C220-E015C

SHIMADZU
Excellence in Science

High-Speed Video Camera

Hyper Vision HPV-X2

X2

eXtreme Sensitivity
eXtreme Recording Speed

- ISO 16,000 - 6 times higher sensitivity compared to conventional cameras, the best in its class *
- 10 million frames per second - the best in its class
- Equipped with a Two Camera Synchronized Recoding Function
- Enable direct camera control by a commercial image analysis software ** NEW

* ISO sensitivity is a reference value.
** Supported software is VIC-3D. (Refer to P.14)

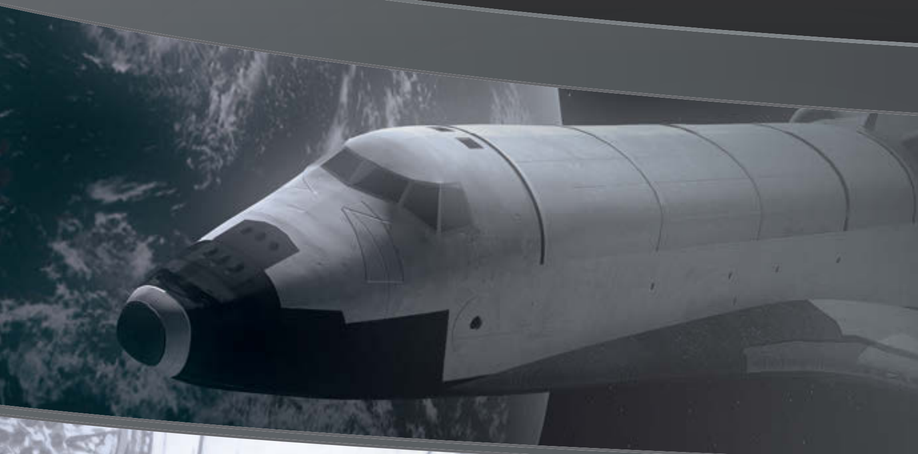
Visualization Technology Is One of the Driving Forces Behind Progress in Science and Technology

Medical science and engineering have made dramatic progress thanks to visualization technology. Examples include the invention of microscopes capable of enlarged observations of phenomena occurring in the microscopic domain, invisible to the human eye, X-ray inspection systems, which enable the observation of images utilizing light at imperceptible wavelengths, and infrared cameras.

Our eyes are incapable of capturing phenomena occurring at times shorter than 50 to 100 ms. As a result, high-speed video cameras have become necessary in order to record phenomena occurring at intervals that cannot be seen with the human eye, and then replay them at a slower rate so that they can be visualized.

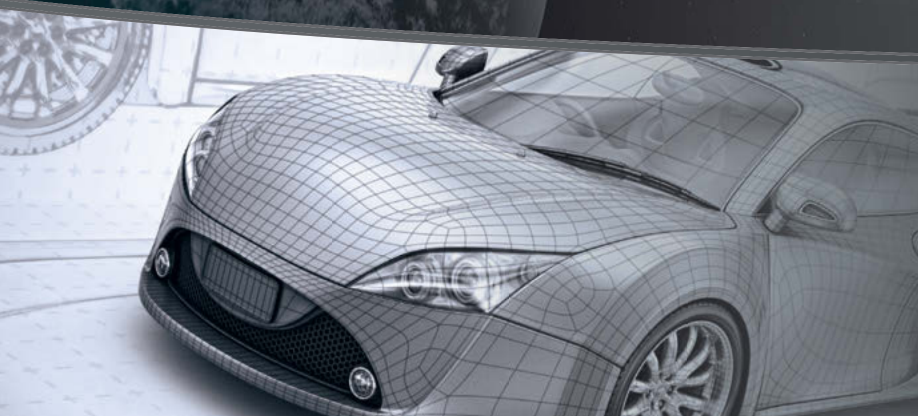
As the standard tool for visualizing ultra high-speed domains, the Hyper Vision high-speed video camera contributes to our understanding of ultra high-speed phenomena in a variety of fields.

Numerous Subjects of Observation Requiring Time Resolution of One Millionth of a Second or Less

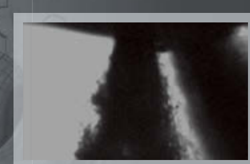


Aerospace Equipment

- Airflow in wind tunnel tests
- High-speed impact tests for aerospace materials
- The behavior of high-speed flying objects
- The generation and propagation of shockwaves



Automobiles



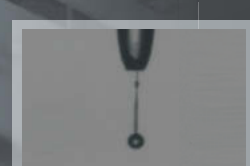
- The failure behavior of automotive body materials
- The combustion process in engines
- The injection process in fuel injection equipment

Advanced Medical Equipment

- The drug release process in drug delivery systems
- The generation and disappearance process of microbubbles, which are utilized for sterilization and ultrasound diagnosis

Consumer Electronics

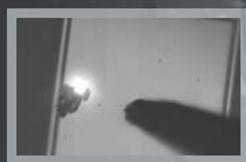
- The inkjet ink discharge process
- The failure process of smartphone glass
- The behavior of MEMS devices used in projectors



Visualization technology, based on the high-speed recording and slow motion replay of phenomena via a high-speed video camera, is widely used in a variety of fields.
The following are examples of fields requiring high-speed observation, requiring time resolution of one millionth of a second or less.

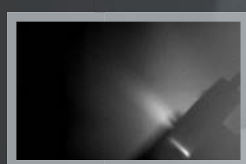
Semiconductor

- The behavior of plasma in plasma generators
- Observation of the failure process of semiconductor devices

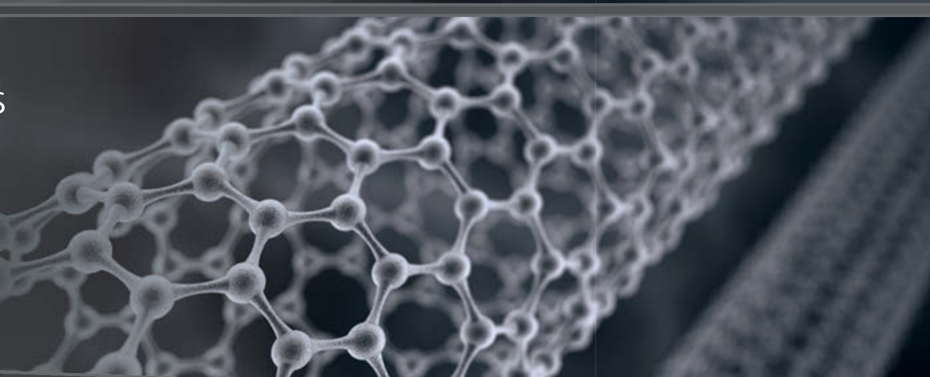


Industrial Equipment

- Observation of the machining process in welding equipment and machining equipment
- Operation error analysis of manufacturing equipment



