3.6.2 Slit - Based Beam Propagation Analyzer M²

NanoModeScan

The NanoModeScan combines the flexibility and speed of the NanoScan with dedicated M² measurement hardware and software. The NanoModeScan provides an automated measurement of M² using either the ISO 11146 or the Rayleigh method.

The ISO Method software and hardware report the ISO 11146 parameters:

- Times diffraction limit: M²
- Beam propagation factor: K
- Beam waist size: d_0
- Beam waist location: Z_0
- Divergence: θ
- Rayleigh range: Z_r

By adding the capabilities of the NanoScan to the ModeScan, the range of possible measurable lasers is greatly expanded and the speed of the measurements dramatically improved. The NanoScan's software controlled variable scan speed allows the measurement of both CW and kHz pulsed lasers with any NanoScan scan head, covering the entire wavelength range from UV to FIR. The NanoScan's

NanoModeScan

rapid beam finding and autoranging speed up the total M² measurement to ~20 seconds for CW lasers. Both 200mm and 400mm lenses are available to generate the proper artificial waist for the laser source under test. For ease of alignment, there is an entrance iris on the optical axis of the NanoModeScan and a precision alignment stage for horizontal and vertical positioning.

The ISO 11146 Method

The ISO 11146 method for measuring the propagation of a laser source calls for the measurement of the beam diameter for at least 10 positions through the waist created by a test lens inserted in the beam path. Five locations should be within ±1 Rayleigh range of the artificial waist and at least five more points beyond two Rayleigh ranges from this waist. These measurements are then used to compute the laser propagation parameters. Once points are selected properly, the ISO Method is the fastest measurement method and best for volume testing of lasers.

The Rayleigh Method

The ISO method requires the user to manually select the measurement points, and changing one or two of the selected points can yield different M² values. The Rayleigh method is completely automated, selecting its own measurement points based on mapping the Rayleigh range of the beam waist. This method is fully discussed in Application Note 230, *Fast M²(k-factor) Measures with Photon Beam Profilers*. In addition, the Rayleigh method can yield more consistent results for M² values for lasers that are not exactly like those for which the ISO standard was written, such as fiber lasers, lensed diode lasers, and VCSELs.

The NanoScan Difference

With the NanoScan-equipped NanoModeScan, all scan heads can measure pulsed beams with repetition frequencies down to 10kHz. Measuring pulsed beams in discussed in the application note *Measuring Pulsed Beams with a Slit-Based Profiler*. The silicon and germanium detectors will measure less than a milliwatt of power. The pyroelectric detector-equipped NanoScan head can analyze higher power lasers at all wavelengths. The increased dynamic range of the NanoScan enhances the signal to noise ratio of the system and allows a much broader range of laser powers to be analyzed with one instrument setup.

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Real-Time Divergence Measurement

By monitoring the divergence angle θ, it is possible to make a measurement that will be directly proportional to M^2. This enables the adjustment of the laser performance in real time at the NanoScan's rapid update rate (up to 20Hz). To use this feature, the scan head is moved to a position one geometric focal length from the test lens. Divergence is the beam diameter divided by the focal length, and the measured divergence is equal to M times the embedded divergence.

Therefore when the beam diameter at this location is minimized, the divergence is at its minimum and the M^2 of the laser should then be optimized. After this real-time adjustment, the full M^2 measurement can be done to generate the required parameter values. This method makes the NanoModeScan an even more valuable tool for the final setup of lasers on the manufacturing floor by decreasing the time it takes both to adjust the laser system and to make the measurements required for quality control documentation.

NanoModeScan Specifications

Sensor/Detector	
Scan head Travel	500mm
Optical Axis Height	140-170mm
Standard Lenses	200mm EFL, BK-7 plano-convex, Broadband AR Coated
	400mm EFL, BK-7 plano-convex, Broadband AR Coated; UV through long IR lenses available
Optional Lens	200mm FL fused silica for UV coated for wavelength of use
	350mm FL fused silica for UV coated for wavelength of use
	190mm FL IR lens for 10.6μm wavelength
Minimum Spot Size	See scan head specifications
Computer/Electrical	
Source Power	See scan head specifications
File Saving and Data Logging	Data files, ASCII Files
AC Power	110V, 60Hz standard
	220V, 50Hz optional
Communication	RS-232 Interface or USB to RS-232 adapter required
Mechanical (Dimensions in mm)	
NanoModeScan Linear Stage	812 × 102 × 78
Photon Motion Controller	273 × 89 × 57
Removable Light Shield	787 × 777 × 110
Weight	
NanoModeScan Linear Stage	8.4kg
Photon Motion Controller	1.5kg
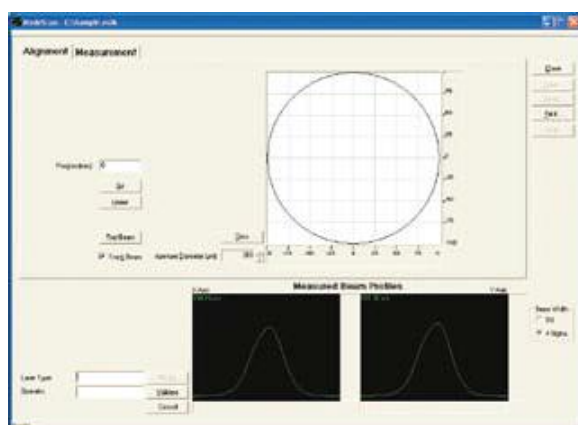
Alignment screen in ModeScan software

