Tomocube

HT-X1™ mini

Holotomography system

Version 1

Hardware User Manual

For research use only. Not for use in diagnostic procedures.

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- At this guide

This user guide is intended for researchers who are operating and maintaining Tomocube's high-performance holotomography imaging system, the HT-X1™ mini.

- User attention words

Two types of user attention words appear in this manual. Each attention word signals a particular level of observation or action, as described below.

NOTE provides information that may be of interest or help but is not critical to the use of the product.

IMPORTANT! Provides information necessary for proper instrument operation, accurate installation, or safety.

- Safety alert words

Two types of safety alert words related to the awareness of relevant hazards appear in this manual. Each safety alert word signals a particular level of observation or action, as described below.

⚠ **CAUTION** indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate harm to users. This alert may also be used to warn against unsafe practices.

⚠ **WARNING** indicates a potentially hazardous situation which, if not avoided, may result in injury. This alert may also be used to indicate the possibility of erroneous data that could result in an incorrect analysis.

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Chapter 1. PRODUCT INFORMATION

1.1 Purpose and Scope of the Document

This manual provides comprehensive guidance for users of the Tomocube HT-X1™ mini Holotomography (HT) System. The primary purpose of this document is to enable users to safely and effectively operate and maintain the HT-X1 mini system. Additionally, this manual aims to assist users understanding the system's basic functionalities and troubleshooting common issues.

1.2 Product Description

The Tomocube HT-X1 mini Holotomography System is a compact and accessible version of the HT-X1, designed to deliver the same high-resolution 3D imaging performance in a smaller, more accessible format. Tailored for individual labs and smaller-scale research environments, the HT-X1 mini enables label-free three-dimensional (3D) visualization of transparent specimens by generating 3D refractive index (RI) tomograms, which can be translated into morphological, chemical, and mechanical properties.

Built upon Tomocube's low-coherence HT optical system, the HT-X1 mini provides the same optical resolution as the HT-X1, making it suitable for detailed live-cell and organoid imaging. The system is optimized for standard culture dishes, ensuring reliable and convenient workflows for routine experiments and advanced research alike.

For advanced applications, the HT-X1 mini offers optional modules:

- **Laser-based autofocus** for stable long-term time-lapse and large-area imaging without focus drift.
- **Stage-top incubator** to maintain temperature, CO_2, and humidity for live-cell experiments across multiple days.
- **Fluorescence imaging** (3 channels: DAPI/FITC/TRITC), enabling correlative imaging with RI tomograms for molecular and structural analysis.
- **Multi-wavelength HT illumination**, allowing users to select the optimal wavelength for their sample type: green illumination for photosynthetic cells (enhanced contrast of chloroplasts) and red illumination for organoids or thick tissue (improved penetration depth).

The HT-X1 mini is operated using the TomoStudioX software platform, providing streamlined control, intuitive workflow, and comprehensive data management. For details on software features, please refer to the TomoStudioX Software Manual.

The HT-X1 mini system is for research use only. It is not intended for diagnostic procedures.

1.3 Key Features of HT-X1 mini

1. **Label-free 3D imaging of live cells**
   Visualize cellular structures and dynamics in real-time without staining or fixation.
2. **Quantitative refractive index tomography**
   Obtain morphological, chemical, and mechanical information from RI-based 3D tomograms.
3. **Compact and accessible design**
   High-resolution imaging performance in a smaller, cost-effective system suitable for individual labs and smaller research groups.
4. **Multi-wavelength holotomography illumination (optional)**
   Select green illumination for photosynthetic cells or red illumination for organoids and thick tissues, optimizing contrast and penetration depth.
5. **Automated imaging with motorized stage**
   Perform precise and reproducible imaging workflows with minimal user intervention; laser-based autofocus available as an option.
6. **Fluorescence imaging integration (optional)**
   Acquire three-channel fluorescence data (DAPI/FITC/TRITC) and overlay with RI tomograms for correlative molecular and structural analysis.
7. **Long-term live-cell monitoring (optional)**
   Maintain temperature, CO_2, and humidity with a stage-top incubator, enabling time-lapse imaging across multiple days.
8. **Streamlined software control with TomoStudioX**
   Manage acquisition, visualization, and analysis through an intuitive and unified software interface.

1.4 Guidance for System Users

This user manual is designed to support both new and experienced users of the HT-X1 mini system. The contents are following a logical flow—from initial setup to advanced imaging and maintenance—allowing users to quickly find the information you need.

1. **Getting started (Chapters 1 - 3)**
   An overview of the system, core features, and setup requirements. Recommended for first-time users.
2. **System components (Chapter 4)**
   Describes each hardware component and its function. Read this section before installation or troubleshooting.
3. **Basic operation (Chapter 5)**
   Step-by-step instructions for powering on the system, loading samples, and performing basic imaging.
4. **Maintenance and troubleshooting (Chapters 6 – 7)**
   Covers routine cleaning, system checks, and issue resolution. Particularly useful for lab managers and advanced users.

5. **Safety and support (Chapters 8 – 10)**
   Include important safety information, product compliance, warranty details, and contact information for technical support.

NOTE First-time users are encouraged to read Chapters 1 through 5 in sequence. For system upkeep or issue resolution, refer directly to Chapter 6 - 10 as needed.

Chapter 2. SYSTEM OVERVIEW

2.1 Standard Included Items

The package of the HT-X1 mini contains the following boxes.

1. Main box
2. Environmental control unit box (optional)
3. Workstation box
4. Laptop box (optional)

The main box contains the following components.

1. HT-X1 mini Holotomography system
2. HT-X1 mini Hardware user manual
3. TomoStudioX Software user manual
4. HT-X1 Series Installation, IQ procedure
5. HT-X1 Series PQ procedure
6. Certificate of Quality
7. AC power cord
8. USB 3.0 A-B cable. 2m
9. Quality Check (QC) samples
10. 35mm Dish Holder (XM-HT35)
11. 50mm Dish Holder (XM-HT50)

The workstation box contains the following components.

1. Workstation for operating
2. Power cable
3. Keyboard
4. Mouse

The environmental control unit box contains the following components in four smaller boxes.

1. Chamber
2. Top cover
3. Bath cover
4. Environmental controller
5. Communication cable
6. Silicon tube
7. Power cable
8. DC adapter
9. Disposable syringe

NOTE A monitor is not included in the workstation box. A 27-inch QHD (2560 x 1440p) or higher resolution display monitor and an HDMI cable to connect with the operating workstation (PC) should be prepared by the user. Contact your local distributor for more details.

Please confirm that all the items listed above are included in the package delivered. If any of the above components are missing or damaged, contact Tomocube for support at support@tomocube.com.

2.2 Optional Accessories

These accessories can be purchased separately to support various specimen types and imaging conditions. Vessel holders and specialized labware enhance compatibility and flexibility for different experimental needs.

2.2.1 Imaging Vessels

Model name	Cat No.	Description
TomoDish 35mm	901002-11	35mm Dish with 1.5H glass
TomoDish 50mm	901002-02	50mm Dish with 1.5H glass
Top Coverslip	901002-03	35mm Dish with 1.5H glass

2.2.2 Vessel Holder

Model name	Cat No.	Description
35 mm Holder for HT-X1 mini *(XM-HT35)*	900112-01	• Single 35mm imaging dish holder compatible with various brands
35 mm Locking Holder for HT-X1 mini *(XM-HTTD35)*	900112-11	• Compatible with live cell incubation vessels like chamber slides • Supports stable long-term live imaging conditions
35 mm 2-Dish Holder for HT-X1 mini (XM-HT35-2)	900112-21	• Dual 35mm imaging dish holder compatible with various brands
35 mm 2-Dish Locking Holder for HT-X1 mini *(XM-HTTD35-2)*	900112-31	• Locking holder for two 35mm dishes with fixed positioning for consistent re-imaging • Compatible with select dish brands (e.g., TomoDish) due to bottom-locking structure
50 mm Holder for HT-X1 mini *(XM-HT50)*	900112-41	• Single 50mm imaging dish holder compatible with various brands
TomoDish 50 mm Locking Holder for HT-X1 mini *(XM-HTTD50)*	900112-51	• TomoDish 50mm-specific holder with positioning notches for precise and reproducible imaging
Microscopic slide holder for HT-X1 mini	900112-61	• Compatible with microscopic slide vessels such as tissue slides

Model name	Cat No.	Description
(XM-HTSG)		• Do not support for long-term live imaging conditions
Chamber slide holder for HT-X1 mini *(XM-HTSG-L)*	900112-71	• Compatible with live cell incubation vessels like chamber slides • Supports stable long-term live imaging conditions

The optional accessories can be purchased separately.
Contact sales@tomocube.com or your local distributor for more information about the items.