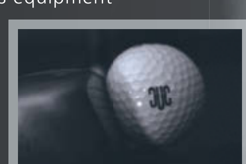
Raw Materials and Other Materials

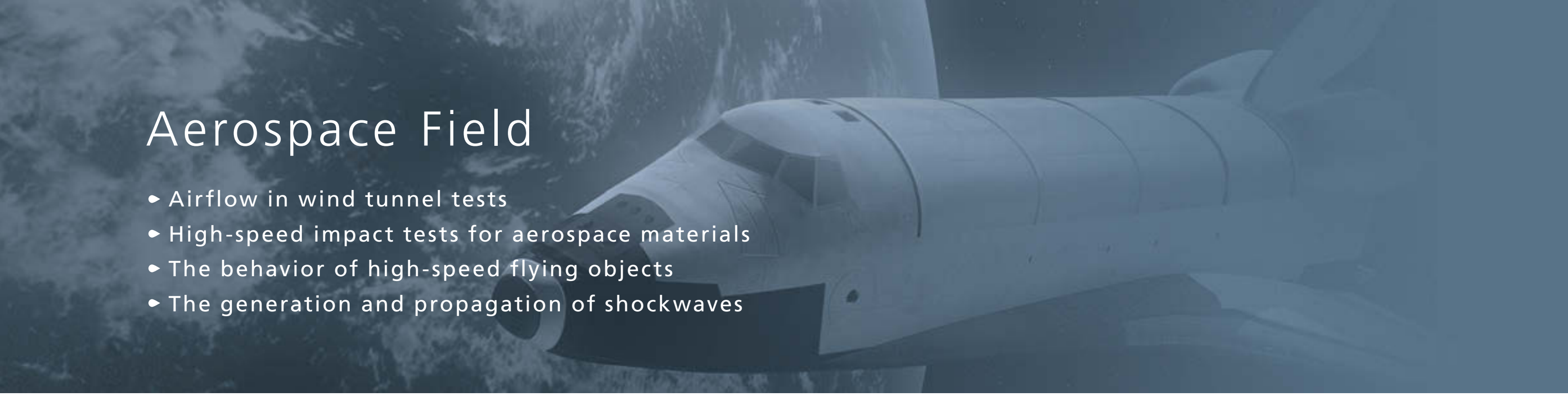


- The process of manufacturing nanomaterials through atomization
- The denaturing process of metals

Sports Equipment

- Motion analysis
- Development of sports equipment

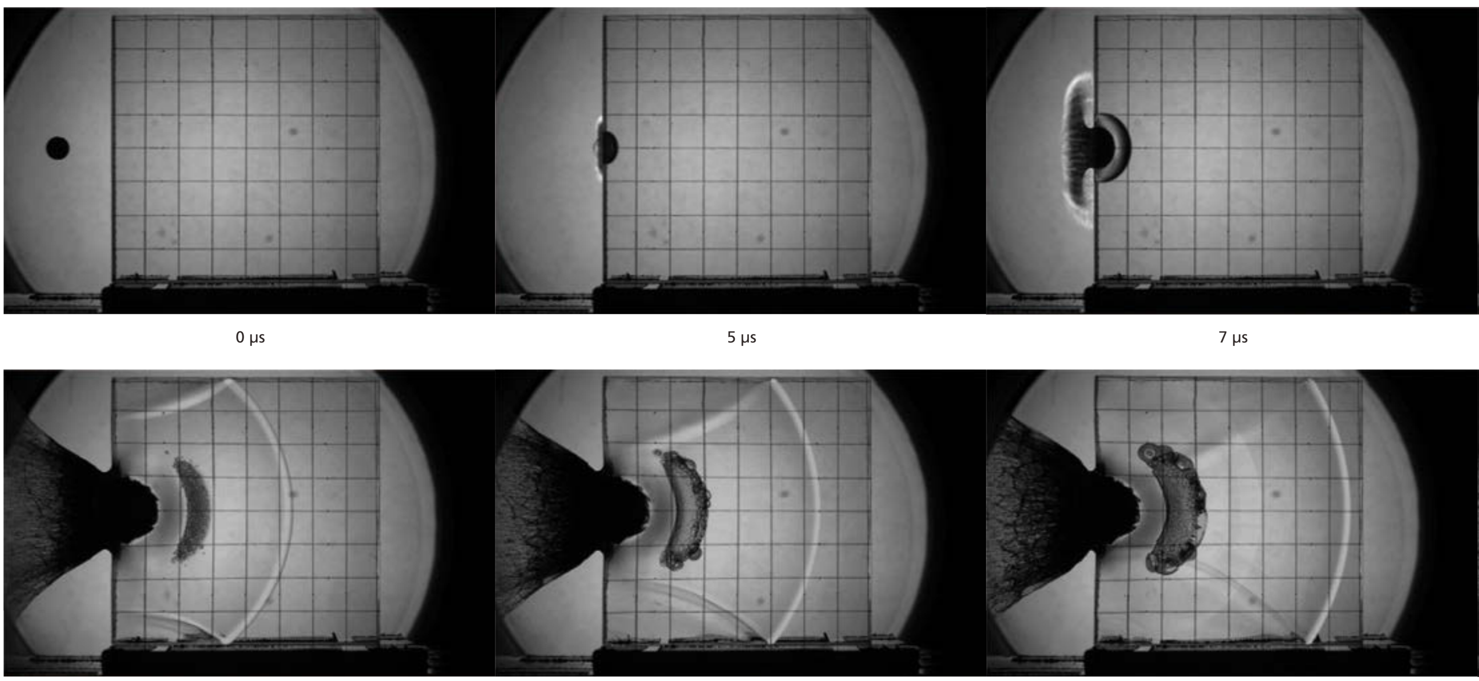




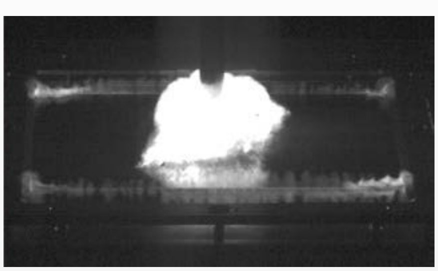
Aerospace Field

- Airflow in wind tunnel tests
- High-speed impact tests for aerospace materials
- The behavior of high-speed flying objects
- The generation and propagation of shockwaves

High-Speed Collision of a Transparent Laminate with a Resin Sphere



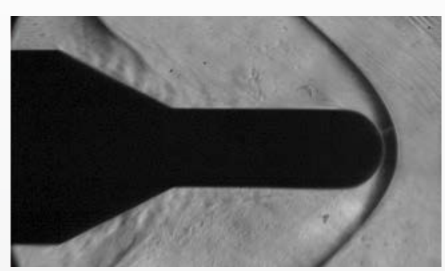
CFRP Lightning Strike Test



Recording speed: 1 million frames/second
Width of field of view: Approx. 150 mm

Lightning strike tests are used to investigate damage from lightning strikes to carbon fiber reinforced plastics (CFRP), which are increasingly used as structural materials for aircraft. The image illustrates the instant gasification of the resin by the lightning current flowing along the direction of the CFRP fibers.

