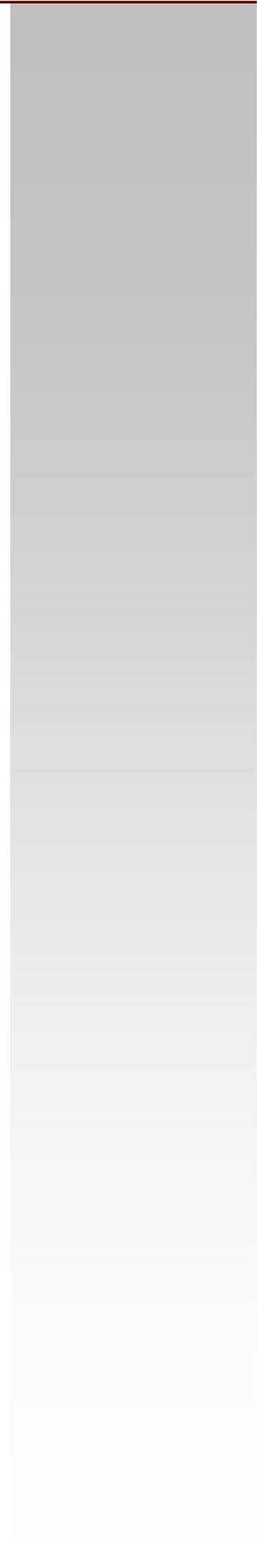
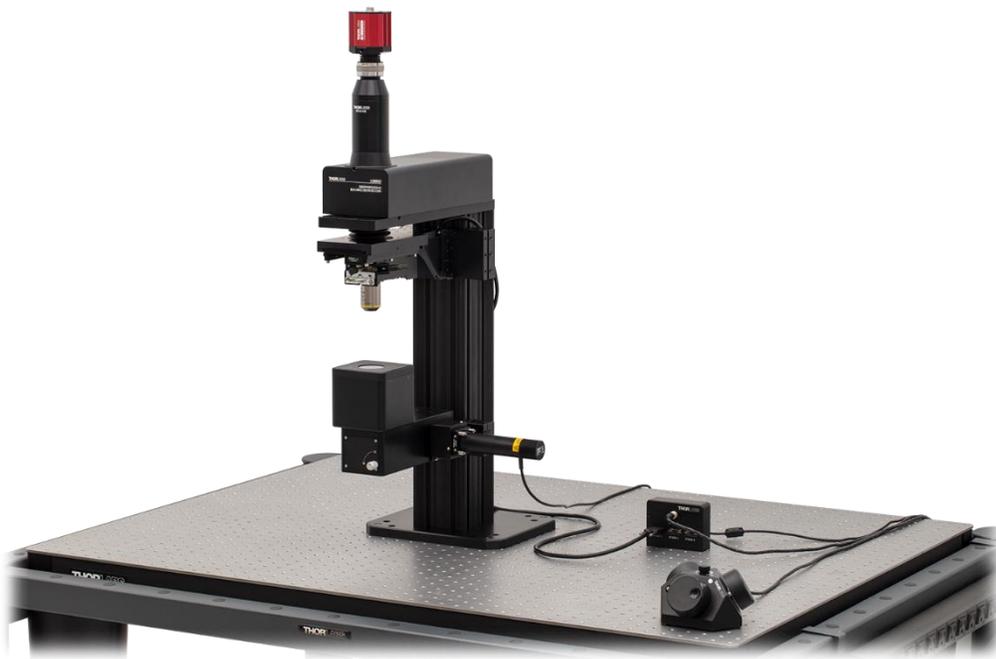




# CM501 and CM502 Cerna<sup>®</sup> Birefringence Imaging Microscopes

User Guide



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## Chapter 1 Safety

**Warning: Risk of Electrical Shock**

High voltage inside. To avoid electrical shock, before powering up, make sure that the ground pin of the power cord is correctly connected to the ground connector in the power socket. Improper grounding can cause electric shock resulting in severe injury or even death. Do not operate without the cover installed.

**Caution**

Except for the main fuse, which is accessible from the outside of the housing, CM501/CM502 has no user-serviceable parts. Service should only be performed by trained service personnel.

**Caution**

This unit must not be operated in explosive environments.

**Caution**

Transportation and delivery may cause the CM501/CM502 to be warm or cool upon receipt. Please wait for the whole device to reach room temperature before attempting to operate.

**Caution**

Do not operate in wet/damp conditions. Do not obstruct the air ventilation slots in the housing.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: Reorient or relocate the receiving antenna.—Increase the separation between the equipment and receiver.— Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.—Consult the dealer or an experienced radio/TV technician for help.

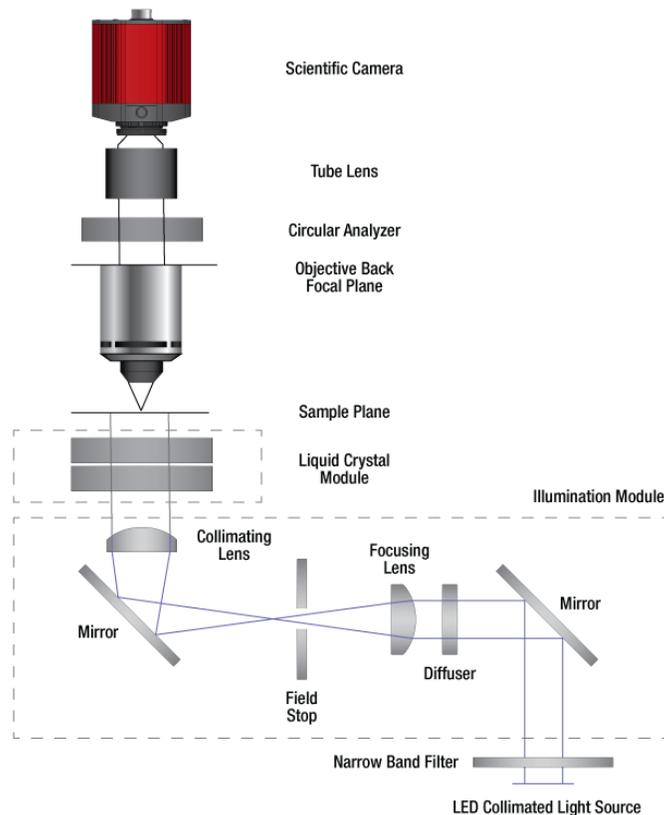
## Chapter 2 Getting Started

### 2.1 Introduction

Thorlabs' CM501/CM502 Cerna® based Birefringence Imaging Microscope is particularly well-suited for characterizing stress-induced birefringence, in addition to measuring the retardance and azimuths of flat, planar samples, such as crystals and liquid crystal devices, visualize biological cells, like a cotton fiber or human hair follicle. These data are useful in academic research, medical diagnostics, industrial manufacturing, and product quality assurance applications.

Thorlabs' CM501/CM502 Birefringence Imaging Microscope is based on Thorlabs's flexible Cerna® microscope and includes a scientific-grade camera and an objective with 10x magnification. System control is provided by a user-friendly Graphical User Interface (GUI). A standard laptop or PC that includes two USB ports (USB 2.0 and 3.0) is required to run the software. The system is designed to operate at a wavelength of 633 nm and measures retardance up to a half-wave (316 nm), as well as the complete azimuth range from  $-90^\circ$  to  $+90^\circ$ . The operational wavelength can be customized from 488 nm to 780 nm. To customize this operational wavelength, please contact Tech Support at [techsupport@thorlabs.com](mailto:techsupport@thorlabs.com) for more details.

A diagram of the system operation for the CM501/CM502 microscopes is shown as below. A Mounted LED in combination with a collimation lens and narrowband Filter provide a 633 nm collimated light source that is steered into the liquid crystal module by a Trans-Illumination Module. The liquid crystal module can set a number of different linear and circular input polarizations. The sample under test is placed at the focal plane of an integrated 10X objective (Nikon Plan Fluorite, 0.3 NA). A circular analyzer is set at the back focal plane of the objective to filter the transmitted light. A Monochrome Scientific Camera records the intensity images for each sequential input state of polarization.



**Figure 1** Optical Schematic of Birefringence Imaging Microscope

## 2.2 Parts List – Accessories

The Cerna®-Based Birefringence Imaging Microscope is carefully packaged in a Pelican 1690 case. The complete system consists of a main unit and the following standard accessories.

### Note

All the CM50x Birefringence Imaging microscopes are supplied with one USB3.0 cable. These cables are constructed to provide reliable data throughput at a length of 3 m. Do not replace this cable with a 3 m cable from a different vendor. The use of a shorter cable (1 m or 2 m) might be acceptable but is not guaranteed. Never use any cable that is longer than 3 m on a USB 3.0 system.

### Item # CM501

- 12 VDC Power Supply, Item # DS12
- Power Cord (Region-Specific)
- USB Drive with Software and Manual
- High Speed USB 2.0 Type-A to Type-B Cable, 2 m
- Super Speed USB 3.0 A to Micro B Cable, 3 m
- Control Cable, 2 m
- Birefringent NBS 1963A Resolution Target, Item # R2L2S1B
- Protective Tapes
- 10x Objective, Item # N10X-PF
- Camera Assembly
- LED Assembly
- 9-Piece Hex Key Set, Metric, Item # CCHK/M

**Item # CM502**

- 12 VDC Power Supply, Item # DS12
- Power Cord (Region-Specific)
- USB Drive with Software and Manual
- High Speed USB 2.0 Type-A to Type-B Cable, 2 m
- Super Speed USB 3.0 A to Micro B Cable, 3 m
- Control Cable, 2 m
- Birefringent NBS 1963A Resolution Target, Item # R2L2S1B
- Protective Tapes
- 10x Objective, Item # N10X-PF
- Camera Assembly
- LED Assembly
- 9-Piece Hex Key Set, Metric, Item # CCHK/M
- Three-Channel Controller and Knob Box (Item # MCM3001) which includes:
  - Knob Box
  - Controller Box
  - Joystick Controller Cable
  - Power Supply
  - Power Cord (Region-Specific)
  - USB Cable (A to B)
  - Two 1/4"-20 Cap Screws, 1/2" Long
  - Two M6 Cap Screws, 12 mm Long
  - Six 4-40 Hex Stand-Offs to Secure Cables

**2.3 Unpacking**

Open the Pelican case and check that all accessories are packed in the case according to the included packing list.

**Note**

Always wear gloves when handling, setting up, and working with the system.

The following procedure is recommended for transferring the CM501/CM502 main unit to the table where it will be operated:

- ❑ **Step 1:** Open the case and remove the first foam layer carefully. Retain the protective tape and use it to protect the main unit from dust when repackaging is needed.

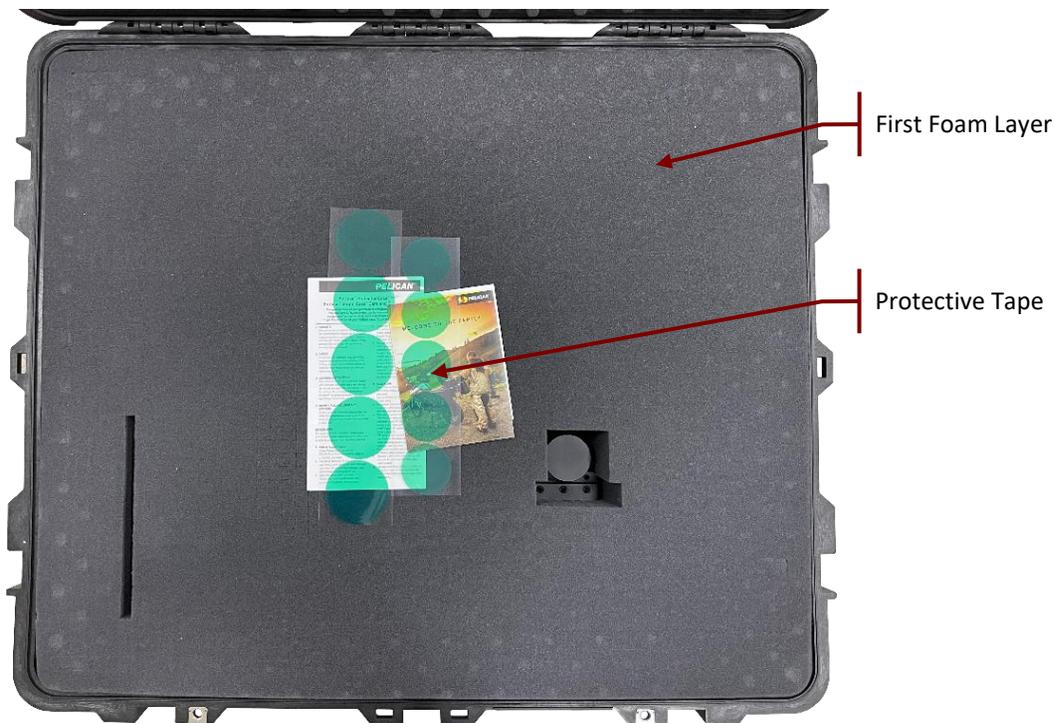


Figure 1 First Layer of CM501 Packaging

- ❑ **Step 2:** Take out the accessories and put them on the optical table. Then remove the second foam layer carefully. Note that main unit should remain in the Pelican case while this is done.

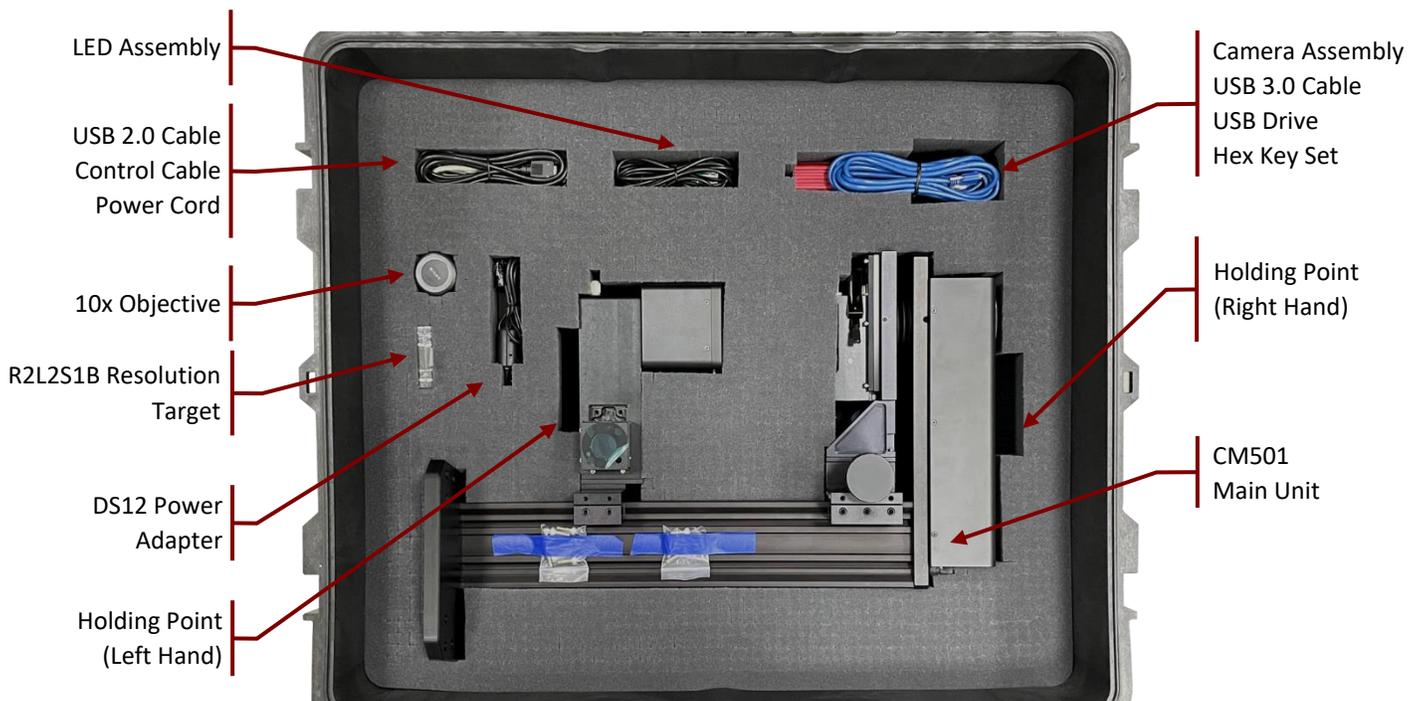
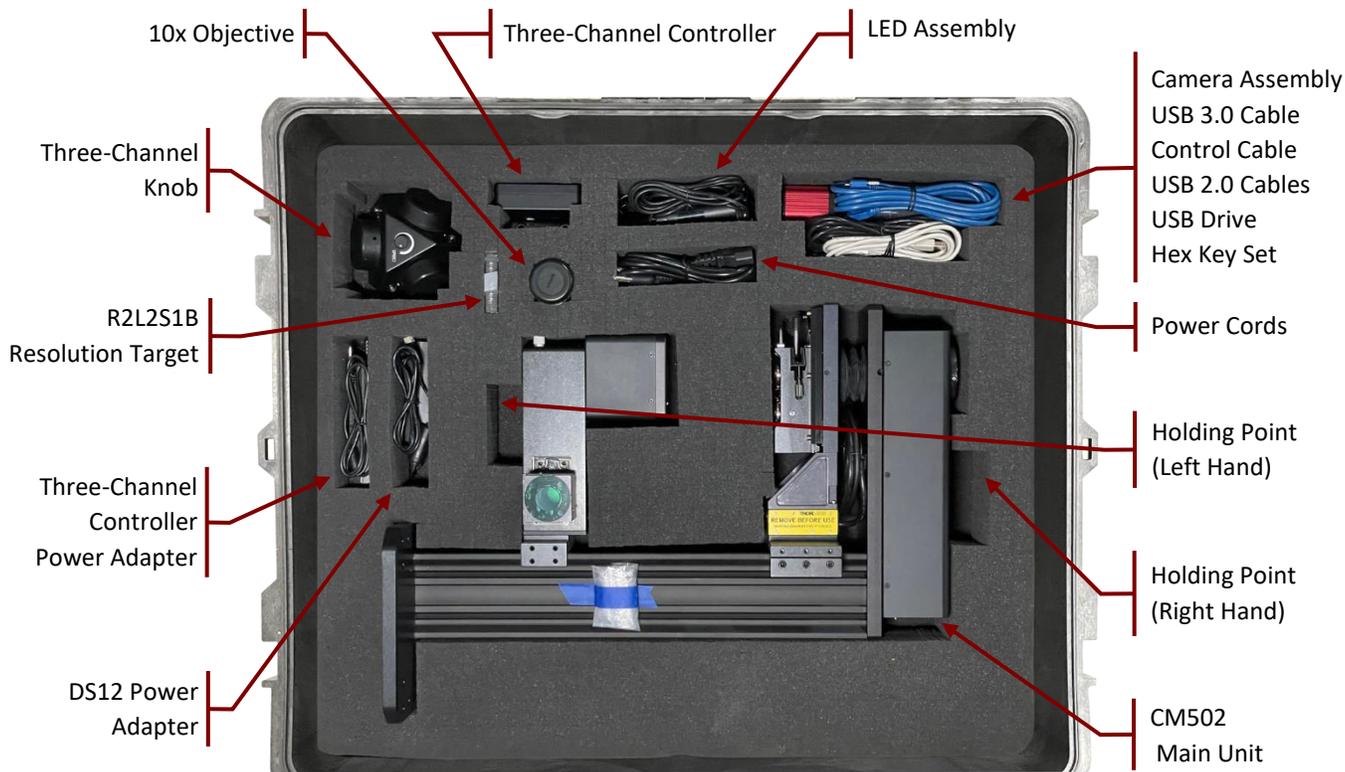


Figure 2 Second Layer of CM501 Packaging



**Figure 3** Second Layer of CM502 Packaging

- ❑ **Step 3:** Use both hands to transfer the main unit, as shown in Figure 4, to the optical table. Then use at least four screws to secure the main unit to the optical table.