Chapter 3. SPECIFICATIONS

When the product is received, be sure to inspect the package box for any damage. If possible, do not remove the instrument from the box; an installation engineer will unpack and install the instrument.

IMPORTANT! The HT-X1 mini system must be installed by a professional technician authorized by Tomocube.

3.1 Physical Specifications

Section	**Description**
Dimensions (mm)	Instrument: 430 x 526 x 492 mm (W x D x H) Package: 570 x 680 x 610 mm (W x D x H)
Weight (kg)	Approx. 30kg (depending on optional configurations)
Power supply	100-240 VAC, 50/60Hz, 3A
Objective lens	40x, NA 0.75, air
Objective working distance	510 μm
Condenser lens	NA 0.72
Image sensor	2.8 Megapixels CMOS Sensor size: 1936 x 1464
Field-of-view	218 μm x 165 μm
Minimum acquisition time	1.3 sec per image (ROI: 55 μm x 55 μm x 31 μm)
Stage	Travel range 80 mm x 60 mm
Auto focus	Optional, Laser assisted active sensor Speed: <1 sec
Light source	Holotomography: 444 nm / Optional 520, 660 nm, LED Fluorescence: Optional 3 channels, LED
Fluorescence filter	Size: ø25 mm / t = 3 to 5 mm (excitation, emission) Exchange time: 100 ms
Installation site	Indoor Use Only
Altitude	≤2,000 m
Overvoltage category	Category II

Section	**Description**
Pollution degree	2
Type of projection against electric shock	Class I Equipment, No applied parts

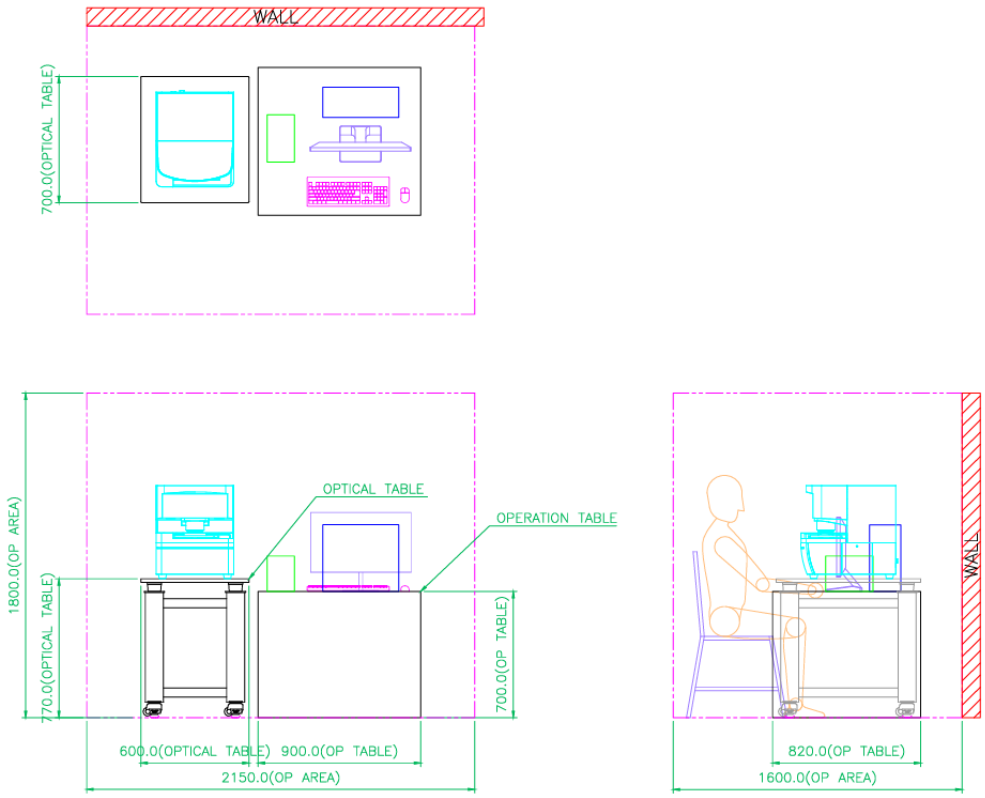
3.2 Environmental Specifications

Section	**Description**
Temperature	23°C to 27°C (73°F to 80°F)
Relative humidity	RH 35-85%, non-condensing

3.3 Operating Site Requirements

The system is recommended to be placed and operated on a stable benchtop of 600 mm x 700 mm or larger. A pneumatic optical table with vibration isolation is preferable but not required.

It is highly recommended to set up alongside the instrument benchtop an additional worktable of approximately 900 mm x 820 mm or wider to place the operating workstation (PC), monitor, and environmental controllers.



The instrument needs at least 5 cm (2 in) of clearance on each side to prevent overheating of the electronic components. Place the instrument on a level surface away from other laboratory equipment that can cause vibration of the instrument during image acquisition.

IMPORTANT! The AC power supply should be 100-240V, 50/60Hz, single phase, and 2 kW.

⚠ **CAUTION** Always place the instrument on a flat, stable platform. Check the positioning on the platform before each use.

⚠ **CAUTION** Use only the authorized power supply provided with the instrument. The use of unauthorized power sources may cause damage to the instrument.

⚠ **CAUTION** The electromagnetic environment must be assessed before operating the instrument.

⚠ **CAUTION** When working with the HT-X1 mini holotomography system, minimize the impact of discharge events by properly grounding the system and the operator.

⚠ **CAUTION** Do not connect the HT-X1 mini system to the same power outlet as other high-power devices. Sudden power surges caused by nearby equipment may result in abnormal system behavior or image acquisition errors.

3.4 Preparation Before Installation

1. **Package inspection**

   Upon receiving the product, carefully inspect the package for any signs of external damage. If possible, do not open the box. A Tomocube-authorized installation engineer will unpack and install the instrument.

2. **Transporting the instrument**

   Ensure that the installation site is cleared and ready before the scheduled installation. If feasible, move the crated instrument and all shipping containers (including accessory boxes) directly to the installation site without unpacking.

⚠ **CAUTION** Physical injury hazard. Lift or move the instrument using proper lifting techniques. It is strongly recommended to lift and move the crated instrument with the assistance of sufficient people with the use of appropriate moving equipment that can protect the persons from unintended dropping or falling. Improper lifting of the instrument can cause permanent injury.

IMPORTANT! Do not unpack the instrument from the package without the assistance of a technical professional authorized by Tomocube.

For more information, refer to the HT-X1 mini installation manual or inquire to Tomocube at support@tomocube.com.