Supersonic Wind Tunnel Test

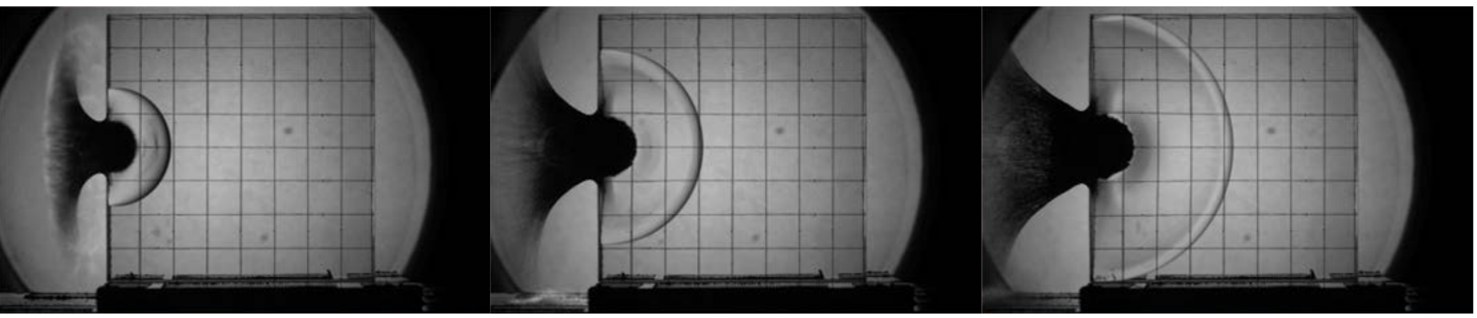


Recording Speed: 200,000 frames/second
Width of field of view: Approx. 80 mm

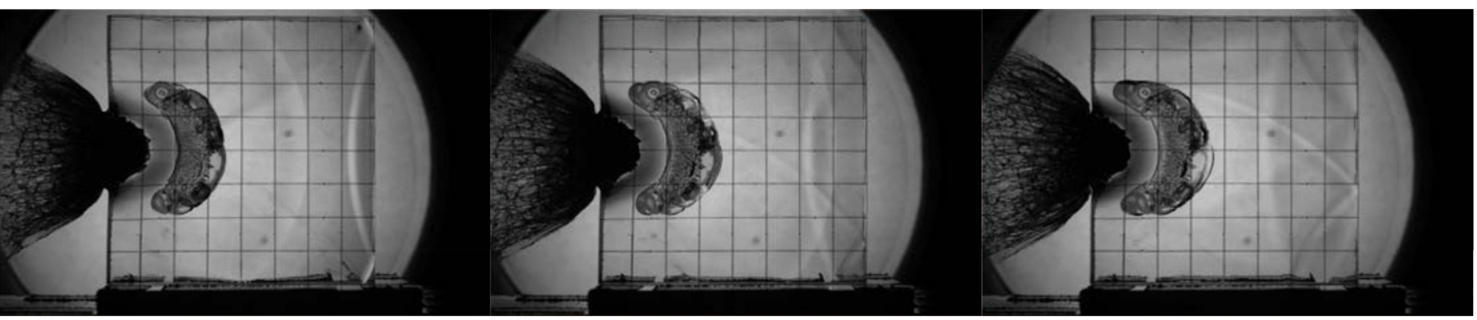
Sonic booms, the shockwaves generated by ultrasonic passenger planes, cause a thunderous noise on the ground, so aerodynamic designs are studied as a means to reduce this problem. The image shows a Mach 2 ultrasonic wind tunnel test. Subtle variations in airflow are captured by the high-speed camera.

Satellite and rocket debris, referred to as space junk, circles the earth at high speeds in satellite orbits. Space junk causes problems when it collides with spacecraft in flight, causing damage.
In addition, in recent years, the conversion of aircraft parts to carbon fiber reinforced plastics (CFRP) has advanced. However, aircraft experience lightning strikes and collisions with birds and hail midflight, so the impact resistance of materials and the damage caused by these occurrences must be investigated beforehand.

In the development of aerospace materials, high-speed cameras are used to investigate the failure behavior of materials caused by high-speed flying objects, and the deformation and failure behavior of materials caused by high-speed impacts. In addition, high-speed cameras are utilized for the development of thrust generators, aerodynamic design via wind tunnel tests, the observation of damage in lightning strike tests, and basic research into shockwaves, detonation waves, and other high-speed wave motion phenomena.



10 µs 15 µs 20 µs



40 µs 45 µs 50 µs

Recording speed: 2 million frames/second
Width of field of view: Approx. 150 mm

These images show the failure process caused by the high-speed collision of a resin sphere (nylon sphere) with a block of a transparent laminate (polycarbonate). The images illustrate the production and growth of cracks inside the block due to the stress wave caused by the collision.
Provided by Professor Arai of Hosei University, Professor Sato of JAXA, Professor Kawai of Kumamoto University

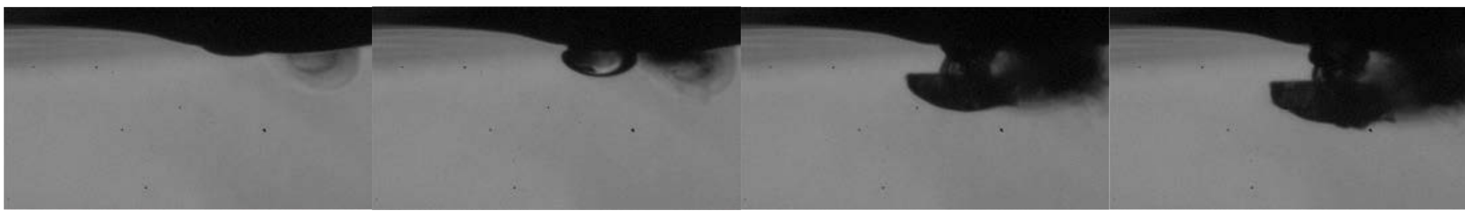
Experimental Setup of High-speed Collision

A resin sphere is injected at 3.5 km per second from the gas gun. The high-speed collision of a transparent laminate with the resin sphere is captured in the backlight system to face the camera and strobe light.

