56 Sparta Avenue • Newton, New Jersey 07860
(973) 300-3000 Sales • (973) 300-3600 Fax
www.thorlabs.com

THORLABS

**OTM211 - December 21, 2018**

Item # OTM211 was discontinued on December 21, 2018. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

# OPTICAL TWEEZERS MICROSCOPE SYSTEMS

OVERVIEW

**Features**

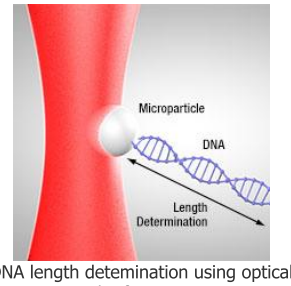
- Optical Trapping Systems for Inverted Microscopes
- Multiple Computer-Controlled Traps
- 1064 nm Laser Source (Other Trapping Wavelengths Available Upon Request)
- Module for Force Measurement and Particle Tracking
- Custom Systems for Integration with Existing Inverted Microscopes

Sam Rubin
General Manager,
Thorlabs Imaging Systems
**Feedback?**
**Questions?**
**Need a Quote?**

Contact Me


Click to Enlarge
OTM200 Add-On Tweezer System Integrated with an Olympus IX83 Inverted Microscope

Thorlabs' Optical Tweezers Microscope Systems are tools for trapping and manipulating microscale objects, and sized to easily fit on a 3' x 4' (900 x 1200 mm) Active-Isolation ScienceDesk, as shown in the image at the top of the page. These systems are designed for users who desire a turnkey optical tweezers solution for inverted microscopes. In addition, our optical tweezers can operate in conjunction with other imaging modalities such as confocal microscopy or Raman spectroscopy. Various configurations can be offered offered covering multiple combinations. The OTM211, for example, is a complete system for trapping and force measurements, including a Nikon Eclipse Ti-S microscope. The OTM200 includes all parts to add trapping capabilities to an existing inverted microscope and is configured for the specific type of microscope (Nikon Ti, Olympus IX or Leica DMI) at the time of ordering. Please contact Tech Support for more information about customization or integration with an existing microscope.




DNA length detemination using optical tweezers. The force measurement capability of optical tweezers is used to determine the length of a DNA fragment that is tethered to a microparticle. For more details on this and other applications of optical tweezers, please see the *Force Measurement* and *Other Applications* tabs.

**System Functionality**

The trapping source for these Optical Tweezers Systems is a power- and wavelength-stabilized 1064 nm laser, which is split into two independently steerable trapping beams with greater than 1 W optical power per beam. Each beam can support several time-shared traps. Other trapping wavelengths and powers are available for specialized applications.

The output of the trapping laser is collimated, and the light is focused onto the sample with diffraction-limited performance, thereby achieving optical gradients capable of trapping particles. The user can precisely position two independent traps in three dimensions. The stiffness of each trap can be individually controlled by adjusting the laser power and is actively stabilized. The GUI control software provides plug and play support for most general trapping experiments. In addition, a software development kit enables users to create application-specific solutions. For more information on the software functionality, please see the *Software* tab.

The OTM211 includes a force measurement module capable of making measurements in the femtonewton to piconewton range. Quadrant detectors monitor a signal sensitive to the relative displacement of the trapped particle from the laser beam axis. As a result, the output of the detector can be used to calibrate the position, stiffness, and force of the optical tweezers. Force measurements with optical tweezers have enabled quantitative studies in diverse areas, such as molecular dynamics, microfluidics and biological systems. Examined properties include adhesion, stiffness and elasticity of cells, and the forces produced by molecular motors. The *Technology* tab provides more details on the functionality of optical tweezers and their force measurement capabilities.

These systems build on the success of our Modular Optical Tweezers, which can be easily customized to meet individual experimental needs. Thorlabs' optical tweezers, or optical traps, have been employed in numerous experiments (see the *References* tab for examples). Biological applications for optical tweezers include trapping viruses and bacteria, manipulating cellular structures, patterning of surfaces, and measuring forces of molecular motors and biological molecules such as DNA and proteins. For details, please see the *Force Measurement* and *Other Applications* tab.


