

ILLUMINATION 101

A Practical Guide to
Custom Illumination
Solutions for Next-
Generation Imaging



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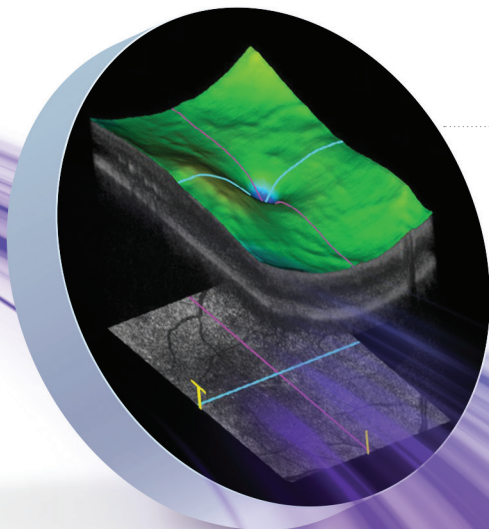
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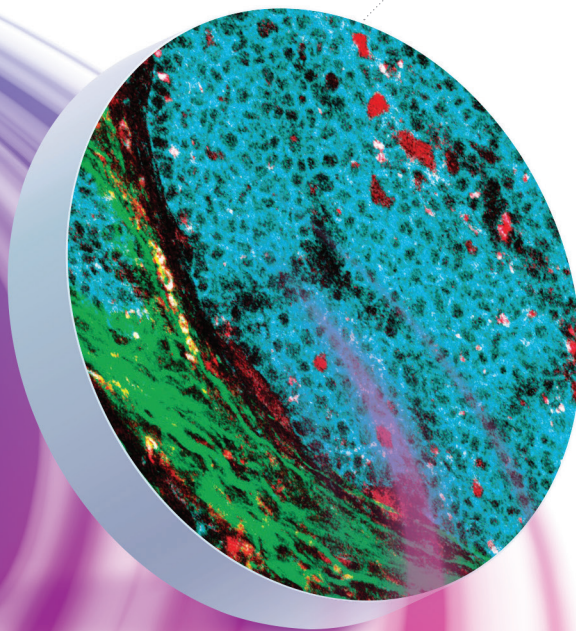
MELLES GRIOT

ILLUMINATION

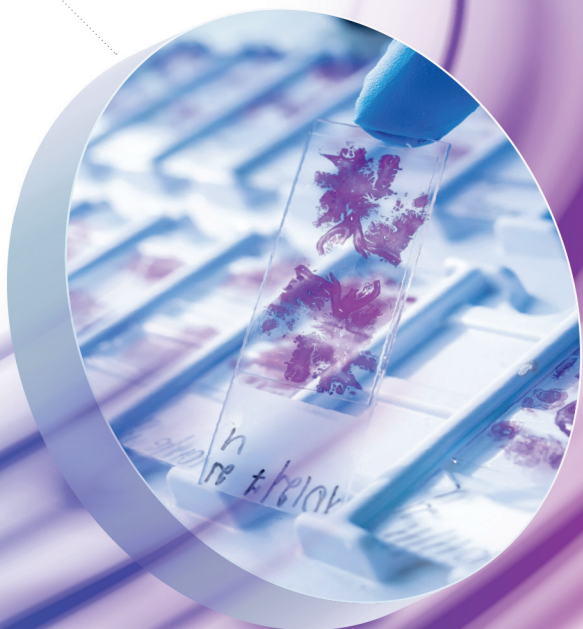


MEDICAL
TECHNOLOGY

LIFE
SCIENCE



DIAGNOSTIC



Introduction

For decades, Melles Griot® Optical Systems from IDEX Health & Science have been at the forefront of illumination technology, partnering with researchers and instrument manufacturers to advance the study of biological samples. From early contributions in flow cytometry and confocal microscopy to our current focus on high-throughput, high-resolution applications, we've consistently delivered innovative solutions that drive scientific discovery.

These fields hold immense potential for significant advancement of our understanding of biological systems by providing a comprehensive view of the various molecular components within a cell, enabling personalized medicine approaches, early disease detection, and the development of targeted therapies. However, throughput limitations often hinder widespread adoption.

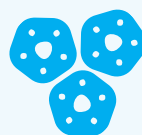
The demand for rapid high-throughput imaging is greater than ever in applications like:



NEXT-GENERATION SEQUENCING (NGS)



DIGITAL PATHOLOGY



SPATIAL BIOLOGY



ANIMAL IMAGING



NEXT-GENERATION PROTEOMICS



SUPER RESOLUTION MICROSCOPY



MULTI-OMICS



MULTIPLEX qPCR



HIGH-THROUGHPUT SCREENING (HTS)



OPTICAL METROLOGY



ADVANCED MACHINE VISION

The Throughput Challenge

High-throughput imaging instruments achieve higher throughput by imaging a larger rectangular field of view using 2D sensors for a step and shoot configuration or rapid continuous line scan imaging configuration using TDI sensors. Fluorescence microscopy is the key technique employed in many instruments and therefore requires higher irradiance, multi-wavelength, speckle-free, uniform illumination over a wide field of view (or line).

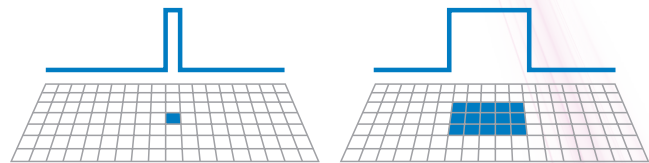
Our Solution: Custom Widefield Illumination Modules

Our custom Widefield Illumination Modules offer instrument designers a comprehensive solution for high-performance 2D or Line-scan imaging of flow cells, microarrays, FFPE tissue slides, and multi-well plates.