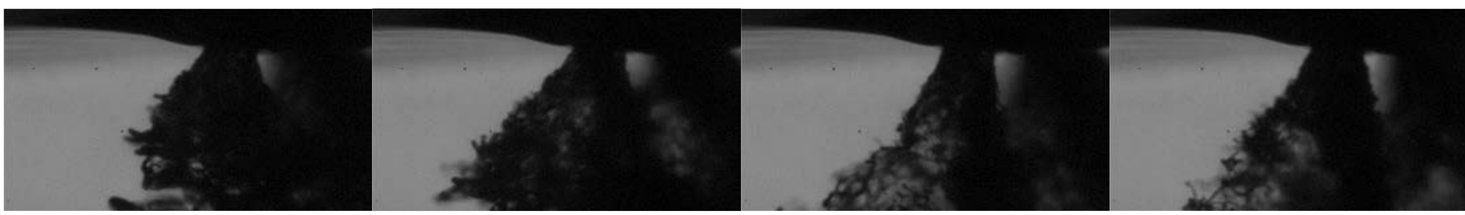
Automotive Industrial Field

- The failure behavior of automotive body materials
- The combustion process in engines
- The injection process in fuel injection equipment

Fuel Injection Nozzle (Injector) for an Automobile Engine



0 μs | 4 μs | 7 μs | 8 μs



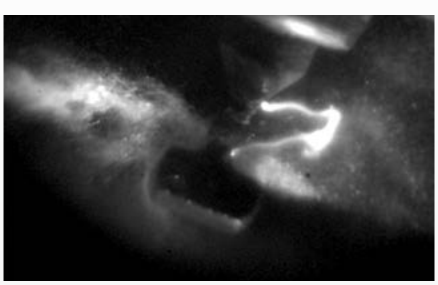
19 μs | 23 μs | 27 μs | 31 μs

Recording speed: 2 million frames/second
Width of field of view: Approx. 1.2 mm

Liquid fuel is injected from the engine's fuel injection nozzle. Analysis of the process of atomization, by which the fuel is changed into fine particles of uniform size, is indispensable for the development of high-power, high-efficiency engines. The images illustrate how the liquid fuel injected at high speed from the pores in the nozzle tip forms a cone-shaped film, which then changes into droplets.

Provided by Professor Kawahara of Okayama University

Spark Plugs



Recording speed: 1 million frames/second
Width of field of view: Approx. 30 mm

The recorded image shows the spark discharge occurring between the electrodes of the spark plug. It is evident that the spark is bent significantly by the impact of the fuel injected from the left side to the right side of the image.

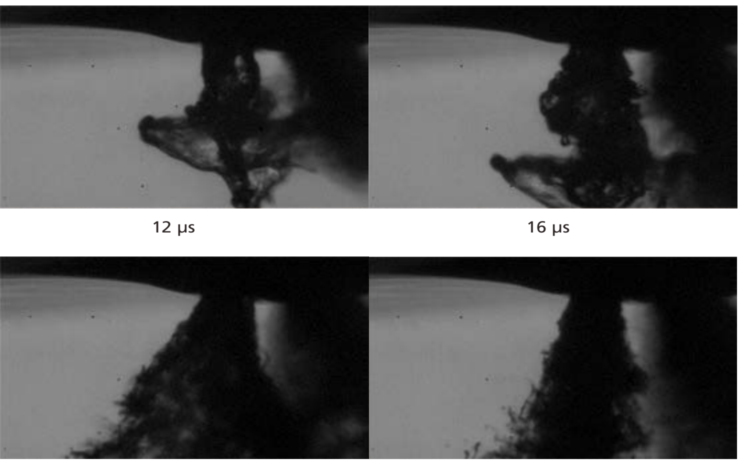
Provided by Professor Kawahara of Okayama University

High-Speed Tensile Test of Carbon Fiber Reinforced Plastics (CFRP)

Recording speed: 10 million frames/second
Width of field of view: Approx. 10 mm

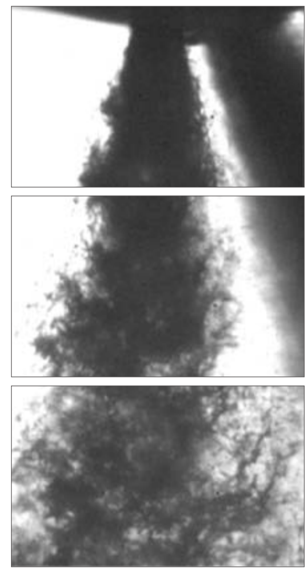
The image illustrates the breakage of the CFRP by the high-speed tensile testing machine. The CFRP fractures instantaneously at the limit load, so a recording speed of 10 million frames/second is required to capture the fracturing process in detail.

In order to develop high-output, high-efficiency automobile engines, detailed observations and analyses of the structural components of the engine are required. This includes the process of fuel injection by fuel injection equipment (injectors), and the process of fuel ignition by spark plugs.
In addition, the development of automobile bodies utilizing new materials such as lightweight and very strong carbon fiber reinforced plastics (CFRP) is actively being pursued. However, in developing such new materials, it is necessary to observe and analyze the deformation and failure behavior of materials when they undergo an impact.
In recent years, the deformation behavior of materials recorded using high-speed cameras has been analyzed using image analysis software. Dynamic analyses of the 2D or 3D strain distributions in the material are also performed.
In addition, high-speed cameras are used to observe the engine combustion process and the behavior of airbags.



12 μs 16 μs 35 μs 40 μs

Atomization Process of Fuels



Near the nozzle outlet
1 mm from the nozzle
2 mm from the nozzle

Recording speed: 10 million frames/second
Width of field of view: Approx. 1.2 mm

The liquid fuel injected from the nozzle is captured. The liquid film turns into the droplets with increasing distance from the nozzle.

