

# Application Note: PMK+ Coating Details for Power Measurement

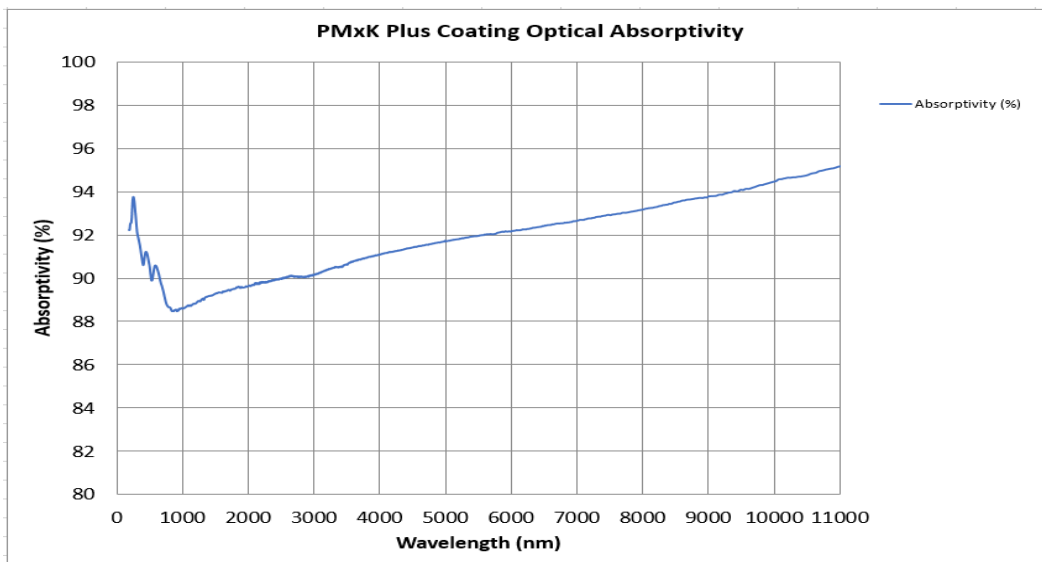
## Introduction

Coherent has designed a new ceramic absorber coating optimized for best heat transfer and high temperature handling on copper heatsinks.

This line of high power water-cooled kW thermopiles incorporates the BB+ broadband coating. The precision-applied coating provides a higher power density threshold than previous kW sensors. These sensors can sustain power densities up to 10 kW/cm<sup>2</sup> at 1kW and up to 2.3 kW/cm<sup>2</sup> at 6kW. There are several models available, with maximum power limits of 1kW, 3kW, and 6kW (identified in this document as PM1K, PM3K, PM6K or PMxK to reflect a range of power).

## PowerMax BB+ Coating Typical Absorptivity

The PowerMax BB+ coating has a flat spectral response. The following chart shows the typical response characteristics for the coating.



