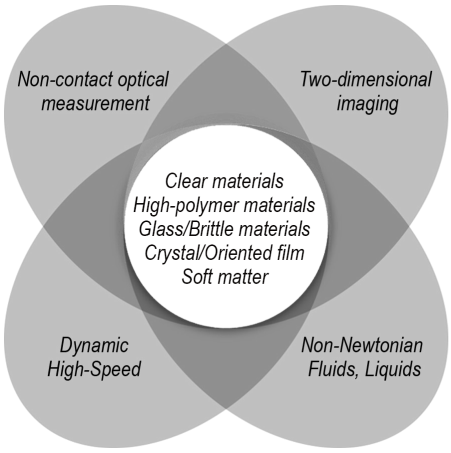
CRYSTA

Introducing the world's fastest 2D polarization camera, providing over one million frames per second

Photron

CRYSTA: High-speed 2D polarization camera series
Product Range Overview

World's fasted polarization camera to visualize orientation and internal stress in clear materials and fluids



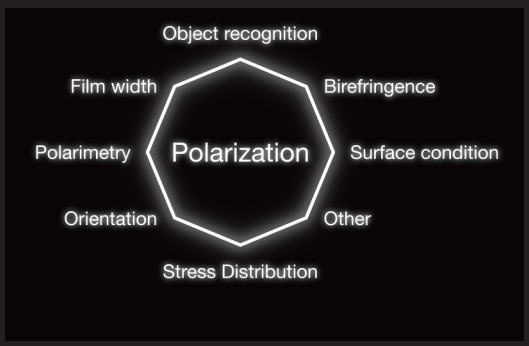
Analysis and visualization of internal stress distribution during material processing

Evaluation of stress propagation around cracks due to impact fracture and cracks

Dynamic observation of crystal axis/orientation state on liquid crystal/crystal materials

Visualization of fluid stress distribution generated by viscoelastic body or soft matter

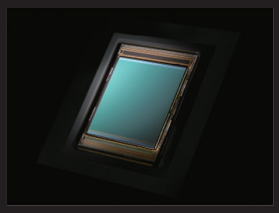
Polarization can measure and visualize various physical quantities and properties



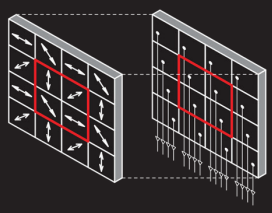
Polarized light cannot be recognized visually but it is light where "light waves oscillate in a single plane".Since the polarization state of light varies depending on the internal structure of the transmission object and the surface shape of the reflected object, it can be applied to measure various physical qualities and visualize phenomena by obtaining the polarization state before entering and after exiting the object. By combining this "polarization information" with the "conventional" high-speed camera images, it is possible to study the load applied to a cutting tool at the same time as analyzing the stresses inherent in the transparent material in the images, and understand the stress propagation and relaxation processes in impact tests and flow phenomenon. This enables us to visualize events that cannot be seen by 'conventional means', quantitatively measuring the uniformity of the spatial performance of the alignment film in a non-contact manner.

Proprietary core technology "Polarization high-speed image sensor"

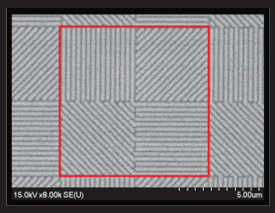
The unique image sensor uses a photonic crystal type micro-polarizing element array with different orientation for each pixel, that was jointly developed by Photron and Photonic Lattice. It does not require a rotating polarizing plate that was previously viewed as the indispensable tool for polarimetry. The light intensity information that is necessary for polarization measurement can be now acquired with a single ultra-short exposure by the CRYSTA. Furthermore, by directly connecting the sensor's unique pixel parallel readout circuit with the polarizing element, we have developed a completely new type of image sensor, with repeatable sampling speeds that are over 1,000 times faster than what was previously achievable.



High-speed 2D polarization image sensor



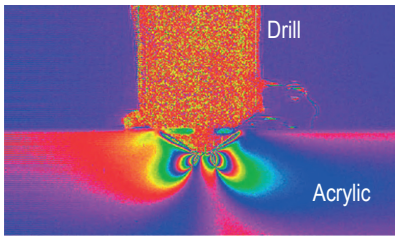
Micro polarization element array high-speed image sensor



SEM view of four adjecent pixels, each potentially as small as 5μm square.