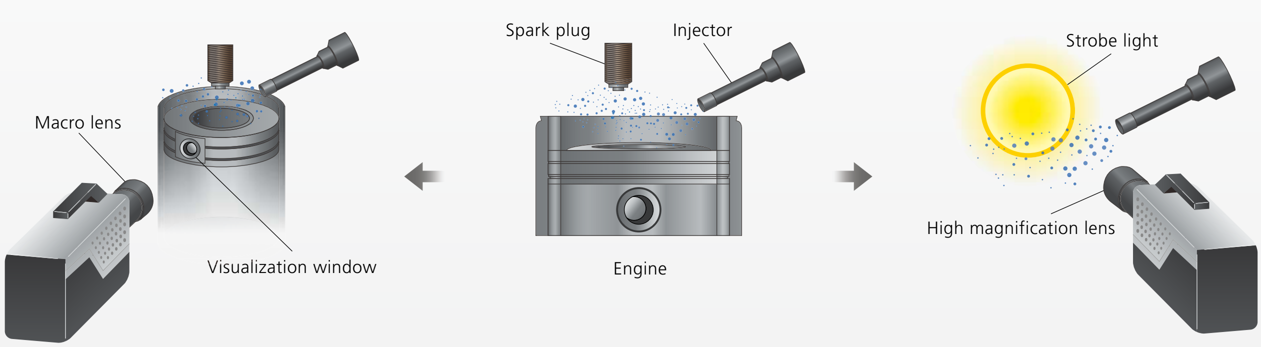
Provided by Professor Kawahara of Okayama University

Observation and Analysis of Engine Components

Discharge of spark plug or fuel injection from the nozzle can be observed in part alone or by visualization engine and analyzed in detail.

Observation of spark plug by visualization engine

Observation of fuel injection from the nozzle

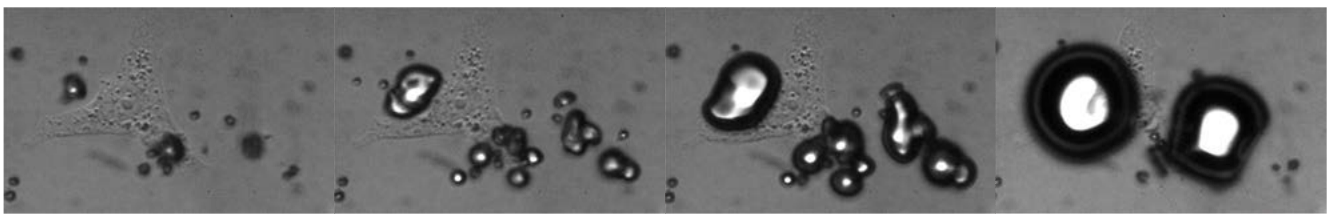


Medical Treatment and Biotechnology Fields

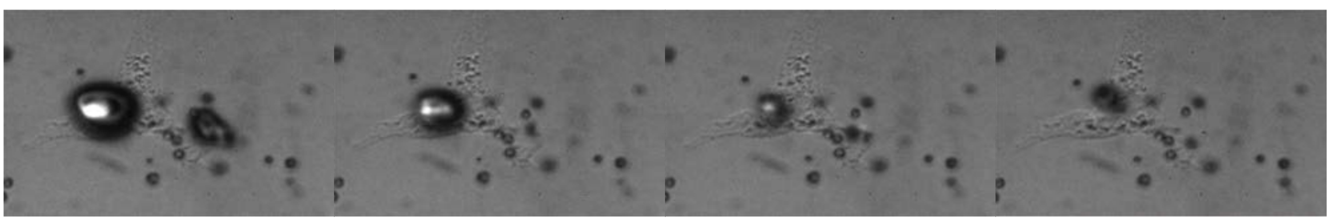
- The drug release process in drug delivery systems
- The generation and disappearance process of microbubbles, which are utilized for sterilization and ultrasound diagnosis

In medical treatment and biotechnology fields, research is advancing using the dynamics of so-called microbubbles, microscopic bubbles on the order of 1 to 100 microns.
When microbubbles in a fluid are exposed to ultrasonic waves, they expand, contract, and then disappear, a process that generates a localized, high-speed flow referred to as a microjet. Research is being performed regarding the use of this phenomenon to open pores in cells so as to introduce genes and pharmaceutical agents directly into cells.
Microbubbles are extremely minute, so the process of expansion, contraction, and destruction occurs at very high speeds. Accordingly, a high-sensitivity, high-speed camera is required to analyze this behavior.
In addition, high-speed cameras are used to observe the behavior of ultrasonic waves from ultrasonic generators.

The Destruction Process of Microbubbles in Proximity to Cancer Cells Using Ultrasonic Waves



0 μs | 0.4 μs | 0.8 μs | 7.8 μs



11.4 μs | 11.8 μs | 12 μs | 13 μs

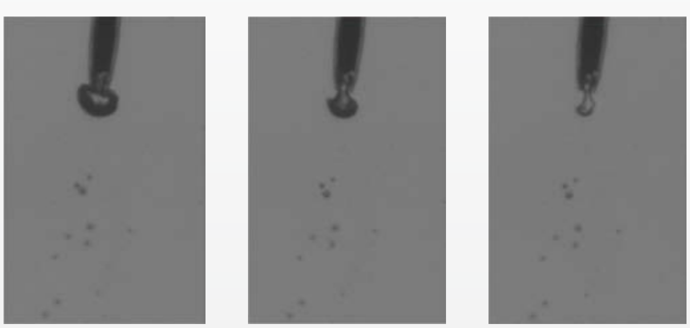
Recording speed: 10 million frames/second
Width of field of view: Approx. 130 μm

Research is advancing into a drug delivery system in which microcapsules containing pharmaceutical agents and microbubbles are introduced in proximity to cancer cells. Exposure to ultrasonic waves is used to rupture the capsules, and the pharmaceutical agents are then guided into the cancer cells. The images illustrate the expansion, contraction, and destruction of microbubbles in proximity to cancer cells, and the mechanical impact of this process on the cells.

Provided by Division of Bioengineering and Bioinformatics at Hokkaido University

High-Speed Contraction of Microbubbles

The images illustrate the contraction and disappearance of microbubbles resulting from an electrical discharge at the tip of a microscopic tube.
Research is being conducted into micro-scalpels and other applications using the high-speed flow generated when microbubbles disappear.
(Provided by the Yamanishi Laboratory at the Shibaura Institute of Technology)



0 μs | 2.4 μs | 3 μs

Recording speed: 1 million frames/second
Width of field of view: Approx. 0.2 mm

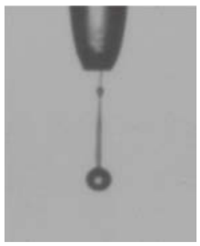
Consumer Electronics Field

- The inkjet ink discharge process
- The failure process of reinforced glass
- The behavior of MEMS devices used in projectors

High-speed cameras are used to observe high-speed phenomena in the micro domain. These include observations of the failure process of brittle materials such as the reinforced glass used in mobile information devices, the ink discharge process in inkjet printers, and the behavior of MEMS devices used in projectors.

