Leica 3-D Imaging Systems

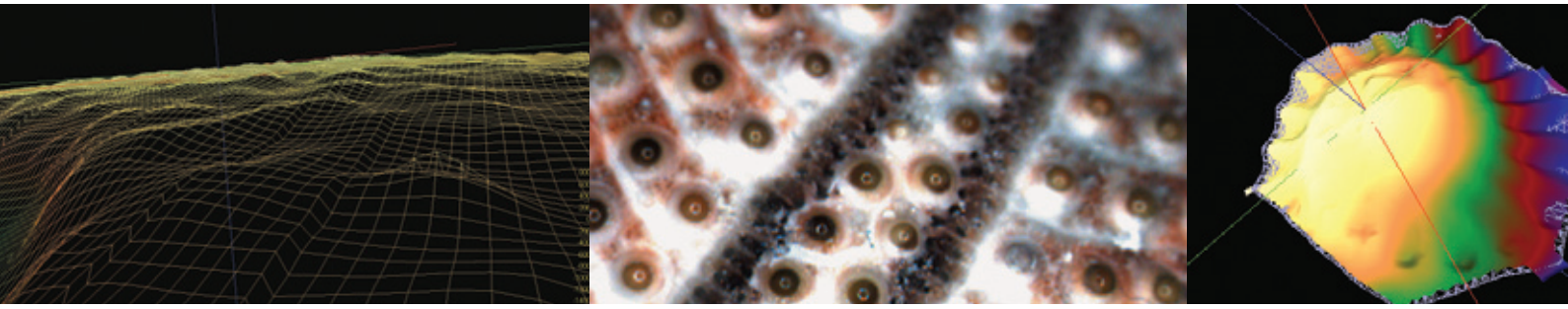
A complete offering for visualization, documentation, 3-D reconstruction, and quantitative analysis

Leica
MICROSYSTEMS

Three-dimensional Reality

Stereo photographs are fascinating; unlike two-dimensional images, they convey realistic, lifelike depth representations to the viewer and offer an unlimited range of applications in science and technology. As early as the fourth century B.C., the Greek mathematician Euclid studied the question of why human vision has depth perception. However, it was not until 1832 that English physicist Charles Wheatstone finally explained the principle of 3D vision. In 1838, to prove his theories, he constructed a device for viewing a drawn pair of images and called it a stereoscope, after the Greek word "stereo", meaning solid or three-dimensional.

Daguerre and Niépce invented photography in 1839. That same year, Wheatstone had stereo photographs made which, for the first time, simulated realistic spatial views and the depth of objects. The development of the first stereoscopic binocular camera in England by Sir David Brewster in 1849, and its introduction at the 1851 London World's Fair, caused a real "boom" in stereoscopic imaging. However, it was not until the digital age that the technical means for creating, projecting, and evaluating 3D images came about, which also provide valuable information in professional microscopy applications.



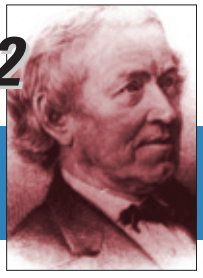
Leica expertise in 3-D visualization

Since designing its first stereomicroscope in 1958, Leica Microsystems' skill in visualizing the third dimension has been well established. Leica stereomicroscopes are held in high esteem worldwide since our performance standards far exceed comparable products. Since 1958, stereomicroscope performance has advanced by leaps and bounds resulting in stereoscopes being used for a myriad of different tasks. Today, such micro-scale tasks as micromanipulation, specimen mounting and sorting, and animal surgeries would be nearly impossible without a stereomicroscope.

From visualizing 3-D to imaging in 3-D

Leica Microsystems is proud to introduce the most complete 3-D microscopic imaging system. What was only possible to visualize through stereoscope eyepieces can now be captured and displayed electronically. Starting with a high-performance stereomicroscope, we add a dual-chip digital camera which can produce a true 3-D image on screen for training purposes and capture these images for further processing to reveal specimen measurement data such as profile, surface area, and volume. The complete 3-D picture of microscopic specimens, from eyepiece to on-screen to topographical measurements, is now at your fingertips.

