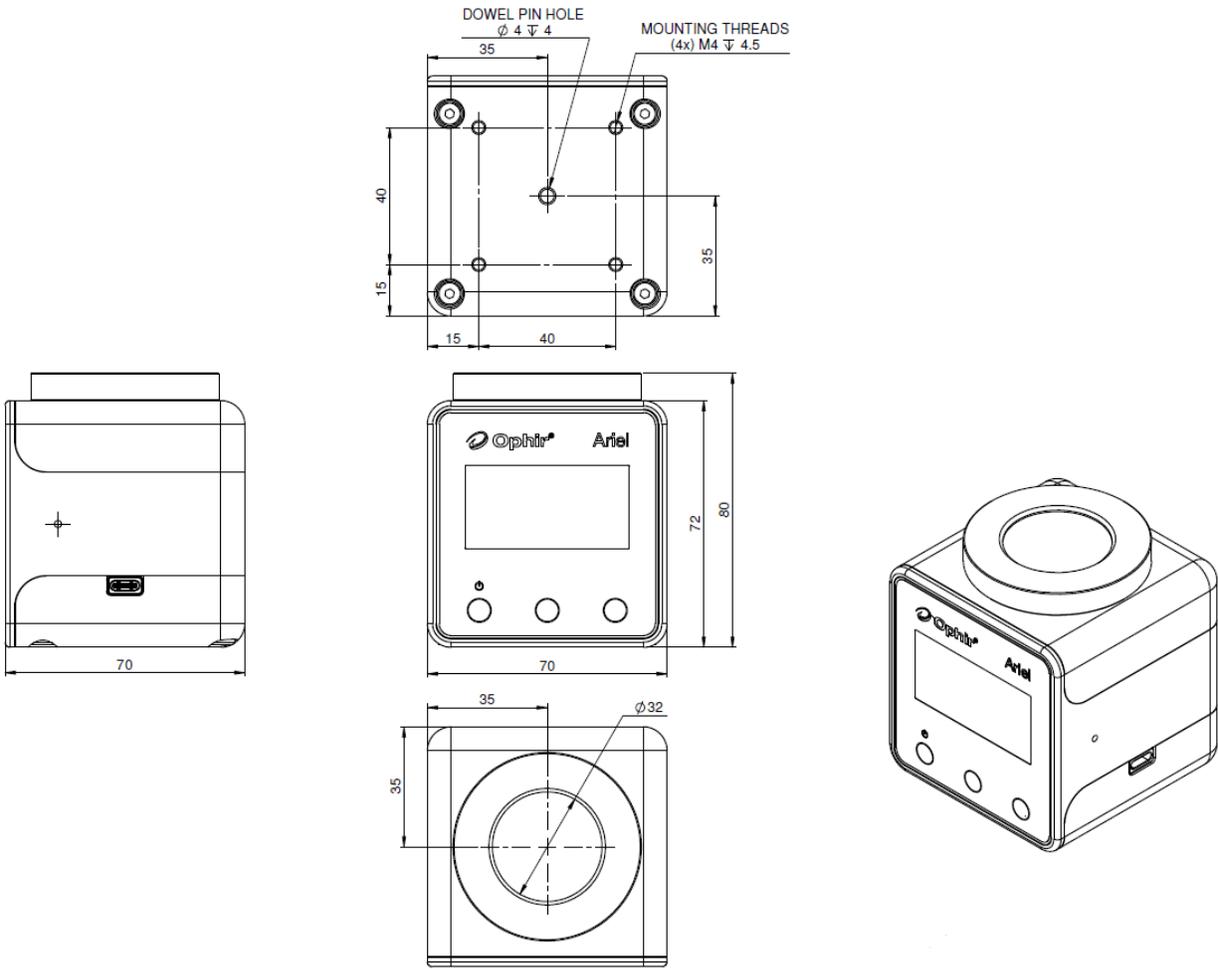
Table 1: The Ariel specifications

Figure 2: The Ariel drawing

Chapter 3: Accessories and Features

The Ariel has several accessories and features:

- Window – used for regular measurements.
- Diffuser – used for higher power-density beams, refer to specifications for details.
- Protective Cover with target – used to protect the diffuser and window from scratches, and for laser aiming. Should be used with pointers only, and removed before switching on the laser.
- USB-C cable – used for charging and as a data cable for StarLab.
- Wall charger
- Case – has a separate sleeve for the window/diffuser while not in use
- USB rubber plug – used in order to protect the USB socket from dust. The device itself is protected even if the rubber plug is detached. The rubber plug may be removed permanently using a simple screwdriver without any harm to the dust and splash proof protection.
- Heatsink screw holes – there are screws on the bottom side of the Ariel that allow mounting on a heatsink.