After installation, the system offers a fully enclosed beam path and interlock system and is classified as a class 1 laser product. Therefore, it can be used in general lab environments without dedicated safety measures.

| OTM211 Microscope Specifications | |
|---|---|
| Inverted Microscope | Nikon Eclipse Ti-S |
| Focusing | Via Nosepiece, Manual or Motorized |
| Condenser | 0.9 NA |
| Objective | >1.2 NA, Oil Immersion |

| OTM211 Force Module Specifications | |
|---|---|
| Travel Range | 200 µm x 200 µm x 200 µm |
| Stage Resolution (Closed Loop) | 1 nm |
| Detection | Dual QPD Module |
| Data Acquisition | 16 Bits, 5 ns Timing Resolution |

| Computer Specifications[a] | |
|---|---|
| Operating System | Windows® 7 Professional (English Version) |
| Disk Space | 500 GB |
| Monitor | 21.5" (54.6 cm) |
| RAM | 4 GB |
| Video RAM | 1 GB |

- Computer Type Subject to Change without Notice

| OTM200 and OTM211 Optical Trap Specifications | |
|---|---|
| Center Wavelength | 1064 nm |
| Emission Bandwidth | <0.25 nm |
| Laser Output Power | 5 W |
| Laser Power Noise (RMS) | <0.2% |
| Beam Diameter at Objective Back Aperture | 8 mm |
| Trap Scan Area[b] | > 80 µm x 80 µm |
| Number of Independent Trap Beam Paths | 2 |
| Maximum Number of Trap Sites per Beam Path[b] | 15 |

- Tested with 2 µm fused silica beads in water, using the standard RMS100X-PFO objective (100X Olympus Plan Fluorite Oil Immersion Objective, 1.30 NA, 0.2 mm WD), and a No. 1.5 coverslip. Please contact Tech Support if your application requires a higher number of trap sites.

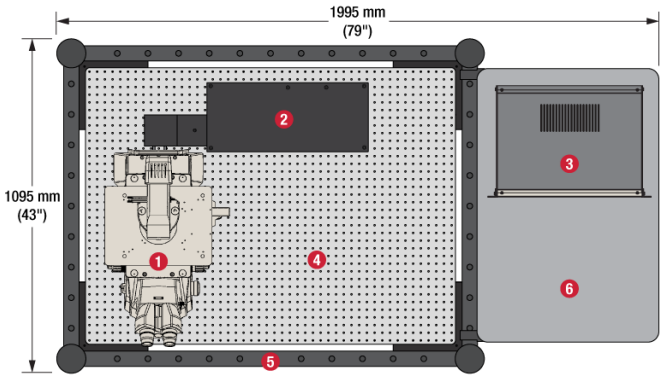
| OTM200 and OTM211 General Specifications | | |
|---|---|---|
| Voltage | 120 - 240 VAC | |
| Maximum Power Consumption | 1000 VA | |
| Operating Temperature | 10 °C to 40°C | |
| Humidity | Non Condensing | |
| **Module** | **Dimensions (L x W x H)** | **Weight** |
| Optics Module | 17" x 8" x 19" (432 mm x 204 mm x 483 mm) | 40 lbs (18 kg) |
| Electronics Module | 17" x 15" x 10" (432 mm x 381 mm x 254 mm) | 20 lbs (9 kg) |
| Power Supply Module | 17" x 13" x 9" (432 mm x 331 mm x 229 mm) | 40 lbs (18 kg) |
| Piezo Stage Controller[a] | 17.7" x 3.5" x 13.5" (450 mm x 88 mm x 343 mm) | 17.5 lbs (7.9 kg) |

- Not Including Mounting Rails, OTM211 Only

## Suggested Table Setup

The schematic to the left shows a sample OTM211 configuration on a 3' x 4' ScienceDesk Antivibration Workstation. The numbered items shown are:

1. Nikon Eclipse Ti-S Microscope (Included with OTM211 Only)
2. Optics Module (Included with the OTM211 and OTM200)




3. Power Supply and Control Modules (Stacked; Included with the OTM211 and OTM200)
4. 36" x 48" (900 mm x 1200 mm) Nexus Optical Breadboard
5. SDA90120: 3' x 4' (900 x 1200 mm) ScienceDesk Frame with Active, Self-Leveling Isolators
6. PSY351: 900 mm x 600 mm Side Shelf