Inkjet Printers


0 µs


23.2 µs


32.4 µs

In the development of inkjet printers, it is necessary to enlarge the microscopic amount of ink discharged from the nozzle and to observe its behavior in detail using high-speed cameras.
(Provided by Associate Professor Enomoto of Kanazawa University)

Recording speed: 5 million frames/second
Width of field of view: Approx. 0.2 mm

Semiconductor and Industrial Equipment Fields

- The behavior of plasma in plasma generators
- Observation of the failure process of semiconductor devices
- Observation of the machining process in welding equipment and machining equipment
- Operation error analysis of manufacturing equipment

High-speed cameras are used to observe and measure high-speed phenomena. These include the behavior of plasma in etching systems, sputtering systems and other plasma equipment, and machining processes in laser machining systems, electrical discharge machines, and cutting machines. In addition, they are used for failure mode analysis, including observations of the moment of destruction of the insulating film on the semiconductor devices.

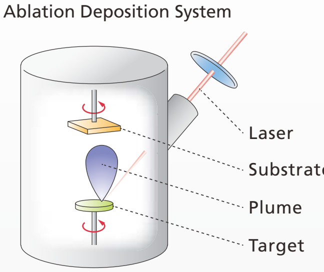
Laser Ablation Film Forming Apparatus


0 µs


0.8 µs

Recording speed: 10 million frames/second
Width of field of view: Approx. 50 mm

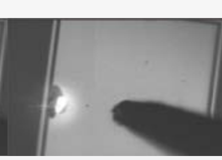
Laser Ablation Deposition System

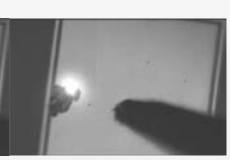


If the laser pulse is irradiated to a target substance, a substance surface stripped (ablation), particles with a light-emitting called plume will pop out. The laser ablation film forming apparatus utilizes this phenomenon, a substrate to be formed a film is arranged opposite to the target substance, and a film by depositing the particles generated by abrasion on the substrate. The image is obtained by observing the generation and disappearance process of the plume with the laser pulses emitted horizontally from the left.
Provided by the Tanabe Laboratory at Kyoto University

Dielectric breakdown of the semiconductor device


0 µs

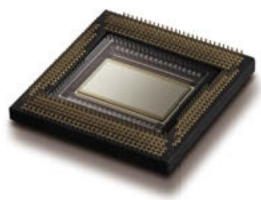

64 µs

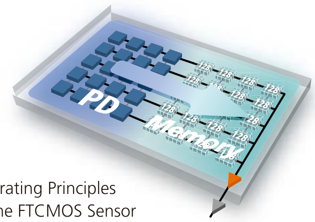

147 µs

Dielectric breakdown of MOS (Metal - Oxide - Silicon, the basis of semiconductor integrated circuit) device is observed. The breakdown process is captured in which the thin-film metal electrode is going to peel from the oxide film while emits a flash.
Provided by the Sugawa Kuroda Laboratory at Tohoku University

Recording speed: 1 million frames/second   Width of field of view: Approx. 0.8 mm

FTCMOS2 Advanced, Next-Generation Burst Image Sensor

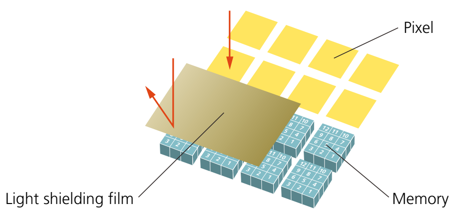




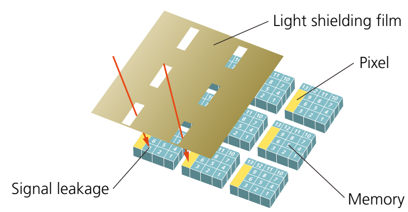
Operating Principles
of the FTCMOS Sensor

Burst Method Enables Ultra High-Speed Recording

For typical high-speed video cameras, image storage memories are located outside of the image sensor. Because the number of signal output taps are overwhelmingly small compared to the number of pixels, the transfer of the video signals from the pixels to the memories must be a sequentially serial process; therefore, ultra high-speed recording of more than 1 million frames per second could not be realized. In contrast, Shimadzu's burst image sensor has the same number of built-in memories as number of frames recorded. Furthermore, a pixel and memories are connected by wire in a one-to-one manner in order to completely parallel transfer the video signal from the pixels to the memories. This makes it possible to realize ultra high-speed recording at 10 million frames per second. In addition, since it not limited to the number of signal output taps as with conventional serial transfer system, high-resolution recording at ultra high speed is available.



Burst Image Sensor Using Next-Generation CMOS Technology



Burst Image Sensor Using Conventional CCD Technology

Next-Generation Burst Image Sensor Based on CMOS Technology

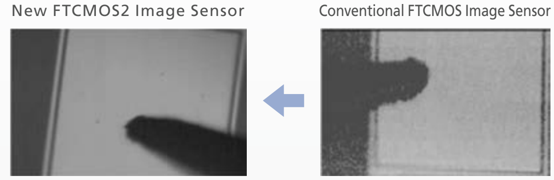
Conventional burst image sensors are based on CCD technology, in which the memory is positioned adjacent to the pixels. As a result, there are problems with decreased image quality due to signal leakage from pixels to memory. Accordingly, the Shimadzu FTCMOS burst image sensor adopts CMOS technology, in which the pixels and memory are spatially separated to achieve high image quality with no signal leaks.
In addition, with the FTCMOS2, light sensitivity is six times better than with FTCMOS, thanks to the adoption of a new CMOS process.

Note: FTCMOS and FTCMOS2 sensors were developed through collaborative research with Prof. Shigetoshi Sugawa of Tohoku University. Patents: 04931160, 04844853, 04844854

Improved Signal-to-Noise Ratio Thanks to Six Times the Conventional Sensitivity

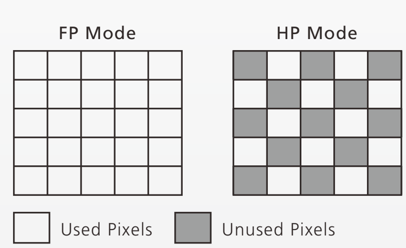
The light sensitivity of the HPV-X2 has been improved six-fold compared to our conventional products by adopting the FTCMOS2 image sensor. The resulting improvement in signal-to-noise ratio yields clearer images compared to conventional products, if the optical systems are the same.