CRYSTA can measure the distribution of the “phase difference (nm)” and “main axis azimuth (°)” of transparent materials and complex fluids such as resin and glass. The phase difference is proportional to the strength of the stress inside the material and the main axis orientation informs as to the orientation angle of the internal structures. Since it can still be used as a ‘conventional’ monochrome high-speed camera, CRYSTA is being used as a totally new evaluation technology in numerous research and development fields. Here are some examples of the applications that can be studied using the CRYSTA.

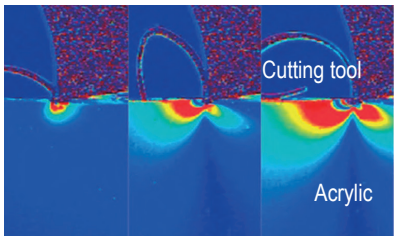
Internal Stress



Stress distribution during precision machining

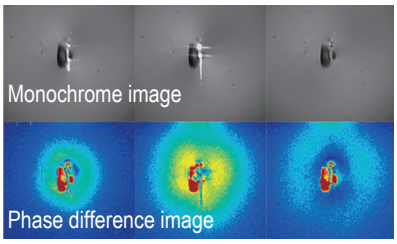
We can visualize the spatial distribution of the developing stress in high-speed detail, and so evaluate the cutting performance and processing accuracy by increasing or decreasing the load applied to the cutting tool.

Case Study #1, Details on page 4



Stress characteristics during ultrasonic machining

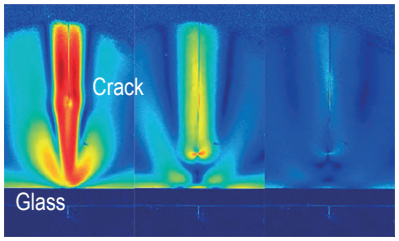
It is possible to take pictures synchronously for different signals input to the cutting machine. This high-speed capability has enabled me to photograph in slow motion how the stress concentrating on the tip of the tool changes under different test conditions.



Laser processing of glass

Stress distribution during laser drilling. It can be applied to the measurement and processing conditions to evaluate stress concentrations surrounding stress propagation and relaxation as a result of different laser settings.

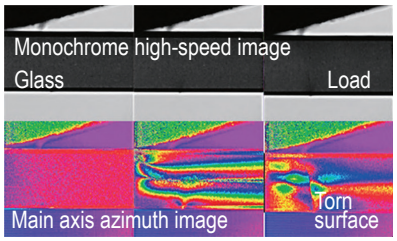
Stress Propagation



Laser glass cutting

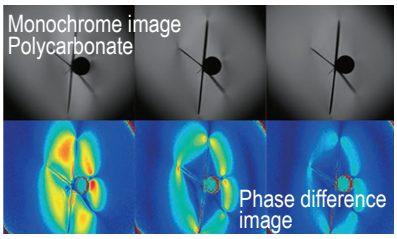
By visualizing the stress developing around the laser induced crack as it propagates at high-speed, the process can be evaluated and understood with the goal of improving the quality of the finished product.

Case Study #2, Details on page 5



Main axis azimuth at torn surface

Even with phenomena that are difficult to visualize with a conventional high-speed camera, it is possible to gain new knowledge by visualizing the internal state of materials using polarized light.

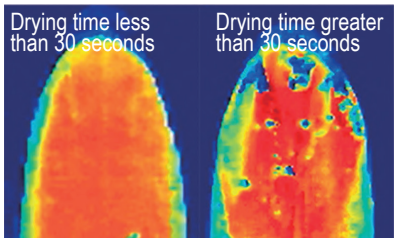


Impact test of brittle material

Record the transmission of stress in high-speed impact tests. Also effective in measuring high-speed destructive phenomena in transparent and semi-transparent birefringent materials and fluids.