Chapter 4. HARDWARE COMPONENTS DESCRIPTION

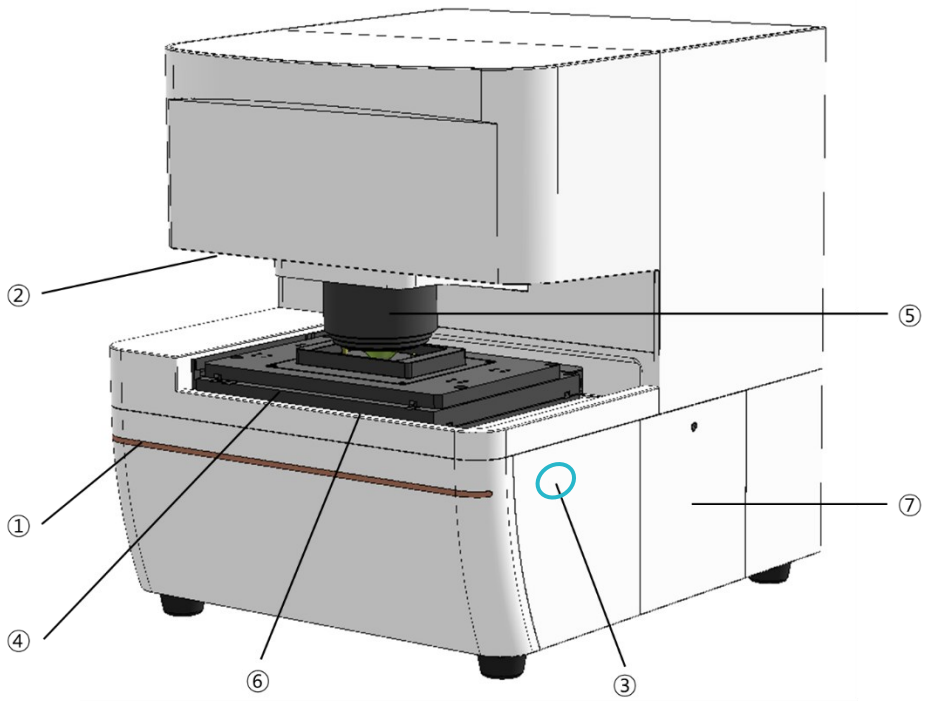
4.1 Exterior Components of HT-X1 mini System

The exterior components of the HT-X1 mini System constitute the essential hardware for successful sample imaging experiments. This section details the main external features and functions of the system's core unit, the HT-X1 mini (Main Unit), Workstation used for system operation and Stage Top Incubator which regulates the cell culture environment.

4.1.1 HT-X1 mini (Main Unit)

HT-X1 mini is a microscope body that uses Holotomography technology to capture 3D Images of samples. It's an essential tool for advanced life science research, designed for comprehensive, long-term cellular analysis.

1. **Oblique view with number labeling**



#	Component	Description
1	Status Indicator Lamp	Displays the system status using color codes. Help users quickly recognize the current state. (e.g. Standby, operation, error)
2	Work Light	Provides illumination inside the instrument to assist with sample positioning.
3	Work Light Button	Turns the work light on or off.

#	Component	Description
4	Stage with sample guard	Stage area with low protective guard to secure holders and prevent sample spillover.
5	Condenser Lens	Provides illumination for holotomography image.
6	Objective Lens	Collects transmitted light to form high-resolution holotomography images.
7	Fluorescence Engine Access Door	Removable panel for installing the optional fluorescence light engine module.

2. **Status lamp color codes**

Color	Mode	Indication
Black	Solid	System off
White	Solid	Device initializations stand-by
Teal	Solid	Ready for system operation
Green	Blinking	System in operation
Red	Solid	Error

The front side of the HT-X1 mini includes essential components for user interaction and sample access:

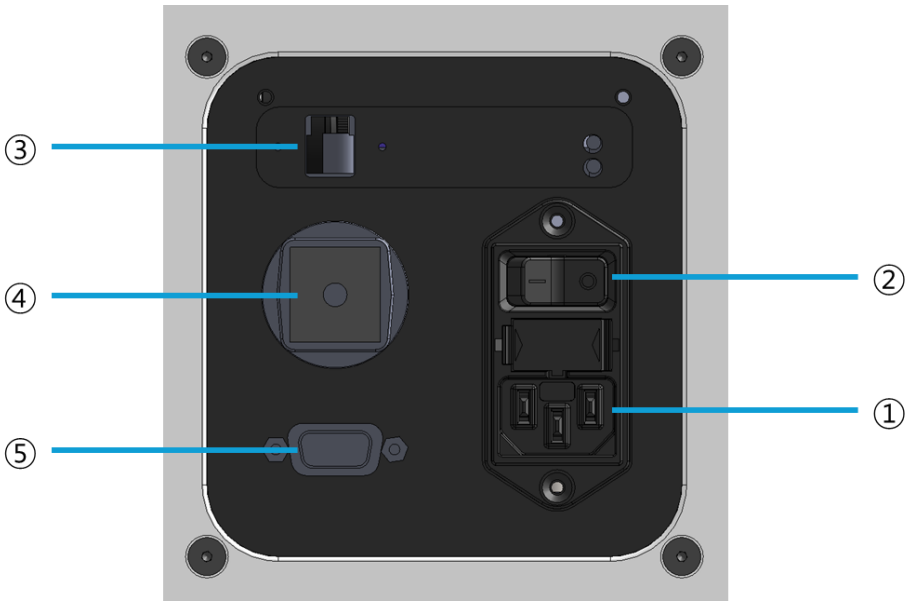
A status lamp displays the system status using color codes: black for off, white for initialization, teal for ready, green for active operation, and red for error.

IMPORTANT! If the status lamp turns red at any stage in operation, turn off and on the HT-X1 mini power.

3. **Main external connection ports of rear panel**

The HT-X1 mini system's main external connection ports are located on the lower-right side of the rear panel. These include the AC power inlet and main power switch, as well as ports for incubator control. Additional ports support communication and synchronization with the workstation, including USB connections for camera data transfer and system control.

On the lower-left side of the rear panel, a product label is affixed. This label displays the model name, power specifications, country of manufacture, serial number (S/N), and applicable regulatory certifications (e.g., CE, UKCA, FCC). This label serves as the system's primary identification and should be referenced when registering the product or contacting technical support.



This rear-panel layout supports organized cable management and ensures convenient access for installation and maintenance.

#	Component	Description
1	Power port	Connects the system to an external power source.
2	Main power switch	Push-button switch that turns the HT-X1 mini system ON or OFF.
3	System USB port	Rear USB port for direct connection to the control PC.
4	HT camera port	Port for connecting the HT imaging camera to the PC
5	Lens warmer port	Connects to the onstage incubator controller to regulate temperature of objective lens warmer.

NOTE Ports ③ and ④ must be connected to USB 3.0 ports on the workstation. Using lower-speed ports may result in unstable communication or performance issues.

4.1.2 Operating Workstation

The operating workstation is a high-performance PC provided with the HT-X1 mini system. It is pre-installed and configured to run TomoStudioX software for system control, image acquisition, and real-time processing of HT and fluorescence data.

The workstation includes required hardware specifications such as a CUDA-compatible GPU and Windows 10 operating system. It connects to the HT-X1 mini via USB and trigger cables and must remain powered during operation.

NOTE The USB connections from the HT-X1 mini must be connected to USB 3.0 ports on the workstation to ensure stable data transfer and device control.

NOTE Do not disconnect any cables or install unrelated software on the Operating Workstation, as this may affect imaging performance or system stability.

4.1.3 Operating Laptop (Optional)

An optional high-performance laptop can be used with the HT-X1 mini system as an alternative to the standard workstation. When equipped with a CUDA-compatible GPU with at least 24 GB VRAM, the laptop can fully support system connection and real-time processing of HT and fluorescence data using TomoStudioX software.

The laptop connects to the HT-X1 mini via USB and trigger cables and can be pre-configured with the required software environment for imaging and analysis.

NOTE The laptop must remain connected to AC power during system operation and processing. Running on battery power may cause performance degradation, resulting in unstable device recognition or interrupted processing.

4.1.4 Stage Top Incubator (Chamber & Controller)

The Stage Top Incubator facilitates long-term live cell observation with the HT-X1 mini. It mounts directly onto the stage, precisely controlling temperature, humidity, and gas levels to maintain an optima environment for cells. This ensures cell viability and physiological stability throughout extended imaging experiments.