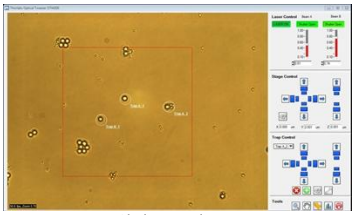
Not included in the schematic, but also recommended:

- PSY180: 260 mm x 450 mm Computer Shelf (For Holding Computer)
- PSY351: 900 mm x 600 mm Side Shelf (For Holding Piezo Stage Controller Under the Table, OTM211 Only)
- PSY222: 300 mm x 1200 mm Overhead Shelf with Posts (for Holding Microscope Controller)

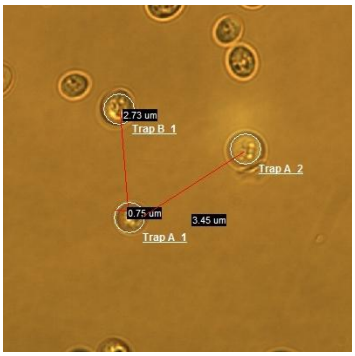
These items will build the configuration similar to the one shown in the image at the top of the page. We offer many other ScienceDesk accessories, such as monitor and keyboard mounts, which could be useful in configuring an optical tweezers system for a particular laboratory environment.

## SOFTWARE

The OTM200 and OTM211 systems include a Windows-based software package that contains everything needed for system control and data acquisition. It enables users to control all hardware components in the optical tweezers system. In addition, a Software Development Kit (SDK) is provided to allow users to easily create applications optimized for their particular requirements.



Click to Enlarge
Main screen of the OTM software. Three Ø1 µm beads are trapped and labeled A_1, A_2, and B_1.




Click for Details
The software offers measurement capabilities. The distances between traps A_1 and B_1 and between traps A_1 and A_2 are measured. Additionally, the diameter of the particle trapped in A_1 is measured.

## Functionality

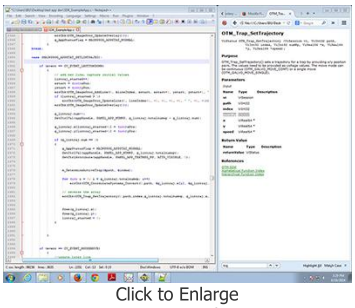
- Trap Positioning via On-Screen Manipulation (See the Video Below)
- Adding / Removing Trap Sites
- Stage and Trap Step Positioning
- Laser Power Control
- Camera Control

## Features

- Acquisition of >50 Frames per Second (1600 x 1200 Pixels)
- Video Capture, Selected Region or Full-Frame, AVI Format
- Save / Select Calibration Settings for Different Objectives
- On-Screen Distance Measurements
- Force Measurement Readout

**Software Development Kit**

The tweezers system is supplied with a Software Development Kit (SDK). The SDK gives access to all features of the instrument, thus enabling the creation of custom, application-specific software. The SDK is provided as a 64-bit Windows dynamic link library (DLL). Language bindings for C, National Instruments LabVIEW, and C# are available. For details, please refer to the OTM200 Programmer's Reference Manual.



Click to Enlarge
SDK Screenshot

**Software Operation Video**

Multiple traps can be turned on and manipulated by the software. This clip shows Ø2 µm beads in water trapped by the OTM211 optical tweezers system.

# Force Measurement

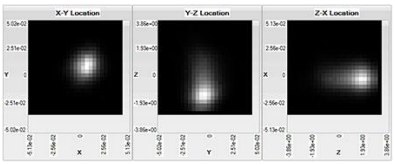
*Click to Jump to a Topic:*



## Trapping of Dielectric Particles and Force Measurement

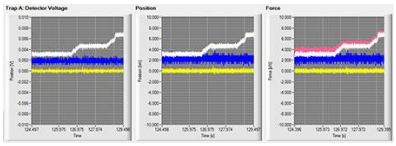
Dielectric particles with sizes ranging from sub-micron to larger than 20 µm can be routinely trapped using these Optical Tweezers systems. Spherical particles made from fused silica or polystyrene are commonly used for trapping. Polystyrene in particular can be readily functionalized to bind to particles that are otherwise difficult or impossible to trap, such as protein fragments.