We address the core challenges of uniform multi-wavelength illumination, high-power delivery, and system integration with a suite of advanced technologies:

- › Medium to High Power Reliable Laser Diodes or LED Light Engines
- › Flat-Top, Speckle-Free Widefield Illumination
- › Beam Shaping to Match Sample Field of View and Sensor
- › Advanced Laser Modulation and Thermal Management
- › Compact, Drop-In Footprint
- › Free Space or Fiber Delivery
- › Compatibility with IDEX Health & Science XPLAN™ Objectives

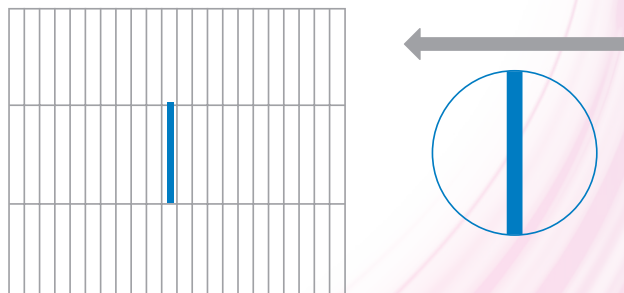
LARGER FIELD STEP-AND-SHOOT IMAGING



More power to maintain sufficient irradiance.

2D flat-top beam shaping to match the sample illumination to the sensor.

HIGHER SPEED CONTINUOUS LINE SCAN IMAGING



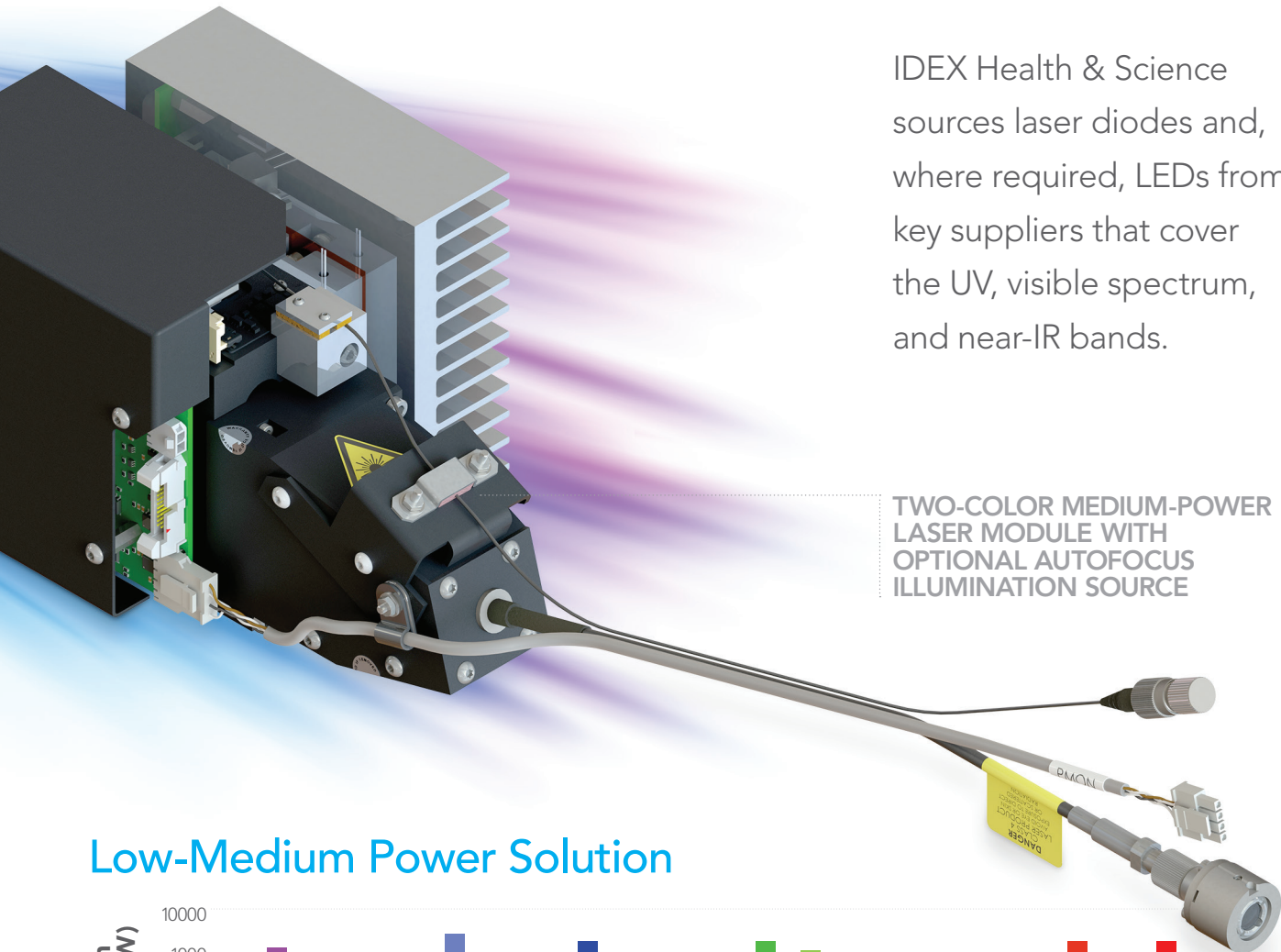
More power to compensate for short exposure.

Line flat-top beam shaping to match the sensor.