The incubator system consists of:

a. A compact chamber (Installed on the stage)
b. A dedicated controller with touchscreen interface
c. Multiple heating elements (top, bath, stage, and lens heaters)
d. Gas inlet ports for CO_2 supply
e. Optional feedback sensor for real-time sample temperature control

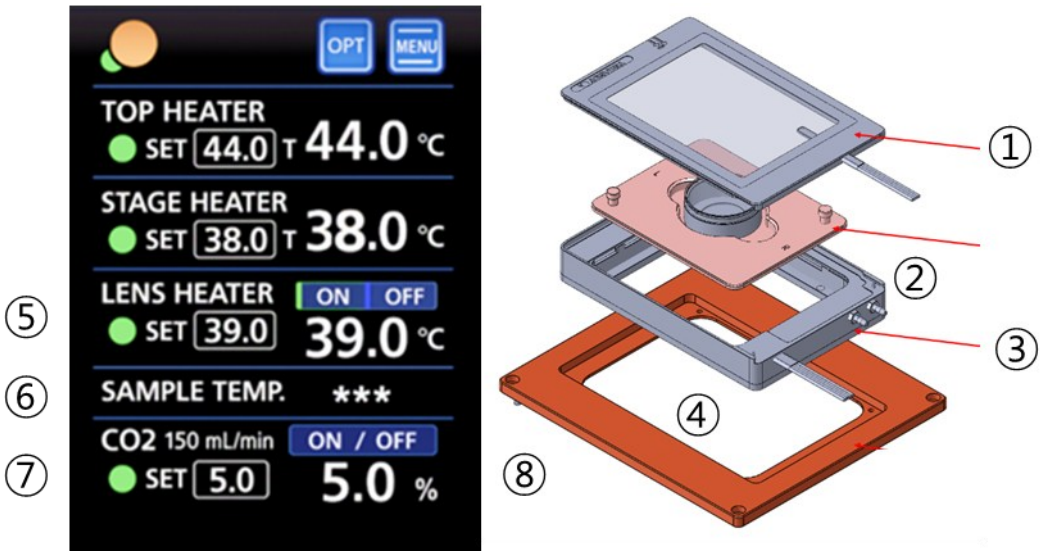
NOTE The temperature feedback sensor is not included as standard. It can be purchased and installed separately if high-precision sample temperature regulation is required.

1. **Controller unit**

The environmental control unit maintains physiological conditions by regulating temperature, CO_2 concentration, and humidity directly on the microscope stage.

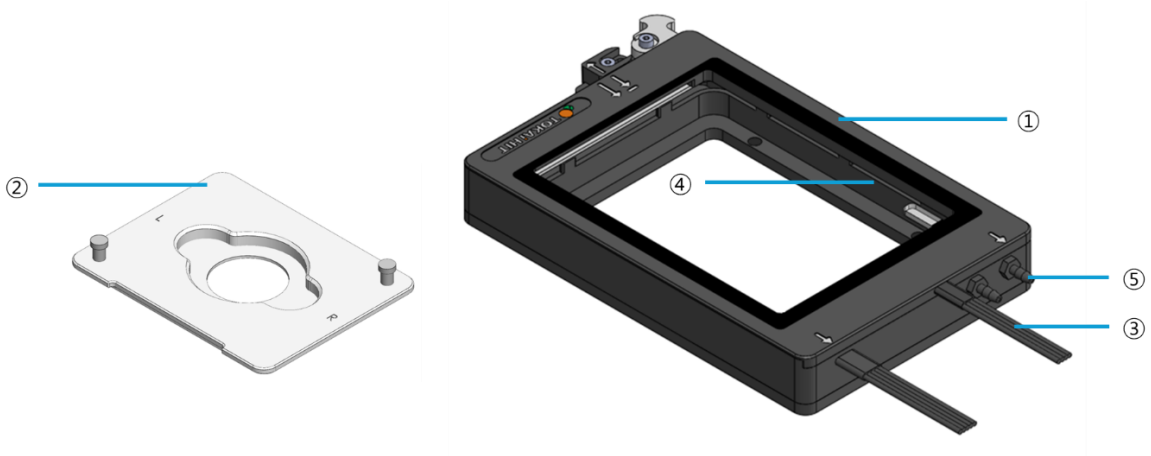
#	Component	Description
1	Controller On/Off Button	Turn the incubator ON or OFF. The Light yellow LED ring lights up when power is on.
2	Main Display Panel	Touchscreen interface showing current and set values for heaters (top, stage, bath, lens), sample temperature (if sensor is installed), and CO_2 concentration. Allows direct control and monitoring.
3	CO_2 IN Port	Connects to a 100% CO_2 gas cylinder. This port receives pure CO_2 to be regulated and mixed internally. Refer to the front panel label for the recommended input pressure (typically 0.1–0.15 MPa).
4	Gas OUT Port	Delivers CO_2 mixed with air (typically 5%) to the incubator chamber for maintaining proper atmospheric conditions.
5	Cooling Fan	Provides ventilation for internal components. Do not block the rear side of the unit to ensure proper airflow and cooling.
6	PC LINK Port	Communication port for PC connection. Not used during standard HT-X1 mini operation.
7	GM LINK Port	Port for connecting a gas mixer (GM). Not used in the standard HT-X1 mini configuration.
8	CHAMBER Port	Connects to the chamber to control internal heaters and sensors. Connect this to the CHAMBER port (No. ③) on the HT-X1 mini rear panel.
9	DC IN Port	Input for the system's DC power supply (typically 24V). Connect to the external power adapter.
10	TEMP SENSOR Connector	Connection port for the optional external sample temperature sensor. No sensor is connected by default.
11	SUB1(SUB HEATER)	Added to control optional heating items such external humidifier, additional lens heater, tube heater etc. through STXG controller.

2. Controller main display panel and components



#	Component	Description
1	Top Heater	Prevents condensation on the chamber lid and assists with sample temperature control.
2	Bath unit	Humidifies the chamber interior by generating steam.
3	Stage Heater	Heats the dish attachment and minimizes heat loss from the stage area.
4	Lens Heater	Prevents heat loss from the objective lens to maintain stable sample temperature.
5	Lens Heater ON/OFF Switch	Enables or disables lens heater.
6	Sample Temperature Sensor	(Optional) Measures actual temperature near the sample. Used for feedback control. (Not included by default)
7	CO_2 Concentration Display	Shows the current (PV) and target (SV) CO_2 gas concentration in the chamber.
8	CO_2 Supply ON/OFF Switch	Enables or disables CO_2 gas flow into the chamber. (Should be OFF when gas supply is disconnected.)

3. Chamber



#	Component	Description
1	Chamber Top Cover	Seals the chamber top, precisely maintaining internal temperature, humidity and gas.
2	Dish Holder	Secures standard culture vessels within the incubator to ensure accurate positioning and minimize movement.
3	Chamber cover Connector	Connects the chamber to the controller and enables temperature and humidity regulation.
4	Water Bath	Maintains humidity inside the stage-top incubator by enabling evaporation of sterile distilled water. It evaporates at 0.5 to 1ml per hour.
5	Access Port	Allows liquid injection or removal during imaging by connecting external tubing.

4.2 Overall System Configuration Diagram

This chapter visually explains the overall system configuration of the HT-X1 mini system and the connection methods between its major components.

4.2.1 HT-X1 mini and Workstation Connection

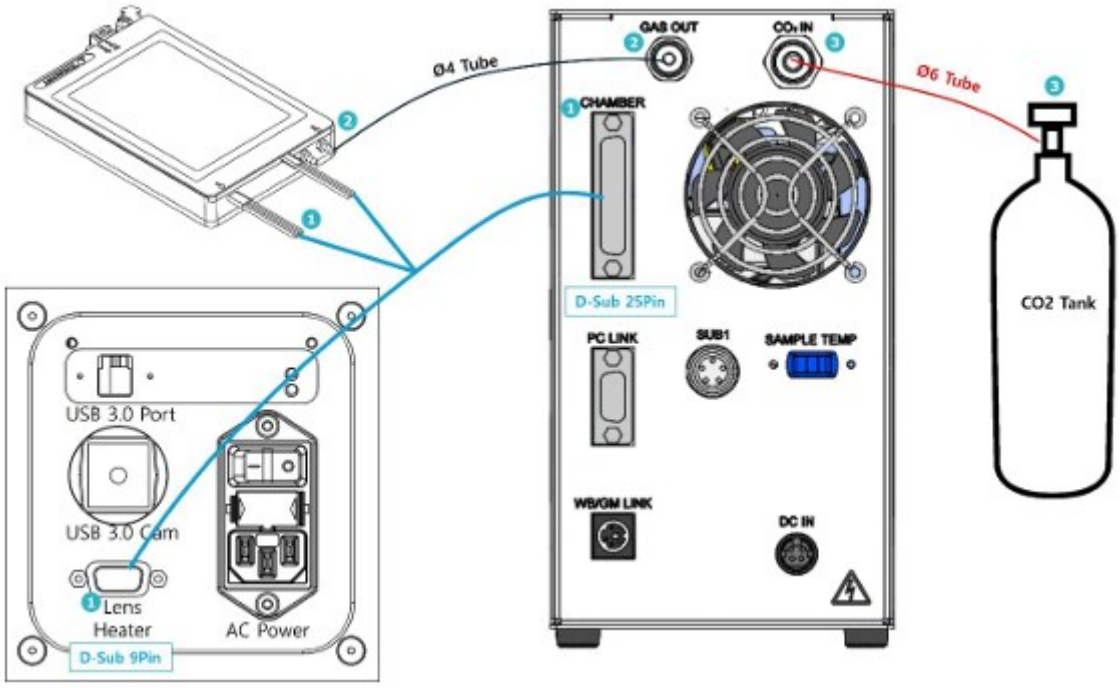
1. Connect the HT camera port on the HT-X1mni to a USB 3.0 port on the workstation. This cable transfers image data from the main camera.
2. Connect the system USB port on the HT-X1 mini to a USB 3.0 port on the workstation. This enables system control communication.
3. Both connections must be made to USB 3.0 ports (blue, labeled “SS”) on the workstation for stable operation.