1832



Charles Wheatstone built the first mirror stereoscope in 1838.

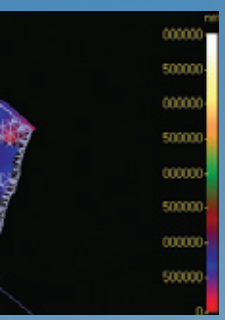
1849

Sir David Brewster's prism stereoscope for presenting three-dimensional images

Leica MZ16 A automated stereomicroscope
with integrated Leica IC 3D camera

Three-dimensional photography

Due to the convergence of the optical axes within a stereomicroscope, your eyes perceive objects from two perspectives that differ slightly. The fusion of these two different images in the brain form a single 3-D image allowing us to perceive the depth within the specimen. To convert what your eyes see through the eyepieces to a computer screen, a dual-chip camera is used to capture two single images from each optical axis which are then recombined into a single image.



Leica Design by Christophe Apothéloz

Leica IC 3D Digital Camera – Compact, Powerful, Precise

The heart of the Leica 3-D imaging system

In order to digitally capture, display, and measure a 3-D object in the most accurate fashion, a pair of photos, each with a slightly different perspective of the specimen, need to be attained. Just as the eyepieces of a stereomicroscope see slightly different views of the specimen, the new, dual-chip Leica IC 3D digital camera captures pairs of stereo images (stereo-pairs) for 3-D analysis. Each of the two 3.3 Megapixel chips within the compact IC 3D camera is perfectly aligned above each image path of a Leica M-series Stereomicroscope. With the click of a mouse, the IC 3D captures a high-resolution stereo-pair that can then be used to create 3-D images for training or documentation. These 3-D images can then be analyzed to obtain measurement values such as surface profile, area, or volume. In fact, the resolution is so high and the dual-chip alignment so precise within the IC 3D, that measurements taken with this imaging system are comparable to much more expensive scanning laser profilometer systems. Superior three-dimensional image display and measurement starts with high-quality images, which is why the Leica IC 3D camera is truly the heart of our system.

Compact design

The Leica IC 3D camera is positioned between the binocular head and the zoom optics, which eliminates the need for additional phototubes and C-mount adapters. This makes the IC 3D solution cost-effective while making the stereoscope slimmer, more compact, and, thereby, more ergonomic. Only one cable is required for connection of the IC 3D to a laptop or desktop computer, which keeps the workplace clutter-free.

Product highlights

- Integrated stereomicroscope camera capable of capturing a stereo-pair
- 2 × 3.3 Megapixel CCD with Bayer Array RGB filters for outstanding color pictures
- Fast data transfer with a single standard FireWire connection
- Live window for quick focusing and specimen positioning
- Exposure time between 230 microseconds and 30 seconds
- 8-bit or 12-bit color depth for each channel
- Simple connection to all Leica M-Series stereomicroscopes without the need for C-mounts
- Intuitive user interface with practical functions for image archiving and processing
- With Leica StereoViewer software, offers direct display of a 3-D image on the Leica ASD 3-D monitor
- With Leica StereoExplorer software, offers direct recording and measurement of a stereo-pair or display of a live 3-D image (anaglyph)

1851

Jules Dubosq's binocular stereo camera

1853

Wilhelm Rollman designs the first viewer for anaglyph technology with red and blue glasses.

Powerful performance
The dual 3.3 Megapixel RGB sensors of the IC 3D each provide a resolution of 2088 × 1550 pixels (interpolated up to 7.3 Megapixels = 3132 × 2325 pixels) which perfectly blends speed, manageable image size and image quality. Light captured by the IC 3D sensors is directly converted to a 12-bit digital signal in the camera module, which ensures the richest color detail. Further, advanced color algorithms in the IC 3D and APOchromatic lens correction guarantee true color reproduction and excellent image quality. Leica IC 3D FireWire technology allows high data transfer speed to the computer without a loss of information or image quality when viewed at the monitor.