Figure 3: Protective cover

Figure 4: Ariel parts

Chapter 4: Wavelength options

The Ariel supports four different operation modes:

	Wavelength	Aperture	Accessory	Illustration
Window	500 – 1100nm	Ø32mm	Window must be mounted	Figure 5: Window
Diffuser	500 – 1100nm, high power density	Ø10mm	Diffuser must be mounted	Figure 6: Diffuser
2.94µm	2.94µm	Ø32mm	The top cover should be left open.	
10.6µm	10.6µm	Ø32mm	The top cover should be left open.	Figure 7: Empty top

Table 2: Wavelengths options

Make sure to screw the window/diffuser tightly, in order to preserve the sealing.

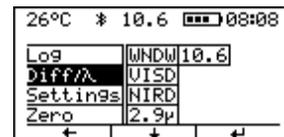- Click menu (☰)

- Select "Diff/λ"

- Select the proper setting

Figure 8: Diff/λ screen

Note	👆	**At 2.94µm and 10.6µm, the photodiode will not be able to measure the pulse width, and the device will not be protected against dust or water while there is no window or diffuser mounted properly.**

Chapter 5: Pulsed Power

5.1: Physical Principle

The core of the Ariel is a high power copper thermopile disk that can measure short exposures of high power lasers.

An internal, un-calibrated silicon photodiode detects the backscattered light to measure the exposure time.

Average power is then calculated by, $P = \frac{E}{\Delta t}$, where P is power, E is energy, and Δt is the time interval.

5.2: Limitations

The photodiode's sensitivity depends on wavelength, meaning that the minimum power that may be detected by it also depends on the wavelength. The photodiode is not sensitive beyond 1100nm. Please check the specifications for details.

2.94µm and 10.6µm lasers are not supported by the photodiode.

5.3: Display

The calculated power will be displayed in large digits. The energy will be displayed in small digits on the left side, and the pulse width will be displayed in small digits on the right side of the screen.
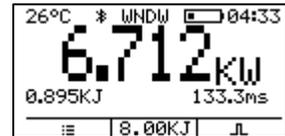

Figure 9: Pulse screen

On the pulsed power screen, a blinking 'RDY' message (meaning "READY") will appear on the top right corner to indicate that the Ariel is ready to measure a pulse.

5.4: Errors

Situation	Device displays	Log note
No trigger detected	0	No trigger!
Pulse is too long	OVER	Pulse too long!
Pulse is too short	UNDER	Pulse too short!

Table 3: Pulsewidth errors

In a situation where the pulse width is not detected but the energy is measured, the device will display the energy but not the calculated peak power. The peak power can be calculated manually if the pulse width is known, using the equation above.

Chapter 6: Using the Ariel

6.1: Power on
In order to power on the Ariel just click the left button (which has a small on/off icon), or attach a powered USB-C cable. The Ophir logo will appear, followed by the date and time, and then the measurement screen.

Figure 10: The Ariel front view

6.2: Power off
In order to power the Ariel off, hold the left button for a few seconds, until a 'powering off' display appears.

6.3: Charging
Connect the USB-C cable to the supplied wall charger or to a computer. During charging, the battery icon will be animated: the constant bars represent the current battery level. When the battery is fully charged, the battery icon will have four constant bars.

Caution	It is recommended to charge the Ariel by connecting the USB cable to a PC with a standard USB 2.0 or USB 3.x socket capable of providing at least 500mA. Alternatively, connect to the provided Ophir wall charger. Using a wall charger or any type of USB socket that cannot provide minimum 500mA will prevent the Ariel from charging properly, and may cause damage to the charger.

6.4: Display and navigation
The display has a status line on the top. This line shows the body temperature, a Bluetooth icon (if enabled; this icon will have dots from both sides if connected to a device), wavelength setting, battery level and time.

Figure 12: Status line

On the bottom line the dynamic functions for each button are displayed.
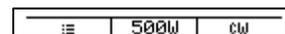
Figure 11: Measurement screen controls

6.5: CW or Pulsed Power
Use the right most button to toggle between CW measurement and Pulsed Power measurement. The current measurement mode name/icon will be displayed on top of the button.
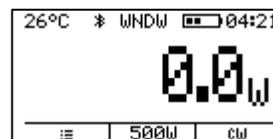
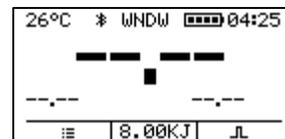Figure 14: CW measurement screen

Figure 13: Pulse measurement screen

6.6: Logging
The Ariel logs measurements automatically. In CW power mode it logs once each second, and in Pulsed Power mode it logs every pulse. The Ariel has space for 32768 entries. When the log reaches maximum, the oldest measurements will be overwritten. You can check the memory status in the information screen, and clear the entire log in the log menu.