IMPORTANT! Do not use USB 2.0 ports. Improper connection may result in unstable performance or software malfunction.

4.2.2 CO_2 Gas Connection

This diagram shows how to connect the 100% CO_2 gas cylinder to the Environmental.

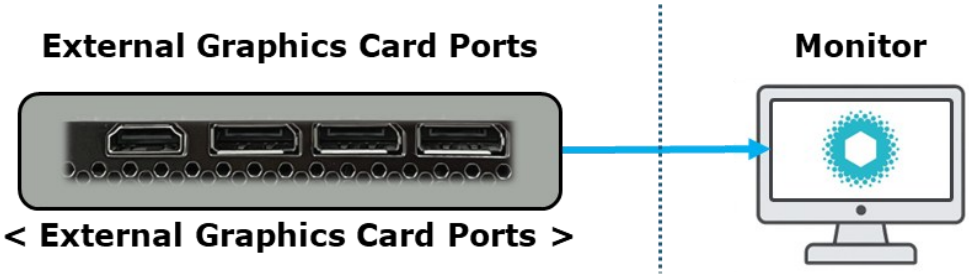
Control unit.CO_2 gas from the cylinder is supplied to the CO_2 IN port on the rear panel of the controller. Ensure that the gas pressure is regulated within the recommended range (0.1–0.15 MPa), as indicated on the front panel. Use only 100% CO_2 and secure all tubing connections to prevent leakage.



4.2.3 Monitor and External Graphics card Connection

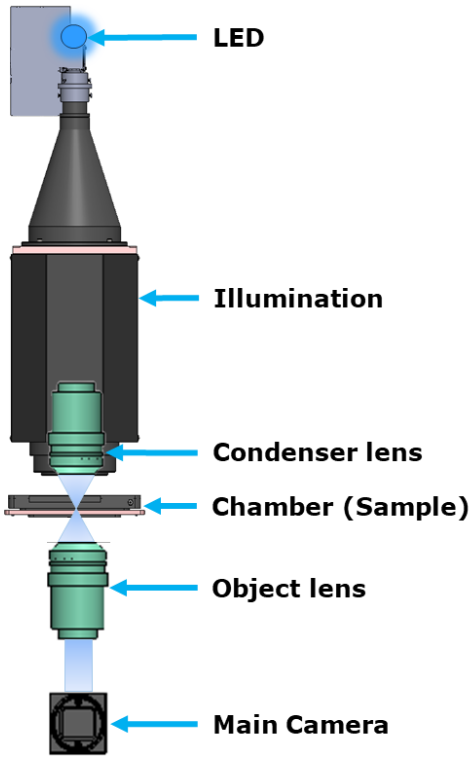
Connect the monitor to one of the output ports on the **external graphics card**, located near the ventilation holes.

IMPORTANT! Do not use the display ports on the motherboard. If the monitor is connected to the wrong port, TomoStudioX may not launch properly or will run without GPU support.



4.3 Optical System Structure and Optical Path

The HT-X1 mini is based on HT technology, which enables label-free 3D imaging by analyzing phase shifts in transmitted light.



Light from the LED source passes through the Illumination and Condenser lens before reaching the sample. The light is then refracted by the Sample. This refracted light subsequently passes through the object lens and reaches the camera. The captured refracted images are then processed using TomoStudioX software to reconstruct 3D RI distribution maps.

NOTE For detailed information regarding TomoStudioX software, please refer to separate TomoStudioX Operation Manual.

Chapter 5. BASIC OPERATION OVERVIEW

5.1 Equipment Power on/off Sequence

1. **Basic operation: Power On**

   To operate the equipment, you must power on the two hardware components: the HT-X1 mini and the workstation. The order in which all pieces of equipment are not critical. However, you must ensure that all devices are powered on before starting the TomoStudioX software to operate the equipment.

2. **Basic operation: Power Off**

   To power off the equipment, first initiate the experiment termination by pressing the 'END' button in the TomoStudioX software. This action will automatically unload the sample and return the stage top incubator to its initial loading position. Once these steps are complete, you may power off the hardware components: the HT-X1 mini and the operating workstation.

5.2 Features of Vessels for HT-X1 mini

The HT-X1 mini system is intended to capture HT of a sample placed in a vessel with a bottom thickness of #1.5H (0.17 mm). Imaging vessels with a different bottom thickness can be a source of aberration or noise in the image results.

To ensure optimal imaging performance, it is recommended to fill each vessel with the recommended volume of cell culture medium, as listed in the table below. Uneven medium volumes between wells can reduce image quality.

Vessel type	Well Size	Recommendation volume of medium	Observable area
50-mm imaging dish	50 mm	3 mL	20 mm x 20 mm
35-mm imaging dish	35 mm	2 mL	8 mm x 8 mm
8-well chamber slide	9.4 mm	300 µL	4 mm x 2 mm

IMPORTANT! Do not use dishes with thick bottoms that are not designed for imaging.

IMPORTANT! Do not write or make any marks on the center of the vessel lids. Ink or stickers on the center of the lid may block light transmission and interfere with the results.

5.3 Compatible Vessels

The products below have been verified as valid for successful holotomography imaging with the HT-X1 mini system. Microscopic slides mounted with #1.5H coverslip or microfluidic devices with a size of 25 mm x 75 mm are also compatible with the system.

Category	Product	Type	Culture area (cm^2)	Working volume(mL)
Imaging dish	TomoDish 50 mm	50 mm	20.2	3
	TomoDish 35 mm	35 mm	7.5	2
	ibidi µ-Dish 35 mm	35 mm	7.5	2
	Cellvis 35 mm dish	35 mm	9.6	2
Slide	ibidi µ-Slide 8 well	8 wells	1.0	0.3

IMPORTANT! Do not use imaging plates with different bottom thickness. (e.g., #1)

NOTE For any inquiries about other imaging vessels not listed above, please contact Tomocube at support@tomocube.com.

5.4 Compatible Vessel Holders

When mounting one of the compatible vessels onto the HT-X1, it is recommended to use an appropriate vessel holder for each type of vessel used. The table below lists the vessel holders provided by Tomocube that are compatible with the HT-X1 system.