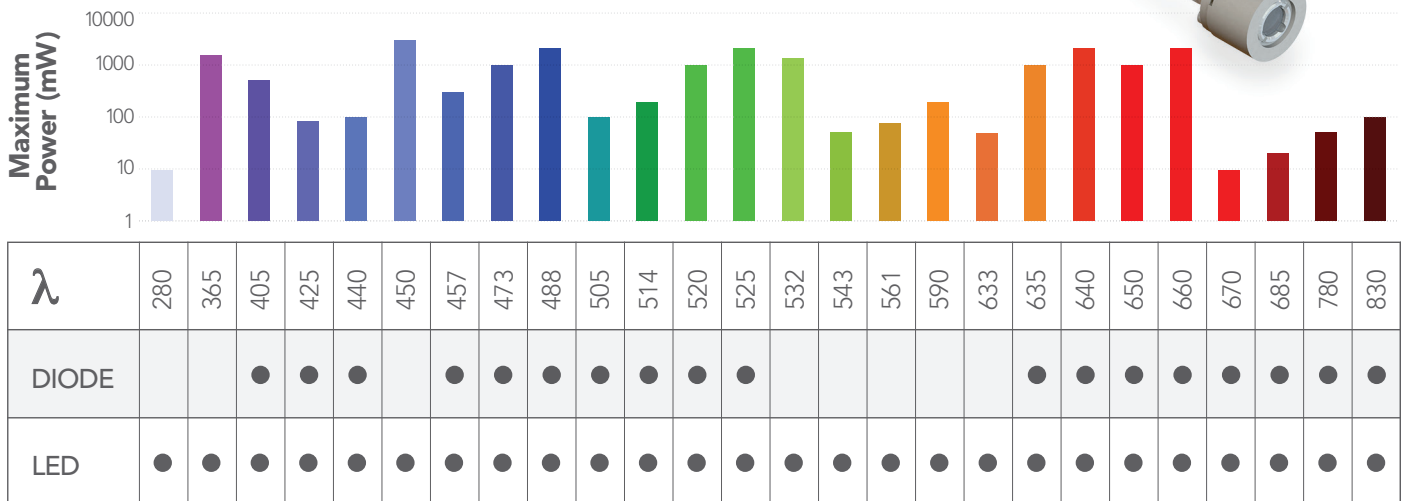
Reliable Laser Diodes and LEDs

IDEX Health & Science sources laser diodes and, where required, LEDs from key suppliers that cover the UV, visible spectrum, and near-IR bands.

TWO-COLOR MEDIUM-POWER LASER MODULE WITH OPTIONAL AUTOFOCUS ILLUMINATION SOURCE



Low-Medium Power Solution



High Power Solution

SINGLE WAVELENGTH OPTIONS

λ	638	532	525	488	465	455
~ 5 W	✓	✓	✓	✓	✓	✓
~ 10 W	✓	✓	✓		✓	✓
~ 15 W	✓	✓	✓		✓	✓
> 20 W			✓		✓	✓

DUAL WAVELENGTH OPTIONS

λ	638	532	638	525	532	488	525	488	532	465/455	525	465/455
~ 5 W	✓		✓		✓		✓		✓		✓	
~ 10 W	✓		✓						✓		✓	
~ 15 W			✓						✓			

TRIPLE WAVELENGTH OPTIONS

λ	638	532	488	638	525	488	638	532	465/455	638	525	465/455
~ 5 W (2 W 488)		✓			✓			✓			✓	
~ 10 W								✓			✓	
~ 15 W											✓	

Our workhorse laser bands with some example combinations.

Reliable Laser Diodes and LEDs (Continued)

We have developed lifetime data on the diodes, based on operating conditions, careful drive circuits, and thermal management solutions. All our illumination modules undergo a lifetime test to ensure a reliable production solution. The power output can range from 100's of mW to ~20 W.

High-power options are available in some discrete RGB bands thanks to the innovative work of IDEX Health & Science experts. This aligns with the trend in many markets toward higher throughput enabled by wider fields of view or faster TDI scanning. Both solutions require higher power/irradiance at the sample plane.



RGB HIGH-POWER
LASER MODULE

Currently our high-power solutions are offered at 450 nm, 465 nm, 488 nm, 525 nm, 532 nm, and 640 nm. Our experts have engineered a quick-turn product around these bands where you can select the required wavebands (single or multi-band), and our team can deliver a high-power solution in a short timeframe.



EXTERNAL
ELECTRONICS
CONTROL

Add-On Options

LASER CONTROL OPTIONS

- › Analog Controller Unit
- › Built-In Digital Controller

THERMAL MANAGEMENT OPTIONS

- › TEC Control Assembly
- › Fan Cooling
- › Water Cooling

BEAM SHAPING OPTIONS

- › Square FOV Format
- › Rectangular FOV Format
- › Line Beam Shaping – Single Beam
- › Line Beam Shaping – Dual Beam

Flat-Top, Speckle-Free Widefield Illumination

Our proprietary beam shaping technologies produce flat-top, low-speckle, high-uniformity illumination for both 2D and line beam profiles.



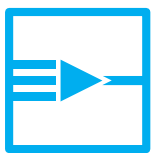
HIGH-POWER LASER MODULE

With Built-In Electronic Control,
Thermal Management, Speckle Reducer,
and Beam Shaping Optics

Beam Shaping Technology Ensures a Consistent Signal Across the Entire Field of View, Maximizing Data Quality and Throughput

Our primary delivery method provides sharp edges and a highly uniform image. In certain applications, a more traditional illumination delivery may be adequate, where the fiber face is re-imaged to the sample

plane. At IDEX Health & Science, we offer flexible delivery solutions that enable us to configure a quick-turn module with the core laser engine, matching the needs of our customer's field of view.