**Note**

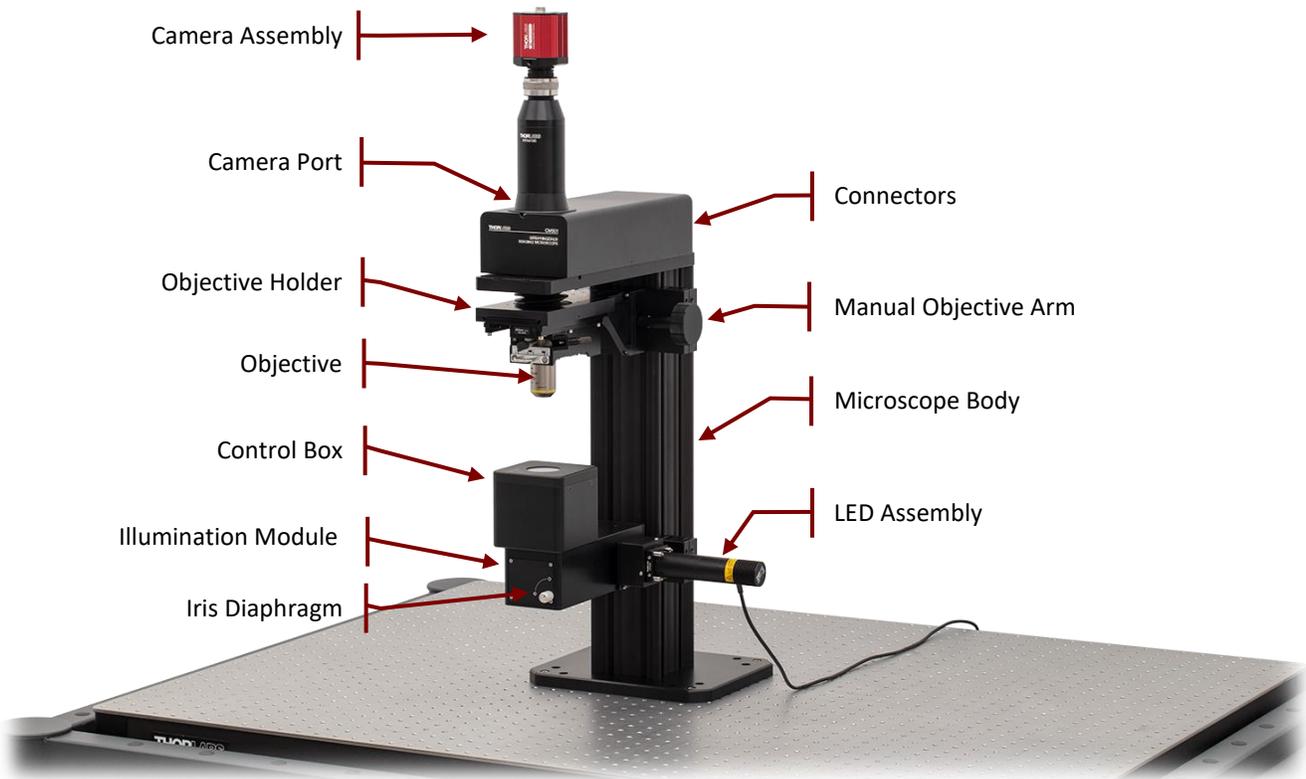
Lifting the unit while grasping it at points other than those shown in Figure 4 is not recommended, as this may cause damage to the main unit as well as human injury. If there is difficulty transporting the unit with two hands to its final location, the unit may first be placed upright on an intermediate surface that is stable and flat. The unit may then be transported to its final location using one hand grasping the main body rail and the other hand supporting the base.



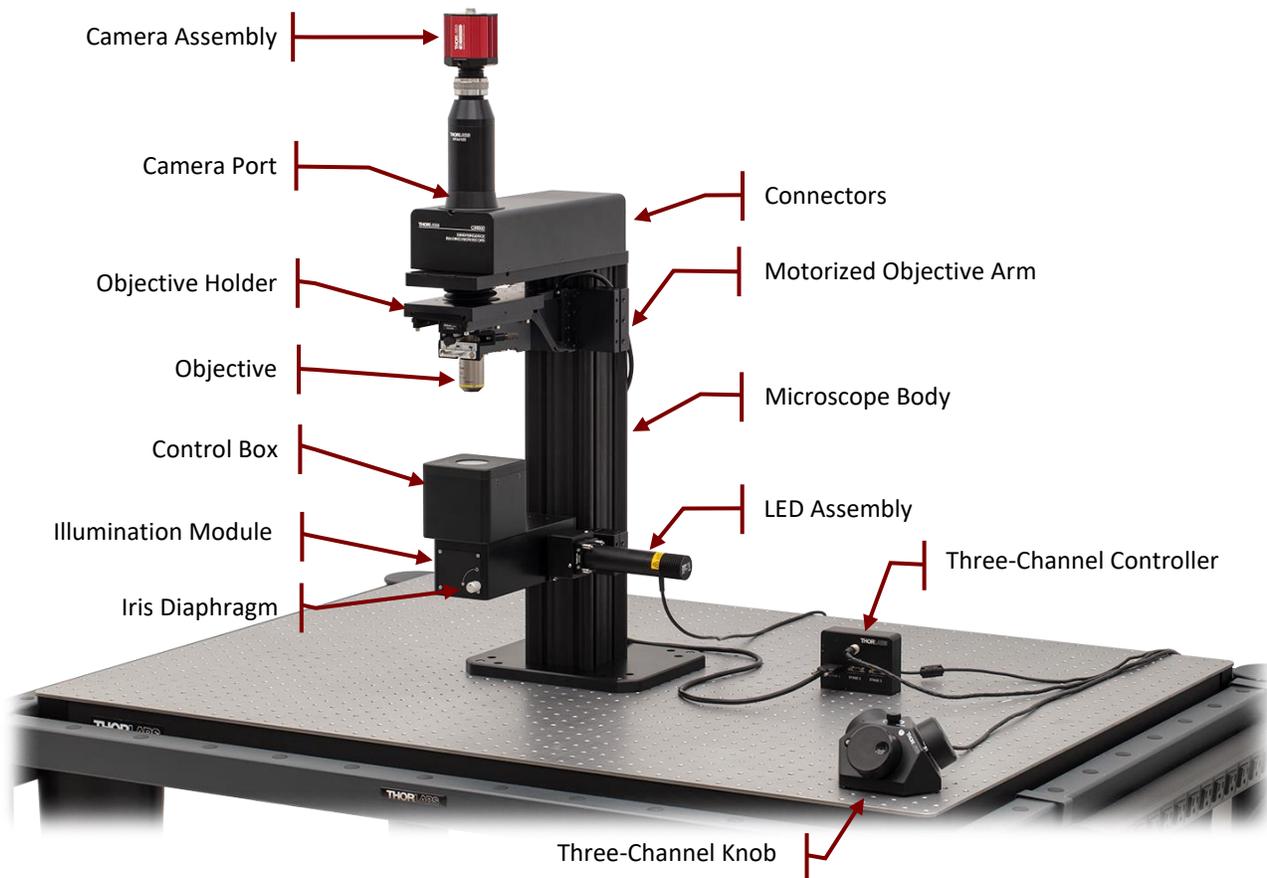
**Figure 4** Recommended Operation to Transfer the CM501/CM502 Main Unit from One Place to Another

After unpacking the system, store the packaging cartons and the Pelican case. If the Birefringence Imaging Microscope needs to be serviced or returned, it must be transported within the Pelican case.

### 2.4 Identification and Function of System Components



**Figure 5** Identification of CM501 Imaging Microscope



**Figure 6 Identification of CM502 Imaging Microscope**

The tables below list the standard components of CM501 and CM502 Imaging Microscopes:

Component	CM501	CM502
<b>LED Assembly</b>	625 nm, 700 mW (Min) Mounted LED, Item # M625L4	
	Collimating Lenses, Item # LA1134-A, ACL12708U-A	
	Ø1" Laser Line Filter, CWL = 632.8 ± 0.2 nm, Item # FL632.8-1	
	Cage Assembly Rod, 1" Long, Item # ER1	
	SM1-Threaded 30 mm Cage Plate, Item # CP33/M	
<b>Illumination Module</b>	Transmitted Light Illumination / DIC Imaging Module, Item # WFA1000	
<b>Microscope Body</b>	Cerna Microscope Body with Epi-Illumination Arm, 500 mm Rail, Item # CEA1500	
<b>Connectors</b>	USB 3.0 USB 2.0 Control LED Connector Power Adapter Connector	
<b>Control Box</b>	Liquid Crystal Optical Components Integrated	
<b>Camera Assembly</b>	1X Camera Tube with C-Mount, Item # WFA4100	
	Kiralux 5.0 MP Monochrome CMOS Camera, USB3.0 Interface, Item # CS505MU	

Component	CM501	CM502
Objective Arm	Manual Module with 1" Travel for Edge-Mounted Arms, Item # ZFM1020	Motorized Module with 1" Travel for Edge-Mounted Arms, Item # ZFM2020
	N/A	Three-Channel Controller and Knob Box for 1" Cerna Travel Stages, Item # MCM3001
Objective	10X Nikon Plan Fluorite Imaging Objective, Item # N10X-PF	
Objective Holder	Nosepiece for 2 Objectives, Item #s CSN1202 and CSA1200	

Standard systems use an integrated 633 nm LED as the light source. If a light source with a custom wavelength was selected, then it will instead be integrated into the delivered system.

All of the CM501/CM502's optical components are designed and tuned for either 633 nm or for the custom operational wavelength specified at the time of purchase. The configuration and positions of the optics within the system are carefully aligned in the factory. There are no user serviceable components.

An integrated Thorlabs' CS505MU Monochrome CMOS camera is used to capture the sample image. The camera's sensor has 2448 x 2048 (H x V) pixels. The default imaging microscope configuration provides an objective with 10x magnification and a camera tube lens with 1x magnification. This results in a spatial resolution and field of view of the system of 1.055  $\mu\text{m}$  and 0.84 x 0.71 mm.

#### 2.4.1 Sample Stage and Sample Holder

The standard CM501/CM502 system is a pre-installed microscope system. It is compatible with Thorlabs' sample holders (available separately, see the following for more information) which support slide holders, petri dishes, recording chambers, micromanipulators, and other samples that will be inserted into a Cerna® microscope's optical path. There are also manual and motorized stages providing XY translation, which can be integrated with the rigid stands.

Manual and motorized kits below are recommended for general applications. All of them are convenient for space-constrained microscopy systems, in which several stands are used.

❑ Manual Kit – Option 1



**Figure 7 Rigid Stand Slide Holder and manual XY Translation Stage with CM501**

This manual kit consists of an MP200-MLSH rigid stand, an MLS203P2 Petri Dish/Slide holder, an XRN25P-K1 XY translation stage and an MPA1 Adapter. It offers X and Y horizontal axis translation up to 25 mm and maintains a slim profile that consumes a minimal amount of space in and around the optical path.

Item Number	Qty.	Description
MP200-MLSH	1	Large Insert Holder, Adjustment Height: 248.1 - 410.1 mm
MLS203P2	1	Petri Dish/Slide Holder for Inverted Microscopes
XR25P	1	25 mm Travel Linear Translation Stage, Side-Mounted Micrometer
XR25C	1	25 mm Travel Linear Translation Stage, End-Mounted Micrometer

### ❑ Manual Kit – Option 2



**Figure 8** *Olympus U-SV Manual XY Stage with CM502*

The second manual kit contains an CSA1051 Olympus Stage Adapter Arm, an CSS2000 manual Olympus XY stage Slide Holder and an CSS2001 manual Olympus XY stage. It provides 80 mm (3.1") of translation along the X axis and 54 mm (2.1") of translation along the Y axis without obstruction. A Vernier scale with 100  $\mu\text{m}$  resolution alongside each axis provides high precision sample positioning.

Item Number	Qty.	Description
<b>CSA1051</b>	1	Olympus Stage Adapter Arm for Cerna Microscope
<b>CSS2000</b>	1	Manual Olympus XY Stage Slide Holder
<b>CSS2001</b>	1	Manual Olympus XY Stage for Upright Microscope

Other customized sample holder adapters are available. Please contact Thorlabs' Tech Support prior to purchase.

### ❑ Motorized Sample Stage

The motorized kit consists of an 2D XY motorized translation stage (Item # PLS-XY) and an MP100-RCH2 rigid stand. The MCM3001 3-Axis Controller is used to adjust the stage's position. The stage is compatible with loads up to 42 lbs and mounts to the bottom of the rigid stand, which maintains the stand's compact footprint.



**Figure 9 Rigid Stand and motorized XY Stage with CM501**

Item Number	Qty.	Description
MP200-MLSH	1	Large Insert Holder, Adjustment Height: 248.1 - 410.1 mm
PLS-XY	1	2D Motorized Translation Stage for Rigid Stands
MCM3001*	1	Three-Channel Controller and Knob Box for 1" Cerna Travel Stages

#### Note

\*The standard CM502 contains an MCM3001 three-channel controller with two free ports available. Therefore, it is not necessary to purchase this additional MCM3001 controller if the motorized sample stage solution is chosen.

## 2.5 System Information and Connections

An XY-Coordinate is engraved on the top surface of control box for the indication of Azimuth (Fast-Axis orientation) measurement.



**Figure 10** XY-Coordinate for Azimuth measurement

The control connector is located on the rear side of the control box.



**Figure 11** The back of control box

The system connections, serial number and the manufacturing number are located on the rear side of the main unit:



**Figure 12** The back of the main unit

Connections from left to right:

- Control
- Service Switch (for Technical Support only)
- USB 2.0 Type B Connector to laptop or PC
- Light Source Connector
- Power Supply Connector
- Power Switch

## 2.6 Setting Up the CM501/CM502

### 2.6.1 General Setup

For optimal image acquisition, we strongly advise that the following standard practices are met:

- Acquire images with the system mounted on actively isolated platforms or vibration-damping tables. Failure to utilize appropriate mounting platforms results in poor quality images. Thorlabs offers a wide array of optical tables and mounting platforms providing the required stability.
- Avoid placing other instruments or machines that vibrate in close proximity to this imaging microscope. Such items include refrigeration units, cell culture incubators, hoods, etc.
- Minimize air drafts, as these can result in movement of the imaging microscope and affect sample focus. Drafts can also lead to particulate contamination that can damage your hardware and/or introduce artifacts into your imaging field.
- Operate in light-controlled environments to reduce optical noise.
- Ensure the system's environment meets manufacturer's specifications. Considerations include mounting the system in a location that provides sufficient distance between it and surrounding walls and ceilings, proper regulation of temperature and humidity, sufficient sources of electrical power, and etc.

## 2.6.2 System Installation



### Caution

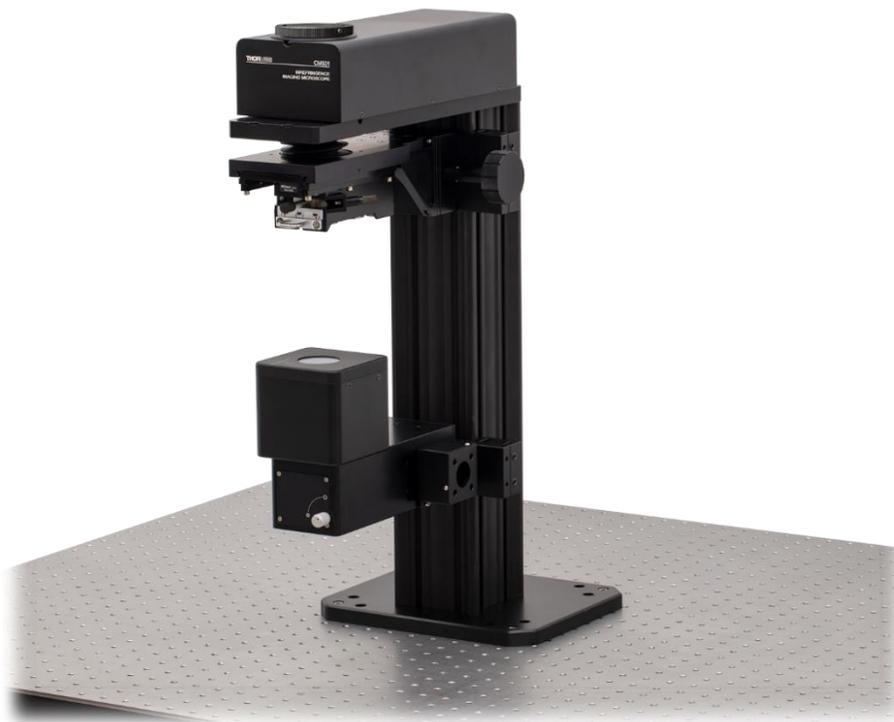
Initial component assembly required. Should assistance be required, arrangements can be made for a service appointment to install the system. Please contact Thorlabs (techsupport@thorlabs.com or imagingtechsupport@thorlabs.com) to obtain a quotation for installation services

Steps for installing the system, which is done before running the system software, are described in the following:

- ❑ **Step 1:** Mount the main unit onto the optical table as shown below. Secure the main unit to the mounting platform using at least four screws, i.e., at least one screw at each corner.

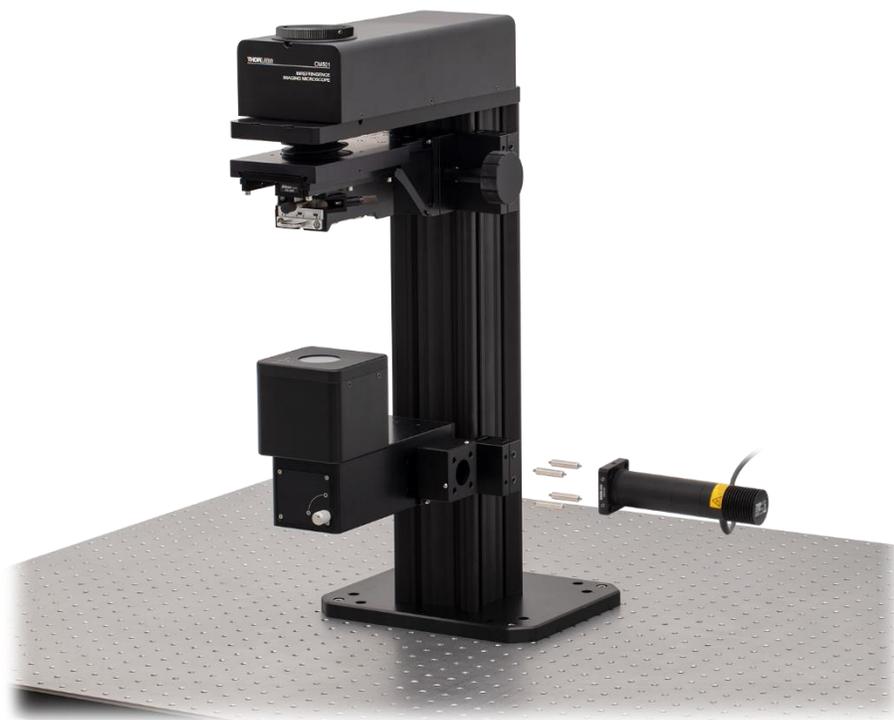


**Figure 13** Counterbores for main unit securing



**Figure 14** Mount the main unit onto the optical table

- ❑ **Step 2:** Mount the LED Assembly onto the illumination module of main unit.



**Figure 15** Mount the LED assembly onto the illumination module

**Note**

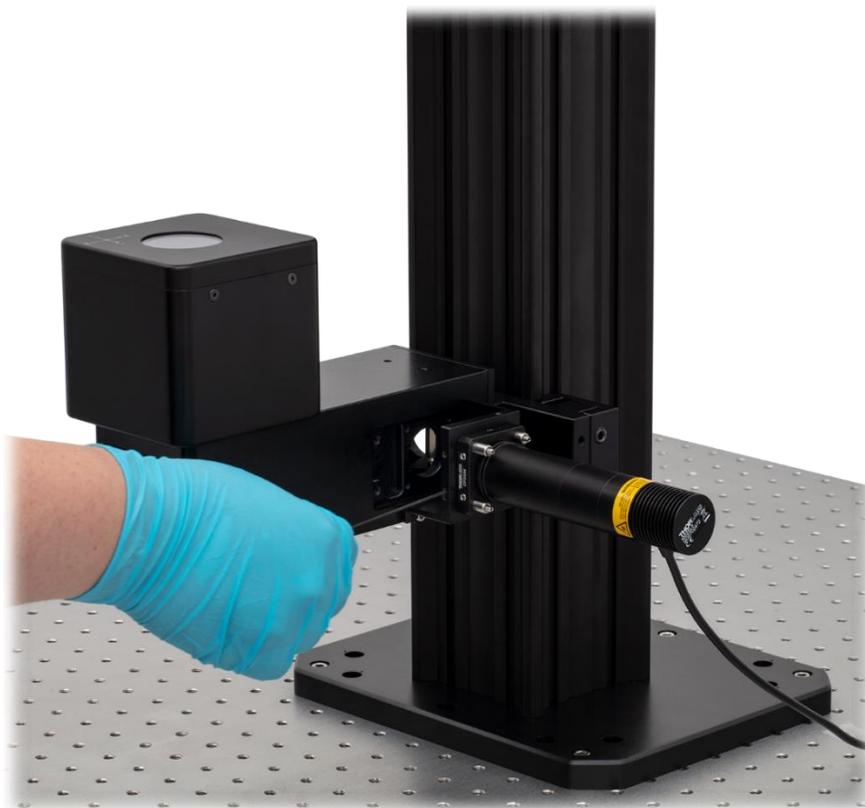
Remove the Green Tapes on LED Assembly and Illumination Module before Installation!

To mount the LED assembly onto the illumination module, use a 2.5 mm hex key or ball driver to remove the locking screw of the dust cover on the illumination module.



**Figure 16** Loosen the locking screws of dust cover (2 sets)

Attach the LED assembly on the illumination module with four cage rods. Secure the locking screws between illumination module, cage rods and cage plate by using a 1.3 mm hex key or ball driver.