## Beam Size Dependency and Power Compensation

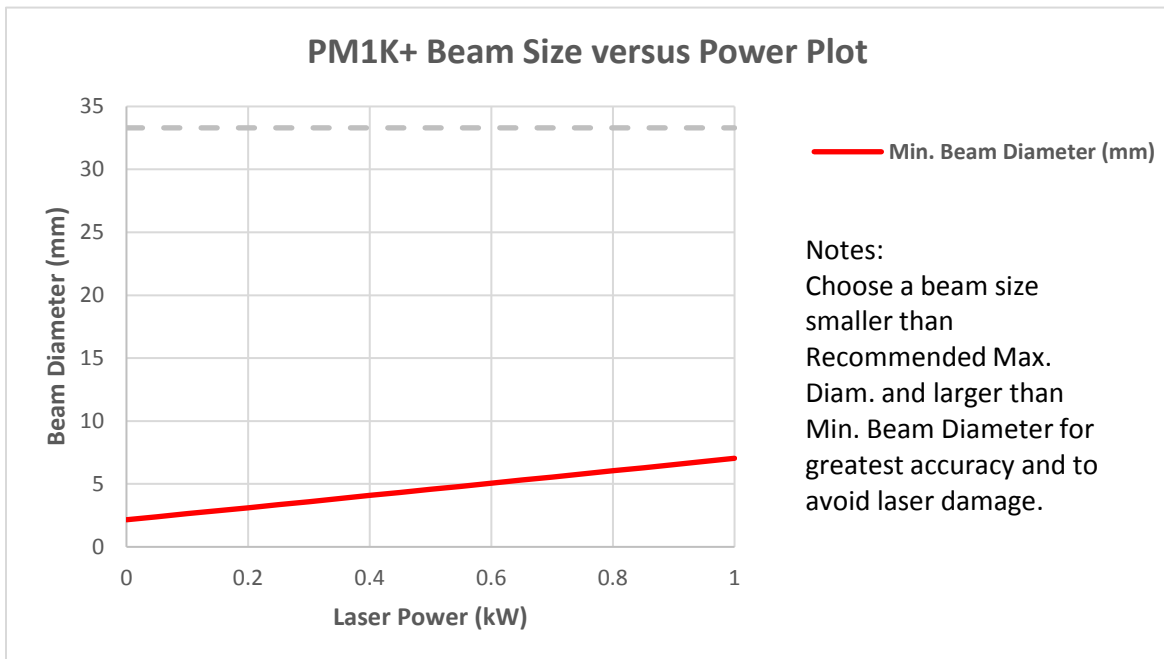
Testing found that there is some beam size sensitivity with legacy kW sensors. Additional power compensation is implemented in the PM3K+ and PM6K+ sensors to flatten the sensor response over the entire usable power range, provided the beam size is within the recommended range for each model.

To minimize these effects on your measurement, Coherent calibrates the sensor with an ideal beam size to minimize errors related to beam diameter.

The following graphs show recommended beam diameters for given power measurements. Following these guidelines can reduce any additional error related to beam diameters, while observing the minimum beam diameters to prevent laser damage.

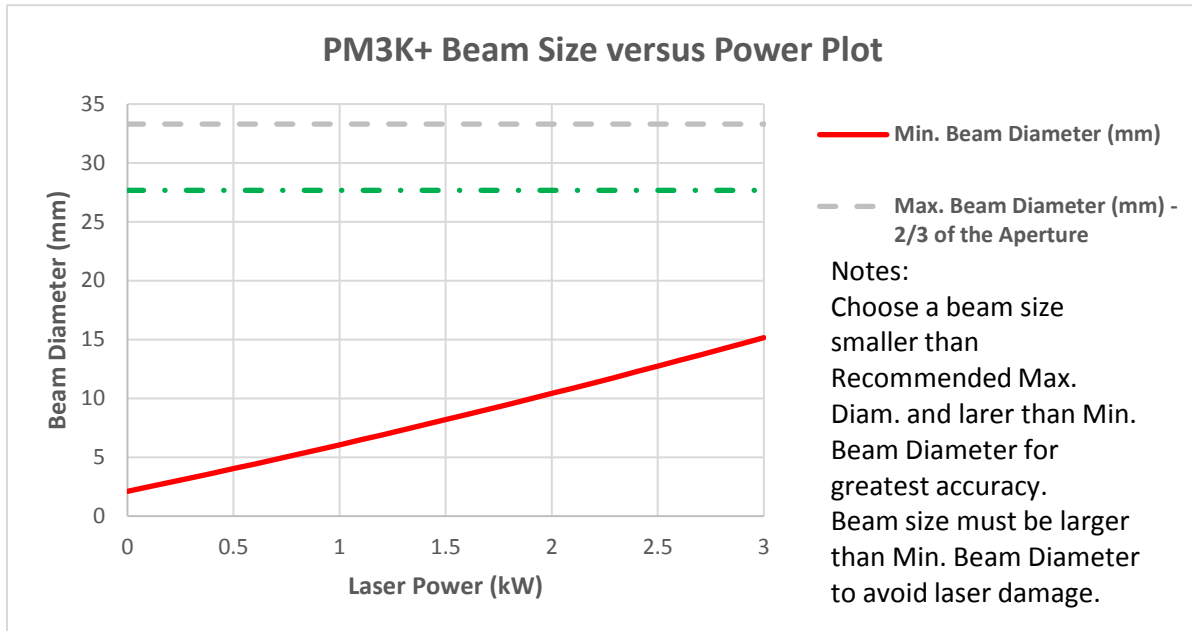
### PM1K+ Beam Diameter/Power Recommendations