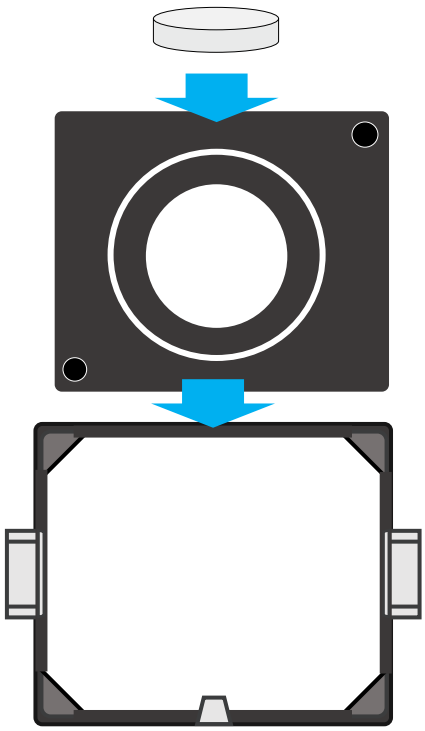
Model name	Description
35 mm Holder for HT-X1 mini (XM-HT35)	• Versatile holder for standard 35mm imaging dishes
35 mm Locking Holder for HT-X1 mini (XM-HTTD35)	• TomoDish 35mm-specific holder with positioning notches for accurate repositioning
35 mm 2-Dish Holder for HT-X1 mini (XM-HT35-2)	• Dual 35mm imaging dish holder compatible with various brands
35 mm 2-Dish Locking Holder for HT-X1 mini (XM-HTTD35-2)	• Locking holder for two 35mm dishes with fixed positioning for consistent re-imaging
50 mm Holder for HT-X1 mini (XM-HT50)	• Versatile holder for standard 50mm imaging dishes
TomoDish 50 mm Locking Holder for HT-X1 mini (XM-HTTD50)	• TomoDish 50mm-specific holder with positioning notches for accurate repositioning
Microscopic slide holder for HT-X1 mini (XM-HTSG)	• Compatible with 75 mm x 25 mm microscopic slides

Model name	Description
Chamber slide holder for HT-X1 mini (XM-HTSG-L)	• Compatible with live cell incubation vessels like chamber slides • Supports stable long-term live cell imaging conditions

NOTE The optional vessel holders are not included in the standard included items. To purchase optional accessories, contact sales@tomocube.com or your local distributor for more information about the items.

5.5 Sample Setup (Pre-Operation)

Once the HT-X1 mini main unit and the operating workstation have been powered on to control the system using TomoStudioX software, the next step is to place the sample inside the chamber.



5.5.1 Necessary Components for Pre-Operation

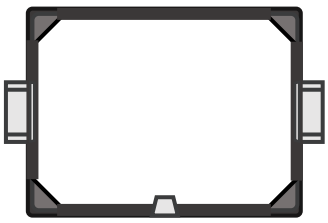
To integrate with the chamber, holder attachment is fundamentally required. Additionally, depending on the type of vessel your sample contains, an alternative vessel holder is necessary in addition to the holder attachment.

NOTE The image above is for illustration purposes only. For a comprehensive list of compatible Vessels and Vessel Holders.

Vessel Category	Vessel Model	Compatible Vessel Holders
Imaging Dish	TomoDish 35 mm	• 35mm 1-dish holder • 35mm 1-dish locking holder • 35mm 2-dish holder • 35mm 2-dish locking holder
	TomoDish 50 mm	• 50mm 1-dish holder • 50mm 1-dish locking holder
	Cellvis 35 mm dish	• 35mm 1-dish holder • 35mm 2-dish holder
Slides	75 mm x 25 mm tissue slide	• Microscopic slide holder
	ibidi µ-Slide 8 well	• Chamber slide holder

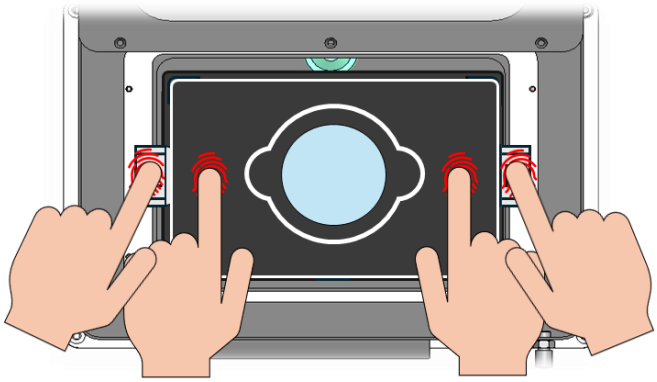
5.5.2 Mounting vessel onto the chamber stage

1. Prepare holder attachment.



2. Attach the vesel holder to the chamber holder.
3. Attach the vessel to the ATX-W according to its type.
4. Mount the assembled holder onto the Chamber Stage.

   Once assembled, correctly orient and insert the prepared ATX-W into the chamber stage.
5. Ensure it is securely seated on the chamber stage.



After placing the assembly inside the chamber, gently press it down from above to ensure it is fully seated against the chamber bottom and securely positioned. This ensures stable placement and prevents any movement during imaging

NOTE If the vessel is not properly seated during this step and remains slightly lifted, it may lead to autofocus failure or unexpected errors during the imaging process.

⚠ **CAUTION** Applying excessive force may cause damage. Service charges may apply for damage resulting from user negligence or improper handling.

Chapter 6. MAINTENANCE AND INSPECTION

The HT-X1 mini imaging system does not require routine maintenance or calibration.

To maintain its optimal condition, it is recommended to clean the external and internal surfaces before and after each use, or as needed.

6.1 External Surface Cleaning

To clean the external surface of the instrument, use only a soft, dry tissue or cloth. Gently wipe away dust from the surface; avoid rubbing with force.

6.2 Internal Cleaning for the Incubation Chamber

Internal cleaning of the microscope is performed only for the stage top incubator, which consists of two main parts: the water bath and the top cover.

For the water bath, which prevents medium evaporation, only pure water should be used. If any foreign substances are present, remove them with water and alcohol.

The top cover's inner and back surfaces should be cleaned carefully with a lens tissue or similar soft material to avoid damage, as foreign matter can affect light transmission to the sample.

For the rest of the microscope's interior, only light cleaning, such as gently wiping away dust or using an air blower, is recommended.

6.3 Lens Maintenance

To maintain optimal imaging performance, regularly inspect the objective lens for signs of contamination (e.g., smudges, debris, or fogging).

IMPORTANT! Do not attempt to clean the lens without guidance. The lens is deeply recessed and may be damaged by improper handling.

If contamination is suspected, contact Tomocube's service support team. Cleaning should only be performed under the guidance of authorized personnel, either remotely or through a scheduled service.

The following cleaning procedure is provided for reference only and must not be carried out without prior approval and instruction from Tomocube support:

1. Remove loose dust or particles using a lens blower. Avoid touching the lens with any tool at this stage.
2. Soak a lens cleaning swab (or Stick) in isopropanol. Use only lint-free swabs designed for optical surfaces.
3. Gently wipe the lens surface in a single direction. Do not apply excessive pressure or rub in circles.

   NOTE Recommend for using CTA10 (Lens cleaning stick) by Thorlabs.
4. Allow the lens to air dry completely. Do not use tissue or compressed air to speed up drying.

6.4 Key Precautions for Laptop Operation

When operating the HT-X1 mini system using a laptop instead of a desktop workstation, the following guidelines must be strictly followed to ensure stable data transmission and precise hardware control.

IMPORTANT! Always keep the AC power adapter connected to prevent system interruption due to low battery during operation.

IMPORTANT! To prevent data loss during long-term time-lapse imaging, disable both 'Sleep' and 'Turn off display' options in the Windows Power Management settings

IMPORTANT! To minimize noise from voltage instability, do not share the same power outlet with high-power consumption equipment such as centrifuges, ultra-low temperature freezers, or incubators. It is highly recommended to use X-safe for a stable power supply.

⚠ **CAUTION** You must connect directly to a USB 3.0 port (indicated by blue color or 'SS' mark). The use of USB hubs is strictly prohibited to ensure sufficient data bandwidth.

⚠ **CAUTION** Ensure that the USB cable remains securely connected during imaging. Communication loss can cause hardware malfunctions.

6.5 Magnetic Vessel Holder Handling Guide

The HT-X1 mini features a magnetic attachment system for user convenience and precise positioning.

IMPORTANT! Always keep the AC power adapter connected to prevent system interruption due to low battery during operation.

1. Magnetic Attachment: Vessel holders are easily and accurately mounted onto the incubator or dummy incubator plate via magnets.
2. Holder Orientation: All vessel holders have a specific Left/Right (L/R) orientation. Always check the orientation marks before mounting to maintain proper alignment with the optical axis.

6.6 Prevention of Typical Handling Mistakes & Maintenance

To prevent common operational errors in practical use environments, please familiarize yourself with the following instructions.

6.6.1 Prevention of Lens Contamination and Damage

⚠ **CAUTION** At the sample loading position, the objective lens is exposed upward and is highly susceptible to contamination and damage. Double-check that the holder is securely fixed in the correct position before mounting it or closing the chamber door.

⚠ **CAUTION** Be careful not to touch the upper condenser lens with your fingers when loading/unloading the vessel holder. To avoid contamination, always hold the holder by its edges.

