

Optical Rheology System - CSS450

The CSS450 stage was developed in collaboration with Cambridge University, Chemical Engineering Department and is a unique instrument to enable high resolution imaging of samples under various shearing conditions and temperature.

Features and Benefits

'The Linkam Optical Shearing System - CSS450, allows structural dynamics of complex fluids to be directly observed via standard optical microscope while they are under precisely controlled temperature and various shear modes. Using the optical shearing cell, it is possible to study the microstructure evolution of complex fluids in great details for many physical processes, e.g. coarsening of binary fluids during their phase separations, flow-induced mixing and demixing of polymer blends, defects dynamics of liquid crystals, aggregation of red blood cells and their deformation in flows etc. We are then in a good position to correlate micro structural dynamics with rheological data for gaining insight into rheology of complex fluids. The images captured by microscope can also be used to validate numerical results from our computer simulations as well as other experimental data from indirect measurements such as by scattering techniques'. (Dr. X.F. Yuan - Manchester University).

The CSS450 uses two highly polished quartz plates that are parallel to within 2um. Each plate is in thermal contact with an independently controlled pure silver heater utilising platinum resistors sensitive to 0.1°C.

The bottom plate, on which the sample is placed, operates in either oscillatory, steady or step shear modes programmed within a motor control spread sheet.

To facilitate various textures or particle sizes in different samples, the gap between the two plates can be precisely set from 5 to 2500um, the speed of this change in gap setting can also be varied.

Recently the CSS450 has been used with X-Ray techniques and also with a liquid nitrogen cooling option (Cryo CSS450) further extending the temperature range to -50°C which has enabled work on the effects of shear on ice crystals.

The intuitive Linksys 32X software is used to setup a temperature and shearing profile so that the user can quickly and easily characterize a sample to correlate with the data produced by quantitative measurements made through conventional Rheometry.

System Options

There are two versions of the CSS450 Optical Rheology System. A standard width version and extra wide body version. The wide body is designed specifically for use with the Zeiss Axio-Imager.

Both these versions are available as either standard ambient to 450°C or low temperature option, -50 to 450°C (Cryo-CSS450).

The Low temperature Cryo-CSS450 is supplied with a liquid nitrogen pump and Dewar.



The CSS450 optical shearing stage



Lid of CSS450 being lifted off to reveal sample loading area



Low temperature Cryo-CSS450 system including dewar

And LNP cooling pump

Optical Specifications

The CSS450 is designed to be used with an upright microscope, where the objective lens is above the sample.

When working with heating and freezing stages, it is necessary to use long working distance objective lenses. If viewing the sample using transmitted light you also require a long working distance condenser lens.

The objective lens is isolated from the sample by the stage lid window which is a fixed distance from the heating/cooling element. In the CSS450 this distance is 7.4mm. We recommend that you use an objective lens with at least 7.4mm working distance.

We recommend a good metallurgical 10X or 20X and if higher magnification is required, a 50X. A metallurgical 50X with NA of 0.5 and working distance of 10.6mm was used to image blood cells (approximate size, 7um).

The condenser lens is isolated from the sample by the stage base plate window and the thickness of the heating/cooling element. In the CSS450 this distance is 14mm.

Linkam make condenser extension lenses for many types of condenser, please select the condenser extension lens from the optical accessories section of our website.

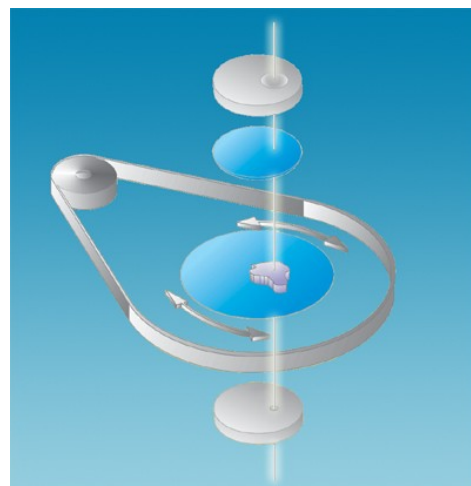
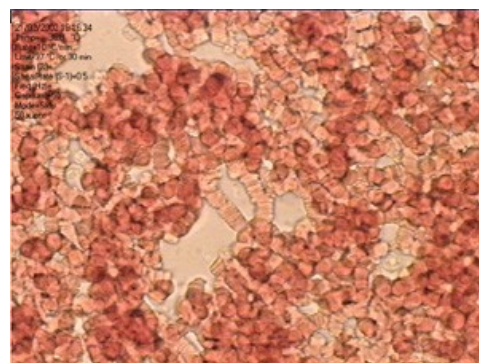


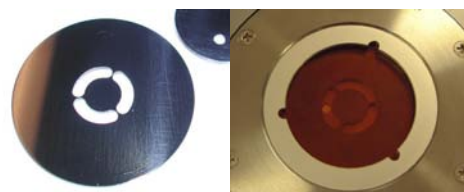
Diagram of objective light path through silver heating element and quartz shearing windows.