Orientation State

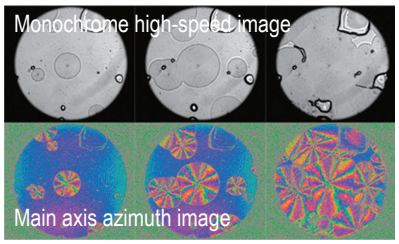
Courtesy of Professor Takahashi from Nagaoka University of Technology



Evaluating coating film orientation characteristics

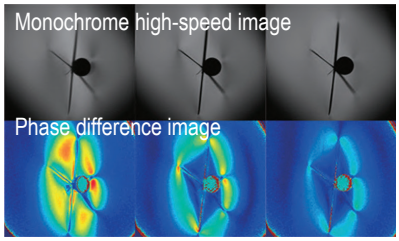
Understand the Phase difference distribution when the liquid crystal film is dried under different conditions. It is also possible to see changes caused by the drying process, and evaluate defects that cannot be seen through point measurement techniques.

Case Study #3, Details on page 6



Orientation of polymer spherulites

Quantitative display of the principal axis orientation of crystals through visualizing the respective angles of orientation as different colors. It is also possible to evaluate crystal axis and lattice distortion of Silicon Carbide (SiC) and other materials, including polymer materials.

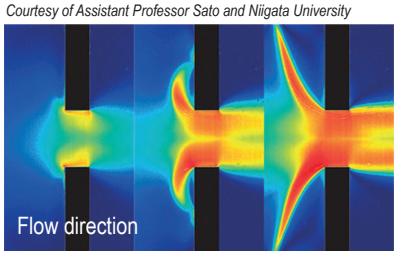


Evaluation of different material characteristics through stretching

By utilizing the CRYSTA alongside a tensile testing machine, it is possible to measure local stress distribution and thickness non-uniformity with high temporal resolution.

Flow Anisotropy

Courtesy of Assistant Professor Sato and Niigata University

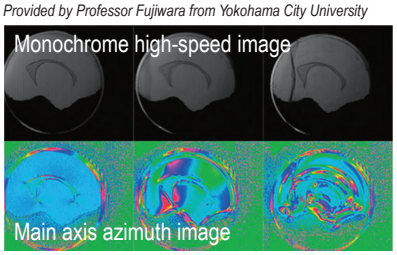


Flow anisotropy in micro-channel

It is possible to quantitatively measure the process of flow anisotropy and stress-relaxation by using the CRYSTA mounted on a microscope.

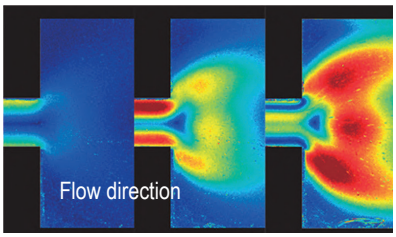
Case Study #4, Details on page 7

Provided by Professor Fujiwara from Yokohama City University



Damage analysis of biological samples

CRYSTA can also be utilized in the medical field. This image is an example of using a gelatin model simulating the human brain to replicate the brains response to force, simulating shaken baby syndrome (SBS).



Fluid flow visualization of polymer liquid

CRYSTA can also benefit the identification and minimization of defects by visualizing stress, such as in the investigation of the flow channel shape and its resultant effect on the resin injection molding process.

High-speed and high-magnification observation of phase difference distribution occuring internally

Case Study 1

Transparent Material x Internal Stress

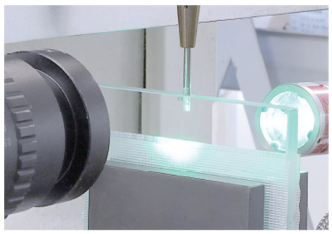
Visualization of stress distribution during high-speed machining

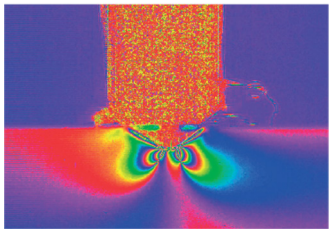
Analysis of cutting tool behavior and internal stress distribution within the subject material

Nagaoka University of Technology, Precision Machining and Mechanism Laboratory, Hiromi Isobe