New FTCMOS2 Image Sensor　　Conventional FTCMOS Image Sensor



FP Mode and HP Mode

- The FTCMOS2 sensor has 100,000 pixels and a 12.8 million bit memory.
- In FP mode, each 128 bit memory element is assigned to 100,000 pixels.
- In HP mode, each 256 bit memory element is assigned to 50,000 pixels.
- The maximum recording speed in HP mode is 10 million frames/second, and the number of frames recorded is 256, twice the number in FP mode. However the resolution is 1/2, at 50,000 pixels.*



	HP (Half Pixel) Mode	FP (Full Pixel) Mode
Max. Recording Speed	**10 million frames/second**	5 million frames/second
Resolution	50,000 pixels	**100,000 pixels**
Number of Frames Recorded	256	128

* When images are displayed using software, and when saving image data, the pixels that are not used in HP mode are supplemented by the software, so the equivalent of 100,000 pixels is displayed or saved.

High-Speed Synchronized Recording Function Using Two Cameras

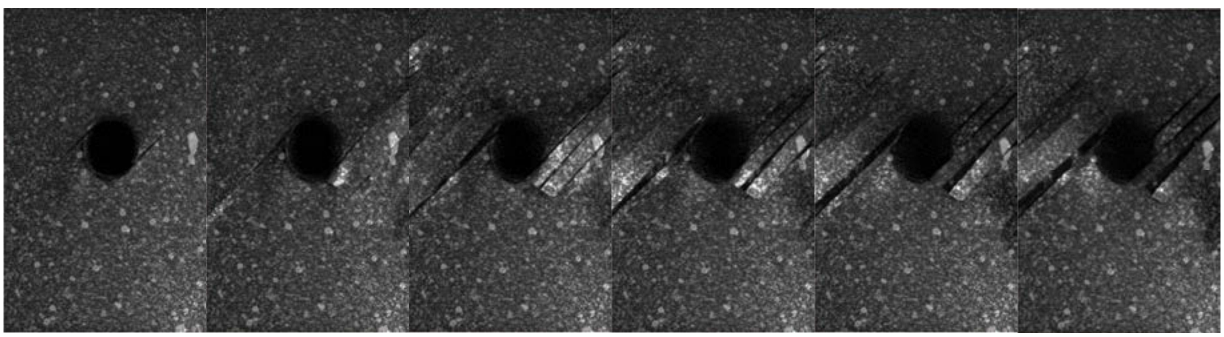
Accurate synchronized recording can be performed using two cameras at a frame rate of 10 million frames/second, so high-speed phenomena can be recorded simultaneously from two directions. Also, 3D image analysis can be performed in combination with commercially available image analysis software.

- Two directional simultaneous recording using two cameras
- 3D image analysis in combination with commercially available image analysis software

Two Directional Simultaneous Recording of the Breakage of Carbon Fiber Reinforced Plastic (CFRP) in a Tensile Test

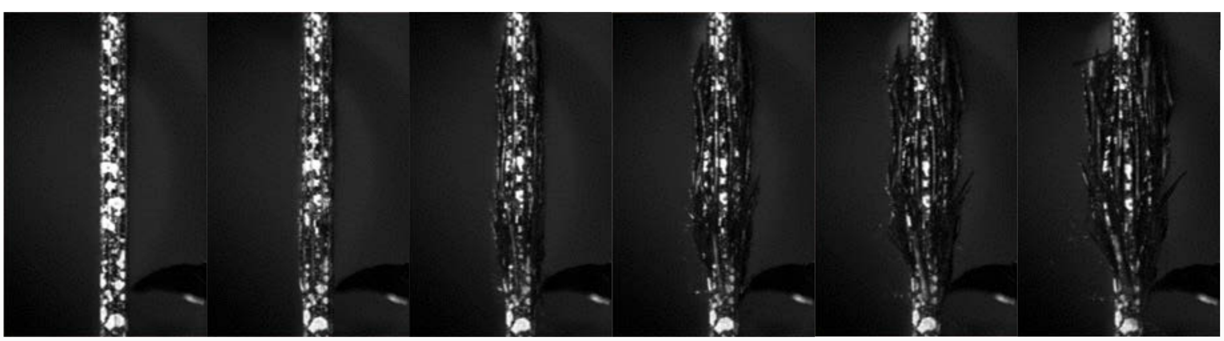
Recording speed: 1 million frames/second

Front



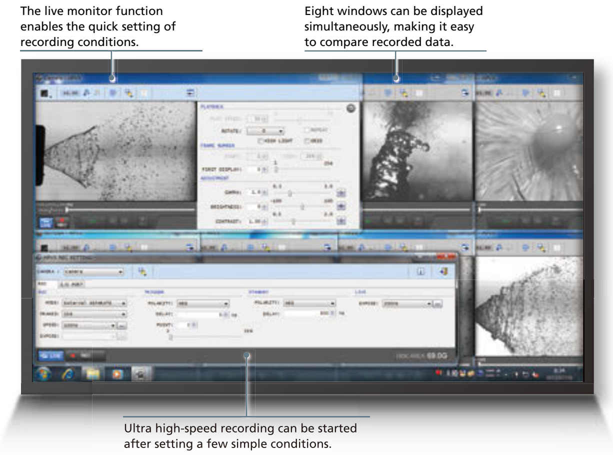
0 µs 15 µs 30 µs 45 µs 60 µs 75 µs

Side



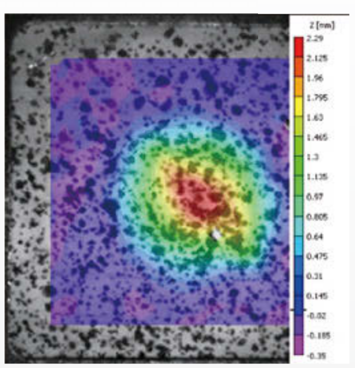
Windows Compatible Control Software

- Windows compatible control software is provided. Just connect the camera and PC using a LAN cable and configure the simple settings to start recording at high speeds immediately.
- In addition to a special format, the recorded images can be saved in common formats such as AVI, BMP, JPEG, and TIFF.