Note	👆	**If the Ariel stays long enough on CW measurement screen, the entire log will be overwritten.**

6.7: <u>Ranges</u>

Use the middle button to toggle between ranges, in order to choose the most compatible measurement range. The current range will be displayed on top of the middle button.

6.8: <u>Temperature</u>

Please see the specifications for details about the temperature limitations. When either the disk or the sensor body exceeds its respective temperature limit, the screen will blink and display the text "TOO HOT!". In this case, immediately turn off the laser, and let the Ariel cool down. Take into account, that unless it cools down completely to room temperature, the number of additional measurements will be limited and depends on the sensor's body temperature.

Mounting the Ariel on a heatsink, using the bottom screw holes is strongly recommended in order to improve temperature performance (to extend duration before cool down is needed and to shorten cool down duration).

Warning	✋	**Overheating the Ariel or using power-density higher than stated in the specifications may cause damage to the Ariel, and can be dangerous.**

6.9: <u>Ingress protection</u>

The device is provided with ingress protection – sealing against dust and splashes. Refer to the specifications for details. The gaskets are intended for single use – any disassembly of the main screws may damage the sealing. The window or diffuser are replaceable, but should be tightened up in order to maintain sealing.

In order to avoid scratches, it is <u>not</u> recommended to wash the window and diffuser with water. The suggested cleaning method is using pressured air and a special lens-cleaning preparation/cloth.

6.10: <u>Menu</u>

Click the left button (☰) to open the menu. Use the middle button to toggle to the desired item, and the right button to select it. The left button will close the current menu and return up one level. While the menu is open, the measurements are stopped.

6.10.1: Log

Use this submenu to clear the log memory, or to list the logged measurements.

List Log

In this view the log entry numbers will be displayed on the top line, and the log entries will be listed showing the following details: time of the measurement, value, type (pulse/CW) and an exclamation mark (!) in case of an error.
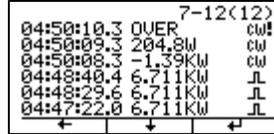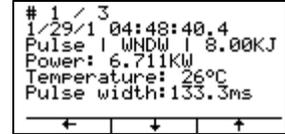

Figure 16: List logs

Figure 15: Log detailed view

Use the right button in order to show a detailed view of the first measurement. In the detailed view, you can scroll up and down the measurements.

6.10.2: Diff/λ

Select the correct wavelength setting. Refer to the chapter Wavelength options for details.

6.10.3: Settings

Backlight

Toggles the backlight on/off.

Contrast

Shows the contrast adjustment screen.

Time/Date

Shows the time/date adjustment screen.

Figure 17: Settings sub-menu

Bluetooth

This submenu allows several actions:

- Disconnect – available only if there is a device connected to the Ariel via Bluetooth.
- Disable/Enable – disables (or enables) the Bluetooth connection.
- Clear All – clears the Bluetooth cache. Use this option only if you encounter pairing difficulties.

Temperature units

Toggles the units used to display temperature on the screen between Fahrenheit and Centigrade

Information

Displays an information screen. In this screen will be listed data such as: date and time, name and S/N, F/W version, Bluetooth name, device body temperature, disk temperature, log size, last and next calibration dates.

6.10.4: Zero

Opens the zeroing screen. Use the zeroing option in order to make the measurement more accurate in CW mode. The zeroing process should be performed while the sensor is protected from light and when the sensor is cool. The protection cover can be left on for this purpose. Zeroing is recommended once a day or before each CW measurement session. It is not required for Pulsed Power measurements.
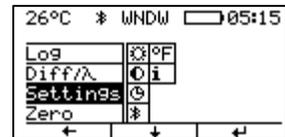
Chapter 7: Applications

7.1: StarLab

Ophir's StarLab software may be used to communicate with the Ariel using the USB-C cable connected to a PC. See more details in the StarLab User Manual.

7.2: StarViewer

The StarViewer app may be used on an Android device in order to communicate with the Ariel using Bluetooth wireless communication.

Note		See our website for more details of both of these applications

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