Quasi-static orthogonal ductile cutting phenomenon is verified through combined theoretical, analytical and experimental strategies. A dynamometer is a typical lab instrument, used to measure the cutting force by setting it between the tool and tool holder. However, the dynamometer cannot be used to monitor brittle cutting phenomenon as this is based on crack propagation, and the impulsive cutting force is undetectable from the point of view of time resolution. On the other hand, grains can act as micro cutting edges during grinding. Therefore, deciding the appropriate grinding conditions is complicated and relies a lot on trial and error. Furthermore, with ultrasonic vibration grinding techniques, the grinding wheel is vibrated at ultrasonic frequency, and can be used to successfully machine brittle materials, such as glass, ceramics, etc. The grinding phenomenon occurs repeatedly at ultrasonic frequencies.

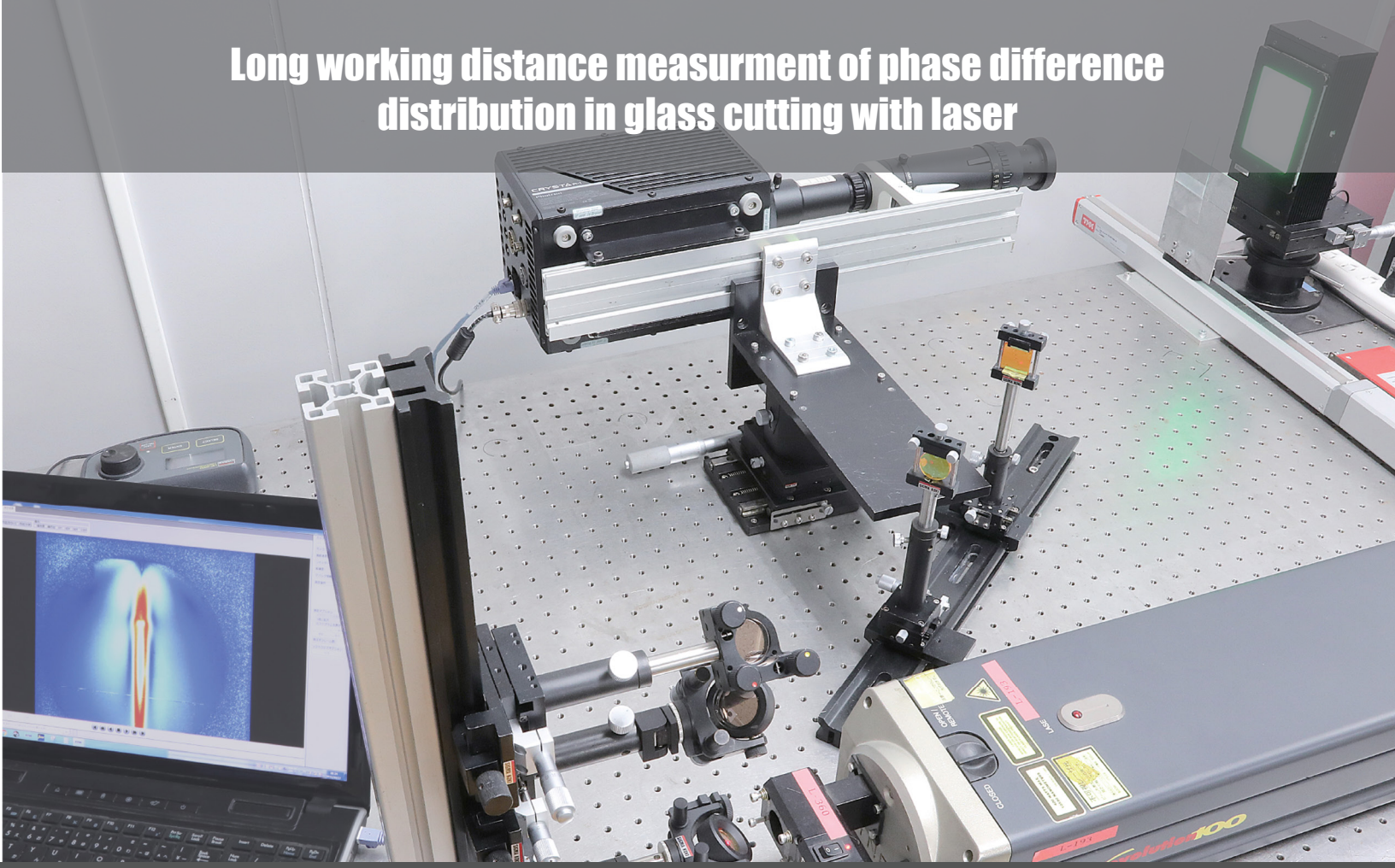
CRYSTA realizes on-machine/in-situ measurement of the stress distribution throughout the grinding process. It clearly shows how different grains effect the finished product. Furthermore, the superior triggering and synchronization capabilities greatly improve image capture of the ultrasonic grinding phenomenon. By making full use of this function, synchronous imaging of ultrasonic processing has become possible.