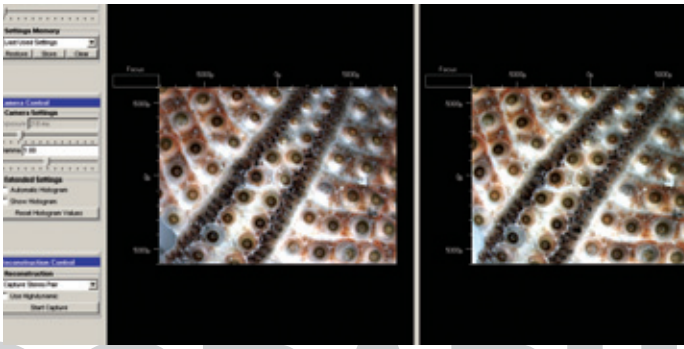
In addition, training other users on microscopic techniques is easy and comfortable since the IC 3D sends images to both stereo eyepieces and the digital CCDs simultaneously.

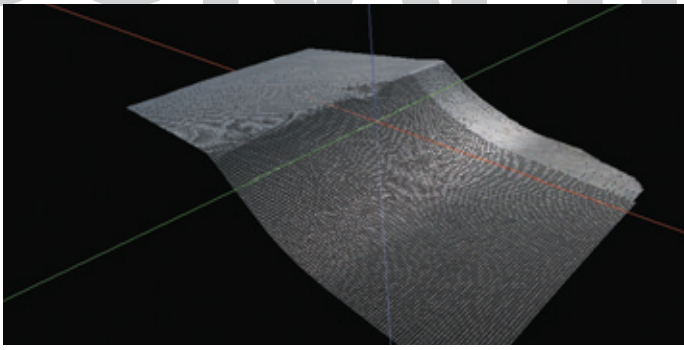
Precise results
When you purchase a Leica IC 3D digital camera, free software is provided to operate this imaging system. Beyond simply capturing and archiving 2-D images, this software allows users the ability to display live or captured images in full-screen mode, which makes images easier to see. Auto-exposure can be turned on to save time spent adjusting the image brightness via the mouse. In addition, there is a Zoom Focus window available in the live image, which allows users to adjust the focus in real time independent from the microscope's eyepieces.

When it is time to ask more from your IC 3D camera, Leica offers StereoViewer and StereoExplorer software modules for sale. With StereoViewer software and a special 3-D monitor, users can display live 3-D images, which is very useful for training and educational purposes. StereoExplorer software allows users to capture and precisely measure 3-D specimens' profile, area and volume.

The Leica IC 3D is also compatible with imaging programs, other than those provided by Leica, via a TWAIN interface. Thus, software such as Adobe Photoshop can be used to operate the IC 3D.

Leica IC 3D in compact camera housing with single FireWire connection


Simultaneous view of the left and right live images of the Leica IC 3D using the Leica StereoExplorer software


3D reconstruction of a metallic surface from a stereo-pair in StereoExplorer

1858

Joseph D'Almeida projects 3-D images with red/green filters. The audience wears glasses with red/green lenses.

1889

The US company Underwood & Underwood engages over 1000 photographers worldwide to meet the demand for pictures.

Leica StereoExplorer 3-D Software Controls, Visualizes, and Analyzes

Digital technology has opened up possibilities for turning stereo-pairs into real three-dimensional images that can be viewed and measured from different perspectives. The modular Leica StereoExplorer software package perfectly complements the Leica IC 3D digital camera for accurate imaging of the three dimensional surfaces. Two-dimensional stereo-pairs captured by the IC 3D are analyzed by Leica StereoExplorer, which then calculates a 3-D data record that can be viewed and measured. The resultant 3-D image, which appears in high relief, makes it easier for the user to visualize surface contours, greatly improves education and training environments, and enables accurate measurement of a wide range of specimens.