The following chart shows the recommended power for PM1K+ sensors:



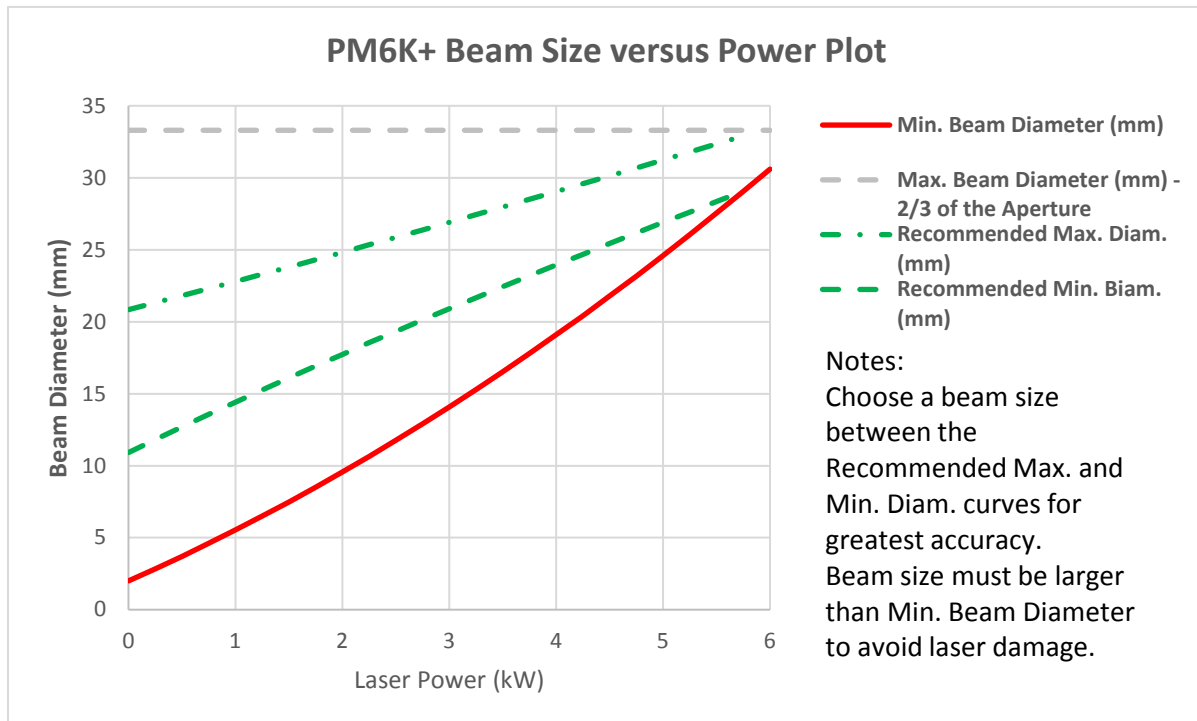
### PM3K+ Beam Diameter/Power Recommendations

The following chart shows the recommended power for PM3K+ sensors:



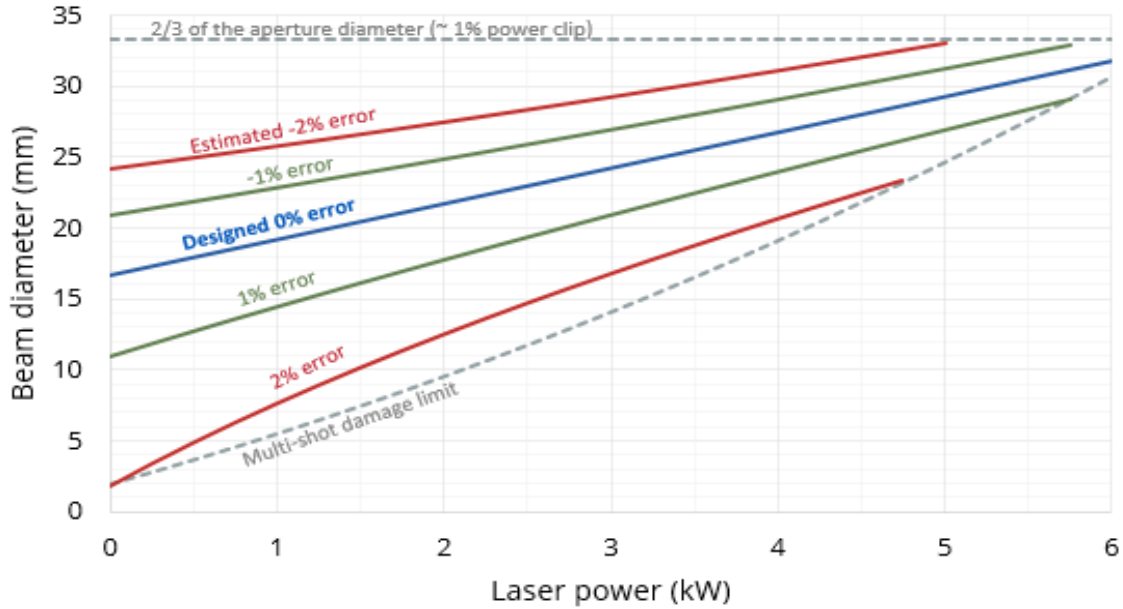
### PM6K+ Beam Diameter/Power Recommendations

The following chart shows the recommended power for PM6K+ sensors:



### Error Estimation for PM6K+

The following chart shows the estimated errors for the PM6K+ based on beam diameter selection.



### Damage Threshold

Thermopile damage threshold is typically specified in the industry as a single-shot damage threshold. That is, if the sensor can survive an individual pulse at a specific intensity, that is the damage threshold.

Testing found that, while single shot is good to understand, the normal use case is for a “multi-shot” damage threshold. This asks the question, “If I continue to use the sensor with these single shot conditions, what can I expect to see?” Testing found that the multi-shot threshold is about 2/3 of the single-shot conditions.

Adhering to multi-shot guidance (as shown in earlier graphs) can ensure that the sensor has a long life with minimal coating degradation. Coherent’s damage threshold specifications reflect expected, instantaneous, single-shot damage thresholds and minimum beam diameter guidelines. These guidelines reflect improved survivability over many laser measurements.

In some measurement conditions, you may see some slight discoloration. This perceived damage does not affect the sensors ability to accurately collect measurements. The discoloration can be caused by debris, soot, and organics on the sensors surface before any laser contact.

**CAUTION: Incorrect cleaning can damage the sensor and impact accuracy.** Do not attempt to clean the sensor until you have read detailed information and precautions for different methods in the *Application Note: Cleaning a PowerMax Thermopile Sensor*.

## Application Note: PMK+ Coating Details for Power Measurement

The following table shows the power density specifications along with beam diameter and power recommendations for PMxK sensors. All specifications are assuming a Gaussian beam profile:

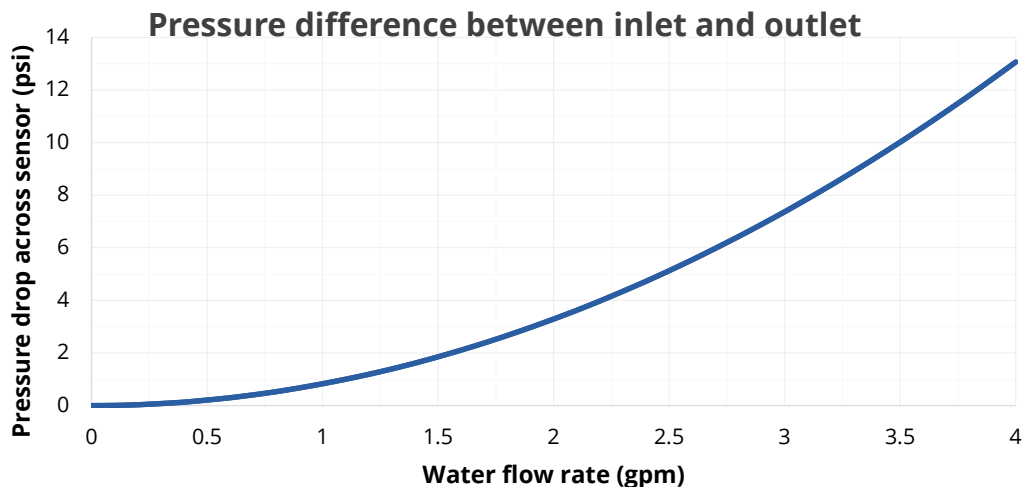
Specification			
Maximum Power Density	20 kW/cm <sup>2</sup> @ 500W	12 kW/cm <sup>2</sup> @ 1 kW	14 kW/cm <sup>2</sup> @ 1 kW
	10 kW/cm <sup>2</sup> @ 1 kW	5.8 kW/cm <sup>2</sup> @ 2 kW	4.7 kW/cm <sup>2</sup> @ 3 kW
		3.8 kW/cm <sup>2</sup> @ 3 kW	2.3 kW/cm <sup>2</sup> @ 6 kW
Recommended Minimum Beam Size	2.6 mm @ 100 W	6 mm @ 1 kW	8 mm @ 1 kW
	5 mm @ 500 W	10 mm @ 2 kW	17 mm @ 3 kW
	7 mm @ 1 kW	15 mm @ 3 kW	31 mm @ 6 kW

## Water Flow Rates and NEP

Water flow for thermopiles is important. In fact, one leading cause of thermopile failure or damage can be contributed to low or lack of water flow.

Coherent monitors and records maximum temperature that the thermopile experiences in operation. During instances of evaluation or repair, testing can see if the device experienced use cases that exceeded expected operation.

The nominal flow rates are shown in the following diagram:



Temperature of the cooling water should ideally be 20 to 25 degrees Centigrade (C). In many cases, the baseline shift is dominated by cooling water temperature stability. Coherent advises  $\pm 1$  degree C per minute or less of actual water temperature change. The variation of water flow should be less than 2% in flow rate per minute.

The PMk+ sensors have a pure electrical NEP of <100mW without water flow.

Coherent's suggested flow rates at various power levels are as follows:

- Minimum water flow rate: **PM1k BB+**
  - .75 GPM (2.8 LPM) at 1 kW
  - 2.0 GPM (7.6 LPM) at 2 kW
- Minimum water flow rate: **PM3k BB+**
  - 2.0 GPM (7.6 LPM) at 3 kW
- Minimum water flow rate: **PM6k BB+**
  - 2.5 GPM (9.5 LPM) at 5 kW
  - 3.0 GPM (11.4 LPM) at 6 kW

## Calibration of the PMK+ Sensors

The calibration for the PMK+ sensor uses Coherent's full spectral compensation to ensure the accuracy of the measurement on the sensor throughout its entire wavelengths operating range (which is from 0.19  $\mu\text{m}$  to 11  $\mu\text{m}$ ). Coherent also provides direct wavelength calibration and verification at 1070 nm and 10,600 nm.

## Contact Coherent

For assistance or additional information, contact Coherent. For example, if you cannot find the calibration cert for your sensor, we can send a replacement.

To arrange for **warranty service or annual recalibration**, first contact your regional Coherent service center to obtain a Return Material Authorization (RMA) number. Use the shipping box and packaging materials you retained to safely transport the sensor back to the factory, and ship to this address:

Coherent, Inc.  
Attn: RMA #  
27650 SW 95th Ave.  
Wilsonville, OR 97070

Contact Coherent Technical Support in the following ways:

- Contact your local Coherent Service Representative (or visit [www.Coherent.com](http://www.Coherent.com) to view a list of contacts worldwide)
- Send an e-mail to: [LSMservice@Coherent.com](mailto:LSMservice@Coherent.com)
- Call the Coherent Technical Support Hotline
  - Within the USA: 1-(800)-343-4912
  - Outside of the USA: 1-(408)-764-4042