The force measurment module, which comes standard with the OTM211 (the OTM200 can be customized to include it), lets the user apply and measure forces in the piconewton range. Within the microscope tweezers system the user can run an automated calibration sequence *in situ* without the need for special samples, which might not match the condition during the experiment. This module also allows the tracking of trapped particles in three dimensions. Figure 1 shows a histogram of a trapped particle's position in the proximity of a glass surface. The XY data shown is symmetric whereas the Z data is truncated, as the particle cannot penetrate the surface.




Click to Enlarge

**Figure 1:** A histogram showing a trapped particle's position in three dimensions in proximity to a glass surface.

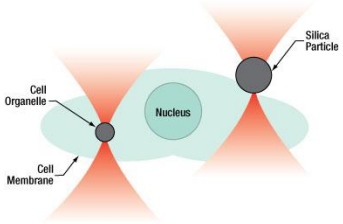


Click to Enlarge

**Figure 2:** A screenshot from the OTM211 software showing force tracking.

## Microrheology

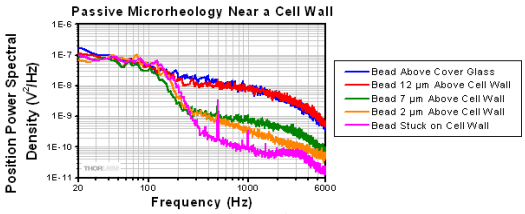
Microrheology is the study of the flow of materials, including measurements of viscosity and viscoelasticity, over micron length scales. One common measurement is to look at the response of a microscopic object subject to an external force; optical tweezers can be employed to apply the external force while the movement of the particle is recorded. Figure 2 shows a schematic of two measurement schemes using optical tweezers; either an organelle inside the cell can be trapped for use as a probe, or the probe can be a silica particle attached to the cell's membrane.




Click to Enlarge

**Figure 2:** Schematic showing two microrheology methods using optical tweezers. On the left, an organelle inside the cell is trapped and is used as a probe for measurements. On the right, the probe is a silica particle attached to the cell's membrane.

Figure 3 shows the position power spectral density (PSD) of a particle above a coverslip at 5 different distances from a cell wall. The PSD shows the frequency content of the particle's motion; for more details on PSD measurement, please see the *Technology* tab. In Figure 3, it can be seen that the higher frequency components of the particle's motion are supressed. A particle in a Newtonian fluid will have a PSD with a Lorentzian shape, as with the blue and red curves shown in the figure. As the particle is moved closer to the cell, the PSD begins to deviate from the Newtonian ideal and more complex models must be used to describe the fluid's behavior.




Click to Enlarge

**Figure 3:** Plot showing the position PSD as a fused silica bead is moved closer to the cell wall. While the PSD for the cases where the bead is above a coverslip or far from the cell wall has a Lorentzian shape, the PSD shape deviates as the bead is moved closer to the cell.

## Other Applications

*Click to Jump to a Topic:*

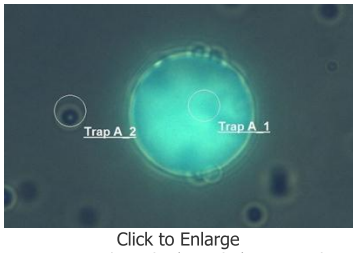


---

**Combination with Other Imaging Modalities**

The OTM200 and OTM211 Optical Tweezers can be combined with a wide variety of imaging and spectroscopic methods, such as phase contrast, differential interference contrast, fluorescence imaging, confocal imaging, or Raman spectroscopy.

Figure 1 shows a combination of optical trapping and fluorescence microscopy. A 15 µm diameter polystyrene sphere was dyed using Dragon Green and is being lifted by the optical tweezers in the location labeled "Trap A 1." In the adjacent trap, labeled "Trap A 2," a 2 µm diameter sphere that has not been dyed is being held. The dye was excited using a high-power plasma light source, which was coupled into the microscopy path using a standard filter set. The emission of the Dragon Green dye, which is centered around 520 nm, can be clearly observed on the color micrograph.




Click to Enlarge

**Figure 1:** A sample with Ø2 and Ø15 µm polystyrene particles was prepared. The Ø15 µm particle trapped in the center of the field of view is dyed with Dragon Green. The emission at 520 nm provides the light green-blue glow in the image.