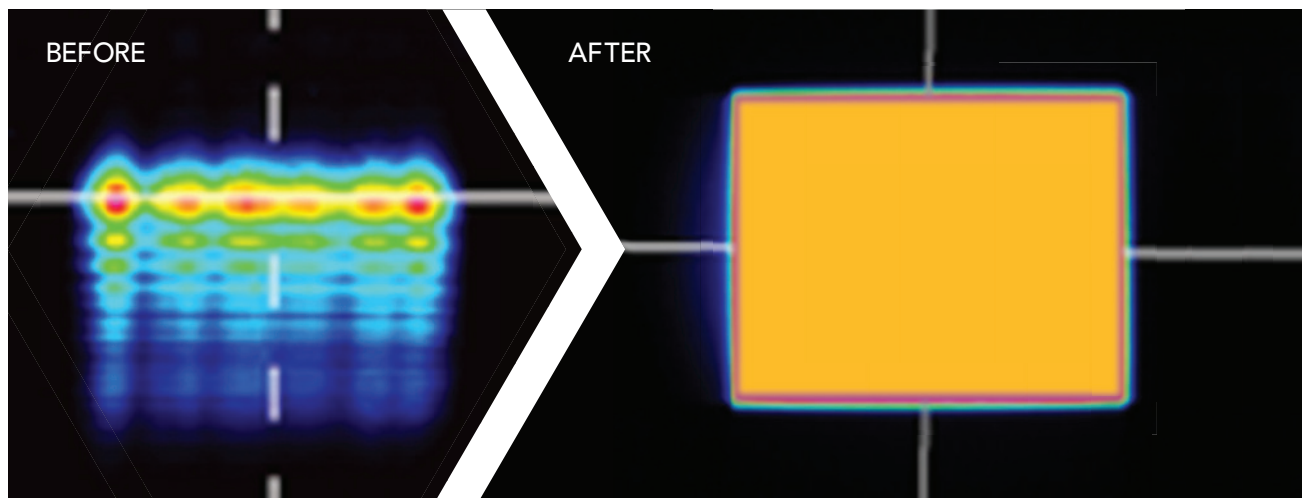


Beam Shaping to Match Sample and Sensor

We design custom beam shaping optics to precisely match the field of view of the flow cell, objective, and sensor (CCD, CMOS, TDI). This maximizes photon efficiency and ensures uniform imaging across the entire field.

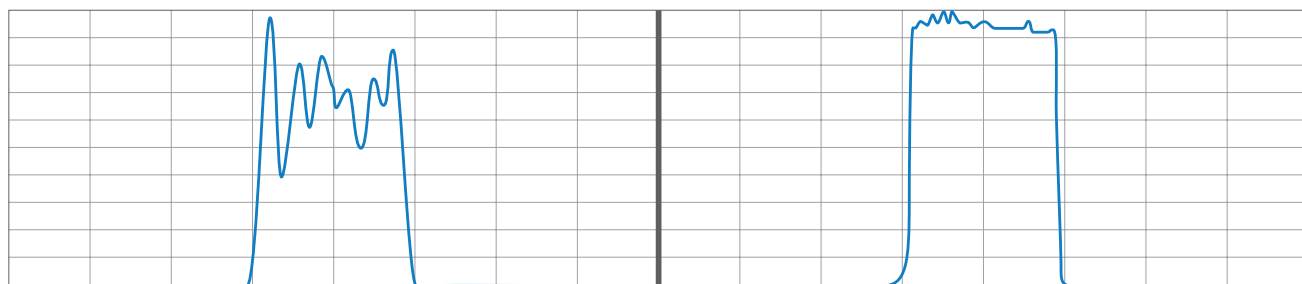
Flat-Top, Speckle-Free Widefield Illumination (Continued)