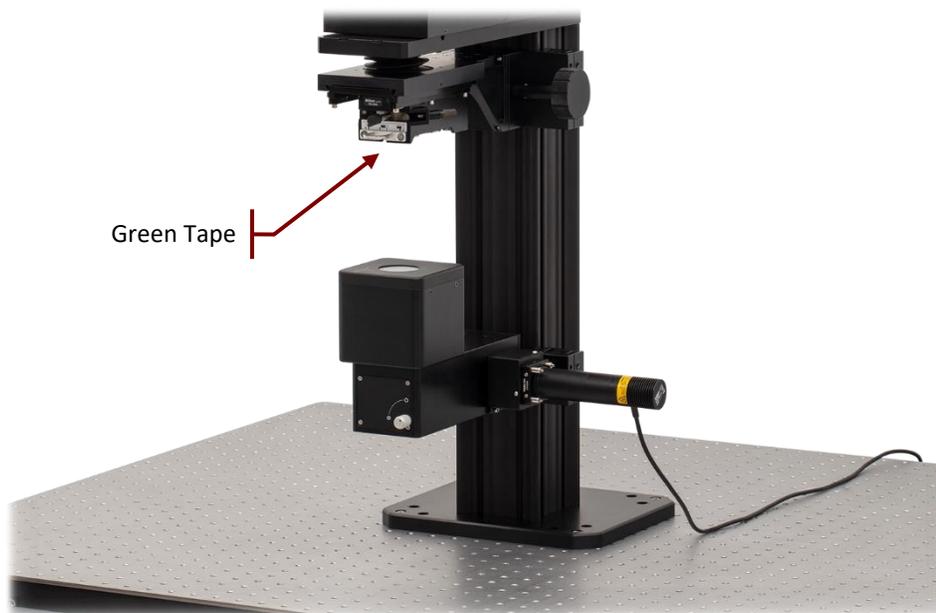
**Figure 17** Secure the locking screws between illumination module and cage rods (4 sets)



**Figure 18** Secure the locking screws between Cage Plate and cage rods (4 sets)

- ❑ **Step 3:** Install the objective on the objective holder.

Remove the Green Tape on objective holder and install the objective on the objective holder.



**Figure 19** Remove the green tape before objective installation



**Figure 20** Objective installed

- ❑ **Step 4:** Loosen the locking screw with a 2 mm hex key or ball driver and remove the dust cover on Camera Port.



Figure 21 Remove the dust cover on camera port

**Note**

When repacking is needed, put the dust cover back by aligning the dot parallel in front of the front side of main unit.

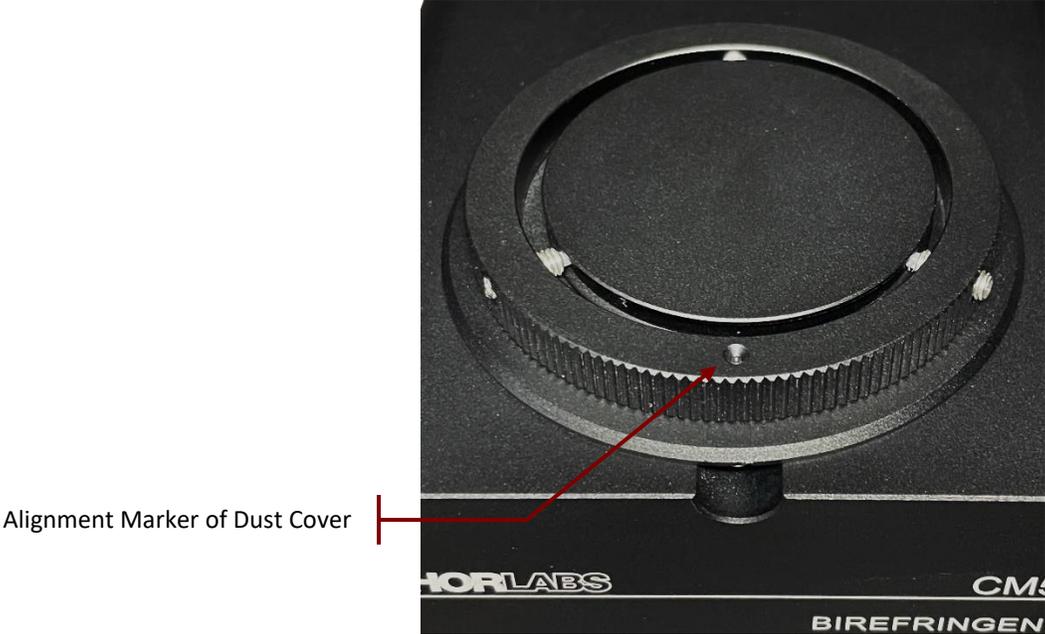


Figure 22 Remove the dust cover on camera port

- ❑ **Step 5:** Loosen the locking screw with a 1.5 mm hex key or ball driver and remove the dust cover of camera assembly.

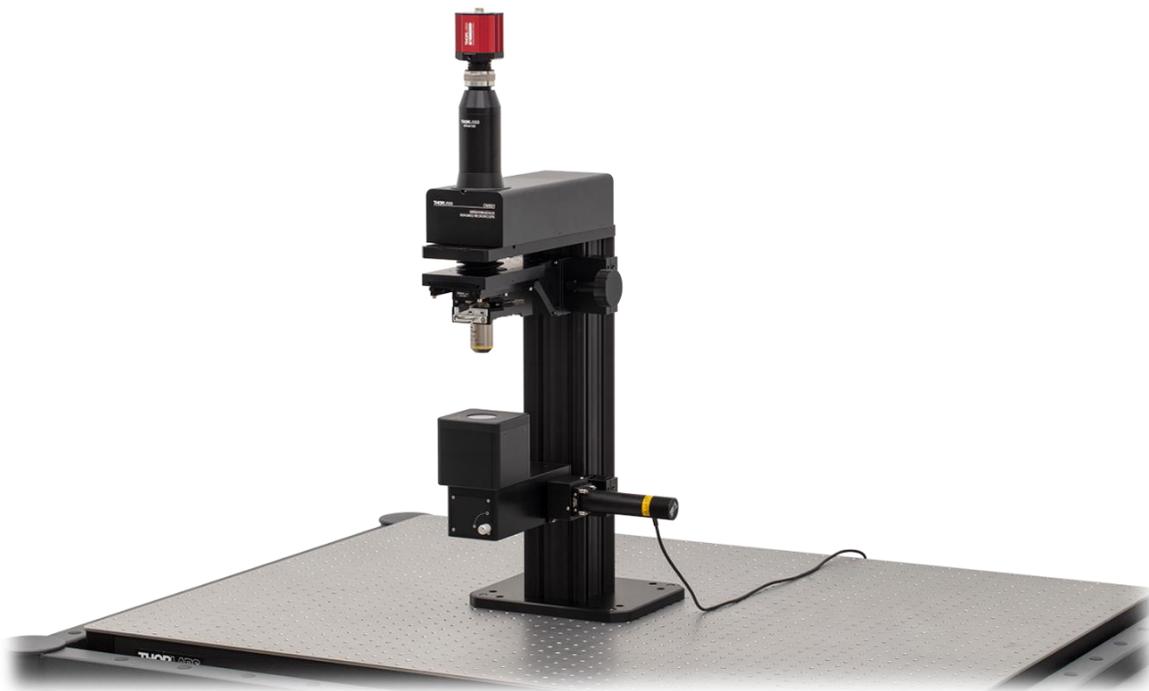


**Figure 23** Camera Assembly

- ❑ **Step 6:** Put the camera assembly on the camera port and secure the camera assembly with the locking screw.



**Figure 24** Put the camera assembly on the camera port



**Figure 25** CM501 Final Arrangement

- ❑ **Step 7:** Place a proper sample holder and stage underneath the objective.



**Figure 26** Sample holder placed underneath the objective

**Note**

Three options of sample stage are recommended in Chapter 2.4.1. Rigid Stand and other parts can be customized prior system installation.

- ❑ **Step 8:** Connect the CM501/CM502 system cables:

**CM501**

- Connect the Control cable between main unit and control box.
- Connect the USB 2.0 cable between the main unit and laptop or PC.
- Connect the USB 3.0 cable between camera and laptop or PC.
- Connect the LED cable between main unit and LED assembly.
- Connect the 12 VDC power supply to the main unit.
- Connect the power cord to the power supply and connect the other end to a wall plug.

**CM502**

- Connect the Control cable between main unit and control box.
- Connect the USB 2.0 cable between the main unit and laptop or PC.
- Connect the USB 3.0 cable between camera and laptop or PC.
- Connect the LED cable between main unit and LED assembly.
- Connect the 12 VDC power supply to the main unit.
- Connect the power cord to the power supply and connect the other end to a wall plug.
- Connect the Controller cable between Three-Channel controller box with knob box.
- Connect the cable between motorized objective arm and Three-Channel controller box.
- Connect the power supply to Three-Channel controller box.
- Connect the power cord to the Three-Channel power supply and connect the other end to a wall plug.



**Figure 27** Connector of control box of CM501/CM502



**Figure 28** Connected Cables of CM501/CM502

## Chapter 3 System Operation

### 3.1 Starting the System

**Warning: Risk of Electrical Shock**

High voltage inside. To avoid electrical shock, before powering up, make sure that the ground pin of the power cord is correctly connected to the ground connector in the power socket. Improper grounding can cause electric shock resulting in severe injury or even death. Do not operate without the cover installed.

**Caution**

This unit must not be operated in explosive environments.

**Caution**

Transportation and delivery may cause the CM501/CM502 to be warm or cool upon receipt. Please wait for the whole device to reach room temperature before attempting to operate.

**Caution**

Do not operate in wet/damp conditions. Do not obstruct the air ventilation slots in the housing.

For proper initialization of the system, the following steps are needed:

1. Start the device by switching the power switch to the “I” position. Wait for 90 seconds while system initializes.
2. After powering on, the system performs a warm-up procedure, which can take up to 30 minutes to complete.
3. The system can be operated during system warm up. However, during the warm-up period, the measurement result accuracy may not meet the quoted system specifications.
4. Install the CM501/CM502 software on the user-provided laptop or PC as described in Chapter 3.3.
5. Connect the CM501/CM502 to the laptop or PC and wait for the computer to recognize the hardware.
6. Run the system software.

### 3.2 Computer Hardware and Operating System Requirements

To run the CM501/CM502 software, the user-provided laptop or PC must meet the following requirements:

- Operating System: Windows 10, 64 bit
- One Available High-Speed USB 2.0 Port

- One Available Super-Speed USB 3.0 Port
- CPU: Intel Core i3 or Above
- RAM: 2 GB or More

### 3.3 Installing the Software

The CM501/CM502 software can be downloaded from the Thorlabs website or from the bundled USB drive.

#### Note

Do not connect the CM501/CM502 to the laptop or PC prior to software installation. Administrator privilege is required to complete software installation.

#### Note

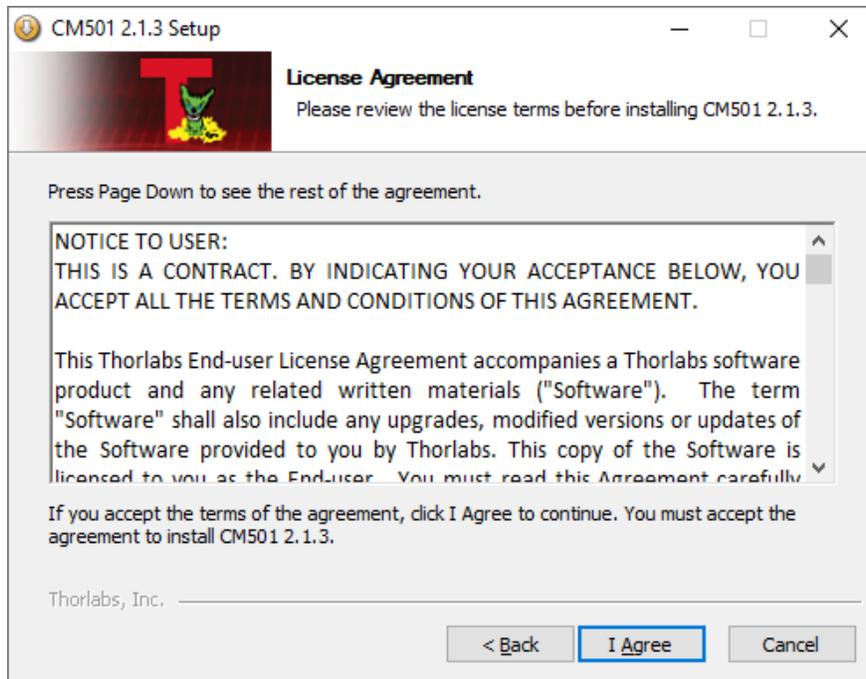
Completing the installation of the CM501/CM502 software requires that either Thorlabs' ThorCam™ Software or the ThorCam Driver also be installed on the computer. If ThorCam is not installed, then the installation procedure will automatically install the CM501/CM502 GUI as well as the ThorCam driver. If ThorCam has already been installed on the computer, then the new software will skip the installation of the ThorCam driver. If the installed ThorCam version supports the USB 3.0 Camera, then the CM501/CM502 software can run properly. If the installed ThorCam version does not support the USB 3.0 Camera, then an error will occur when running the CM501/CM502 software. If this occurs, it is necessary to first uninstall the old ThorCam driver. Then either repeat the CM501/CM502 software installation or install the latest ThorCam version, which supports the USB3.0 Camera.

The following procedures describe the installation of the CM501/CM502 software on a computer whose operating system is Windows 10, 64-bit.

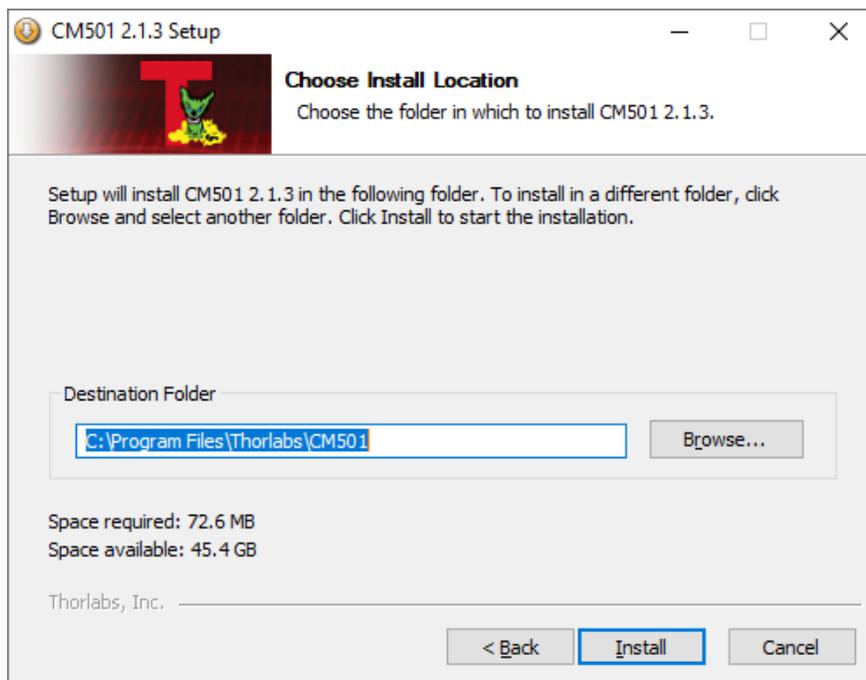
- Start the Install Shield Wizard by double-clicking "setup.exe". Click "Next" to continue.



- Click "I Agree" to continue the installation.



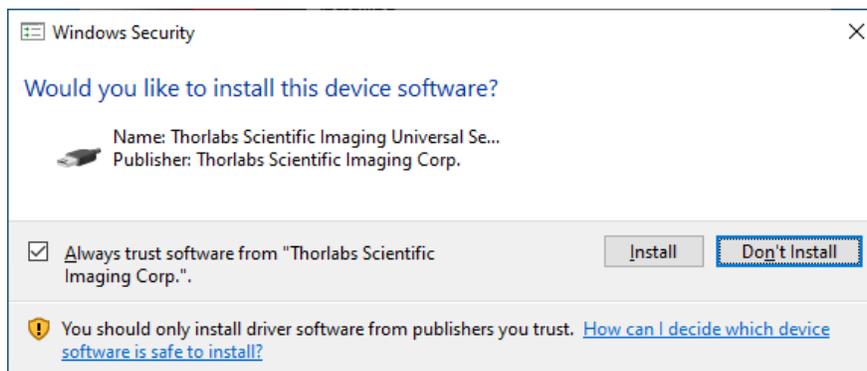
- Choose the install location and click “Install” to continue.



- Click “Finish” to close the Installation.



- If the window shown in the following image appears, click "Install" to finish the Camera Driver installation.



### 3.4 Software GUI

The CM501/CM502 Software GUI is divided into 6 functional areas:

- Main Menu
- Image Preview Window
- Camera Control
- Light Source Control
- Measurement Control
- Measurement Data View Tabs
- Status Bar

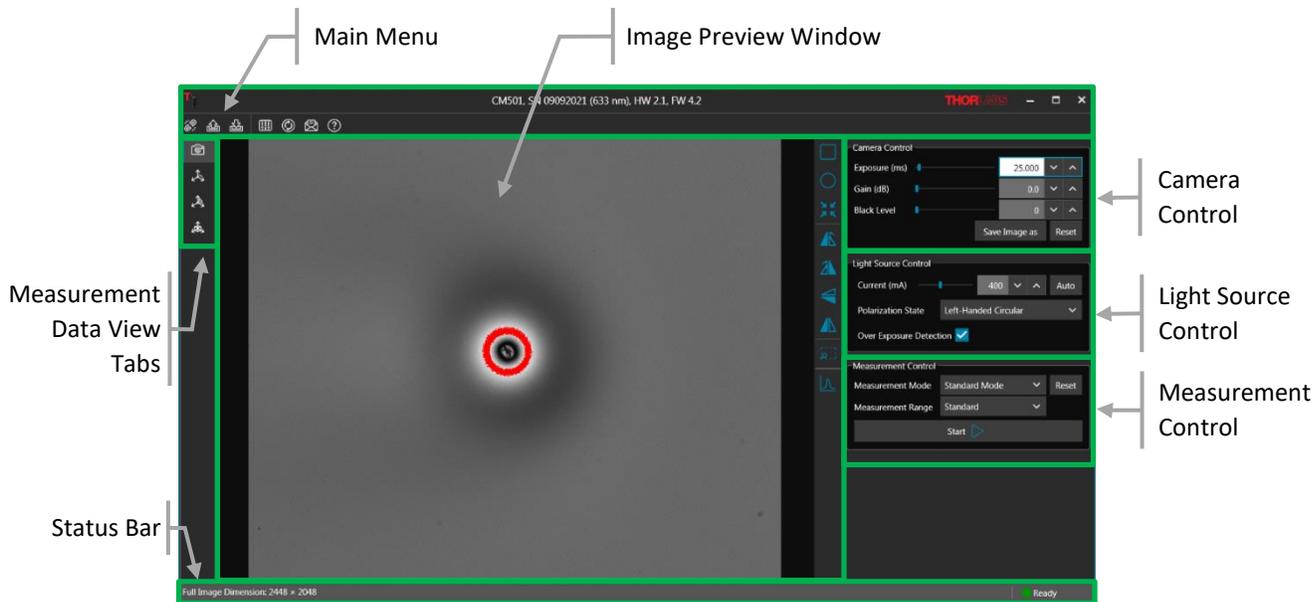


Figure 29 Front Panel of GUI

### 3.4.1 Main Menu

Controls for all user operations are included in the main menu, which consist of 3 sections:

- Device Information
- Link to Thorlabs
- Operation Buttons

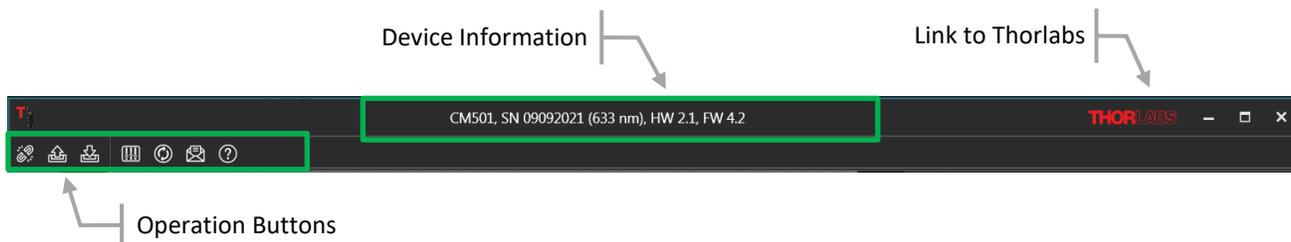


Figure 30 Main Menu Area of GUI

#### Device Information

Display the Device Model, Serial Number, Operating Wavelength, Hardware Version and Firmware Version

#### Link to Thorlabs

Open the Thorlabs home page by clicking the Thorlabs logo.