The Camera Can Be Used in Combination with Commercially Available Image Analysis Software

- High-speed phenomena can be subjected to image analysis and numerical analysis by saving the recorded images in a common format, and then loading them into commercially available image analysis software.
- In particular, to obtain strain distributions for samples during material tests, commercially available strain distribution analysis software can be used, which operates on the principle of digital image correlation (DIC).



3-D strain analysis of CFRP thin plate

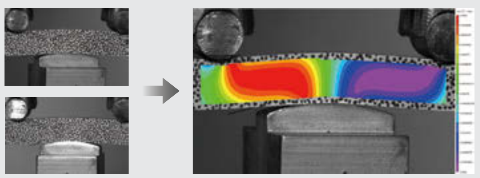
The deformation behavior of a CFRP thin plate colliding with a steel ball emitted by a gas gun at supersonic speed has been captured by two high-speed cameras. By using 3D-DIC software, it is possible to analyze a temporal change of the strain distribution in the direction perpendicular to the thin plate.

Provided by the Tanabe Laboratory at Nagoya University

3D-DIC Analysis Software VIC-3D (Option: Correlated Solutions Inc.)

VIC-3D can control two HPV-X2 units in direct through its' graphical user interface to perform high-speed three-dimensional strain analysis.

*In order to make HPV-X2 direct control function by VIC-3D available, a license authentication kit (S348-09838-01) is required in addition to VIC-3D.



Specifications

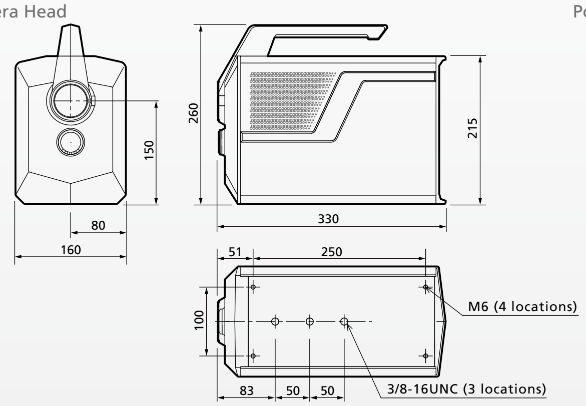
P/N: 348-00021-42/-45/-58
Model Name: HPV-X2

Camera Head		
Lens Mount	Nikon F-mount[1]	
Image Sensor	FTCMOS2 image sensor	
Recording Speed[2] (frame rate)	HP mode	10 Mfps, 5 Mfps (fixed) (fps = frames per second)
	FP mode	5 Mfps (fixed)
	Both modes	Variable recording speed between 60 fps and 2 Mfps (in 1/10 ns steps)
Continuous Recording Capacity	HP mode	256 frames max.
	FP mode	128 frames max.
Resolution	HP mode	50,000 pixels (zigzag lattice pixel array)[3]
	FP mode	100,000 pixels (400 (horizontal) × 250 (vertical))
Color/Gradations	Monochrome, 10 bits[4]	
Exposure Time[5]	10 Mfps (fixed at 50 ns), 5 Mfps (fixed at 110 ns)	
	Variable in a 10 ns interval starting from 200 ns in a range from 60 fps to 2 Mfps	
External Trigger Input	Two channels (TRIGIN, STANDBY) TTL level (5 V), capable of either positive or negative polarity	
Recording Mode	Internal trigger, external trigger, continuous trigger	
Synchronization Function	Capable of synchronized recording with two cameras connected	
Optional Outputs	Two channels (exposure start timing, trigger detection timing, or other outputs depending on settings)	
Trigger Point Setting	Can be set to any frame from the second frame onwards.	
Interface	One 1000 Base-T/100 Base-TX port	
External Monitor Output[6]	NTSC/PAL output	
Data Memory Format	10-bit dedicated format, BMP, AVI, JPEG, TIFF (8-bit and 16-bit formats supported)	
Power Supply Unit		
Power Rating	Single phase 120 V/220-230 V, 200 VA, 50/60 Hz	
Required Specifications for the Control PC		
Operating System	Windows10 Pro[7] (64bit)	
CPU	Intel Core i5 or faster	
Memory	4 GB or more	
HDD	250 GB or more	
Screen Size	1,366 × 768 or larger	
Interface	1000 Base-T/100 Base-TX	
External Recording Device	DVD-RW	
Other Peripherals	Mouse and keyboard	
Environmental Conditions		
Operating Temperature Range	5 to 40 °C	
Operating Humidity Range	35 to 75 % RH with no condensation	
Storage Temperature Range	0 to 50 °C	
Storage Humidity Range	20 to 80 % RH with no condensation	
Size and Weight		
Camera Head	W160 × D330 × H260 mm, approx. 6.4 kg	
Power Supply Unit	W150 × D392 × H185 mm, approx. 5.2 kg	
Length of Interface Cable Between Camera and Control Computer	Approx. 2 m	
Length of Cable Between Camera and Power Supply Unit	Approx. 2.8 m	

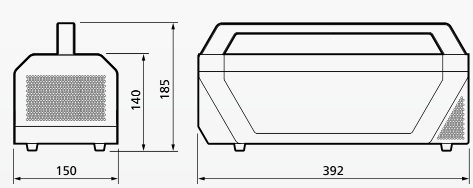
Note 1: Shimadzu does not guarantee that all F-mount lenses can be attached.
Note 2: The recording speed is a reference value. It is not guaranteed to be an accurate value for the time interval between recording frames.
Note 3: Stored images will be 400 pixels (horizontal) × 250 pixels (vertical).
Note 4: 10-bit refers to the data format. It does not indicate a guarantee of data precision.
Note 5: These exposure times are rough indications and are not guaranteed as exact exposure time ratios for all recording speeds.
Note 6: Online image to be displayed on the external monitor, appears smaller than the monitor screen, not full screen display.
Note 7: Windows is a registered trademark of Microsoft Corporation in the USA and other countries.
Note 8: The FTCMOS2 image sensor used in this camera is manufactured using high accuracy technology, but defective pixels may exist. Note that this is not a defect or failure of the product.

External Dimensions

Camera Head



Power Supply Unit



Units: mm

Precision Universal Testing Machine

Autograph precision universal testing machine
AG-Xplus Series

Systems for Evaluating the Dynamic Strength Characteristics and Fracturing of Materials

Hydroshot high-speed impact testing machine
HITS Series

Export Control Regulations
Any export of Shimadzu High-Speed Camera, HPV-X2/HPV-X/HPV-2 is subject to export control regulations of the nation, based on Part 2 of the NSG guideline, 5.B.3.
Please contact sales agent or representative of Shimadzu should you have any question.

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