Multimode Diode Output Shaped to IDEX Health & Science Flat Top



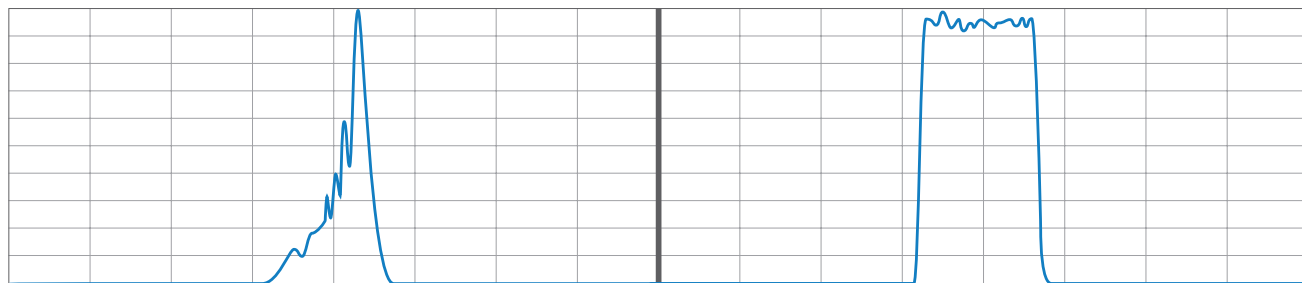
HORIZONTAL LINE PROFILE - BEFORE

HORIZONTAL LINE PROFILE - AFTER



VERTICAL LINE PROFILE - BEFORE

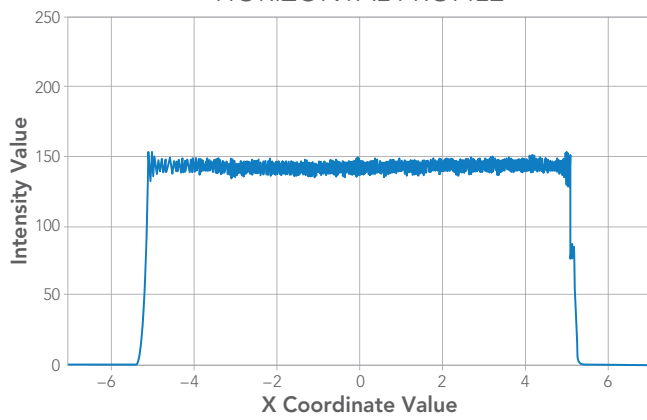
VERTICAL LINE PROFILE - AFTER



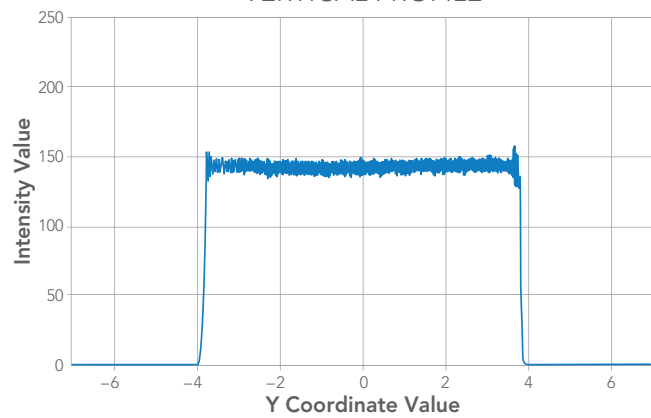
2D Illumination Profile



HORIZONTAL PROFILE



VERTICAL PROFILE



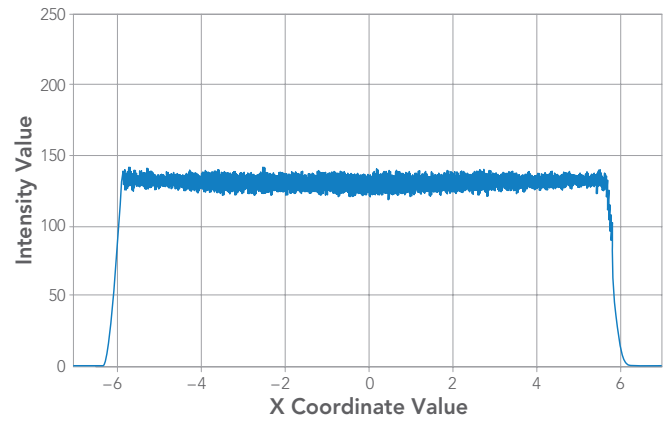
Single Line Illumination Profile



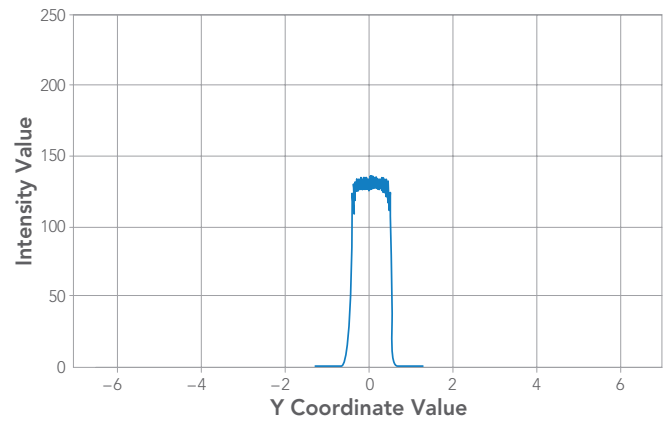
Dual Line Illumination Profile



HORIZONTAL PROFILE



VERTICAL PROFILE



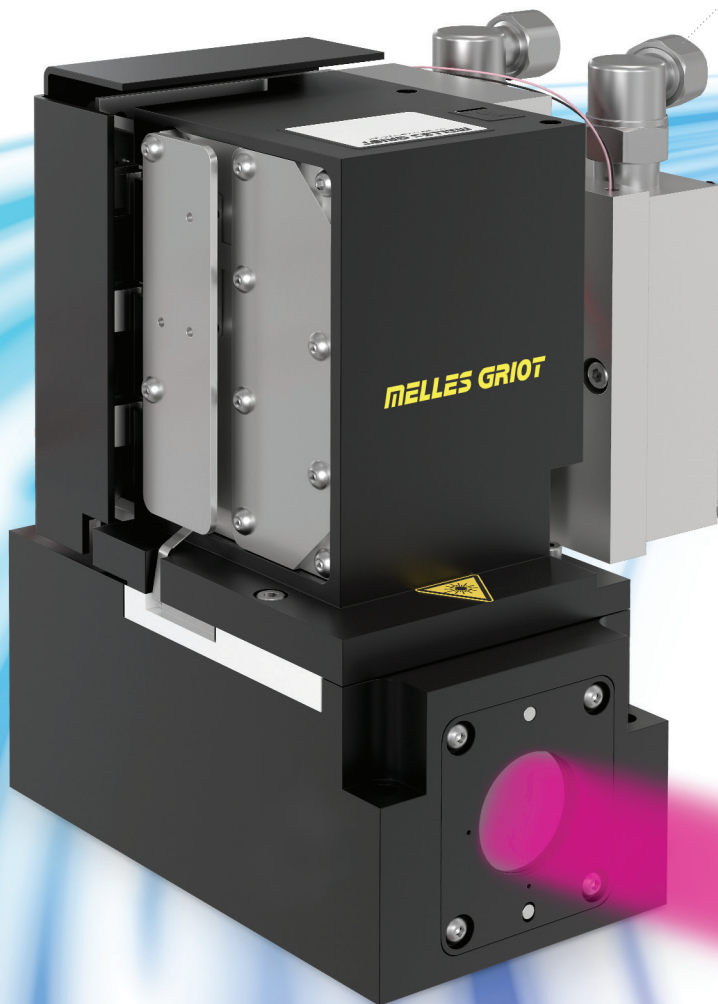
Free Space or Fiber Delivery

IDEX Health & Science offers a direct free space interface to the platform, or via fiber, enabling remote positioning of the laser engine, which is the preferred option for the majority of our customers' applications. The fiber is selected depending on power needs, beam shaping requirements, and instrument architecture (the path between the laser engine and the beam shaping module).

INTEGRATED FEATURES

Free space or collimated fiber output with optional on-board autofocus source and drive electronics.