Blood cells imaged using 50X Metallurgical Lens

X-Ray Imaging

Many CSS450 users have used SAXS equipment to characterize their samples with shearing stress. Linkam can supply Kapton or Mica coated stainless steel discs with slots to replace the quartz windows.



Stainless steel shearing plate for x-ray.

Kapton coated stainless steel plate loaded into CSS450

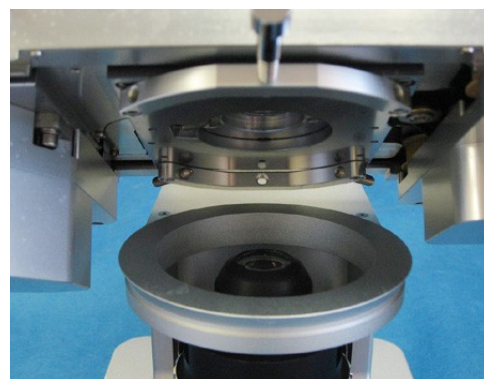
Attaching CSS450 to Microscope

Upright microscopes whether standard optical, or part of a Raman or IR system, usually have an XY table or circular POL table to move the sample relative to the objective lens. These tables are mounted to the microscope substage and need to be removed when using the hotstage.

Linkam manufactures different stage clamps to attach the CSS450 stage to many different brands of microscope. The stage clamps are required to adjust the position of the hotstage relative to the light path of the objective lens.

Select the stage clamps you require from the [Stage Clamps](#) section on our website.

Please note: the CSS450 weighs 5kg. Only large research grade microscopes are suitable. The Linkam [Imaging Station](#) is a potential alternative to this kind of microscope designed specifically to obtain high resolution images with the CSS450 stage and facilitate sample loading.

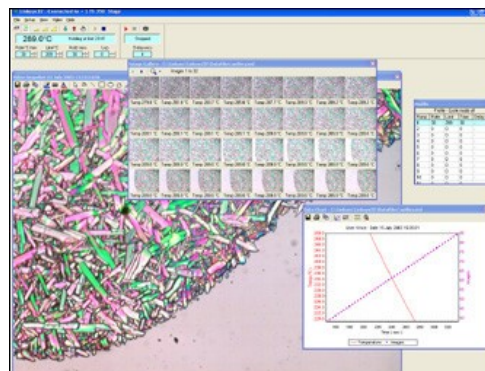


CSS450 stage with stage clamps being attached to circular dovetail substage.

Increase Capability Options

Linksys 32X-DV (Digital Image Capture) and Digital Camera

Add digital capture to the Linksys 32X system controller software and one of the range of Q-Imaging digital cameras to enable time lapse image capture including all controller data saved with the image. Quickly find single or groups of images by dragging a box around an area of the time/temperature graph or scrolling through the gallery. Create movies of experiments and add scale bar, annotations and measurements. (See '[Image Capture](#)' on our website for more information).



Screen shot of Linksys 32x DV showing image gallery and live image.

QImaging Cameras

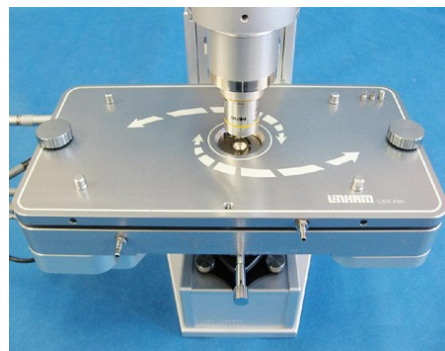
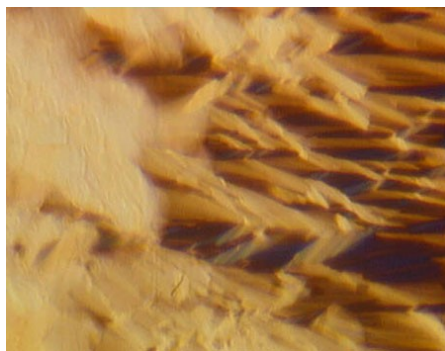
Linkam supports the entire range of Q-Imaging CCD firewire cameras.

The QICAM fast 1394 shown here is designed for high resolution brightfield scientific and industrial applications. A progressive scan interline CCD sensor gives a resolution of 1.92 million pixels in 12-bit digital output.



Imaging Station

Free up time on your research microscope by attaching your CSS450 stage to the Linkam Imaging Station instead. The imaging station has been designed specifically for optical rheology no drift in the substage. Standard microscope lens can be loaded into the quick lock mounting jaws which can be easily swung back out of the way of the stage to allow greater sample access to the CSS450 stage. A long working distance condenser is built into the base with polarizer and diaphragm. A 100W halogen light source and C-mount for a camera is also supplied. (See '[Imaging Station](#)' on our website for more information).



CSS450 stage mounted on the Linkam Imaging station. Sample image shows polymer flow using polarized light and phase contrast 10X objective.