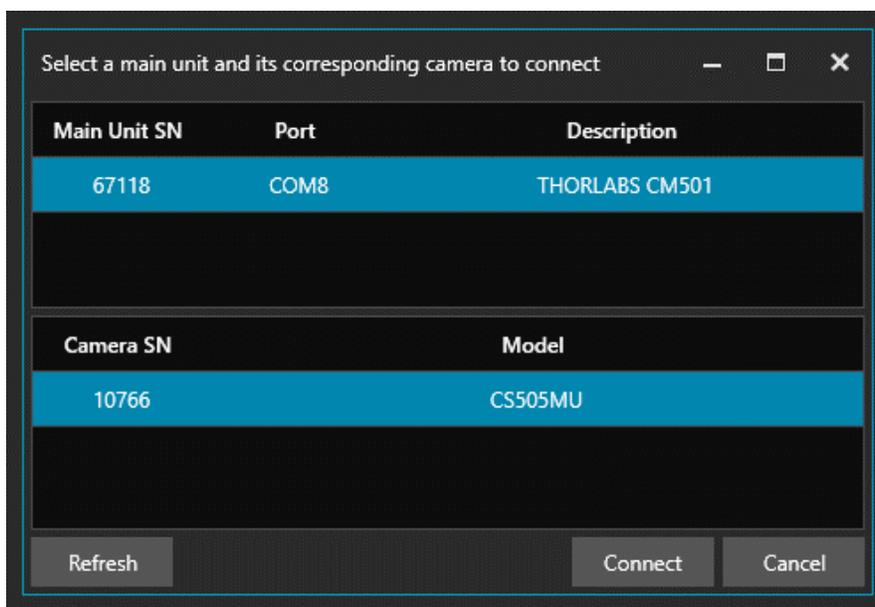
#### Operation Buttons

Seven buttons provide the functions summarized in the table and described following the table:

Icon	Operation	Icon	Operation
	Connect		Disconnect
	Save Profile		Load Profile
	Options		Update
	Technical Support		Help

**Connect/Disconnect**

Enable or disable the connection between the CM501/CM502 and the laptop or PC. When the software recognizes the CM501/CM502 hardware, the connect button will be enabled. If the connect button is grayed out, check that the CM501/CM502’s power switch is turned on and the USB cables are properly connected to the computer. If this is in order, please check for solutions in Chapter 8.



**Note**

If more than one CS505MU is connected to your computer, be sure to confirm the camera serial number matches that of the camera integrated into the CM501/CM502.

**Save Profile**

Save the user defined settings in XML format.

**Load Profile**

Load the user defined settings in XML format.

**Options**

The camera settings and other values can be set using controls accessed via the options tab.

- **Exposure Time Range (ms)**

Define the range of Camera Exposure Times that the front panel Exposure control provides.

- **Over Exposure Highlight Threshold**

Defines the threshold of pixel saturation, default is set to 85% of 4095.

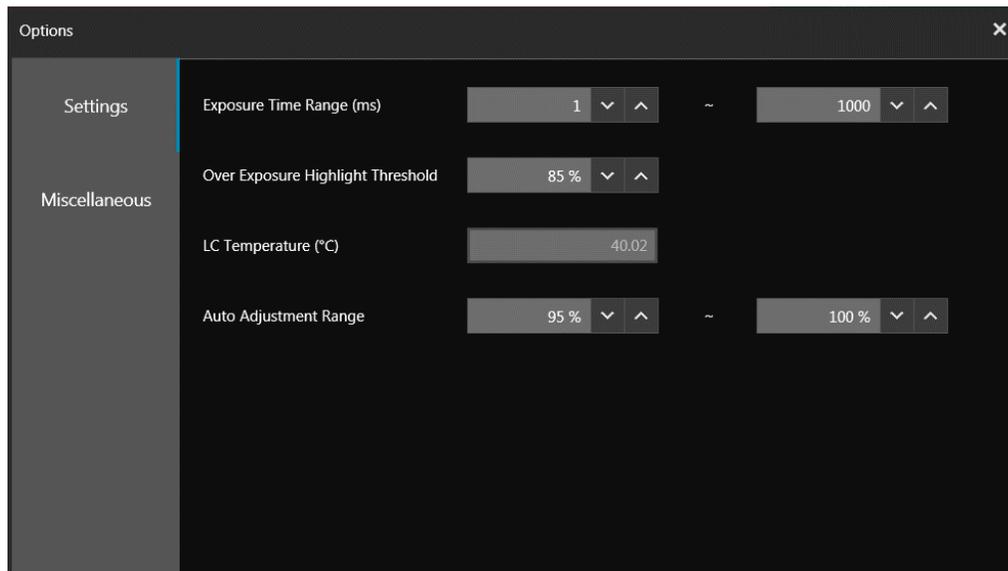
Pixels exceeding this threshold value will be color-coded as RED, as discussed in Section 5.4.4, if the Over Exposure Detection option in the Light Source Control panel has been checked.

- **LC (Liquid Crystal) Temperature (°C)**

Displays the actual temperature of the Liquid Crystal components.

- **Auto Adjustment Range**

This range is used to specify the source Current (mA) settings for the LED source and the input Polarization States, in order to provide the desired intensity level.

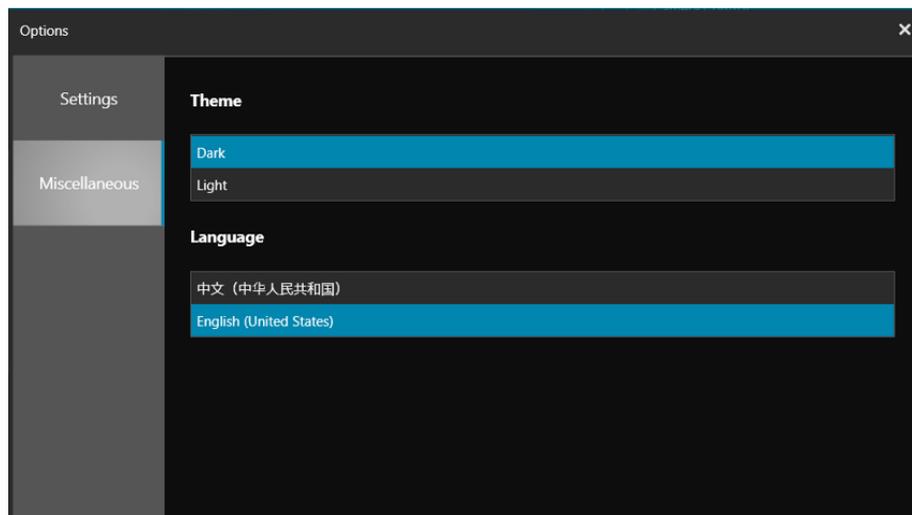


- **Theme**

Set the Software Theme to Dark or Light.

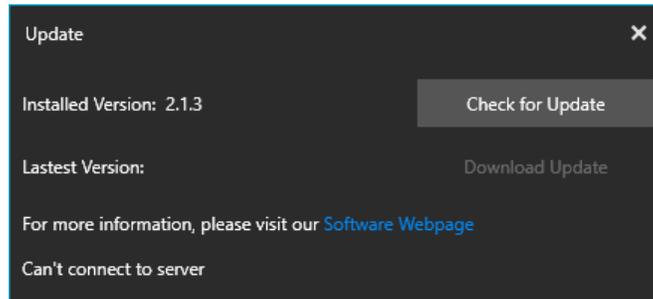
- **Language**

Set the software language to Chinese Simplified or English (United States).



## Update

Update the CM501/CM502 software to the most recent version.

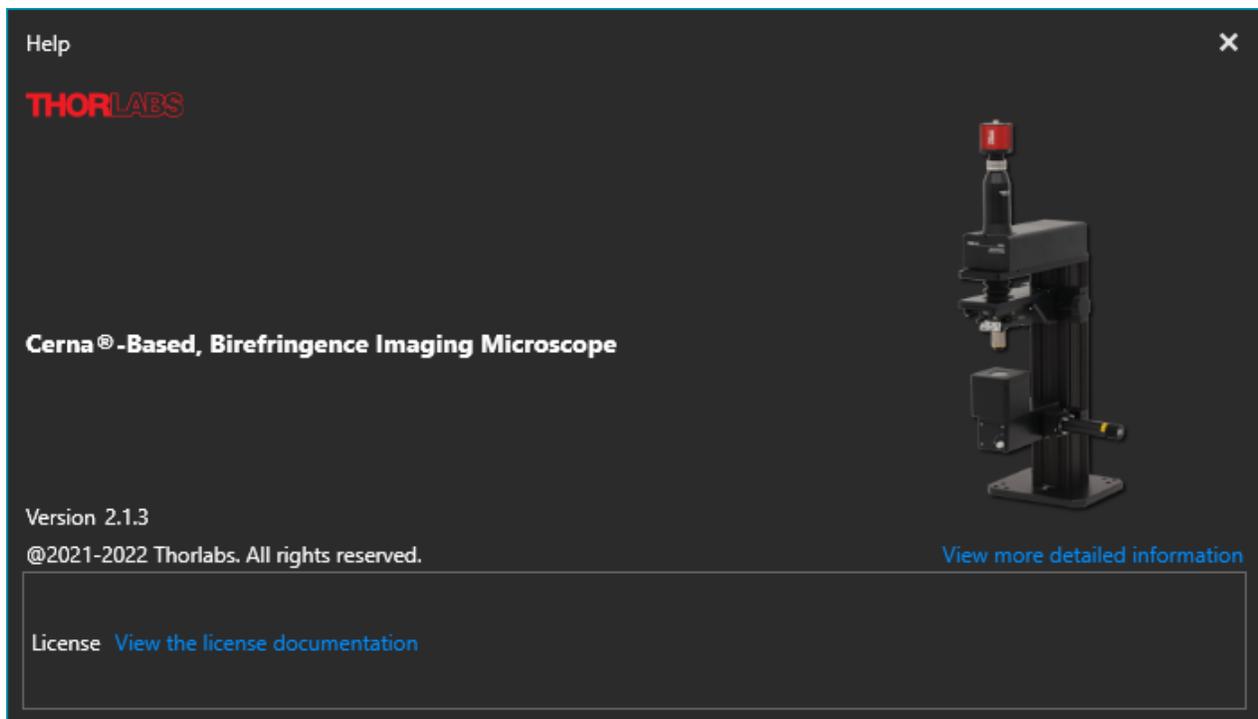


## Support

Microsoft Outlook is launched (if installed), and a new email with the address set to [techsupport@thorlabs.com](mailto:techsupport@thorlabs.com) is opened.

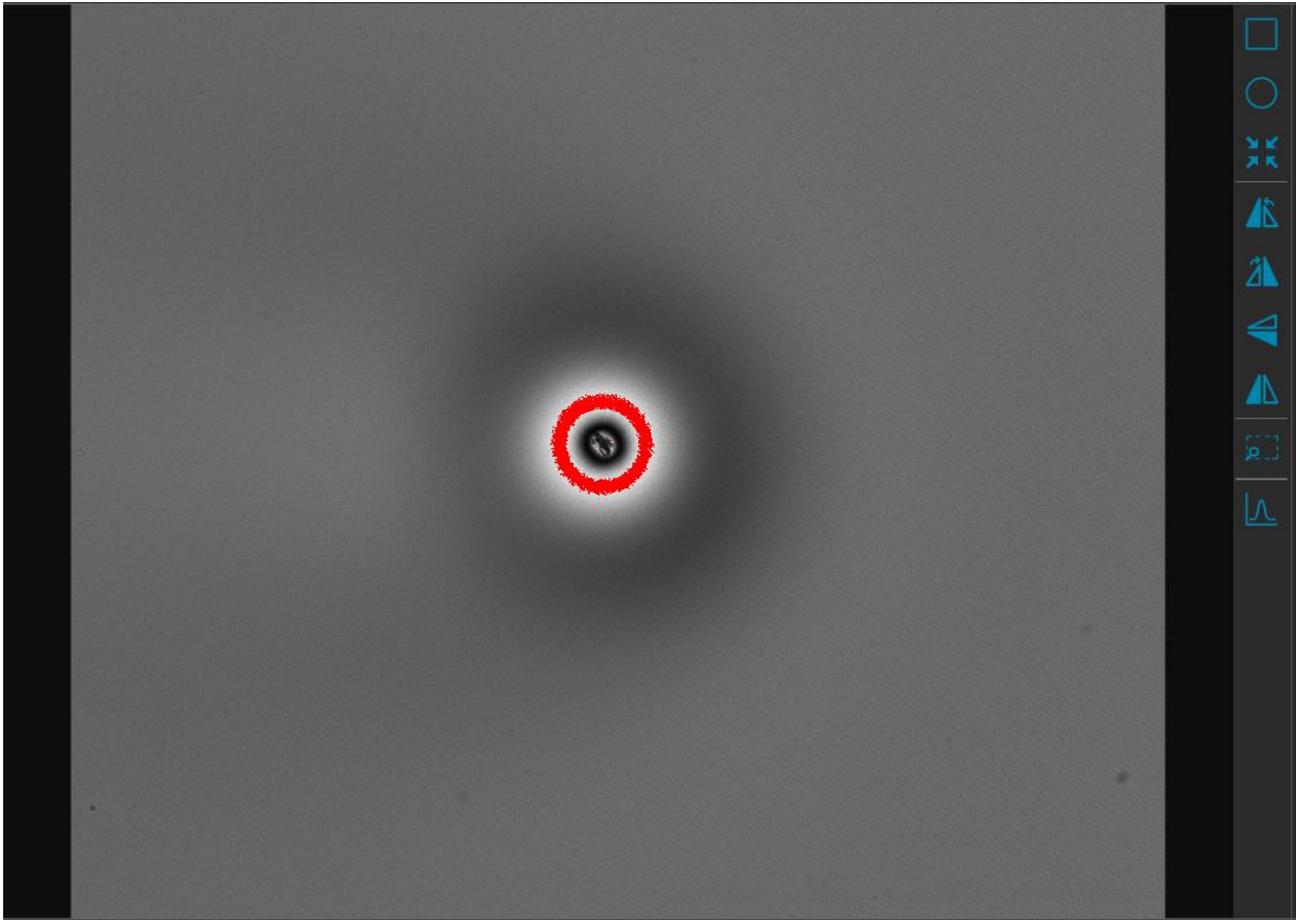
## Help

Displays the detailed information about the CM501/CM502 software. Please have these details available when contacting the Thorlabs' Tech Support.



### 3.4.2 Image Preview Window

The image preview window is the main window for the camera image preview. By default, when the 10x objective is integrated into the system, a clear field of view of 0.84 mm x 0.71 mm is provided.



**Figure 31** Image Preview Window of GUI

The toolbar on the right side can be used to customize several image settings, which are listed in the table and described in the following

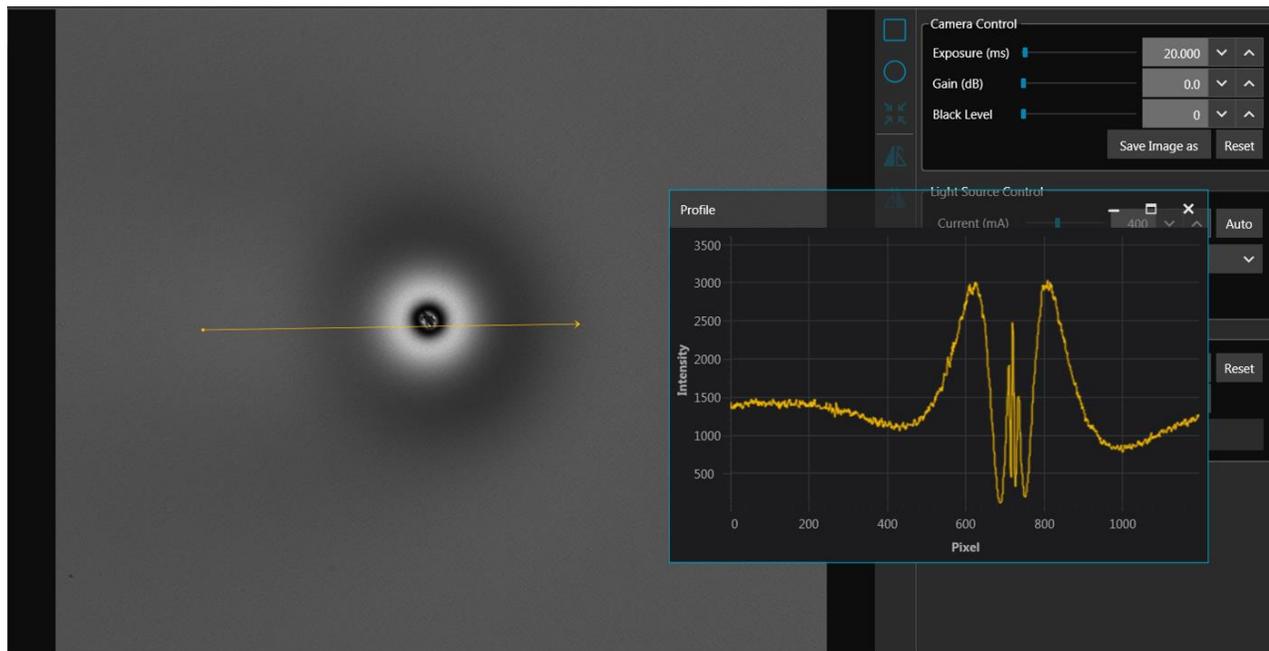
Icon	Description	Icon	Description
	ROI* of Rectangle		ROI of Circular
	Resume to Full image		Rotation in Anti-Clockwise
	Rotation in Clockwise		Flip in Horizontal
	Flip in Vertical		ROI indication
	Line Profile		

**Note**

\*The Region of Interest (ROI) can be selected by dragging a rectangular or circular region in the image preview window. With ROI selected, the camera reads out only the ROI area and it can increase frame rate, which can increase measurement speed.

**Line Profile**

Select the Line Profile tool to draw a line across the image that indicating a linear path of interest. The intensity values measured by the pixels along the line are displayed in a separate window.



**Figure 32** Line Profile Tool of GUI

**3.4.3 Camera Control**

The camera control settings enable the desired exposure time, gain, and black level values to be selected.



**Figure 33** Camera Dynamic Setting Area of GUI

**Exposure Time**

Set the exposure time appropriate for all frames to be acquired. The unit here is milliseconds.

The setting range can be changed in the Option Tab. The default range is defined from 0.021 ms to 7330 ms with ~0.007 ms increments.

**Gain**

The relative gain applied to the analog signal from the image sensor. The increment here is 0.1 dB per step (typical).

**Black Level**

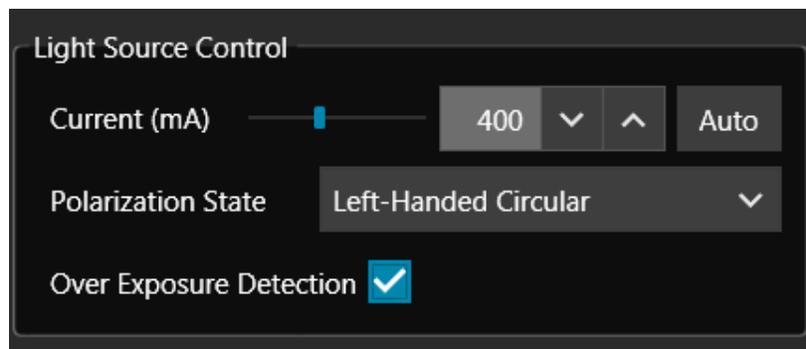
The average image signal from the camera in the absence of light. Increments of 1.0 ADU (Analog to Digital Unit) are used.

**Save Image As**

Save the preview image in PNG or TIFF format.

**Reset**

Reset the camera parameters to default values.

**3.4.4 Light Source Control**

**Figure 34** Light Source Control Area of GUI

**Current (mA)**

Sets the current supplied to the LED to a value between the minimum and maximum.

**Auto**

Adjusts the LED brightness (intensity level) automatically. Since the level chosen by the software depends on the current sample under test, place the sample in the sample stage and orient to the desired position before using the Auto Adjustment tool.

**Over Exposure Detection**

An over-exposure detection tool is integrated in the software. If the “Over Exposure Detection” option has been checked, pixels that are over-exposed will be identified using red highlighting overlaid on the preview image and the status bar will display an over-exposure alert. If over-exposure occurs, reduce the LED current, or use Auto Adjustment, before starting a measurement.

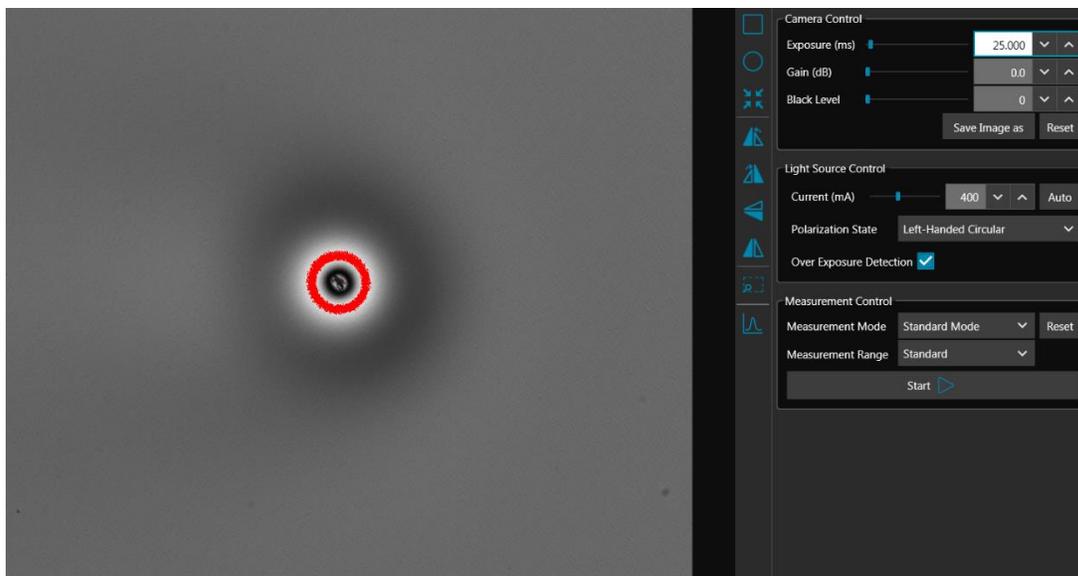


Figure 35 Over-exposed Pixels in Image Preview Window

### Polarization State

Set the Polarization States of input light on the sample. There are six states available in total.