** High-speed and high-magnification observation of phase difference distribution occurring internally.*

Long working distance measurment of phase difference distribution in glass cutting with laser



Case Study 2

Brittle Material x Stress Propagation

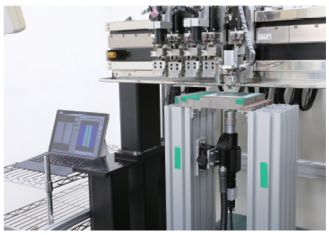
Evaluating Crack Propagation in Glass

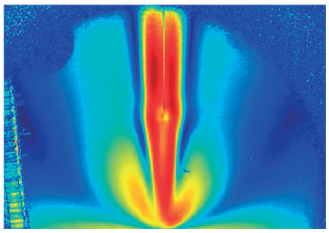
Real-time examination of glass cross-section quality through high-speed polarization measurement

Chiba University, Department of Mechanical Engineering, Noboru Morita, Hirofumi Hidai And Souta Matsusaka

Glass substrates, used for such as electronic devices etc., are often divided into the desired shape by cutting, and with the reduction in the size and weight of these devices, there is a strong demand for improvement in the quality of the fracture surfaces of glass. The fracture surface morphology of the cut depends on the crack propagation behavior of the formed crack, which is determined by the internal stress field of the glass Therefore, if the internal stress field around the propagating crack can be measured through polarization measurement, it is possible to estimate the quality of the fracture surfaces.