The combination of optical tweezers and Raman spectroscopy enables the investigation of a single, particular specimen and increases the possible integration times, since the specimen will not diffuse out of the laser focus. Furthermore, the background signal from the solvent is reduced and many-body effects, such as chemical signaling in biological samples, can be avoided. Results from a Thorlabs system with Raman spectroscopy capabilities are described in Butler *et al.* (Proc. of SPIE Vol. 8225 82250C-1).

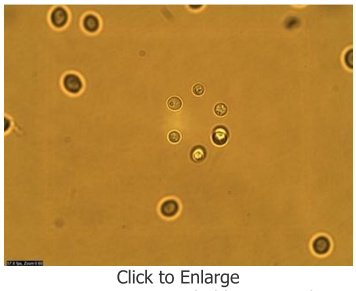
To discuss integration of an optical tweezers system into your existing experiment, please contact Tech Support.

---

**Trapping of Cells**

Optical tweezers can be employed to trap biological cells. While the cells themselves can be quite large and are filled mostly with water, the tweezers can trap the cell nucleus or other organelles, thereby stabilizing the cell's position. It is also possible to attach functionalized polystyrene particles to the cell walls.

Figure 2 shows live yeast cells in a microfluidic channel. In the absence of flow, the cells have sedimented on the bottom of the channel. The OTM211 tweezers system has picked up seven cells from the channel bottom and simultaneously holds them in a cirlce in the focal plane. In the video below, the cells are trapped in a "T" configuration, and then the traps are moved so that the cells form a circular pattern.



Click to Enlarge

**Figure 2:** OTM211 Tweezers holding several yeast cells in a circle. The cells are lifted from the bottom of the microfluidic flow channel.

In combination with other diagnostic techniques, cells can be trapped, evaluated, and sorted based on the results; only cells with interesting properties will be kept for processing.

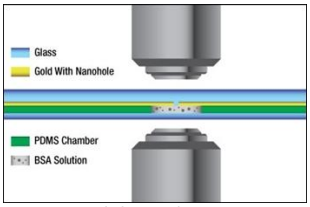
This video shows several trapped yeast cells being moved by the software from a "T" configuration into a circle.

---

**Trapping of Metallic Nanoparticles and Single Molecules**

Nanoparticles and single molecules can be trapped by optical tweezers under certain circumstances. Please contact techsupport@thorlabs.com to discuss your samples. The video below shows a Ø300 nm gold particle trapped by the OTM211. Gold nanoparticles play an important role in *in-vivo* studies, due to good biological compatibility. Trapping of gold particles with diameters ranging from tens of nanometers to a few hundred nanometers has been reported.

The illustration in Figure 3 shows a specialized sample environment that has been implemented using Thorlabs tweezers. It utilizes plasmonic enhancement to trap gold nanoparticles with a diameter of 10 nm, as well as single bovine serum albumin (BSA) proteins. The BSA molecules have a hydrodynamic radius of 3.4 nm. For details, see Pang and Gordon (Nano Lett. 12, 402-406, 2012 and Nano Lett. 11, 3763–3767, 2011).




Click to Enlarge

**Figure 3:** A diagram showing a setup for trapping Bovine serum albumin (BSA) proteins. The PDMS chamber is a sample chamber made of a silicon polymer often used in fabricating microfluidics chips. Diagram adapted from Pang and Gordon, Nano Lett. **12**, 2012.

This video shows a gold nanoparticle in a trap (labeled "TrapA_1") being moved, released, and recaptured (9 seconds in the video).

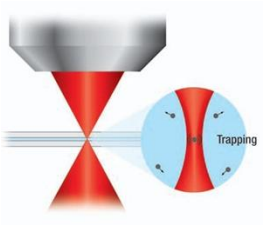
---

**Optical Trapping of Diatoms**

The video shows a Ø200 µm diatom being trapped and moved by Thorlabs' OTM211 Optical Tweezers.

The video to the right shows a diatom particle trapped using Thorlabs' optical tweezers. Diatoms are among the most common type of plankton. Most diatoms are unicellular, and enclosed within a cell wall made of silica (frustule). The large diatom disk in the video has a diameter of about 200 µm. Thorlabs' tweezers are capable of producing large forces with minimum damage, which improves the prospect for wider use of optical tweezers in microbiology. This video was taken at the Boston University Photonics Center.