FREE SPACE MULTI WAVELENGTH
MEDIUM-POWER ILLUMINATION
MODULE WITH LIQUID COOLING



 Compact,
Drop-In
Footprint

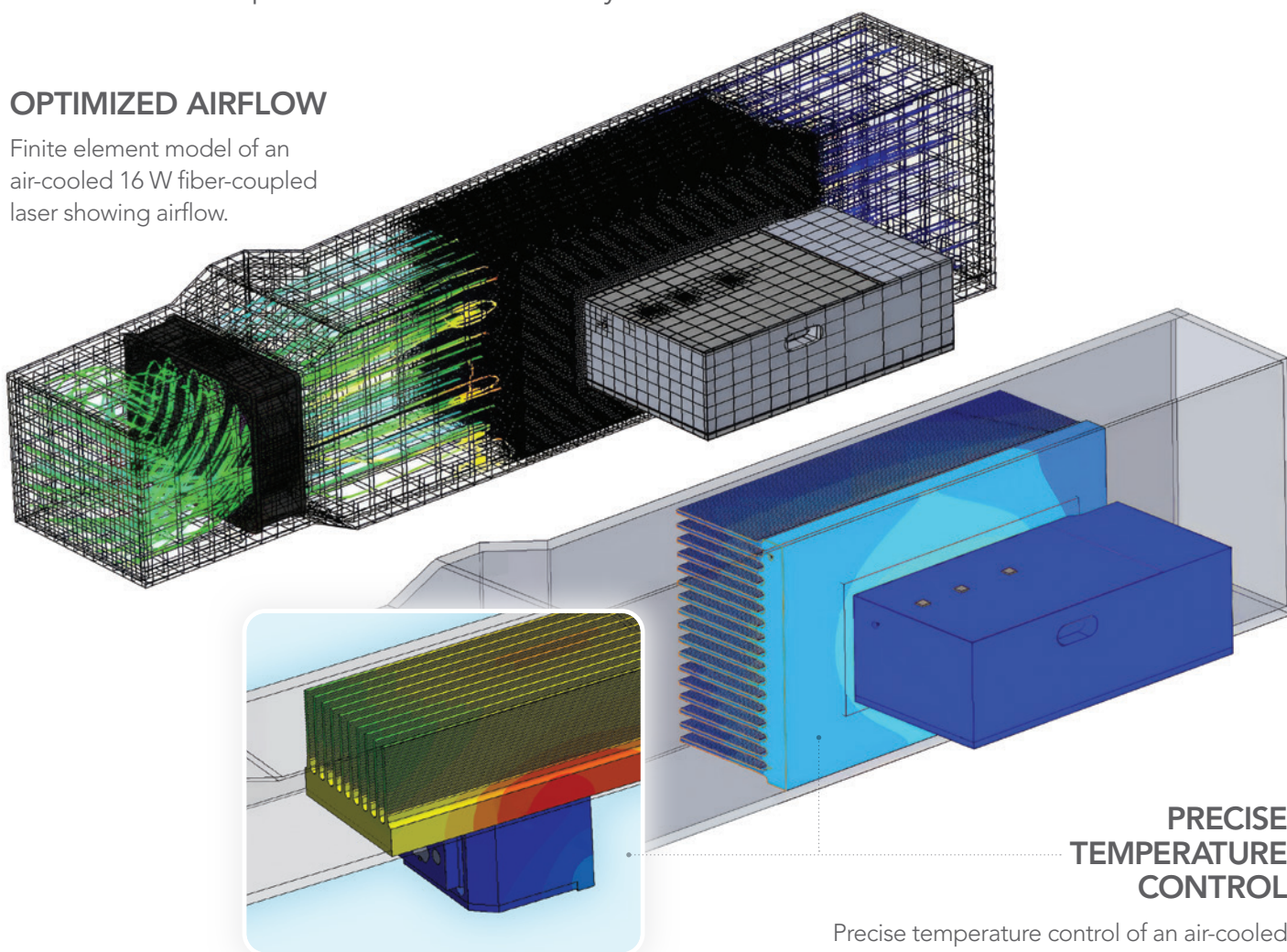
Our modules are designed with a compact, drop-in footprint, facilitating easy integration into your new and existing instrument designs. We offer both free space and fiber coupling options for maximum flexibility.

Advanced Laser Modulation and Thermal Management

We incorporate advanced laser modulation and thermal management capabilities, crucial for maintaining stability and performance, especially with high-power diode lasers. This ensures reliable operation and extends the lifespan of the illumination system.

OPTIMIZED AIRFLOW

Finite element model of an air-cooled 16 W fiber-coupled laser showing airflow.



PRECISE TEMPERATURE CONTROL

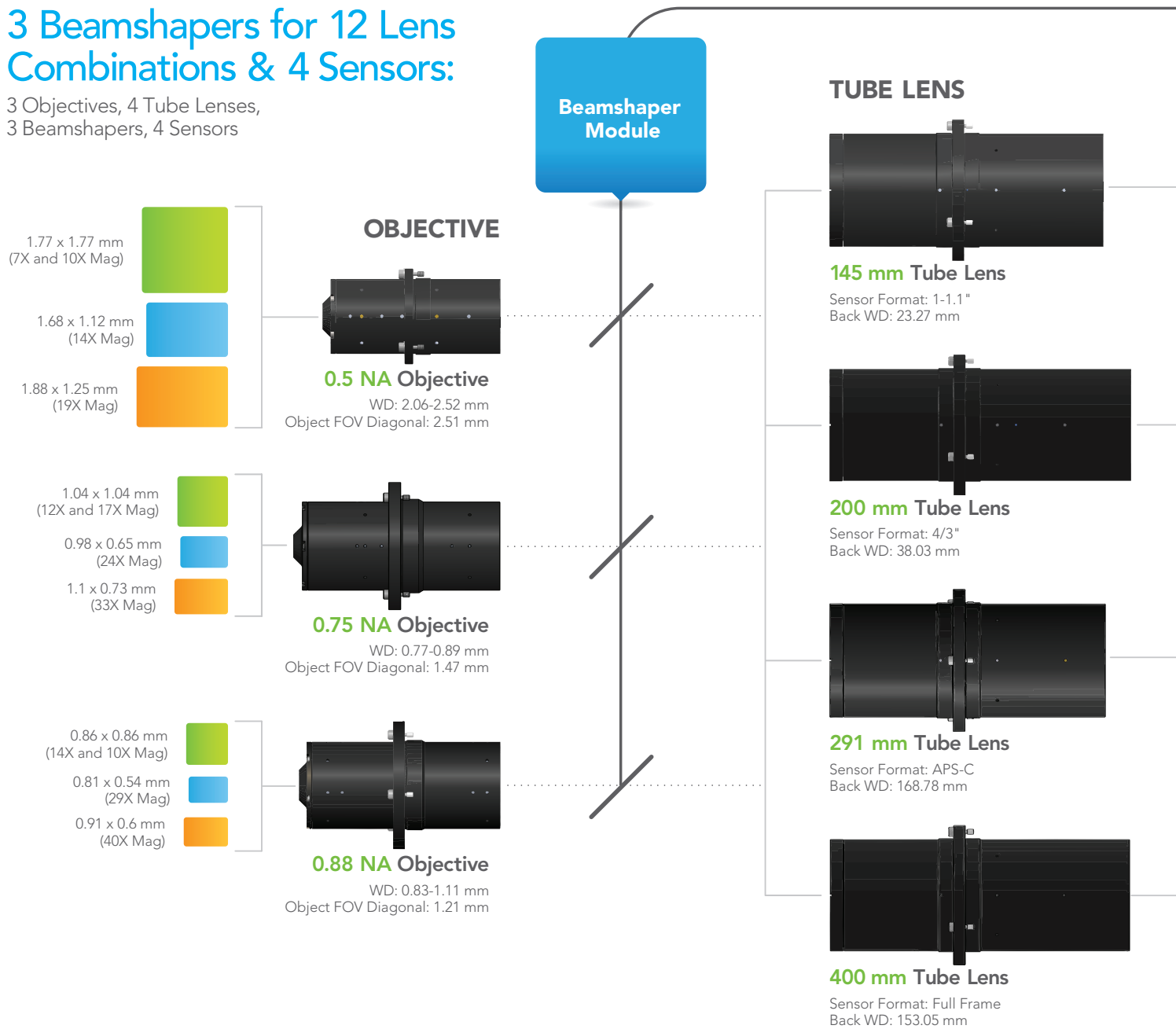
Precise temperature control of an air-cooled 16 W fiber-coupled laser.