Measurement results screen in ModeScan software

Ordering Information - NanoModeScan M² Systems

All NanoModeScan Systems include (unless otherwise noted):

- High-resolution scanhead with rotation mount.
- Two BK 7 lenses and mounts. Standard are 200 and 400mm focal length.
- Lens coating Choices:
  - VIS Visible: 430–700nm (not for use with Germanium detector)
  - NIR Near IR: 650–1000nm
  - LIR Long IR: 1000–1550nm (not for use with Silicon detector)
- VLIR: Very long infrared >1550nm. The two glass lenses will not be included but instead credited toward the very long wavelength IR lens or lenses that will require an optional charge (for use with MSP-NS-Pyro/9/5 only).
- OPTIONAL UV: If ultraviolet application, the two glass lenses will not be included; instead we will send one 200 mm focal length lens coated for wavelength of use.

Be sure to specify XXX wavelength when ordering.

Item	Description	P/N
NanoModeScan M² Systems		
USB MSP-NS-Si/9/5	Model 1740 ModeScan with NanoScan Silicon (Si) Detector 9mm aperture 5µm slits Si detector, 63.5mm diameter head, 9mm entrance aperture, and matched pair of 5.0µm wide slits. Use from 190 to 1000nm wavelengths.	PH00233
USB MSP-NS-Ge/9/5	Model 1740 ModeScan with NanoScan Germanium (GE) Detector 9mm aperture 5.0µm slits. Germanium detector, 63.5mm diameter head, 9mm entrance aperture, and matched pair of 5.0µm wide slits. Use from 700nm to 1.8µm wavelength.	PH00234
USB MSP-NS-Pyro/9/5	Model 1740 ModeScan with NanoScan Pyroelectric Detector 9.0mm aperture 5µm slits. Pyroelectric detector, 63.5mm diameter head, 9mm entrance aperture, and matched pair of 5µm wide slits.	PH00235
MSP-NS-Pyro/20/25	Model 1740 ModeScan with HP NanoScan scanhead with 9mm Pyroelectric Detector 5µm slits, 100mm diameter head, 9 mm entrance aperture, and matched pair of 5µm wide slits; scanhead is fan cooled.	PH00218
USB MSP-HPNS/10/5	Model 1740 ModeScan with HP NanoScan scanhead with 9mm Pyroelectric Detector 5µm slits,100mm diameter head, 9 mm entrance aperture, and matched pair of 5µm wide slits; scanhead is fancooled.	PH00236
NanoModeScan Accessories		
LENS 200 UV-XXX	Optional 200mm quartz lens for use between 190–400nm wavelengths.	PH00090
LENS 400 UV-XXX	Optional 400mm quartz lens for use between 190–400nm wavelengths.	PH00091
LENS 190 10.6	Optional 7.5-inch focal length lens for use at 10.6µm wavelength.	PH00092
LENS 100 VIS	Optional 100 mm focal length lens for use 400–700nm wavelength.	PH00093
LENS 100 NIR	Optional 100 mm focal length lens for use 650–1000 nm wavelength.	PH00094
LENS 100 LIR	Optional 100 mm focal length lens for use 1000–1550nm wavelength.	PH00095
1740 LENS MNT	Lens mount for users wanting to use their own 25mm diameter lens.	PH00075
CUSTOM LENS	Specify wavelength, focal length	PH00088
Model 1740	ModeScan Rail w/o scan head	PH00074
1740 LENS PREP	ModeScan custom lens	PH00076
1740 TRNG	ModeScan onsite operation training	PH00077
Lens 400 2um	Optional 400mm focal length lens for use at @2µm wavelength	PH00224
Lens 200mm VIS	Optional 200mm focal length lens for use 400-700nm wavelength	PH00237
Lens 400mm VIS	Optional 400mm focal length lens for use 400-700nm wavelength	PH00238
Lens 200mm NIR	Optional 200mm focal length lens for use 650-1000nm wavelength	PH00239
Lens 400mm NIR	Optional 400mm focal length lens for use at 650-1000nm wavelength	PH00240
Lens 200mm LIR	Optional 200mm focal length lens for use at 1000-1550nm wavelength	PH00241
lens 400mm LIR	Optional 400mm focal length lens for use at 1000-1550nm wavelength	PH00242