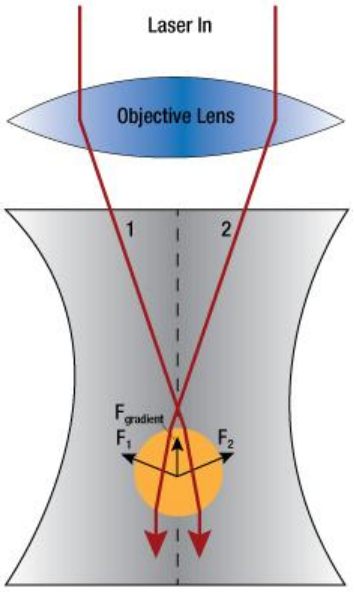
**Basic Theory of Optical Tweezers**




Optical Tweezers, or traps as they are often called, are created by using a high numerical aperture objective to tightly focus a laser beam, thereby creating a spot where a particle with dimensions on the order of microns will experience a force due to transfer of momentum from the scattering of photons.

Arthur Ashkin in the early 1970s originally demonstrated that optical forces can manipulate micro-sized dielectric particles in water (A. Ashkin. Phys. Rev. Lett. **24**, 156 - 159 [1970] and A. Ashkin *et al*. Opt. Lett. **1**, No. 5, [1986]). This technique has become an important tool in a wide range of fields such as bioengineering, material science, and physics due to its ability to hold and manipulate particles and to measure forces in the femtonewton and piconewton ranges.

The relationship between particle size and the trapping wavelengths presents two regimes to consider when developing a theory to describe optical trapping. In the Mie size regime, the diameter of a trapped particle is much larger than the wavelength of light and trapping can be described using ray optics. Rays of light are refracted as they pass through the particle, exerting a force due to the momentum change. In the case where a particle is not aligned axially in the center of the laser beam, the rays closer to the center of the beam will be more intense and will transfer more momentum to the particle than those rays closer to the edge of the beam. This will apply a lateral "gradient" force to the particle towards the center of the beam. Once the particle is in the center of the beam, the rays refracting through the particle will be symmetric, and the particle will be laterally trapped.




Click to Enlarge

Schematic showing the net gradient force on a particle (larger than the wavelength of light) in a focused laser beam.

The forces in the axial direction are more complex. As rays are backscattered at the solvent-particle interface, the light will transfer momentum to the particle, leading to a scattering force in the forward direction of the beam. With a particle near the focus of a laser beam, the gradient force $F_{gradient}$ will act towards the focus, as shown in the schematic below and to the right. The resulting overall potential has the minimum slightly offset downstream from the focus of the beam. In order to trap particles in the image plane of the microscope, the laser focus has to be slightly offset to compensate for the scattering force.

In the Rayleigh regime, the diameter of the particle is much smaller than the wavelength and the ray theory breaks down. To understand the forces, the trapped particle is considered to be a point dipole. The scattering force arises from absorption and re-radiation, while the gradient force results from the interaction between the inhomogeneous field and the induced dipole (C. N. Keir and M. B. Steven. Review of Scientific Instruments **75**, No. 9, 2004).

For particle sizes comparable to the wavelength, neither the Mie theory nor the Rayleigh theory applies; therefore, the electromagnetic field analysis is more complex. There are several references detailing this theory, such as E. Almaas and I. Brevik. J. Opt. Soc. Am. B **12**, 2429, 1995; J. P. Barton, J. Appl. Phys. **64**, 1632 (1988); P. Zemanek *et al*. J. Opt. Soc. Am. A **19**, 1025 (2002); K. F. Ren *et al*. Opt. Commun. **108**, 343 (1994).

**Measuring Forces with Optical Tweezers**

The capability of optical tweezers to measure forces on particles offers a unique and valuable tool for studying cell components such as biological proteins and molecular motors. Optical tweezers apply a force toward the focus of the trapping laser beam with a magnitude proportional to the distance of the particle from the focus for small displacements from the center of the trap. As the laser beam passes through a trapped particle, it will be deflected by an amount that depends on the position of the particle relative to the center of the trap. The deflection is converted to an electrical signal by a quadrant photodiode, which produces a voltage proportional to the particle position through back focal plane interferometry (F. Gittes and C. F. Schmidt. Opt. Lett. **23**, No. 1, 1998).