Leica StereoExplorer controls microscope and camera

Leica StereoExplorer software is available in two versions; automated and manual. The automated version controls not only the Leica IC 3D camera, but also the motorized zoom and focus of the Leica MZ16 A stereomicroscope. Measurement, magnification, and focus position data are updated live on-screen. In addition, the optional Autofocus module saves time in manually adjusting the image sharpness. The automated version of StereoExplorer makes work ergonomic and efficient, particularly during repetitive tasks.

StereoExplorer is also available in a manual version for non-motorized Leica M-series stereomicroscopes. This option offers a lower price tag with the trade-off of reduced ergonomy and the need to enter magnification data manually when images are captured.

3-D reconstruction from stereopairs

Leica StereoExplorer works with the most up-to-date digital image processing algorithms. The 3-D reconstruction is based on two images of the specimen taken from slightly different angles.

Product highlights

- Stereoscopic live viewing on-screen of specimens with anaglyph technology
- User-friendly software interface
- Ergonomic integration of Leica MZ16 A motorized stereomicroscope
- Easy, fast generation of 3-D data records
- 3-D reconstruction for visualization, documentation, and analysis of entire stereomicroscopic specimens
- Modular measurement software for
  - profile,
  - roughness,
  - surface area and
  - volume analysis

1891

Louis Ducas du Hauron produces the first printed anaglyph image using two negatives. It is viewed with 3-D glasses.

1919

Over 50,000 French Verascopes are sold – stereo photography booms in Europe.

This is possible because of the convergent beam paths of the stereomicroscope coupled with the dual-CCD Leica IC 3D camera. Leica StereoExplorer software automatically determines which pixels in the two images of the stereo-pair belong together and then calculates the topography of the specimen (taking into consideration the parameters of angle and magnification) as a Digital Surface Model (DSM). This 3-D data record then serves as the basis for surface and volume analyses.

Impressive visualization of DSMs

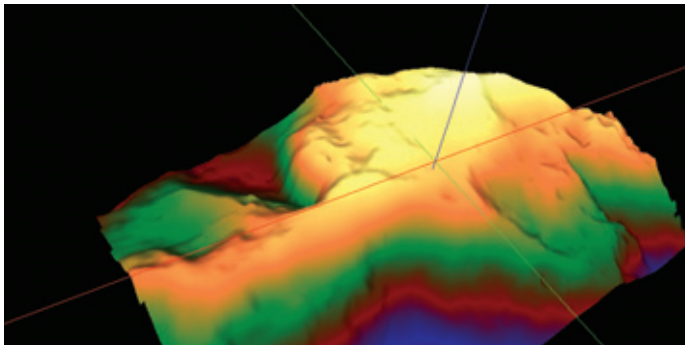
Leica StereoExplorer offers a 3-D Viewer function that is used to visualize the DSM on-screen. Such high quality, 3-D spatial views of specimen surfaces have never before been possible. The DSM can be superimposed over the original stereomicroscope image as a texture or displayed as a height-encoded, pseudo-color to illustrate the vertical range of the specimen. Images can be rotated in three axes and zoomed in and out as desired. Each and every view can be stored as a separate image file (JPG, TIFF, BMP, etc.) and shared with colleagues.

Optional software for analysis

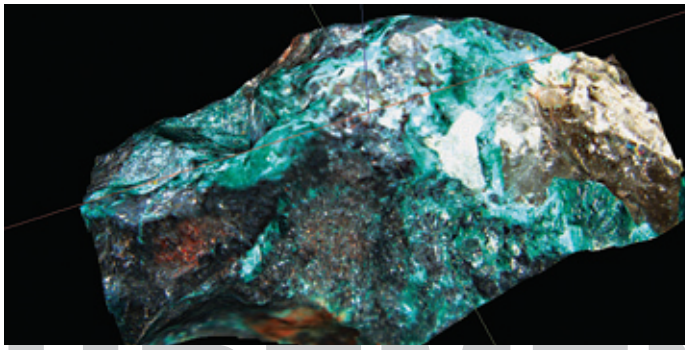
3-D measurement modules are available with Leica StereoExplorer. These modules include profile, area, and volume analysis packages that allow the user to attain in-depth quantitative information about their specimen. For example, profiles can be extracted, roughness or waviness can be determined according to EN/ISO guidelines, and volumes of depressions and elevations can be calculated. The accuracy of StereoExplorer measurement results is amazing; comparable to much more expensive laser scanning profilometry systems. For more detailed information, please see the Leica StereoExplorer application note.