XPLAN™ Compatibility

We offer a series of wide field of view objective lenses at specific NAs. Illumination Beamshaper modules are available, designed to work with our XPLAN™ series and a wide selection of sensors.

3 Beamshapers for 12 Lens Combinations & 4 Sensors:

3 Objectives, 4 Tube Lenses,
3 Beamshapers, 4 Sensors





LASER ENGINE
 $\lambda_1\lambda_2\lambda_3\dots$



**IMX 541
20MP**
4504 x 4504, 2.74 μm Pixels
12.34 x 12.34 mm



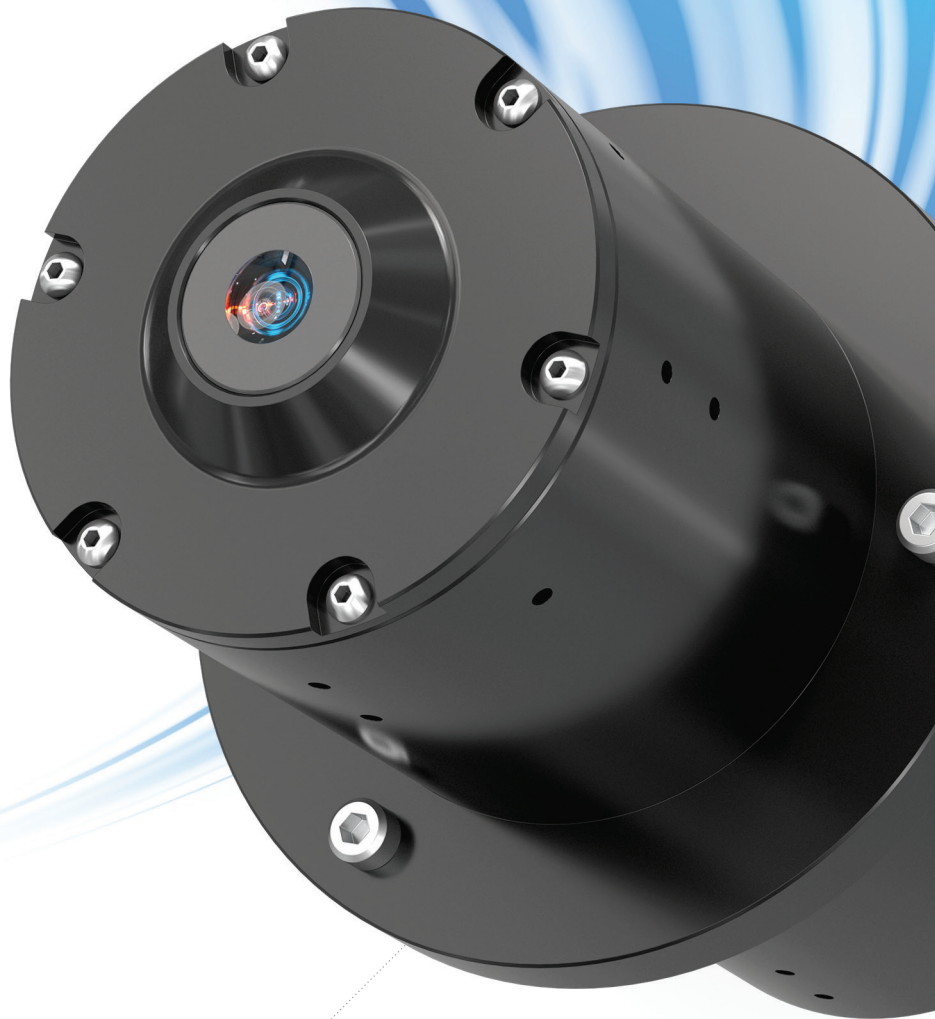
**On Semi XGS 30000
29MP**
5420 x 5420, 3.2 μm Pixels
17.34 x 17.34 mm



**IMX 571
26MP**
6244 x 4168, 3.76 μm Pixels
23.47 x 16.67 mm



**On Semi
KAI-29050**
6576 x 4384, 5.5 μm Pixels
36.17 x 24.11 mm




MELLES GRIOT XPLAN™
CCG LENS SERIES

Laser Autofocus System

Our Melles Griot® Laser Autofocus System is a modular, semi-custom autofocus solution that is tunable for different objectives, sample-plane reflectivity, and wavelength requirements. Available options for both integrated laser diode source or remote source options, where the autofocus source is co-located on an IDEX Health & Science-supplied laser illumination module. Also compatible with our XPLAN™ CCG Lens Series.