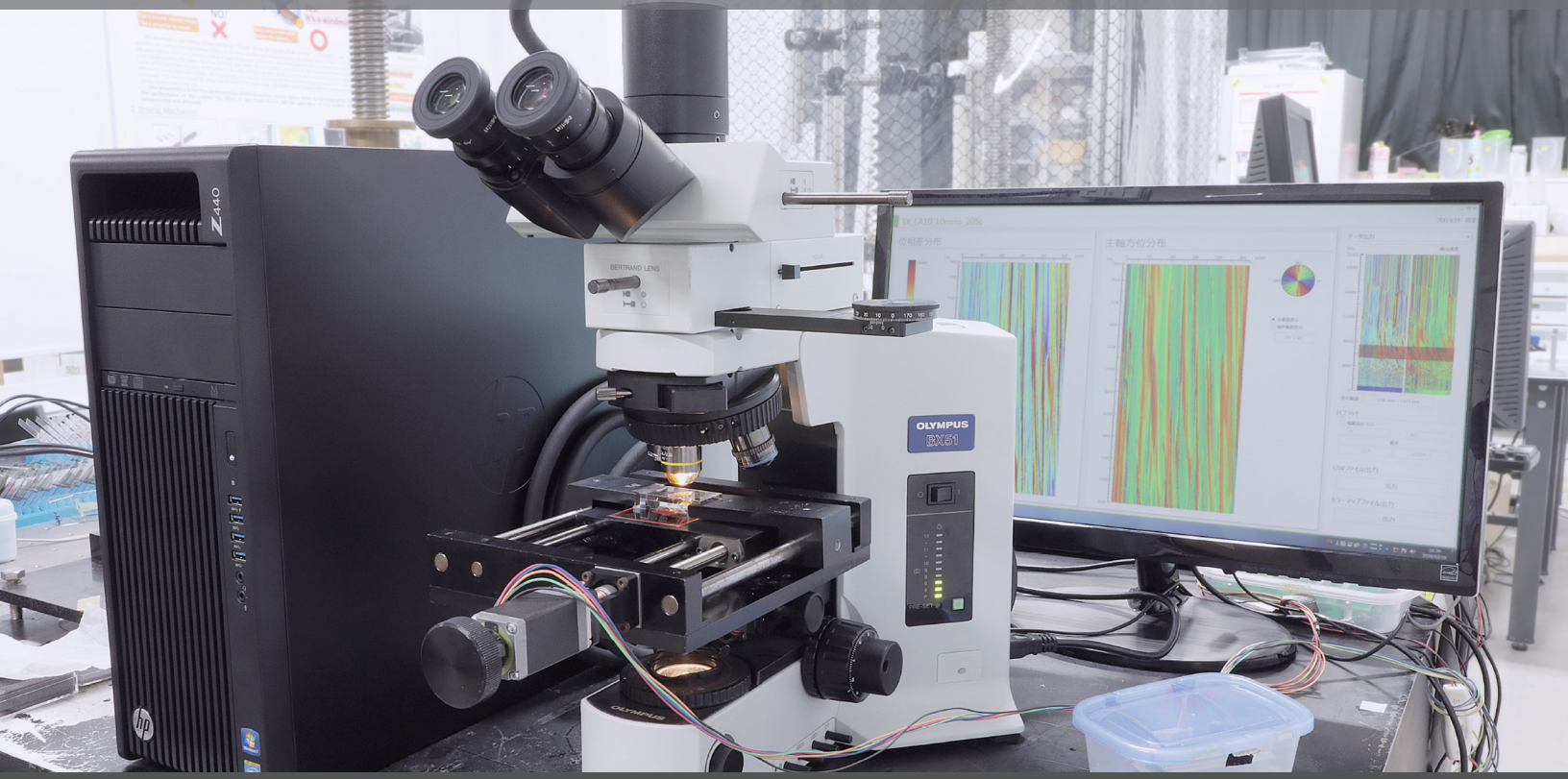
Since CRYSTA can measure Birefringent Retardation with high temporal resolution, it is very effective for a visualization of the stress field of the glass during scribing. We focused on characteristics of the retardation in the crack propagation behavior and proposed a method to evaluate the characteristic of fracture surfaces immediately after crack formation. With the high temporal resolution of CRYSTA, it is possible to understand what caused defects in the fracture surface immediately. Thus, it helps improve the yield ratio for different processing steps in the manufacturing of glass substrate.





** Long working distance measurement of phase difference distribution in glass cutting by laser.*

Microscopic observation of the structural change in the coating and drying process of liquid crystalline dye



Case Study 3

Crystal orientation layer x Alignment

Evaluate entire film coating orientation

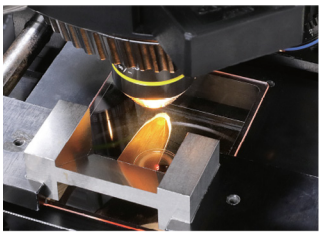
High-speed measurement of the optical characteristics of structural changes induced by the coating and drying processes

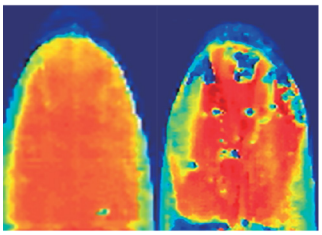
Nagaoka University of Technology, Fluids Engineering Laboratory, Tsutomu Takahashi

I would love an instrument that is able to evaluate the two-dimensional distribution of both Flow Birefringence and Orientation Angle simultaneously and to acquire them at a high frame rate. If I could have such an instrument, there is so much research I could do.

The technology to study flow birefringence two-dimensional flow field of polymer fluids was developed several decades ago, but it has definite limitations due to the long optical path required to measure retardation striped patterns of strongly birefringent fluids in a flow cell viewed using a crossed-Nicol polarizer. However, by using the CRYSTA, the birefringence distribution of viscoelastic fluids in the micro flow channel can be measured very easily. By combining with micro PIV, the velocity and stress fields can be measured simultaneously. This is a dream technology in rheology.