6.6.2 System Relocation and Physical Stability

Do Not Relocate: To maintain optical alignment, avoid moving the equipment once installed.

Proper Transportation: If the equipment must be moved, never lift or grab the upper housing. It must be transported by firmly supporting the bottom part. Do not place any objects (e.g., manuals, holders) on top of the device.

6.6.3 Environmental Control Management (Incubator Models Only)

Water Bath Maintenance: Fill the water bath inside the chamber with approximately 12 mL (Max 15 mL) of sterile distilled water to maintain humidity. A full fill lasts approximately 2 days; check the water level regularly and refill using a syringe.

Chamber Lid Removal: The chamber lid is not a sliding type. To remove it, first ensure the lid is fully closed, then lift it vertically upward.

Chapter 7. TROUBLESHOOTING-GUIDE

7.1 Troubleshooting Guide

These troubleshooting guides are designed to help you quickly identify the root cause of unexpected issues and take appropriate corrective actions. By minimizing downtime and ensuring stable system operation, they support efficient maintenance and continuous use.

The table below summarizes common issues and provides troubleshooting guidance for each case.

Issue	**Possible cause**	**Solution**
The status LED is illuminated in red	Camera communication error	Make sure the system connection cable is plugged into a USB 3.0 port on the PC.
	Motion control communication error	Check that there are no foreign objects or materials inside the system. Then, turn the power off and back on.
Calibration failed after sample loading	The sample is not properly seated and is slightly lifted.	After unloading the stage, check whether the sample is properly seated. If necessary, gently press down to ensure full contact with the chamber bottom.
	Using a vessel with a bottom thickness other than 170 µm (1.5H coverglass).	Using a vessel with a 170 µm (No. 1.5H) optical bottom.
	Incorrect vessel file selected.	Ensure the selected vessel file matches the brand and type of the actual vessel.
Autofocus failure occurs after sample loading.	Trying to focus on a sample located too far above the bottom surface.	Disable autofocus and use the Z Guide feature in TomoStudioX to manually check the maximum focusable height
	Lens contamination or condensation (water droplets on lens)	Clean the lens only under the guidance of Tomocube support.
	Imaging glass-sandwich structures (e.g., tissue slides)	For tissue slides or glass-sandwich samples, disable autofocus and use manual focus adjustment.
'Initialize Failed' warning signs occur in TomoStudioX	System is powered off, or the error state was not properly cleared	Power off and then turn the system back on.
	Communication error due to incorrect port connection.	Make sure the system connection cable is plugged into a USB 3.0 port on the PC.
Live view appears dark in the field of view (FOV)	Condensation formed on the dish lid.	Check if the chamber power is on. If it is, ensure the chamber cable is firmly connected.
Live view shows uneven brightness or poor illumination uniformity	Optical alignment shifted due to physical impact or shock	Contact Tomocube support to request an alignment check. Do not attempt to adjust internal components manually.
CO_2 has an unusually high PV value	Check the In/Out port has not changed.	The CO_2 tube connected to the main piping (gas tank) is connected to In, and the tube going to the equipment is connected to Out.

Issue	Possible cause	Solution
CO_2 has an unusually high PV value, the chamber front screen does not appear.	Check the pressure of the gas connecting to the controller's In Port.	Set the pressure of the gas to 0.1 to 0.15 MPa.
	Make sure the power switch is off.	Power Switch On.
The temperature PV value of the Bath Unit does not reach the SV value.	Check if the chamber communication cable is disconnected.	Connect the cable normally.
The PV value of CO_2 does not reach the SV value.	Power on the controller and make sure 30 minutes have passed.	Power on the controller and check it after 30 minutes.

Chapter 8. SAFETY AND WARNING

The following table describes the symbols appearing in this manual related to the use of the HT-X1™ mini imaging system.

8.1 Safety Symbols

Hazard symbol	Description
	Indicates that you should consult the manual for further information and to proceed with appropriate caution.
	Indicates the presence of an electrical shock hazard and to proceed with appropriate caution.
	Indicates the presence of a laser inside the instrument and to proceed with appropriate caution.
	Indicates the presence of a hot surface or other high-temperature hazard and to proceed with appropriate caution.
	Indicates the presence of moving parts and to proceed with appropriate caution.
	Indicates a potential risk of hand or finger entrapment in moving parts and to proceed with appropriate caution.
	Indicates that the object is heavy or requires multiple people to lift safely. Do not attempt to lift alone to prevent injury or damage.

8.2 Environmental Symbol

Hazard symbol	Description
	Indicates separate waste collection for electrical and electronic equipment. Do not dispose of this product with normal waste. Please contact Tomocube's service office in your region or headquarters.
	Dispose of waste in accordance with the relevant waste disposal regulations of the laboratory. Improper waste disposal can cause a biohazard. Biological samples such as tissues, body fluids, and blood of humans or other animals have the potential to transmit infectious diseases. Follow all applicable local, state/provincial, and/or national regulations. Wear appropriate protective eyewear, clothing, and gloves.

8.3 Electrical Safety

To ensure the safe operation of the HT-X1™ mini Holotomography system and to prevent potentially dangerous electrical hazards, the following safety guidelines must be strictly adhered to:

Hazard symbol	Description
	**WARNING** The instrument must only be connected to a properly grounded electrical outlet. Improper grounding significantly increases the risk of electric shock and can cause severe equipment malfunction. If any damage is observed on the power cord or adapter, discontinue use immediately and replace the defective component to prevent the possibility of fire or electric shock.
	WARNING Under no circumstances should you connect or disconnect the power plug with wet hands. Such actions pose a significant risk of electric shock and can cause irreparable damage to the equipment.
	WARNING Never attempt to open the instrument or repair internal components yourself. These actions present a severe risk of electric shock and will automatically void the warranty. All internal repairs must only be performed by personnel certified by Tomocube.
	WARNING Do not use the instrument near sources of strong electromagnetic radiation (e.g., unshielded radiofrequency sources) as this may interfere with its operation. To ensure proper operation, the user must not place radiofrequency emitting devices (e.g., cell phones, computers, microwave ovens, other laboratory equipment, etc.) on top of the instrument or very close to it.
	CAUTION Avoid excessively bending or pulling the power cord, as this can compromise its integrity.
	**CAUTION** The use of a surge protector is strongly recommended to protect the instrument from voltage fluctuations and power surges.
	CAUTION Exercise caution to avoid applying excessive force when connecting or disconnecting cables from the instrument's external ports. This can result in damage to the ports.
	CAUTION Use only the certified power supply provided with the instrument. The use of non-certified power sources may cause damage to the instrument.
	CAUTION When working with the HT-X1 mini system, minimize the impact of electrostatic discharge by properly grounding the system and/or operator.

NOTE In the event of an emergency, the power can be quickly disconnected by unplugging the power cord from the electrical outlet.

8.4 Optical Safety

To ensure the safe operation of the HT-X1™ mini Holotomography System and to prevent potentially harmful exposure to light, the following optical safety guidelines must be strictly adhered to:

Hazard symbol	Description
	**CAUTION** The LED light source emits high-intensity light, and direct viewing of the light source is strictly prohibited as it can cause severe and irreversible damage to the eyes. Therefore, avoid looking directly at the light source, and avoid prolonged exposure to any intense light emitted from the equipment. **CAUTION** Do not operate the equipment with its covers or protective devices open. This poses a risk of unintended light exposure and increases the possibility of damage to the sensitive optical components within the system. **CAUTION** When the light source is on, never attempt to align or inspect optical components such as mirrors or lenses with the naked eye. Even reflected light can be dangerous and lead to eye injury. **CAUTION** Always ensure that the equipment is completely powered off before attempting to change the light output or replace the LED module. This precaution is essential to minimize the risk of electric shock and prevent damage to the delicate optical components of the equipment.