Our basic laser autofocus platform is offered for low-speed applications (required update rates <math><60\text{ Hz}</math>) and is best suited for imaging scenarios with minimal (or well-compensated) sample tilt, a stable optical path, where high sensitivity to changes in tilt is not a limiting factor.

High-Precision, Flat Sample Imaging

- › Semiconductor wafers
- › Polished substrates
- › Glass slides
- › Pattern-flat metrology

Fixed-Optics Microscopes with Rigid Mechanical Alignment

- › Upright or inverted microscopes with a stable turret
- › Systems where objectives are rarely swapped
- › Long-term fixed-focus imaging setup

BASIC CONFIGURATION

The basic configuration of our Laser Autofocus Module is compatible with most objectives. In this setup, the laser light source is mounted remotely (within the Autofocus Controller or combined with other IDEX Health & Science-supplied light sources), and fiber is coupled to the autofocus module. This configuration also shows cabling routed to the Autofocus Controller, including the autofocus sensor, power monitor, and thermistor signals.

Frequently Asked Questions

Find clear answers to the most common questions we hear from instrument designers about power delivery, beam shaping, and integration.

What life science applications do your illumination systems support?



Our illumination solutions are designed for a wide range of high-throughput, high-resolution applications, including next-generation sequencing (NGS), next-generation proteomics, spatial biology, multi-omics, high-content screening, and digital pathology. Light engines can be configured for both 2D sensor and TDI Line sensor applications.

What makes your illumination uniformity stand out?



Our systems are engineered to deliver flat-top, low-speckle illumination with >80% uniformity, ensuring highly consistent excitation across the field of view. This is critical for quantitative fluorescence imaging and large field of view high-throughput applications.

What types of light sources can you provide?



We source reliable laser diodes and LEDs that are precisely matched to your system's fluorophores. Available power levels range from 100's of milliwatts to ~20 W, enabling flexibility for medium-throughput to high-throughput applications.

Do you design custom beam shaping optics?



Yes. We design beam shaping optics that match the flow cell field of view (FOV), and optimize for the downstream sensor type (CCD, CMOS, or TDI). This alignment maximizes photon efficiency and enables diffraction-limited imaging.

Have a question not covered here?



Every instrument is unique. If you have a question about your system, reach out and we'll help you determine the best approach.

CONTACT AN EXPERT: [idex-hs.com/illumination](https://www.idex-hs.com/illumination)

Can your illumination modules be integrated into existing instruments?



Absolutely. Our solutions feature a compact, drop-in footprint with either fiber-coupled or free-space laser delivery. Fiber-coupled units make them ideal for Field Replaceable Units (FRUs) and retrofit applications.

Can you combine laser diodes and LEDs in one module?



Yes. Depending on your system requirements, we can integrate multiple diodes, LEDs, or hybrid combinations to give you the spectral flexibility your workflow demands.

What makes your illumination systems different from other providers?



We specialize in a unique combination of:

- › Fiber-coupled or free-space, medium- to high-power light engines
- › Beam shaping optics delivering high uniformity (>80%) flat-top low-speckle illumination
- › Precision beam shaping matched to sample field of view and sensor for maximized photon budget
- › Compact cost-effective modular designs
- › Deep experience across life science applications

These attributes make us a leading provider of advanced illumination for high-throughput fluorescence-based imaging instruments.

Do you provide laser drivers and thermal control systems?



Yes. We have extensive experience designing drivers for complex laser cycles, as well as thermal management and TEC control, particularly for high-power diode lasers, where stability and lifetime are critical. The drivers and electronics can be built into the light engine or can be supplied as an external control.

Why Choose IDEX Health & Science?

Your Partner for High-Performance Optical Systems

With decades of experience in illumination technology, IDEX Health & Science is a trusted partner for leading instrument manufacturers. We combine deep expertise in optics, photonics, and engineering to deliver innovative solutions that meet the evolving needs of the life sciences industry. Our commitment to quality, performance, and customer satisfaction makes us the ideal choice for your next-generation imaging needs.

Melles Griot® Optical Systems from IDEX Health & Science lead as the premier innovator, designer, and manufacturer of high-precision optical systems for fluorescence microscope-based applications. Empowering life science OEM companies, we enable the development of cutting-edge, high-throughput, high-resolution imaging instruments, pushing the boundaries of discovery and clinical applications. With a fully integrated approach, we cover the entire optical design and manufacturing process, offering custom and semi-custom solutions that cater to every phase of instrument development,

from proof-of-concept breadboards to volume production. Our extensive portfolio encompasses the full spectrum of fluorescence microscope systems, including illumination and autofocus systems, objective and tube lenses, as well as optical filters.

- › Our team brings over 100 years of experience
- › 300+ total employees, including 160+ engineers who drive innovation
- › Our teams have been awarded ~200 patents
- › 115,000 sq. ft. manufacturing center, including 30% clean room space
- › \$100M+ total infrastructure investment
- › High-performance, purpose-built imaging components and modules (objective tube lens, imaging subsystems) shipped in quantities of 100s to 1000s per year

Benefits for OEMs

Partnering with IDEX Health & Science for your illumination needs offers significant benefits:

Increased Throughput

Our uniform, high-intensity illumination enables faster imaging and higher throughput, reducing costs and accelerating research.

Improved Data Quality

Our flat-top, speckle-free illumination ensures a consistent signal across the field of view, resulting in more accurate, reliable data.

Reduced System Complexity

Our compact, drop-in modules simplify instrument design and integration, reducing development time and costs.

Optimized Performance & Cost

We offer both free space and fiber-coupled options, enabling you to optimize performance and cost based on your specific application requirements.

Customizable Solutions

We work closely with you to understand your specific needs and develop illumination solutions tailored to your exact requirements.

Ready to Design Your Custom Solution?

CONTACT AN EXPERT:
idex-hs.com/Illumination