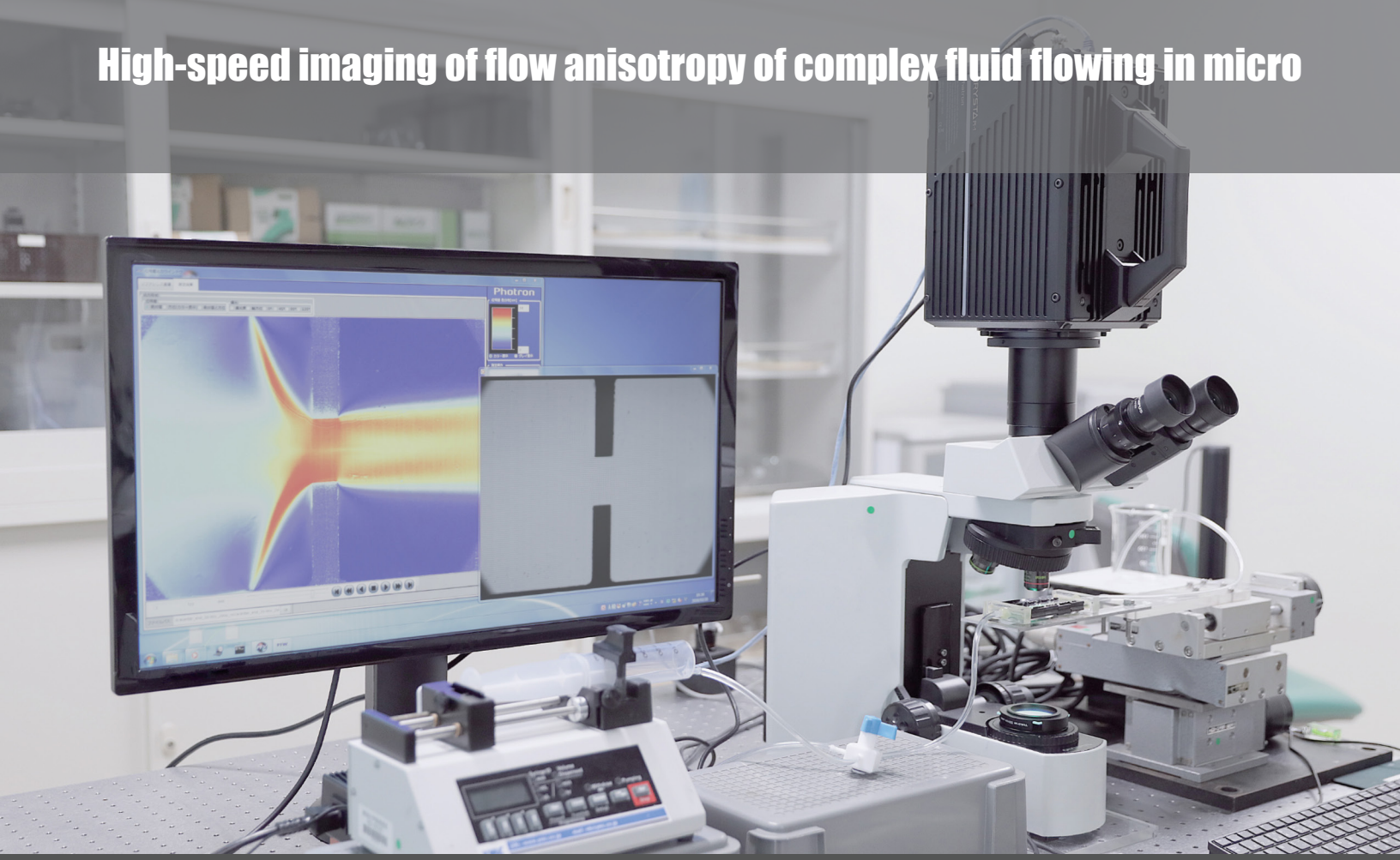
This photograph shows a device for the visualization of the birefringence distribution in the process of coating and drying a liquid crystalline dye. When the sample is applied to glass, it becomes the oriented liquid film with a thickness of 1 to 5 microns. Changes in the orientation state during the drying process were observed by changes in the birefringence distribution. By using the CRYSTA, we found changes in birefringence with a texture formation during the drying progress, none of which could be realized using point measurement techniques. CRYSTA provided us the means to view and understand thin film drying of complex fluids.There are so many more research ideas I would love to carry out that I fear using the CRYSTA might lead to a lack of sleep!