Integrated image database

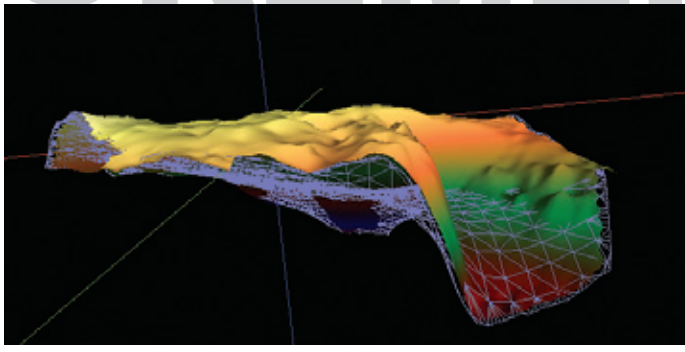
Since Leica StereoExplorer works with image pairs rather than individual images, it features an integrated database. The database allows convenient management of DSMs, stereo-pairs, and calibration data (focal length, pixel size and image offset) to be organized into projects and project folders for easy future reference.



Height-encoded pseudo-color view of a crystal



Digital surface model of a crystal with original texture



Surface model with lattice structure used, can be rotated in three axes as desired

1931

Slides are projected on large screens for three-dimensional presentations to a large audience.

1954

Leica M3 cameras with stereo attachment are an overwhelming success. More than 235,000 are sold in five years.

Leica ASD 3-D Monitor – 3-D in Real Time

Images seen through the eyepieces of a stereomicroscope have long impressed those who have used these instruments because of the magnificent depth perception. Imagine visualizing that same 3-D depth on your computer monitor or notebook. With the Leica Auto-Stereoscopic Display (ASD) 3-D Monitor, this is now possible. Through the use of the Leica IC 3D digital camera, a stereo-pair and resultant 3-D image is captured and literally projected from the 3-D monitor. Objects appear as concrete and vivid as through the stereomicroscope eyepieces and there is no need for 3-D glasses or a helmet-like display.

A new solution for 3-D

Although software solutions for 3-D image reconstruction have been commercially available for some time, 3-D monitors have only recently been introduced. Before the new ASD Monitor from Leica, users were forced to resort to techniques utilizing 3-D glasses or helmet-like displays in order to experience the depth of stereomicroscope eyepieces. The Leica ASD Monitor System is currently the only high-resolution, auto-stereoscopic, 3-D display for spatial viewing and documentation of procedures under the stereomicroscope in real time. To see in stereo, the viewer need only sit in front of the display -no special eyewear or accessories are necessary. The depth of field and color reproduction correspond to the view seen through the stereomicroscope eyepieces.

Two 2-D images = one 3-D image

The principle of the ASD 3-D monitor is based on the ability of the human brain to fuse two partial images into one three-dimensional image. A moving prism mask is located just in front of the Thin Film Transistor (TFT) display.

Feature highlights

- Ergonomic and true-to-life vision in 3-D – without masks, shutters or glasses
- 3-D display and 3-D image acquisition of stereoscopic specimens in real time
- High resolution and optimum brightness
- Image control system that allows user movement during 3-D viewing
- Increased ergonomics during training sessions
- Based on a modular system, thus existing Leica M-series stereomicroscopes can be supplemented with this system without problems
- Fully integrated system with the Leica IC 3D and Leica StereoViewer software for brilliant results

1960

The stereo camera is at its peak – over 450,000 of them, from different manufacturers, are in use.