**Note**

The Polarization States are defined from the perspective of the observer looking into the beam, towards the light source.

No.	Polarization State of Input Light
1	Right-Handed Circular (Default)
2	Left-Handed Circular
3	Linear 0°
4	Linear 45°
5	Linear 90°
6	Linear -45°

### 3.4.5 Status Bar

The status bar displays information about the system status including:



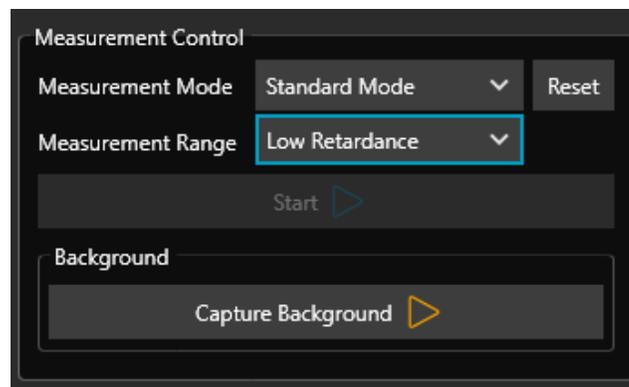
Figure 36 Examples of Status Bar of GUI

- Image Preview Information
  - Image Dimension
  - Image Intensity

- Measurement Information
  - Azimuth
  - Retardance
- System Status Information
  - Initialize
  - Warm Up
  - Ready
  - Error
- Light Source Over Exposure Detection Status

### 3.4.6 Measurement Control

The CM501/CM502 contains three measurement modes with different measurement ranges.



**Figure 37 Measurement Control Area of GUI**

#### Measurement Mode

The measurement rate depends on the camera exposure time. An exposure time of 230 ms (typical) is set as the default, which allows a measurement to be finished within 20 s in standard mode and 4 min in low noise mode.

- **Standard Mode**  
Higher measurement rate with a lower signal-to-noise ratio compared with Low Noise Mode.
- **Low Noise Mode**  
Lower measurement rate with a higher signal-to-noise ratio compared with Standard Mode.
- **Raw Sample Mode**  
The camera collects a set of images corresponding to the six Input Polarization States, i.e. Right-Handed Circular, Left-Handed Circular, Linear 0°, Linear 45°, Linear 90° and Linear -45°.

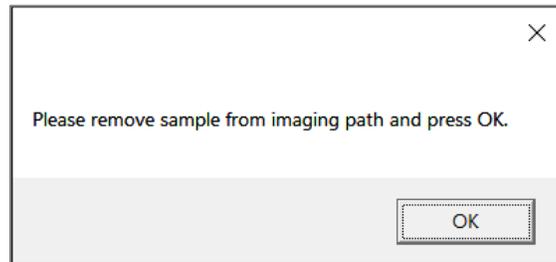
#### Measurement Range

- **Standard Retardance Range**  
The Standard Retardance provides a measurement accuracy of  $\pm 10$  nm for retardance and  $\pm 3^\circ$  for azimuths over the entire measurement range.
- **Low Retardance Range**

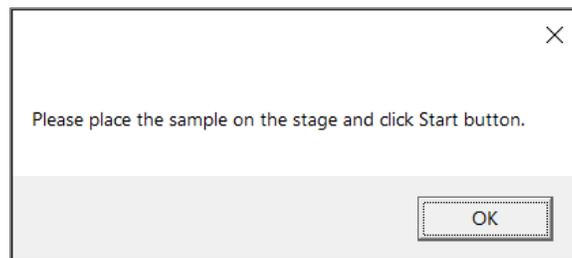
The Low Retardance Range will improve the measurement accuracy of retardance to  $\pm 1$  nm in the retardance measurement range from 0 nm to 100 nm, as well as the measurement accuracy of azimuths to  $\pm 1^\circ$  over the entire azimuth measurement range.

## Background

A background measurement must be collected before making a measurement with Low Retardance Range specified. Click the background button to start the background collection and follow the instructions to complete the acquisition of the background.



**Figure 38** Background Collection Guide Window



**Figure 39** Background Collection Status Indication

A new background must be collected each time any camera or LED settings are changed.

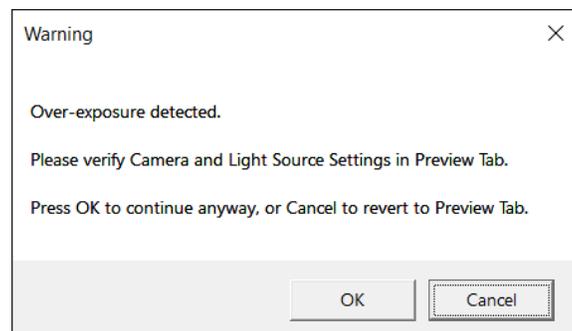
## Right-Click

Right-Click allows to save the preview image file in PNG or TIFF format.

## Over Exposure Warning

A window dialog containing an over-exposure warning is displayed when the number of saturated pixels is more than 2% of the total number of pixels.

Click "OK" to complete the measurement, despite the over-exposure conditions. Click "Cancel" to revert to Light Source and Camera settings.



### 3.4.7 Measurement Data Views

The measurement data views toolbar, on the left side of the window (Measurement Data View Tabs), provides three different options for viewing measurement results. The data is presented in a layout determined by the measurement mode:

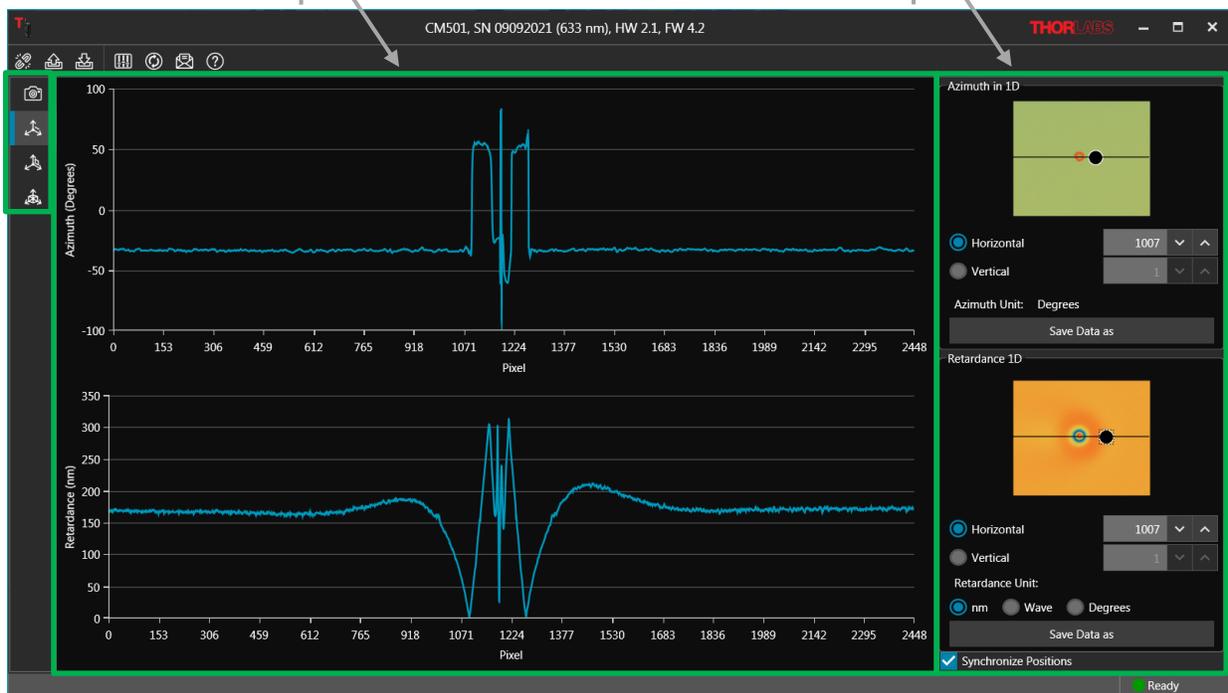
- Layout 1 → Standard Measurement Mode, Low Noise Measurement Mode**
- Layout 2 → Raw Sample Measurement Mode**

- **1D View - Layout 1**

Displays the measurement results of Standard and Low Noise measurement modes in 1D view. The 1D tab consists of two parts:

Measurement Data Display

Display Mode Selection



**Figure 40 1D Data View of Measured Sample, Liquid Crystal Polymer Waveplate, Standard Mode**

#### Measurement Data Display

The curves displayed in the two graphs are horizontal or vertical cross sections of the azimuth and retardance measurement data. The Display Mode Selection controls, which are described in the following, specify the cross section shown in the graphs.

#### Display Mode Selection

The Display Mode area includes colormaps of the complete set of azimuth and retardance measurement data, and these graphs are overlaid by a black bar. The controls beneath the colormaps are used to specify the position and orientation of the black bar, which selects the azimuth angle and retardance data plotted in the Measurement Data Display graphs. The radio button controls select between horizontal and vertical orientations of the bar. The bar can also be dragged to the desired position in each graph.

When the “Synchronize Positions” Box is selected, the positions of the bars in both graphs are constrained to have the same XY coordinates. Both bars move in tandem when one is adjusted.

Click the Save Data As button to save the data in comma separated value (CSV) or Binary (.bin) format.

- **1D View - Layout 2**

Displays the measurement results of Raw Sample measurement mode in 1D view. The 1D tab consists of two parts:



**Figure 41 1D Data View of Measured Sample, Liquid Crystal Polymer Waveplate, Raw Sample Mode**

### Intensity Data Display

The displayed trace is the horizontal or vertical cross section one measurement data sets in the collected raw sample measurement data. The Display Mode Selection controls, which are described in the following, select the particular measurement set, as well as the cross section of that set that is shown in the graph.

### Display Mode Selection

The Display Mode area includes a colormap of one of the raw sample measurement data sets, and this colormap is overlaid by a black bar. There are six data sets in the raw sample measurement data, and each data set corresponds to a different input polarization state. The Polarization States selection box specifies the data set displayed in the colormap.

The other controls beneath the colormap specify the position and orientation of the black bar, which specifies the data cross section to display in the Measurement Data Display graph. The radio button controls select between horizontal and vertical orientations of the bar. The bar can also be dragged to the desired position in the colormap.

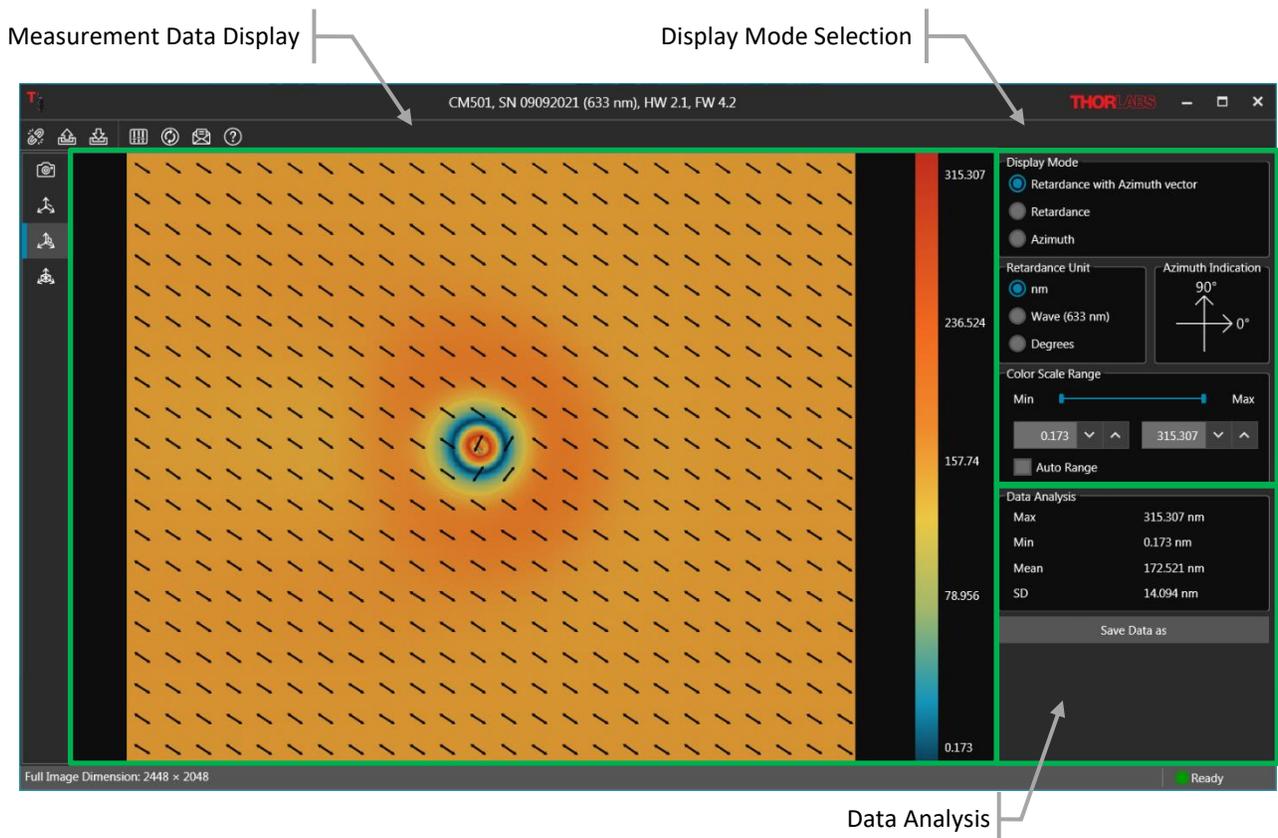
Click to save the data in comma separated value (CSV) or Binary (.bin) format.

- **2D View – Layout 1**

2D view tab for Standard and Low Noise measurement mode contains three sections:

- Measurement Data Display
- Display Setting

- Data Analysis



**Figure 42 2D Data View of Measured Sample, Liquid Crystal Polymer Waveplate, Standard Mode**

### Measurement Data Display

The measurement data is shown as a colormap, with the data range indicated by the vertical bar on the right. The maximum and minimum values of the color bar can be user defined or set as Auto Range.

### Display Setting

Displays the measurement results of Azimuth and Retardance in 2D view with three display modes. Units of nm, waves, and degree are selectable regarding the measured retardance.

Azimuth indicator is shown while the Retardance with Azimuth Vector and Azimuth modes are selected.

- **Retardance with Azimuth Vector**

The colormap shows the measured sample's retardance and the overlaid vector graph with arrows indicates the sample's fast axis orientation (azimuth), see Figure 42.

- **Retardance Mode**

The colormap shows only the measured sample's retardance.

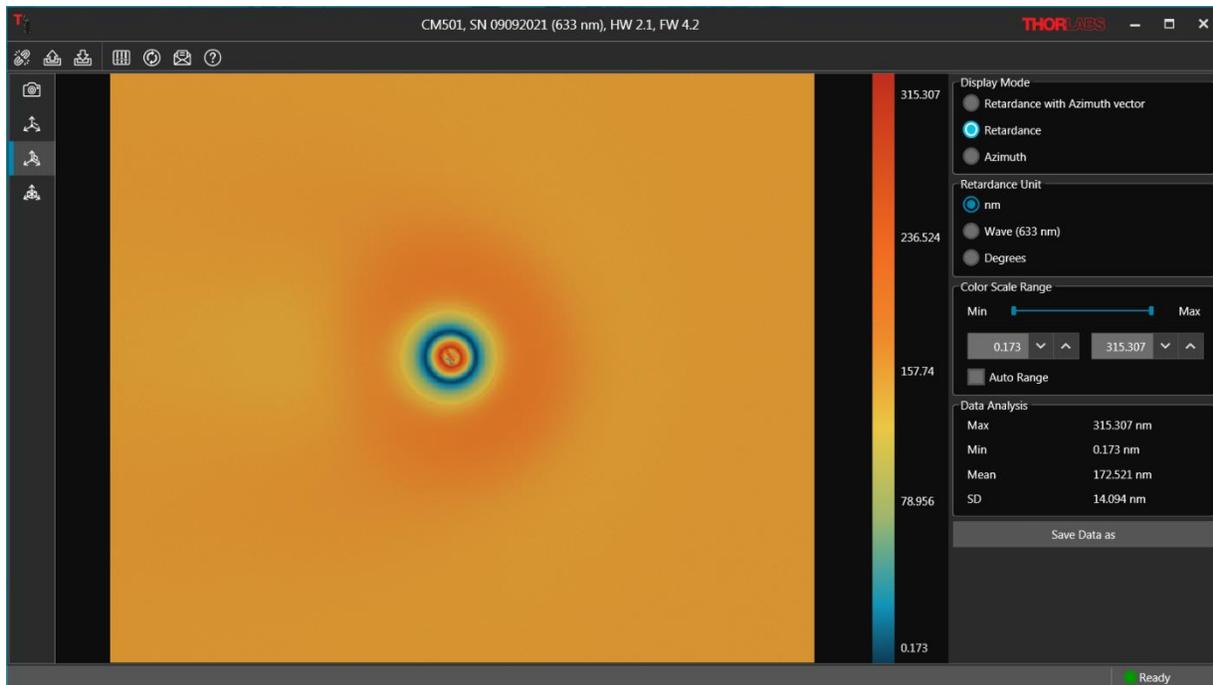


Figure 43 2D Data Display Mode of Retardance

- Azimuth Mode

The colormap shows only the measured sample’s azimuth. Values indicated by the color bar have units of degrees.