** Microscopic observation of the structural change in the coating and drying process of liquid crystalline dye.*

High-speed imaging of flow anisotropy of complex fluid flowing in micro



Case Study 4

Soft matter x Flow anisotropy

Observe the internal structure changes in non-Newtonian fluids

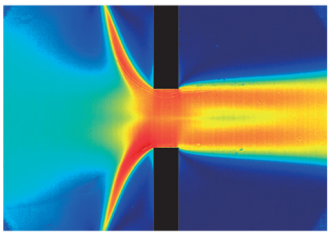
High-speed camera that can measures resin molding flow field and residual stress

Niigata University, Institute for Research Promotion Center for Transdisciplinary Research, Taisuke Sato

The physical properties of molded items are affected by the molecular orientation induced by material flow during the molding process. To improve the quality of the final product, it is crucial to understand how the flow influences both the direction and degree of orientation of the polymers. Therefore, a flow-induced birefringence technique has been used to examine the orientation information of polymers. It was technically very difficult, however, to acquire the birefringence and orientation angle of the polymers using a real-time and field-wide (2D) measurement techniques. The photograph shows the experimental system and the flow birefringence field in a micro-channel obtained by CRYSTA.

Speaking of ‘traditional optical measurement techniques’, so many optical different elements are required that it is not easy to understand because when possible measurement techniques are discussed, there will be a lot of technical terms used, such as “the alignment order is this”, and “the optical axis is that”, meaning a successful application of any technique will depend on many factors. However, if you just use CRYSTA, it is possible to measure the birefringence by simply placing the sample between the light source and the CRYSTA.

CRYSTA is not only a solution to the technical problem I mentioned above, it is also an epoch-making device which allows us to easily measure birefringence.



** High-speed imaging of flow anisotropy of complex fluid flowing in micro channel.*

Model	NOVA CRYSTA S16	Crysta PI-5WP
System characteristics	Ultrafast, high-resolution polarization imaging	Real-time transfer to PC memory and SDK included
Image sensor	High-speed polarization image sensor	
Polarizer	Linear polarizer	Phase shifter + linear polarizer
Polarization operating wavelength range (nm)	500 ~ 550	520 ~ 570
Pixel gradation	A/D conversion 12bit	
Maximum effective pixels	1024 x 1024 pixels	848 x 680 pixels
Maximum framing rate (frames per second - fps) at full resolution	1,000 ~ 16,000fps	15 ~ 250fps
Maximum frame rate fps	1,100,000fps	10,000fps
Minimum exposure time (nsec)	0.2 ussec	2.8 ussec
Lens mount	G-type F mount/C mount, M42 mount	C-Mount
PC connection and control interface	Gigabit Ethernet	PCI Express
Data storage format	RAW, AVI, BMP, CSV & Other *1	
AC supply voltage	100 ~ 240V	100V * Pleasse contact us if you require 200V
AC supply frequency (Hz)	50-60 Hz	50-60 Hz
DC supply voltage (V)	22-32 V	12 V
DC power consumed (VA)	150 VA	20 VA
Memory size (GB)	128GB	32GB
Recording time (seconds)	5.46 (@16,000fps)	11.46 (@250FPS)
Camera (head) external dimensions	120 x 120 x 217.2mm (WHD)	74.4 x 62.35 x 74.5mm (WHD)
Camera (head) weight	3.2Kg	0.48Kg
Camera cable length	-	5m, 15m
Trigger type	Supports TTL, contact, and software trigger	

*1 The format of saved data varies depending on the software used. Please contact us for details.
* If you are considering using our products outside of Japan, p[lease be sure to consult with us as some of our products are subject to export controls.

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