Accurate force measurements depend on precise calibration of the force constant and the responsivity of the particle position detector, which varies with laser power and particle properties. Common methods for ascertaining the force constant are Power Spectral Density (PSD) roll-off, equipartition, and Stokes' drag.

In the PSD roll-off method, the power spectral density of a time series of trapped particle positions (due to Brownian motion) is computed. This is fit to the response of a harmonic oscillator with known damping due to the viscosity of the solvent. This is described by the equation:

$$S_{vv}(\mathrm{f}) = \rho^2 \frac{\mathrm{k}_B T}{\pi^2 \beta (f_o^2 + f^2)}$$

Here, $S_{VV}$ is the uncalibrated power spectrum, ρ is the linear voltage displacement calibration factor, $k_B$ is Boltzmann's constant, T is the temperature of the medium, β is the drag coefficient, and $f_0$ is the characteristic corner frequency.

The equipartition method equates the average potential energy of the particle in the trap to the thermal energy of the solvent molecules. In the Stokes method, the sample is translated with a range of velocities. A force balance between viscous drag on the particle and the trap force is computed. Since each method relies on a different physical principle, the combined results provide a convenient way to verify the calibration. The PSD roll-off method offers a particularly effective way to discover an inaccurate position detector calibration, since it does not depend on the detector responsivity like the other two methods.

## REFERENCES


Roder, P. B., Manandhar, S., Smith, B. E., Zhou, X., Shutthanandan, V. S. and Pauzauskie, P. J. Photothermal Superheating of Water with Ion-Implanted Silicon Nanowires. Advanced Optical Materials, 3, 1362, 2015.

Benjamin J. Gross and Mohamed Y. El-Naggar. A combined electrochemical and optical trapping platform for measuring single cell respiration rates at electrode interfaces. Rev. Sci. Instrum. 86, 064301, 2015

W. N. Wan Aziz, S. K. Ayop, and S. Riyanto. The Potential of Optical Tweezer (OT) for Viscoelastivity Measurement of Nanocellulose Solution. Jurnal Teknologi 74, 45, 2015.

Gusachenko, I.; Truong, V.G.; Frawley, M.C.; Nic Chormaic, S. Optical Nanofiber Integrated into Optical Tweezers for In Situ Fiber Probing and Optical Binding Studies. Photonics 2, 795, 2015.

Abhay Kotnala, Skyler Wheatona, and Reuven Gordon. Playing the notes of DNA with light: extremely high frequency nanomechanical oscillations. Nanoscale 7, 2295, 2015.

Skyler Wheaton, Ryan M. Gelfand, and Reuven Gordon. Probing the Raman-active acoustic vibrations of nanoparticles with extraordinary spectral resolution. Nature Photonics 9, 68, 2015.

Pick Chung Lau, Zhaozhao Zhu, Robert A. Norwood, Masud Mansuripur, and Nasser Peyghambarian. Thermally robust and blinking suppressed core/graded-shell CdSe/$CdSe_{1-x}S_x$/CdS 'giant' multishell semiconductor nanocrystals. Nanotechnology 24, 475705.

Kuan-Yu Chen, An-Ting Lee, Chia-Chun Hung, Jer-Shing Huang, and Ya-Tang Yang. Transoport and Trapping in Two-Dimensional Nanoscale Plasmonic Optical Lattice. Nano Lett 13, 4418, 2013.

Yuanjie Pang and Reuven Gordon. Optical Trapping of a Single Protien. Nano Lett 12, 402, 2012.

Corey Butler, Shima Fardad, Alex Sincore, Marie Vangheluwe, Matthieu Baudelet, and Martin Richardson. Multispectral optical tweezers for molecular diagnostics of single biological cells. Proc. SPIE 8225 82250C-1, 2012.

Ana Zehtabi-Oskuie, Jarrah Gerald Bergeron, and Reuven Gordon. Flow-dependent double-nanohole optical trapping of 20 nm polystyrene nanospheres. Scientific Reports 2, 966, 2012.

Yuhang Jin and Kenneth B. Crozier. An optical manometer-on-a-chip. Proc. SPIE 8097 80971U, 2011.