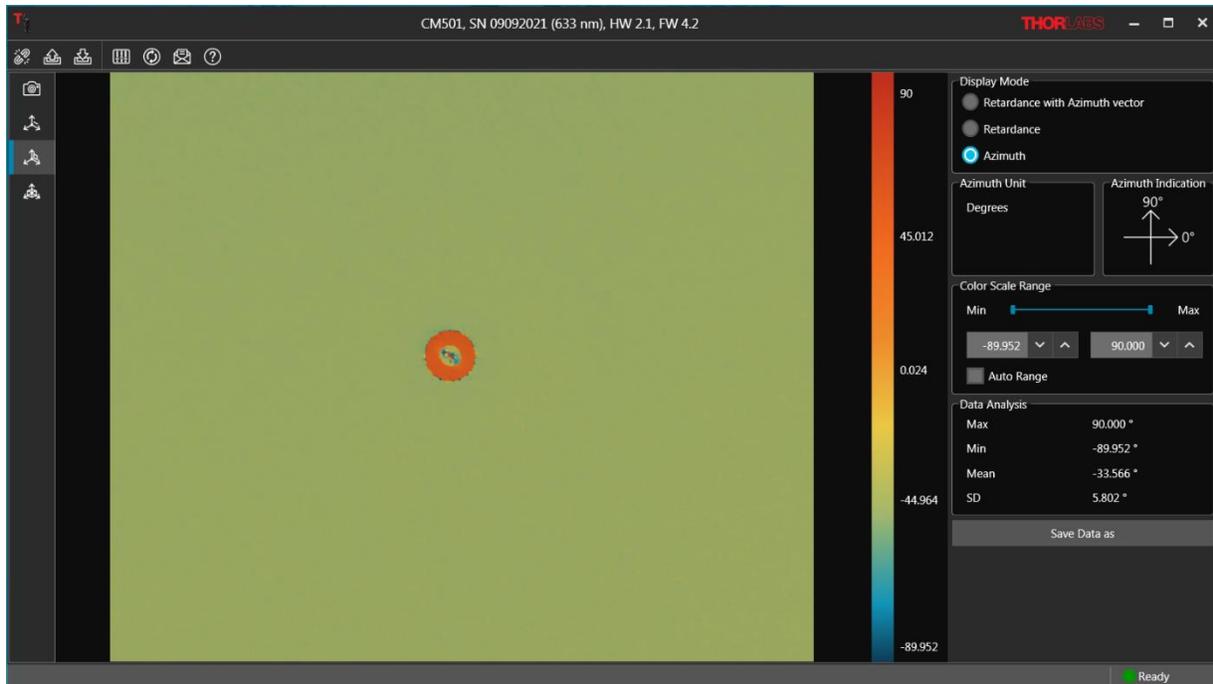


Figure 44 2D Data Display Mode of Azimuth

## Data Analysis

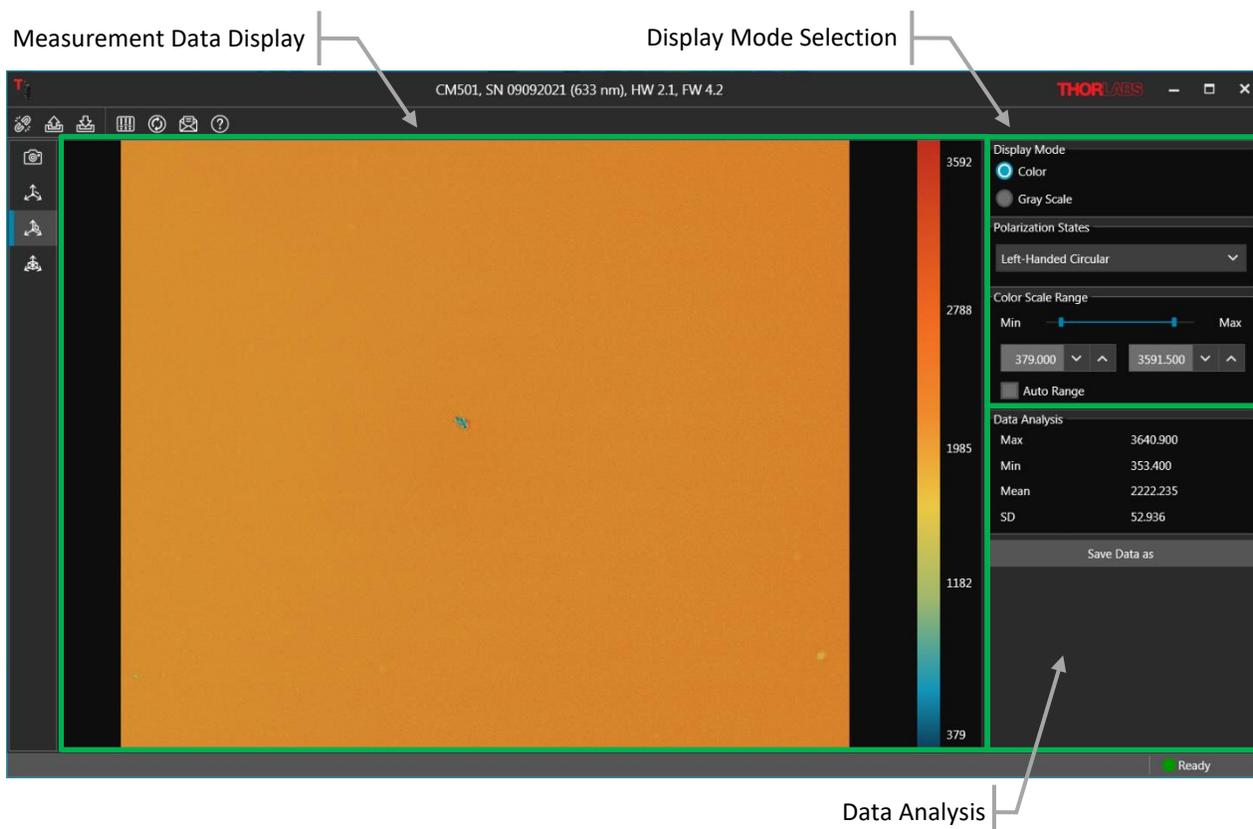
A simple data analysis section shows the maximum, minimum, mean and standard deviation (SD) values, which are based on the selected display mode.

Right-Click or click the “Save Data As” button to save the data or the image of the “Measurement Data Display” area. The data can be saved into CSV or Binary (.bin) file format. The image can be saved in PNG (8 bit) or TIFF (16 bit) file format.

- **2D View – Layout 2**

2D view tab for Raw Sample measurement mode contains three sections:

- Measurement Data Display
- Display Setting
- Data Analysis



**Figure 45** 2D Data View of Measured Sample, Liquid Crystal Polymer Waveplate, Raw Sample Mode

### Measurement Data Display

The measurement data is shown as a colormap, with the data range indicated by the vertical bar on the right. The maximum and minimum values of the color bar can be user defined or set as Auto Range.

### Display Setting

Displays the collected image intensity with selected input polarization state in 2D view with Color or Gray Scale display modes.

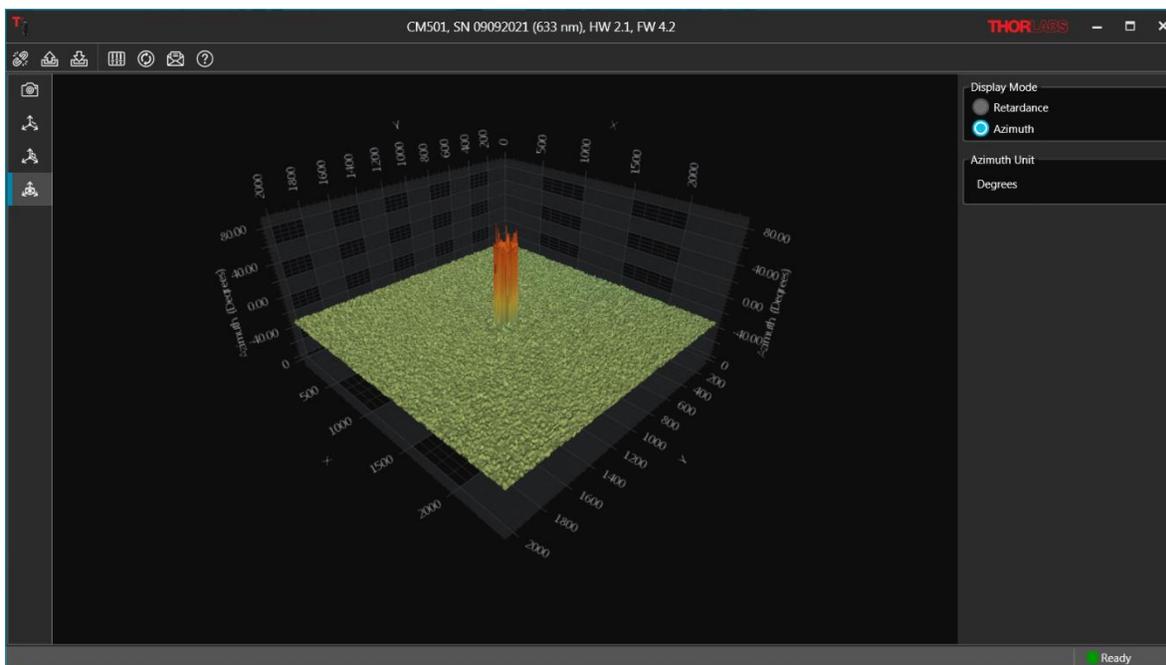
### Data Analysis

Provides the maximum, minimum, mean and standard deviation (SD) values, which are based on the selected display mode.

Right-Click or click the “Save Data As” button to save the data or the image of the “Measurement Data Display” area. The data can be saved into CSV or Binary (.bin) file format. The image can be saved in PNG (8 bit) or TIFF (16 bit) file format.

- **3D View – Layout 1**

This layout is used to displays the measurement results of Standard and Low Noise measurement modes as a 3D graph. Controls on the left are used to toggle between Retardance and Azimuth data, as well as select the desired units. The 3D graph can be dragged with the mouse for different viewing orientations.



**Figure 46 3D Data Display of measured Sample, Liquid Crystal Polymer Waveplate, Standard Mode**

- **3D View – Layout 2**

This layout is used to display data acquired using Raw Sample Mode. Controls on the left are used to toggle between data sets corresponding to the different input polarization states. The 3D graph can be dragged with the mouse for different viewing orientations.3D.

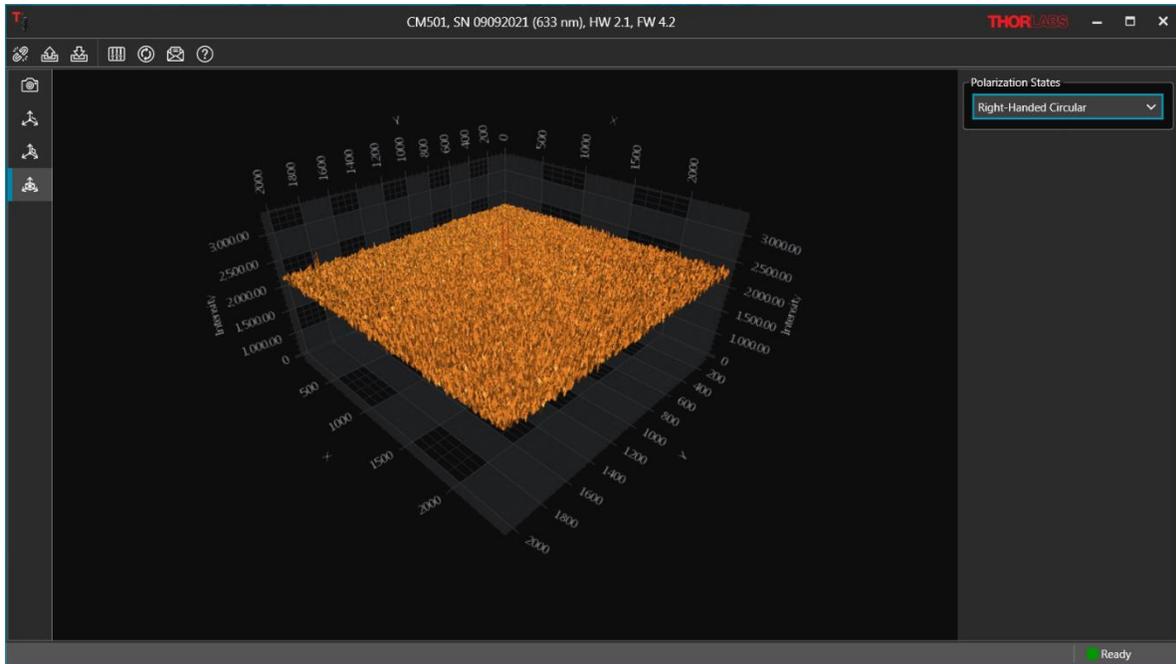


Figure 47 3D Data Display of measured Sample, Liquid Crystal Polymer Waveplate, Raw Sample Mode

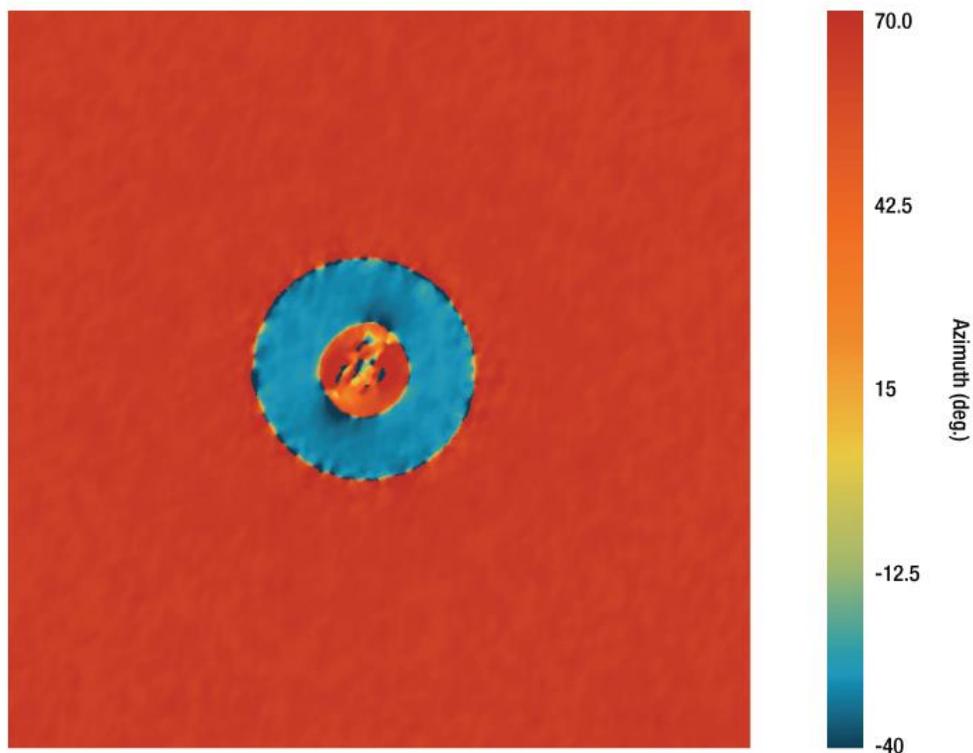
## Chapter 4 Applications

The CM501 and CM502 Microscopes can be applied to a variety of research and manufacturing fields. With retardance measurements as low as  $\pm 1$  nm and azimuth measurements as small as  $\pm 1^\circ$  (Low Retardance Range), paired with the higher resolution of a full microscope system as compared to our LCC7201B Birefringence Imaging System, these microscopes are a versatile solution to birefringence imaging.

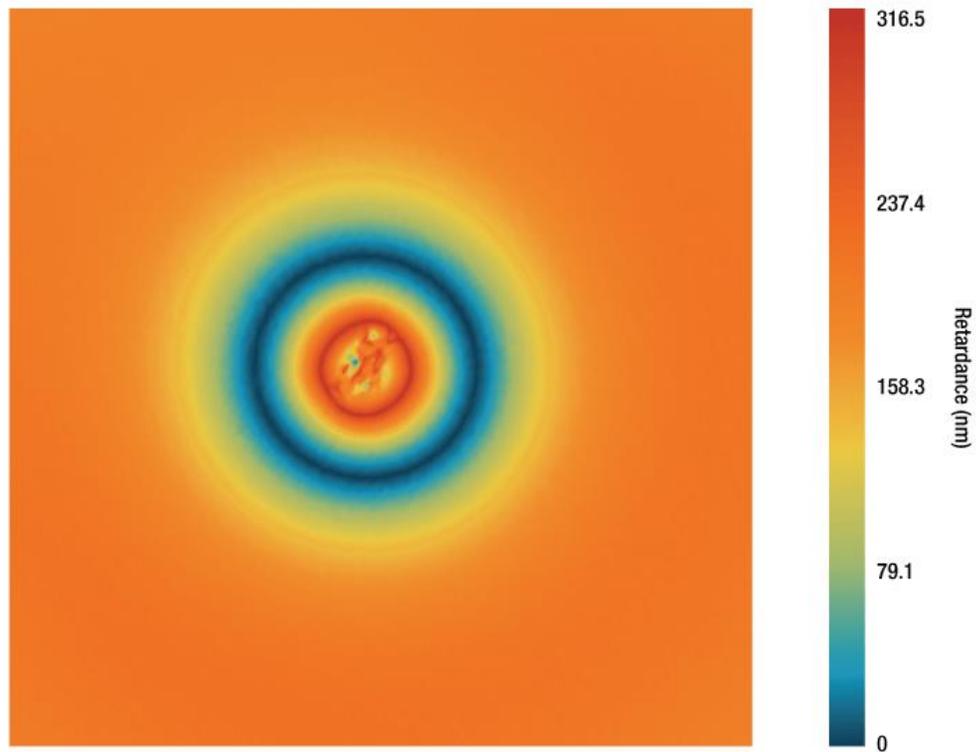
### 4.1 Laser-Induced Birefringence Change in a Polymer Wave Plate

When a quartz or liquid crystal polymer wave plate is integrated into a system for a given application, the laser induced birefringence change, i.e., retardance and fast axis orientation (azimuth), can be critical. Since even a very slight change can create problems in practical applications, the verification of such changes is essential. Typically, these changes are not easily measured by a polarized light microscope, but our Birefringence Imaging Systems, the CM50x microscope and LCC7201B imaging system, are sensitive to retardance and azimuth changes as small as  $\pm 1$  nm and  $\pm 1^\circ$  (Low Retardance Range). The CM501 and CM502 can provide higher spatial resolution.

The example measurement results shown below for a Thorlabs' Liquid Crystal Polymer Zero-Order Half-Wave Plate (Item # WPH10E-830) indicate retardance and azimuth changes due to laser-induced damage threshold (LIDT) testing.



**Figure 48** 2D Azimuth View of Measured Sample, Liquid Crystal Polymer Waveplate

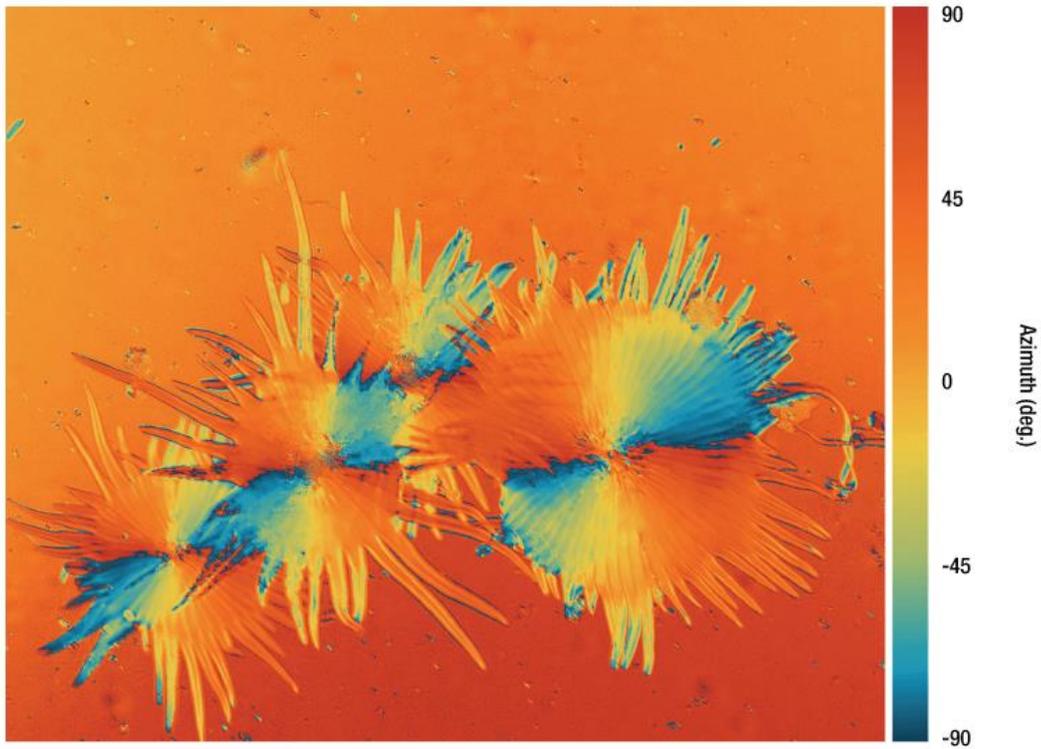


**Figure 49** 2D Retardance View of Measured Sample, Liquid Crystal Polymer Waveplate

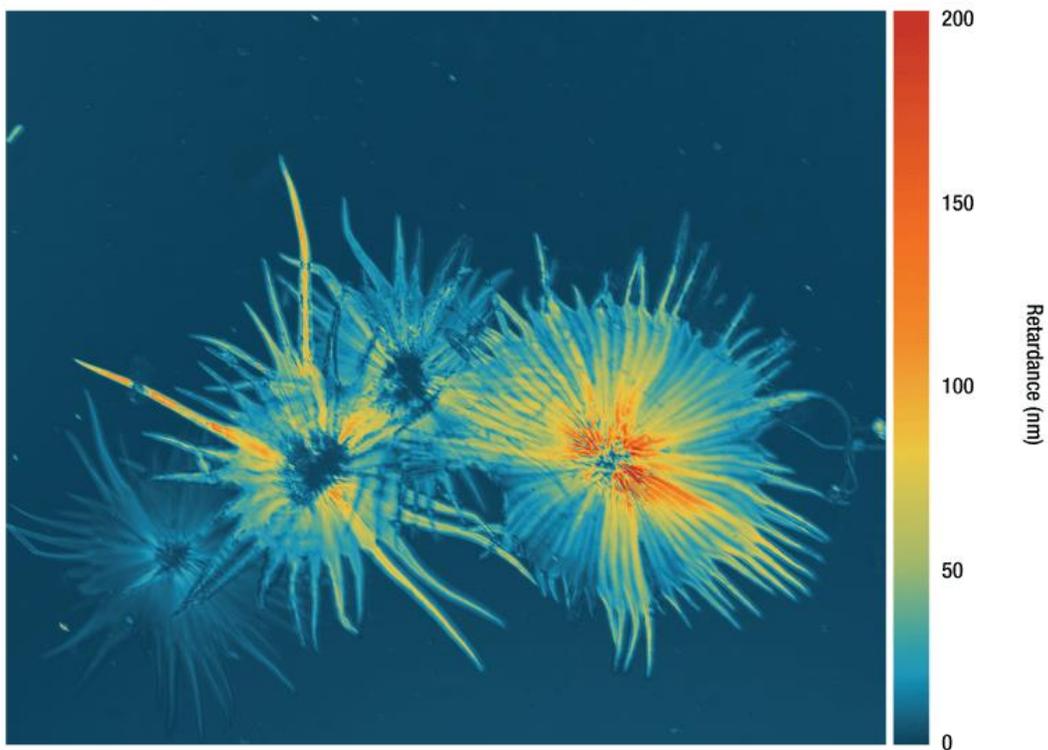
## 4.2 Birefringence in Biological Tissue

The Cerna Birefringence Imaging Microscope is a powerful tool to reveal submicroscopic organization in biological materials. It offers rapid measurements to study and understand the biological structures, such as striated muscle, nerve myelin, mitotic spindle, dermal collagen, and stress fibers without staining or labeling. Some example measurement results are shown below.