CSS450 Specifications

- Temperature range ambient to 450°C (-50 to 450°C on Cryo-CSS450)
- Computer control using Linksys32
- Sample area 30mm diameter
- Gap setting between 5 and 2500µm
- Three modes of operation: oscillatory, step and steady
- 100 Ohm platinum resistor. 1/10th DIN
- Removable lid for easy sample loading and cleaning
- Fixes to most microscopes using stage clamps
- Temperature rates of between 0.01°C to 30°C/min
- Silver heating blocks for high thermal conductivity
- Observation radius 7.5mm diameter, viewing area 2.5mm diameter
- Sample mounted on quartz window
- Temperature stability +/-0.2°C
- Designed for use with the Linksys32-AV and DV video capture system
- Velocity, amplitude and frequency easily changed during run
- Data can be saved to spreadsheet
- Suitable for phase contrast, transmitted and polarized light
- Objective lens minimum working distance: 7.4mm
- Condenser lens minimum working distance: 13mm

Specification	Unit	Range	Resolution	NOTES
Shear Rate	(S-1)	0.003-7500	0.001	Based on a window observation radius = 7.5mm and a gap variation from 5 to 2500um.
Strain	(%)	0.1- 40,000	0.1	
Velocity	(rads/sec)	0.001-10	0.001	The data entry table uses shear rate and strain values. These values are converted to velocity amplitudes in the ranges shown.
Amplitude	(rads)	0.001- 1.6	0.001	
Frequency	(Hz)	0.01 - 9.9	0.01	Not all combinations of frequency and amplitude are possible.
Gap Setting	(um)	5 - 2500	11	
Limit Temperatures	(°C)	RT to 450	1	In oscillatory mode as the system cannot follow both high amplitudes and high frequencies.
Heating Rates	(°C/min)	0.01 - 30	0.01	
Hold Times	(mins)	1- 9999	1	
MODES	STEADY - OSCILLATORY - STEP			

Linkam Complete Temperature Control Solution

What do you need for a complete solution

Select System

Either CSS450 (ambient to 450°C, includes controller and Linksys32 software)

Or Cryo-CSS450 (-50 to 450°C, includes controller, Linksys32 software, LNP cooling pump and 2L Dewar).

(Wide Body Version for Zeiss Axio-Imager users available in standard or Cryo-CSS450 versions)

Add Condenser Lens if using transmitted light

See website '[Condenser Extension Lenses](#)'

Add Stage Clamp to mount to microscope substage

See website '[Stage Clamps](#)'

Add the Digital Video Capture Option

Linksys32-DV (Requires Q-Imaging Camera)

Add Q-Imaging Camera

See website '[Q-Imaging Cameras](#)'

Add Linkam Imaging Station

Alternative to be used in place of your existing microscope for optical rheology. Includes, 100W lamp house and power supply. 10X objective lens, C-mount for 1/2" CCD camera, Polarizer and Analyzer. See website '[Imaging Station](#)'.

Suggested Spares

These spares are organised into convenient kits. Purchase a spares kit to avoid downtime with your stage and eliminate future shipping costs.

The CSS450 is supplied with a full tool kit to assemble and maintain the instrument and 5 spare top and bottom windows. Some samples can become permanently stuck to the windows during temperature controlled experiments and while the windows can be cleaned in a Bunsen flame, we strongly recommend getting some spares to avoid down time.

Part No.	Part Name	Part Description
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	CSS Window kit	
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		Quartz windows for Lid and Base
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W32TQ		
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		32mm diameter Quartz Tapered Edge Lid Window (1.5mm thick) x2
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W55QC		
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		55mm diameter Quartz Base Window (1mm thick, 5um tolerance) x2
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W18Q0.5		
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		18mm diameter Quartz Window (0.5mm thick) x2
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Part No.	Part Name	Part Description
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9581		
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	W32-55SS	
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		X-Ray Kit
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		Stainless Steel Lid and Base Shearing Plates with Kapton or Mica (specify)
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Suggested Spares

Part No.	Part Name	Part Description
22222	CSS Tool Kit	CSS450 Complete Set of Tool Kit
		1x 2047 - Carrier Tool
		2x 2055 - Clear PVC Tubing (150mm)
		2x 2200 - Hose Straight - WGI
		2x 2202 - Hose Valve WVC
		1x 2426 - M5 x 10mm Socket Cap
		2x 2473 - M6 x 16mm Socket Cap
		2x 2474 - M4 x 6 Socket Set
		1x 2911 - Window clamp Tool 32 mm
		1x 2912 - Window Clamp Tool 55mm
		1x 3003 - Adjustment Tool - CSS450
		1x 3022 - External Window Clamp Tool
		2x 3016 - Lid Nuts
		1x 3033 - Motor Nut
		1x 3055 - 1.5mm Hex Key
		1x 3056 - 2.00mm Hex Key
		1x 3057 - 3.00mm Hex Key
		1x 3059 - 5mm Hex Key
		1x 3062 - 2.5mm Ball Driver Hex Key
		1x 3063 - 4.00 mm Hex Key
		1x 3076 - Tommy Bar
		1x 3078 - 55mm Window Sucker
		8x 3079 - Locating Pin 3mm
		2x 3080 - Locating Pin 2mm