8.5 Optical Alignment and Adjustment

Hazard symbol	Description
	**CAUTION** Optical alignment and adjustment of the product is an extremely precise procedure, and therefore, the adjustment of optical components, including lenses, must only be performed by engineers specifically trained and certified by Tomocube. Any unauthorized adjustment of optical components by the user can cause severe problems such as misalignment of the optical axis, degradation of image quality, and equipment malfunction, and any damage to the equipment resulting from such improper adjustments may not be covered by the warranty. In particular, extreme care must be taken to prevent contact with the surfaces of lenses or prisms and to avoid the introduction of foreign matters. These optical components are highly sensitive to specific wavelengths and the polarization of light, and any unauthorized manipulation that deviates from the manufacturer's guidelines can lead to a decrease in equipment performance and permanent damage. Therefore, if optical alignment or adjustment is required, users must never attempt to perform these procedures themselves and should always contact

Hazard symbol	Description
	the Tomocube service center to obtain professional support.

8.6 Restricted Access Components

Hazard symbol	Description
	**CAUTION** The HT-X1 mini Holotomography system contains delicate optical components and hazardous high-voltage circuitry internally, therefore, user access to specific components such as internal covers, alignment modules, and sensor boards is strictly restricted. Any attempt to open the instrument or replace components by unauthorized personnel can result in a serious risk of electric shock, and such actions will immediately void the equipment's warranty. Consequently, if any maintenance or repair of the instrument is required, users must never attempt to perform these procedures themselves and should always contact a Tomocube-authorized service engineer to obtain professional support.

8.7 General Safety

Hazard symbol	Description
	**WARNING** Always wear gloves when working with the instrument.
	CAUTION Always place the instrument on a flat, stable platform. Confirm that the system on the platform is level before each use.
	CAUTION The equipment must only be used within the specified environmental conditions. Temperatures or humidity levels outside the specified range can lead to degraded equipment performance and malfunction.
	CAUTION Avoid using harsh cleaning products or liquids to clean the instrument as they may damage or stain the surface of the instrument.
	CAUTION Exercise caution to avoid placing or spilling liquids on the equipment. If liquid enters the microscope, it can cause severe malfunction.
	CAUTION During experiments, take care to prevent strong vibrations or impacts to the equipment. Even small vibrations can affect the captured images and compromise the accuracy of the data.
	CAUTION Before using an external memory device such as a USB thumb-drive or an external hard disc drive, check that the device is free of malware.

Hazard symbol	Description
	**CAUTION** Be aware of installing any software other than that pre-installed on the operating computer as doing so may lead to unintended consequences or system malfunction.
	Avoid touching the inside of the instrument during use. Keep hands clear of moving parts (e.g., XY Stage) while operating the instrument.
	Do not place your hands near the front door while it is closing. Be careful not to get your hands stuck when the front door closes.
	For continued protection against the risk of fire, replace fuses only with fuses of the type and rating specified for the instrument. The chamber may be hot to the touch depending on its set temperature, so exercise caution when touching it during operation or immediately after shutdown.
	Read the user manual provided by the manufacturer before operating the instrument. Keep it for future reference.
	After installing the equipment, if you decide to lift or move it, relocation and position adjustments must be performed only by personnel approved by Tomocube. Do not attempt to lift or move the equipment without proper lifting equipment or assistance from others. Improper lifting can cause permanent back injury. Equipment moving or lifting operations requires at least four personnel. Please contact Tomocube service office in your region or headquarters.
	Do not use it if package is damaged. Please contact Tomocube service office in your region or headquarters.
	When the equipment is not in use for extended periods, store it in a clean, dry place away from direct sunlight, with the front automatic door closed.

Chapter 9. PRODUCT COMPLIANCE

Symbol	**Description**
CE	This instrument has been tested to comply with the requirements of the following Regulations/directives. Compliance has been demonstrated through the manufacturer's declaration of conformity. Directive 2014/30/EU, Electromagnetic Compatibility Directive 2014/35/EU, Low Voltage Directive 2015/863/EU, Restriction of Hazardous Substances
FC	This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. Compliance has been demonstrated through the Supplier's declaration of conformity.
KC	This instrument has been tested in accordance with Article 4, Paragraph 3 of the Regulation on Conformity Assessment of Broadcasting and Communication Equipment, and its conformity has been verified through the National Radio Research Agency pursuant to Article 58-2, clause 3 of the Radio Waves Act.
UKCA	This instrument has been tested to comply with the requirements of the following Regulations/directives. Compliance has been demonstrated through the manufacturer's declaration of conformity. S.I.2016 No.1091, Electromagnetic Compatibility S.I.2016 No.1101, Electrical Equipment (Safety) S.I.2012 No.3032, Restriction of Hazardous Substances
	This instrument has been tested to comply with the requirements of the following Regulations/directives. Compliance has been demonstrated through the manufacturer's declaration of conformity. Directive 2012/19/EU, Waste Electrical and Electronic Equipment Do not dispose of this product with normal waste. Please contact Tomocube's service office in your region or headquarters.

Chapter 10. SERVICE AND SUPPORT

10.1 Supporting Documents

For more information, refer to the following documents.

1. HT-X1 mini Installation Requirement Checklist
2. Quick Guide: Organoid sample preparation for HT-X1
3. Quick Guide: How to Operate the HT-X1 Holotomography
4. Quick Guide: How to Observe Tissue Slide and Flat Microfluidic Chip with HT-X1
5. Quick Guide: How to Use HT-Ready 96 Well Plate
6. Quick Guide: HT-X1 Specimen preparation guide
7. Quick Guide: How to Observe Real-Time Hypoxia Response Using the HT-X1 with a Perfusion System

10.2 Customer Support

If you require assistance, please contact our technical support team and provide the following information to help us respond efficiently:

1. Description of your inquiry or issue
   a. Specify whether the inquiry is related to instrument operation or software usage.
   b. Provide details of any malfunction, error messages, or unexpected behavior.
   c. Describe any specific requests or desired outcomes.
2. Serial number: A-7-character alphanumeric code found on the product label or certificate.
3. Your contact information
   a. Technical support team: support@tomocube.com
   b. Local distributor: https://www.tomocube.com/contacts/distributors/
   c. Web: www.tomocube.com

10.3 Information Required for Service Requests

When requesting service, please include the serial number (S/N) of your HT-X1 mini system. This allows our support team to quickly retrieve your product information and provide you with faster, more accurate service.

Benefits of providing the serial number include:

1. Faster problem diagnosis
2. Accurate preparation of replacement parts
3. More efficient and streamlined service

Where to find it: The serial number is located on the product label at the rear of the system.

(Refer to Chapter 4.1.1 – Rear view in this manual)

10.4 Product Warranty

Tomocube warrants that its products are free from defects in material and workmanship. In the event of defects in materials and workmanship, Tomocube reserves the right to inspect the Product and to investigate any claim to determine whether the Product is defective. If Tomocube determines that the Product is defective and is covered by this Limited Warranty, Tomocube reserves the right, in its sole discretion, to repair or replace the defective Product.

Tomocube's liability for defective products and Buyer's exclusive remedy shall be limited to such repair or replacement. No Product will be returned to Tomocube without Tomocube's prior written consent. The validity of the warranties contained herein, with respect to certain other defects, are subject to (a) Buyer's demonstration that the Product has been stored, maintained and operated in accordance with instructions provided by Tomocube to Buyer and standard industry; undamaged as a result of negligence, improper handling or accident by anyone other than Tomocube, (b) payment of all invoices by Buyer for any Product or other charges to which Tomocube is entitled, and (c) authorized by Tomocube for repair of the Product; or (d) Buyer's proof that the Product has not been modified or altered without Tomocube's prior written consent. Subject to the foregoing, the warranty contained herein is valid for twelve (12) months from the date of delivery of the product by Tomocube, unless another warranty period is specified on the surface of the Certificate of Quality.

Tomocube makes no warranties with respect to parts with limited technical life, such as data storage, any parts need periodic replacement and consumables. Components or products produced by other manufacturers are warranted by Tomocube only to the extent that the manufacturer supplying such components to Tomocube warrants those components and to the extent that Tomocube may assign them to the purchaser. If Tomocube's software is included in the Product, Tomocube warrants that, when properly installed, software designed for use with a particular hardware product will not be able to execute its programming instructions due to defects in materials and workmanship. If Tomocube is notified of a defect during the applicable warranty period, Tomocube will repair or replace the software media that does not execute programming instructions due to such defects. Tomocube does not guarantee that the software will be uninterrupted or error-free.

If you need further information,

Please email us at support@tomocube.com

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www.tomocube.com

Hardware User Manual

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