**Berry Hair Whole Mount (w.m.) (Complete Organism)**

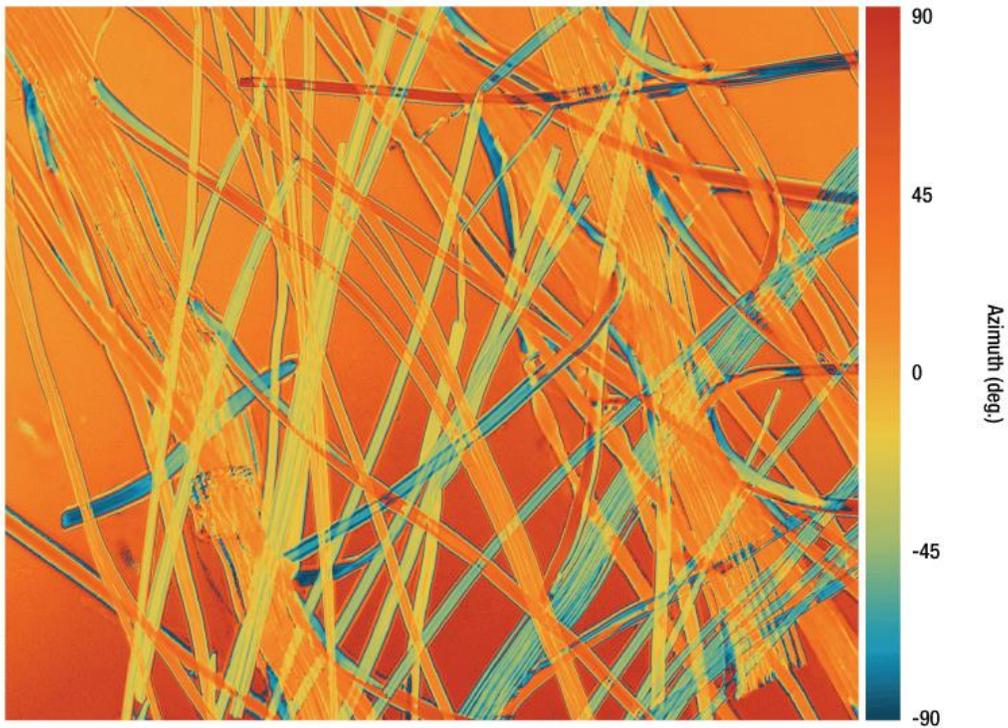


**Figure 50** 2D Azimuth View of Measured Sample, Berry Hair Whole Mount (w.m.)

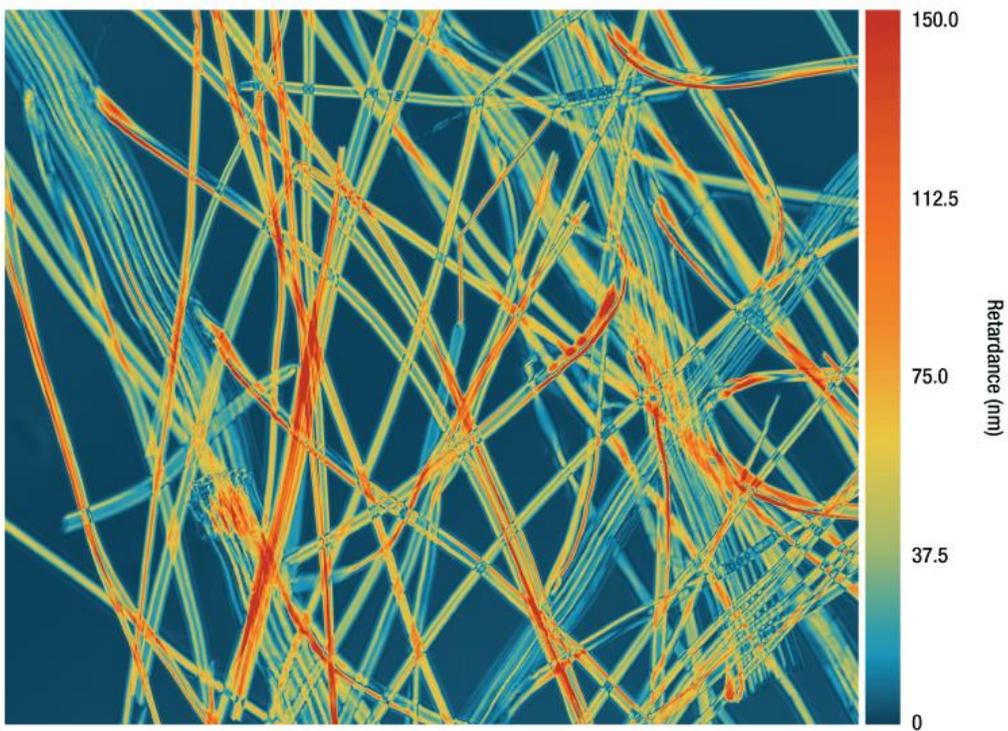


**Figure 51** 2D Retardance View of Measured Sample, Berry Hair Whole Mount (w.m.)

**Dandelion Fuzz Whole Mount (w.m.) (Complete Organism)**

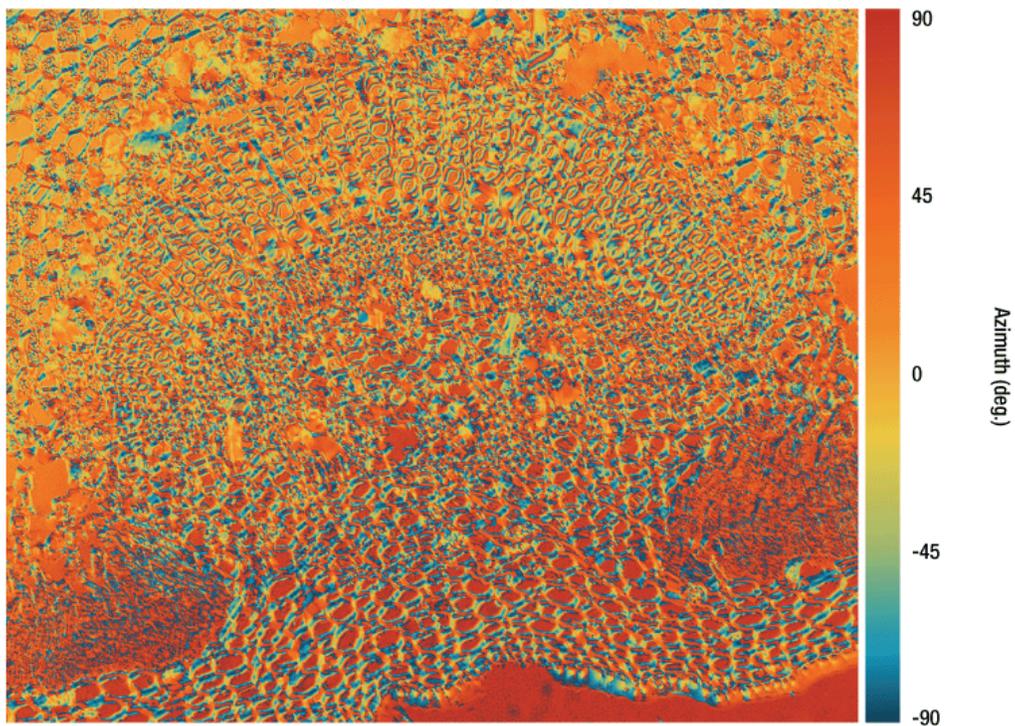


**Figure 52** 2D Azimuth View of Measured Sample, Dandelion Fuzz Whole Mount (w.m.)

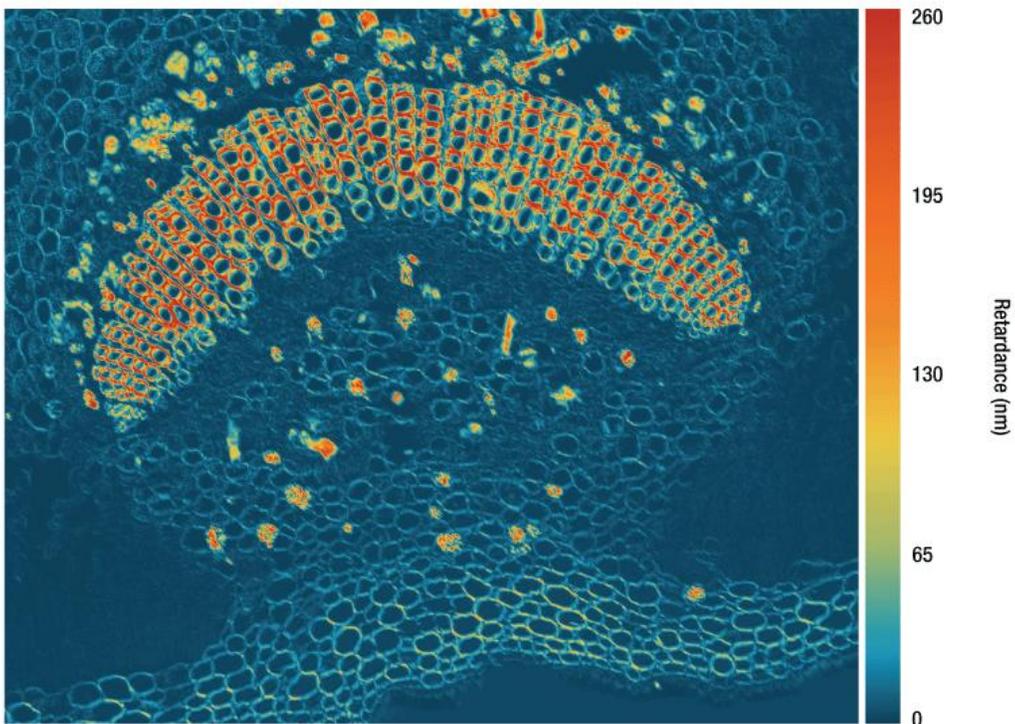


**Figure 53** 2D Retardance View of Measured Sample, Dandelion Fuzz Whole Mount (w.m.)

## Leaf of Nerium Indicum T.S.

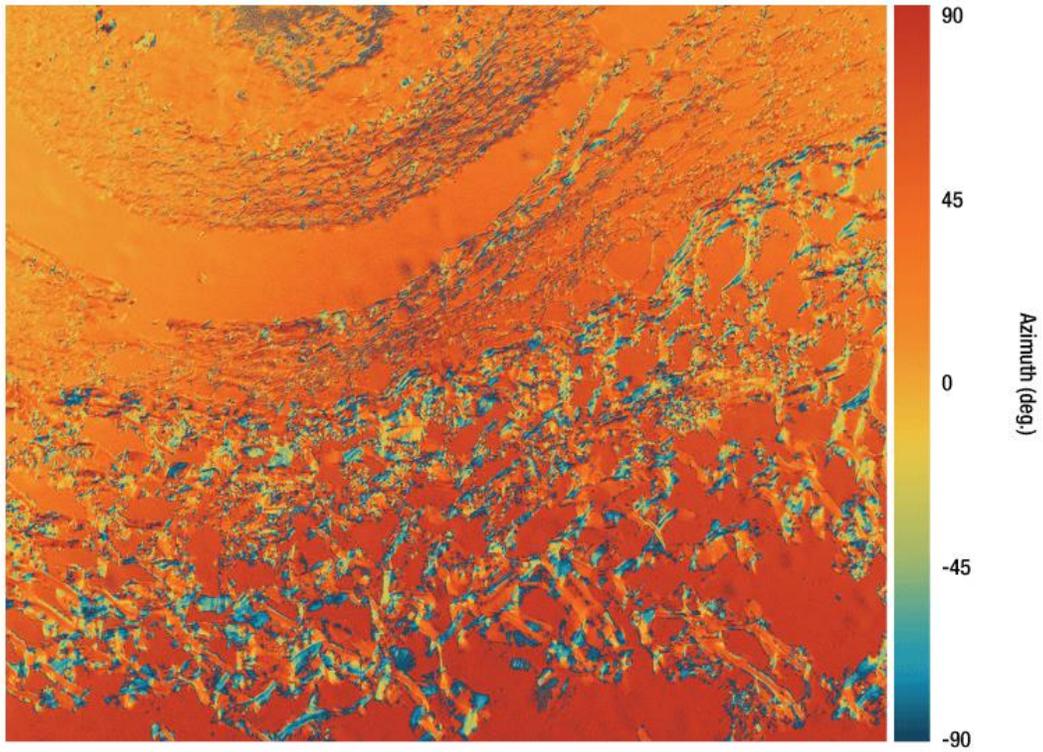


**Figure 54** 2D Azimuth View of Measured Sample, Leaf of Nerium Indicum T.S.

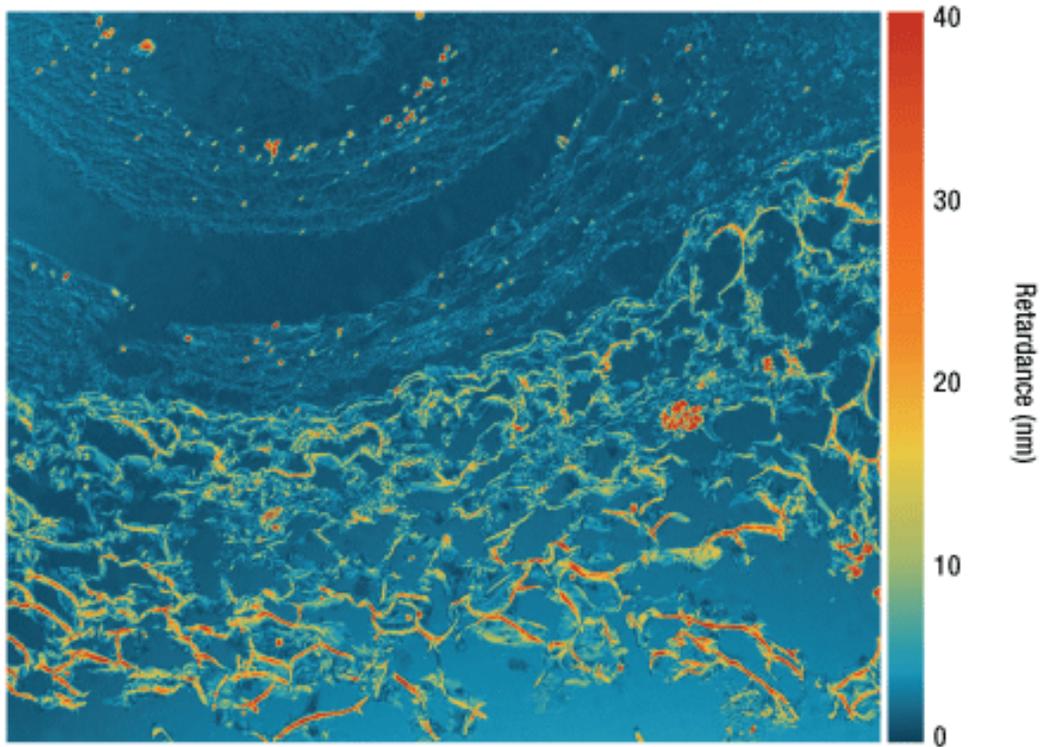


**Figure 55** 2D Retardance View of Measured Sample, Leaf of Nerium Indicum T.S.

**Tomato Flesh Whole Mount (w.m.) (Complete Organism)**



**Figure 56** 2D Azimuth View of Measured Sample, Tomato Flesh Whole Mount (w.m.)



**Figure 57** 2D Retardance View of Measured Sample, Tomato Flesh Whole Mount (w.m.)

Human Hair (w.m.) (Complete Organism)

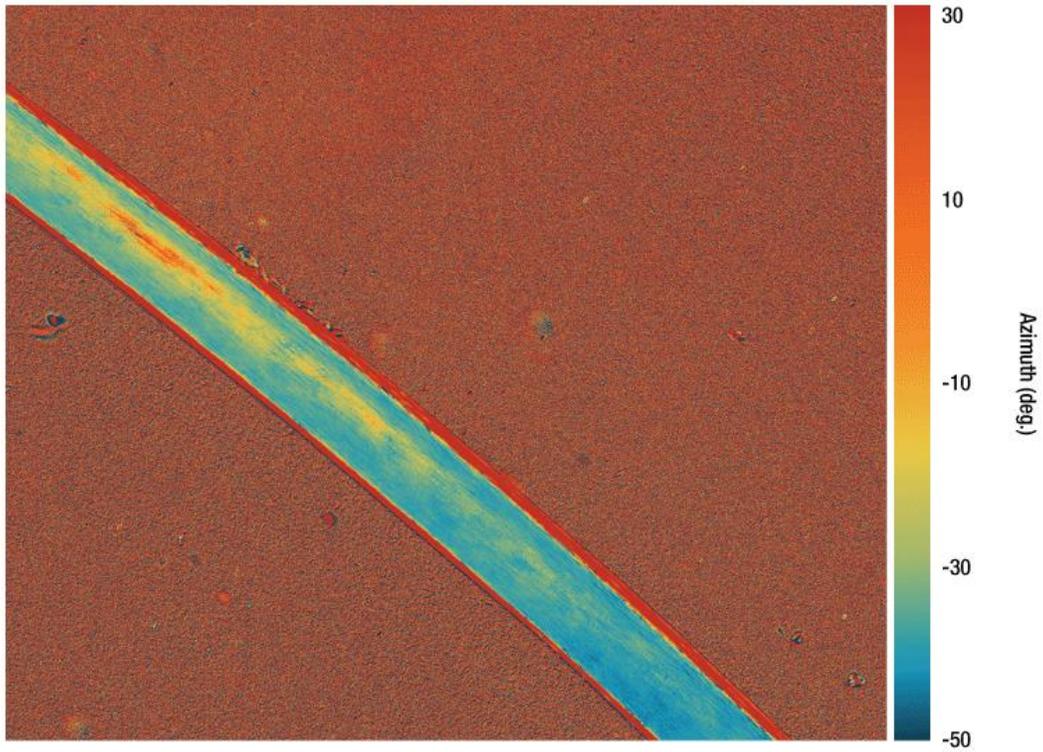


Figure 58 2D Azimuth View of Measured Sample, Human Hair (w.m.)

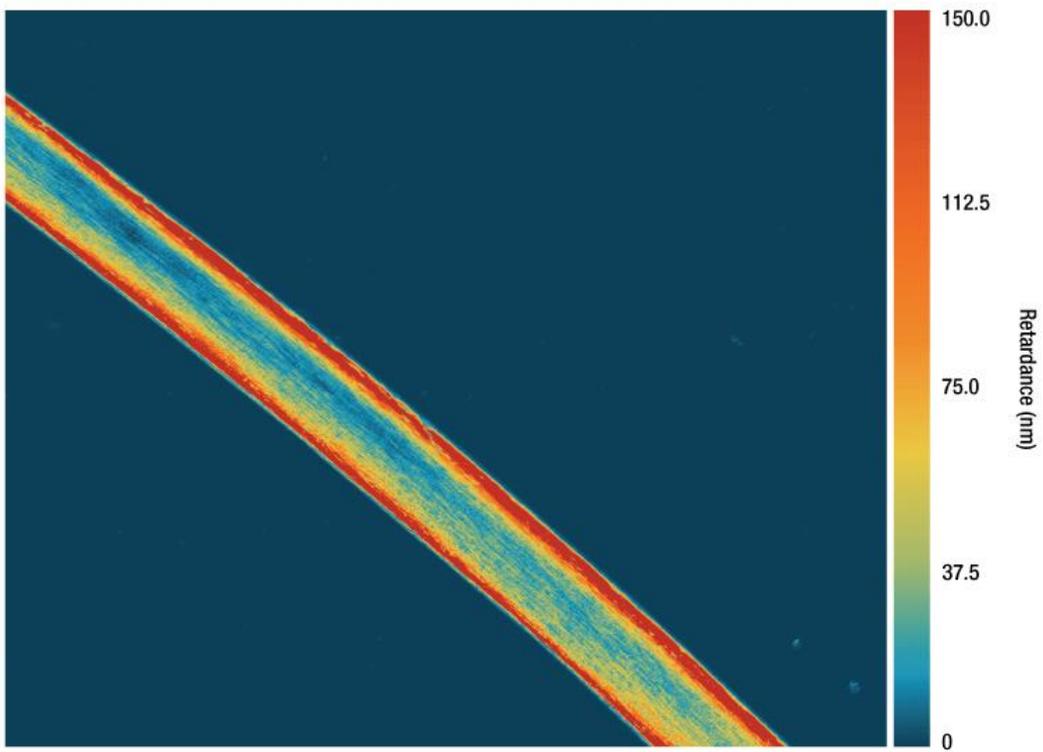


Figure 59 2D Retardance View of Measured Sample, Human Hair (w.m.)