## Complete Optical Tweezers Microscope System

- Particle Tracking and Force Measurement System
- Includes Nikon Eclipse Ti Inverted Microscope and Force Measurement Module
- Dual Beam Paths for Multiple Time-Shared Traps

| Included Components[a] |
|---|
| Nikon Eclipse Ti-S Inverted Microscope |
| 1064 nm Trapping Module, Dual Beam |
| Force Measurement Module for Dual Beam Paths |
| High-Resolution XYZ Piezo Stage |
| Trappping Objective and Condenser |
| CCD Camera |
| Software Package with Force Module Option |
| Computer and Monitor |

Thorlabs' OTM211 provides a complete system, including a Nikon Eclipse Ti-S inverted microscope, for optical manipulation and quantitative force measurements. The optical tweezers module attaches directly to the back port of the microscope, where a dichroic mirror directs the laser beams towards the microscope objective. In addition to the microscope, this system comes complete with the laser source, a high-resolution XYZ piezo-driven stage, force measurement module, control and data acquisition electronics, and a computer with preinstalled software. The included software package provides full control of the traps, as well as force calibration and measurements.

- See *Specs* Tab for Additional Information

The OTM211 is compatible with additional filter turret layers, adding adaptability to the system's overall design. For example, it is possible to add a fluorescence imaging device to the setup. For sample positioning, an XY manual translation stage (70 mm of X travel and 50 mm of Y travel) is combined with a high-resolution (200 µm) XYZ piezo stage.

The laser source of this system is available in wavelengths other than 1064 nm; please contact Tech Support for more information.

| Part Number | Description | Price | Availability |
|---|---|---|---|
| **OTM211** | **Optical Tweezers System with Nikon Eclipse Ti Microscope** | **$0.00** | **Lead Time** |

## Optical Tweezers System Add-On

- System Add-On for Existing Inverted Microscopes
- Compatible with Nikon, Olympus, and Leica Microscopes
- Dual Beam Paths for Multiple Time-Shared Traps

| Included Components[a] |
|---|
| 1064 nm Trapping Module, Dual Beam |
| Trappping Objective |
| CCD Camera |
| Beam Dump Module |
| Software Package |
| Computer and Monitor |

Thorlabs' OTM200 provides an add-on system capable of integrating into an existing inverted microscope system. It is compatible with platforms of most major manufacturers, such as Nikon, Olympus and Leica. This system includes the laser source, control and data acquisition electronics, and a computer with preinstalled software. The included software package provides full control of the traps.

- See *Specs* Tab for Additional Information

This system features a wide range of customized options. Besides configurations for different microscopes, it also supports other camera models and can be offered with customized sets of optics and additional imaging modalities. The OTM200 can be upgraded to include the force measurement module and the laser source is available in wavelengths other than 1064 nm. Please contact Tech Support for more information about customization or integration with an existing microscope.

| Part Number | Description | Price | Availability |
|---|---|---|---|
| **OTM200** | **Customer Inspired! Optical Tweezers Upgrade Configuration for Existing Microscopes** | **$82,000.00** | **Lead Time** |

## Sample Preparation Kit

The OTKBTK is designed for use with our OTKB Modular Optical Tweezers, our OTM200 Optical Tweezers Microscope System, and our EDU-OT2 Educational Discovery Kit. It allows users to quickly prepare a sample and test for optical trapping once they have completed construction. Included with the kit are the following:


Click to Enlarge

- Non-Drying Immersion Oil for Microscopy, Cargille Type LDF
  - Not for Use with EDU-OT2(/M)
- Non-Functionalized Fused Silica Beads in Deionized Water, Ø2.06 µm, 2 g/ml
- Mini Pipette with a 50 µL Volume
- Two Plastic Slides with Built-In Channel, 400 µm Height, 100 µL Volume
- 5 Microscope Glass Slides with Reaction Wells, Ø10 mm, 20 µm Deep
- 100 Pieces of 18 mm x 18 mm Cover Glass, No. 1.5 Thickness
- Dropper for Immersion Oil

| Part Number | Description | Price | Availability |
|---|---|---|---|
| **OTKBTK** | **Optical Tweezer Kit - Sample Preparation Kit** | **$148.00** | **Lead Time** |