## Chapter 5 Maintenance

### 5.1 Basic Care

Handle the complete system with care during transportation and unpacking. Banging or dropping the system can damage the unit or lower the system performance. If the system is mishandled during the shipment, the optical components inside may become misaligned, which would lead to a decrease in accuracy of the measurement performance. If this occurs, the complete system will need to be sent back for realignment and recalibration. Please contact Thorlabs' Tech Support for more information.

- Do not store or operate in a damp, closed environment.
- Do not store or operate on surfaces that are susceptible to vibrations.
- Do not expose to direct sunlight.
- Do not use the solvents on or near the equipment.
- Mobile telephones, cellular phones or other radio transmitters should not be used with a range of 3 m of this unit since the electromagnetic field intensity may exceed the maximum allowable disturbance values, according to EN50082-1.
- Keep away from dust, dirt, and air-borne pollutants (including cigarette smoke). The system is not designed for outdoor use. Protect the equipment from rain, snow, and humidity.
- Do not expose to mechanical and thermal extremes. Protect the equipment from rapid variations in temperature.
- Handle all connectors with care. Do not use unnecessary force, as this may damage the connectors.
- Handle the mainframe with care. Mishandling may cause the body injury.
- Clean the protective window by using a soft, lint free cloth. Use of isopropyl alcohol is permitted; however, do not immerse in any liquid or solvent.
- Clean any accessible optical surfaces with an appropriate optics grade tissue or cloth.

### 5.2 Service

**Caution**

Except for the main fuse, which is accessible from the outside of the housing, CM501/CM502 has no user-serviceable parts. Service should only be performed by trained service personnel.

Only trained and approved Thorlabs' personnel should service the system. Please contact Thorlabs' Tech Support at [techsupport@thorlabs.com](mailto:techsupport@thorlabs.com) and a member of our team will be happy to assist you.

## Chapter 6 Specifications

General Specifications		
Light Source Wavelength <sup>a</sup>	632.8 nm ± 1 nm <sup>b</sup>	
Microscope	Cerna® Series Microscope	
Measurement Range	Retardance	Standard Retardance Range: 0 nm to 316 nm Low Retardance Range: 0 nm to 100 nm
	Azimuth	±90°
Measurement Accuracy	Retardance	Standard Retardance Range: ±10 nm Low Retardance Range: ±1 nm
	Azimuth	Standard Retardance Range: ±3° Low Retardance Range: ±1°
Measurement Rate	<20 sec (Based on Default Camera Settings)	
Field of View <sup>b</sup>	0.84 mm x 0.71 mm	
Spatial Resolution <sup>b</sup>	1.055 μm	
Interface	USB 2.0 & USB 3.0	
Imager Resolution	2448 x 2048 (H x V) Pixels	
Dimensions	469.6 mm (D) x 354.1 mm (W) x 836.3 mm (H)	
Weight	CM501	21.9 kg (48.3 lbs)
	CM502	22.4 kg (49.4 lbs)
Operating Temperature	0 °C to 40 °C	
Storage Temperature	-15 °C to 65 °C	

a. Customizable upon request. Contact Tech Support for details.

b. The M625L4 LED is used in combination with a FL632.8-1 filter to provide a 633 nm light source.

c. Based on standard configuration which includes 10x objective (Item # N10X-PF).

Scientific Camera Specifications	
Item #	CS505MU
Sensor Type	Monochrome CMOS
Number of Active Pixels	2448 x 2048 (Horizontal x Vertical)
Pixel Size	3.45 μm x 3.45 μm
Imaging Area	8.4456 mm x 7.0656 mm (H x V)
Host PC Interface	USB 3.0
Vertical Digital Binning	Continuous Integer Values from 1 to 16
Horizontal Digital Binning	Continuous Integer Values from 1 to 16
Exposure Time	0.021 ms to 7330 ms in ~0.007 ms Increments

Region of Interest (ROI)	Frame Rate
Full Sensor (2448 x 2048)	53.2 fps
Half Sensor (1224 x 1024)	133.7 fps
~1/10th Sensor (260 x 208)	563.2 fps
Min ROI (260 x 4)	947.3 fps

Objective Specifications	
Item #	N10X-PF
Magnification	10X
Numerical Aperture (NA)	0.3
Working Distance (WD)	16 mm

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<b>Parfocal Length</b>	60 mm
<b>Compatible Tube Lens Focal Length</b>	200 mm
<b>Coverslip Correction</b>	0.17 mm
<b>Barrel Diameter</b>	30.0 mm
<b>Length</b>	48.7 mm
<b>Threading</b>	M25 x 0.75

<b>Camera Port Specifications</b>	
<b>Item #</b>	WFA4100
<b>Magnification</b>	1X
<b>Dovetail</b>	Male D1N
<b>Tube Lens Focal Length</b>	200 mm

### Chapter 7 Mechanical Drawing

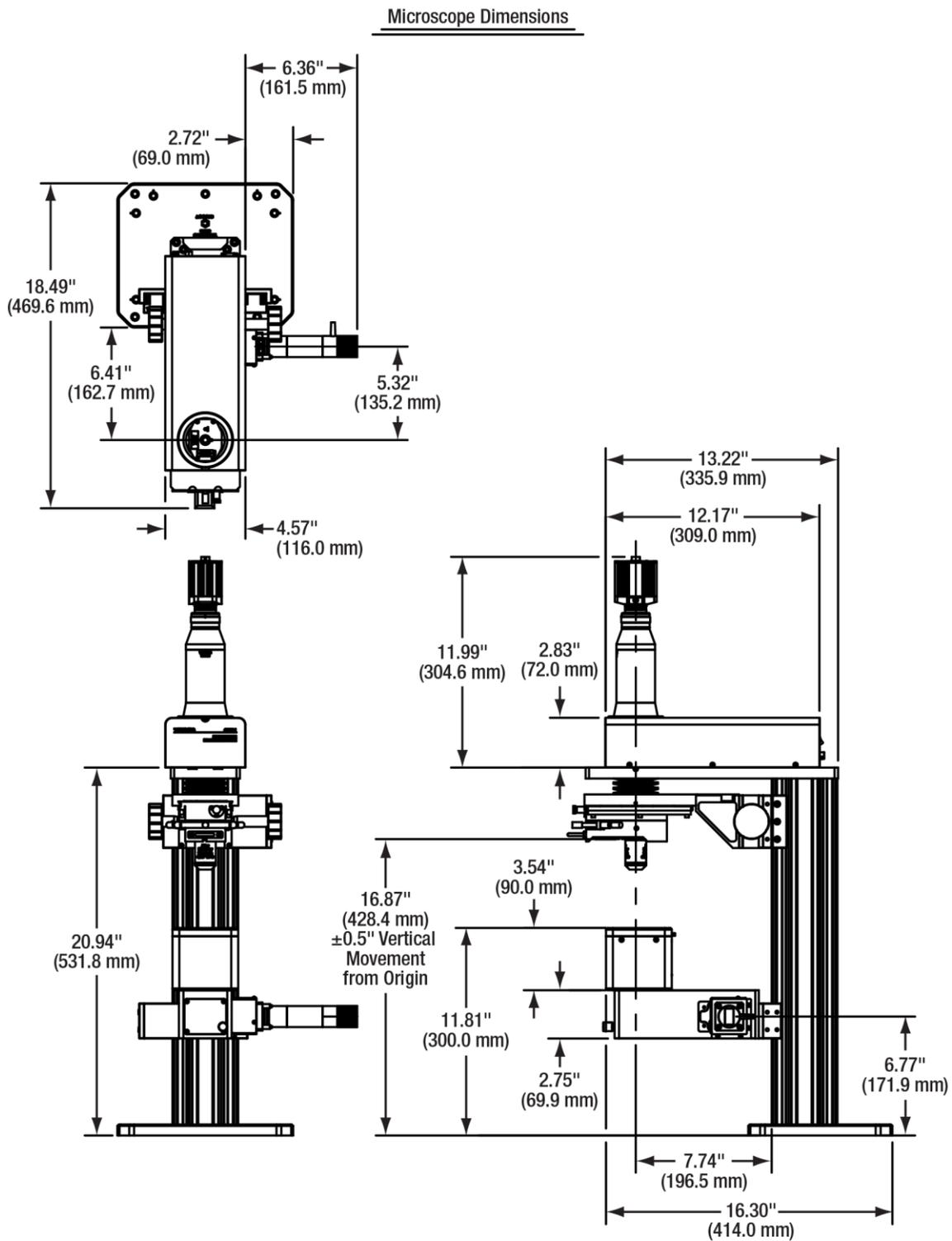
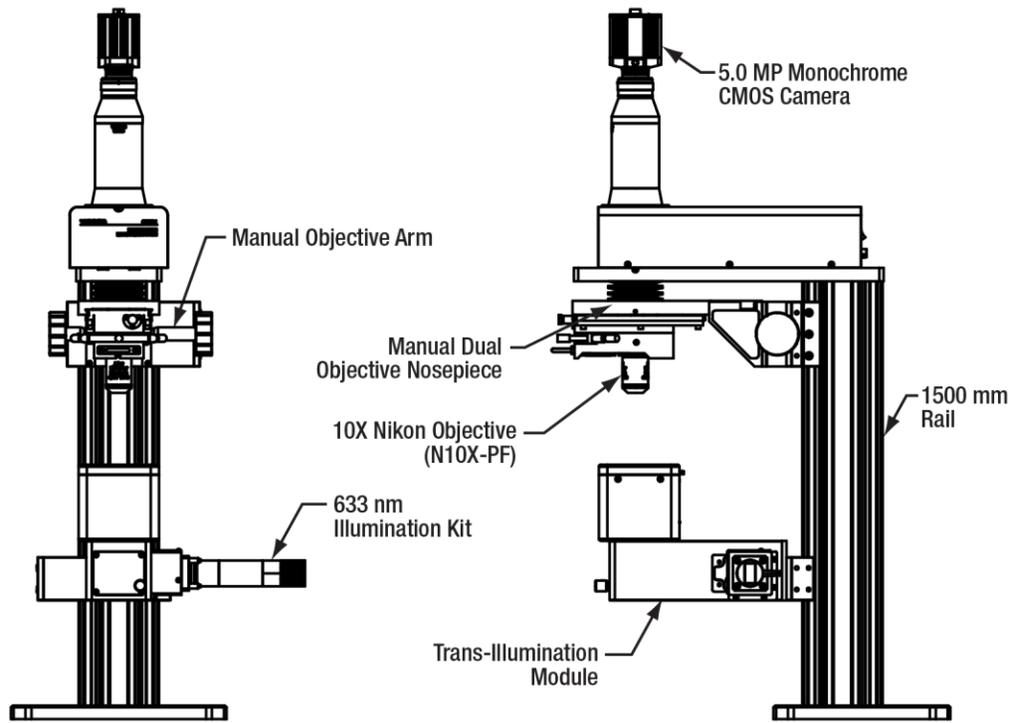


Figure 60 CM501 Microscope Dimensions

Microscope Parts



**Figure 61** CM501 Microscope Parts

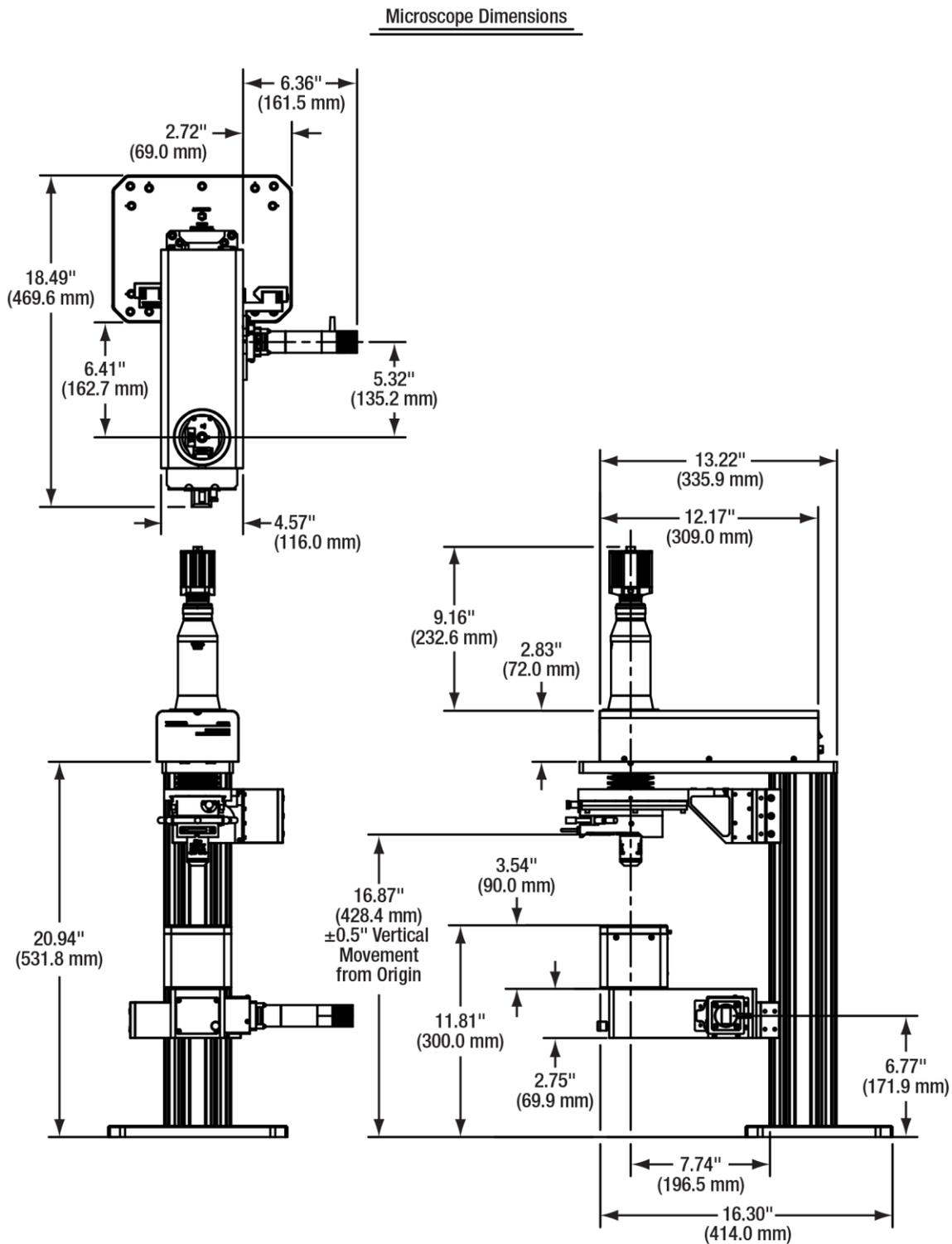
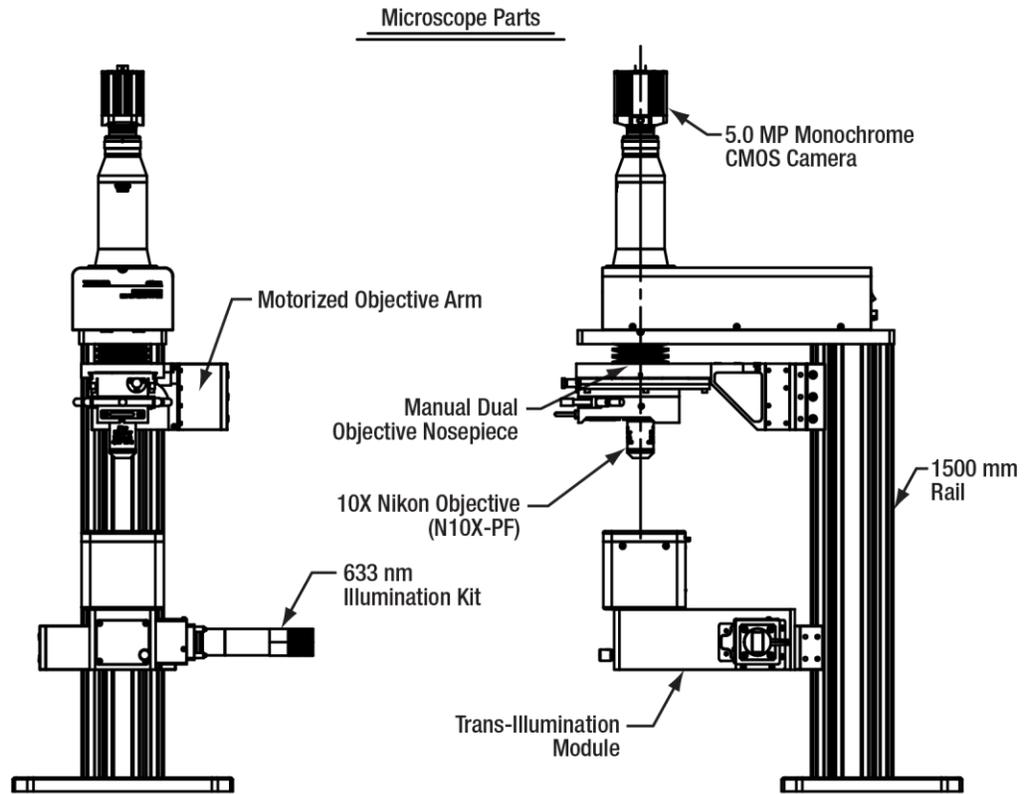


Figure 62 CM502 Microscope Dimensions



**Figure 63** CM502 Microscope Parts

## Chapter 8 Trouble Shooting

Symptom	Possible Cause	Solution
<b>System Does Not Start</b>	No power is supplied to the device	Connect the power supply
	Power switch is off	Switch on the power
	Power cord is broken	Change power cord
<b>Status Indicator in software Does Not Show Ready</b>	Ambient Temperature is fluctuating strongly	Reduce the fluctuation of ambient temperature
<b>GUI Does Not Start</b>	No USB 2.0 cable is connected to the device	Connect the USB 2.0 cable
	No USB 3.0 cable is connected to the device	Connect the USB 3.0 cable
	USB cable is broken	Change USB cable
<b>System Does Not Perform Measurement</b>	Software halted	Restart Laptop or PC
	Poor connection of USB cable	Check USB connection
<b>No Image</b>	Light source intensity is too low	Adjust LED current or camera settings
	Aperture of iris diaphragm on illumination module is too small	Adjust the iris diaphragm on the illumination module to maximum aperture

If problem cannot be identified, please contact Thorlabs' Tech Support.

## Chapter 9 CE/FCC Certification



### Declaration of Conformity

We: Thorlabs Optical Electronic Technology (Shanghai) Co., Ltd  
of: Room A101, No.100, Lane 2891, South Qilianshan Rd, Shanghai

In accordance with the following Directive(s):

2014/35/EU	Low Voltage Directive (LVD)
2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: **CM501, CM502**

Equipment: **Birefringence Imaging System**

Is in conformity with the applicable requirements of the following documents:

EN 61010-1:2010	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use.
EN 61326-1:2013	Electrical equipment for measurement, control and laboratory use. EMC requirements.

and which, issued under the sole responsibility of Thorlabs, is in conformity with Directive 2011/65/EU of the European Parliament and of the Council of 8<sup>th</sup> June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, for the reason stated below:

does not contain substances in excess of the maximum concentration values tolerated by weight in homogenous materials as listed in Annex II of the Directive.

I hereby declare that the equipment named has been designed to comply with the relevant section of the above referenced specifications, and complies with all applicable Essential Requirements of the Directives.

Signed: 

on: 10. May. 2022

Name: Shanshan Song  
Position: General Manager

## Declaration of Conformity

**Thorlabs Optical Electronic Technology(Shanghai) Co.,Ltd  
Room A101, No.100, Lane 2891, South Qilianshan Rd., Shanghai**

declares under it's own responsibility, that the product:

Birefringence Imaging System

Model No.: **CM501, CM502**

fulfills the requirements of the standard

**CISPR PUB. 22, FCC Part 15 Subpart B Class B**

and therefore corresponds to the regulations of the directive.

Signed:



on: 10. May 2022

Name: Shanshan Song  
Position: General Manager

## Chapter 10 Warranty and RMA Information

Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return “end of life” Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out “wheelie bin” logo (see right), were sold to and are currently owned by a company or institute within the EC and are not disassembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own responsibility. “End of life” units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site. It is the user’s responsibility to delete all private data stored on the device prior to disposal.



**Annex I**

### 10.1 Return of Devices

This precision device is only serviceable if returned and properly packed into the complete original packaging including the complete shipment plus the cardboard insert that holds the enclosed devices. If necessary, ask for replacement packaging. Refer servicing to qualified personnel.

### 10.2 Warranty

Thorlabs warrants material and production of the CM501/CM502 Cerna® based Birefringence Imaging Microscope for a period of 12 months starting with the date of shipment in accordance with and subject to the terms and conditions set forth in Thorlabs’ General Terms and Conditions of Sale which can be found at

[https://www.thorlabs.com/Images/PDF/LG-PO-001\\_Thorlabs\\_terms\\_and\\_%20agreements.pdf](https://www.thorlabs.com/Images/PDF/LG-PO-001_Thorlabs_terms_and_%20agreements.pdf).

## Chapter 11 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at [www.thorlabs.com/contact](http://www.thorlabs.com/contact) for our most up-to-date contact information.



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