1961

Legendary director Alfred Hitchcock successfully experiments with the use of 3-D effects in his films.

Two 2-D (partial) images taken by the Leica IC 3D digital camera are projected by the monitor through the prism mask - the left view is directed by the mask to the left eye and the right view to the right eye. The human brain then merges the two partial images together and perceives a real three-dimensional scene. This stereo imaging method causes no loss of brightness in the partial images, and the viewer sees a real, three-dimensional image with true depth representation.

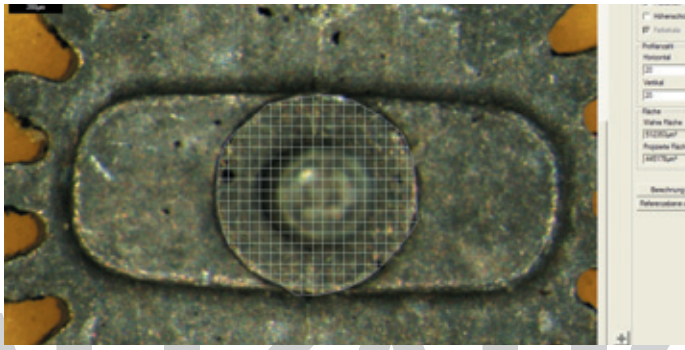
Freedom of movement

The head tracking system of the Leica ASD Monitor gives the user freedom to move his or her head over a wide area in front of the monitor, without losing the 3-D effect. A small camera in the monitor frame continuously tracks the viewer's pupils and, with each head movement, sends a correction command to the computer, which instantaneously adjusts the monitor's prism mask using a precise mechanical system. Therefore, the spatial impression remains the same for every viewing position over a 40° range.

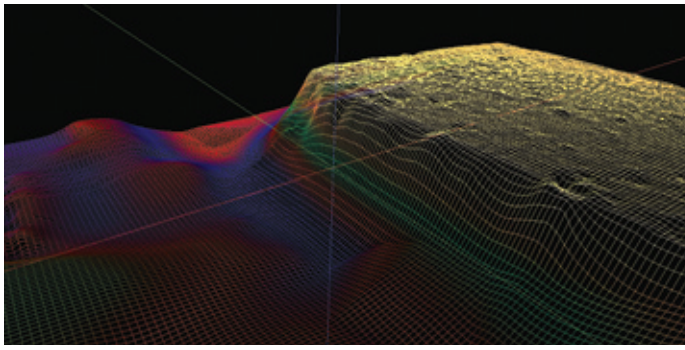
The complete 3-D workstation from Leica

Leica Microsystems offers a fully integrated solution for the best possible 3-D documentation and analysis utilizing our high-performance M-series stereomicroscopes, the Leica IC 3D digital camera, StereoViewer and StereoExplorer software packages, and Leica ASD 3-D Monitor System. All components are guaranteed to enhance the 3-D information that can be extracted from your specimens. From the user-friendly software, to the most accepted stereomicroscope hardware in the world, Leica is ready to be your 3-D partner.

Work is fatigue-free, with no special glasses required. The three-dimensional specimen appears to jump out of the monitor.



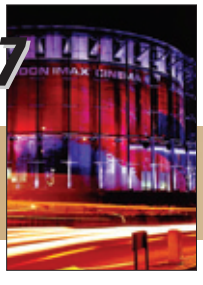
Indentation or elevation? With Leica ASD monitors, you can tell immediately.



In combination with Leica StereoExplorer, three-dimensional specimens can be measured and documented.

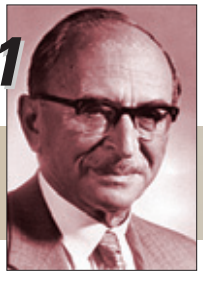
Thanks to Mr. Peter Schnehagen, President of the "Deutsche Gesellschaft für Stereoskopie" (German Society for Stereoscopy) and Prof. Mag. Dr. Armin Denoth of the Institute of Experimental Physics at the University of Innsbruck, Austria, for providing texts and images.

1967



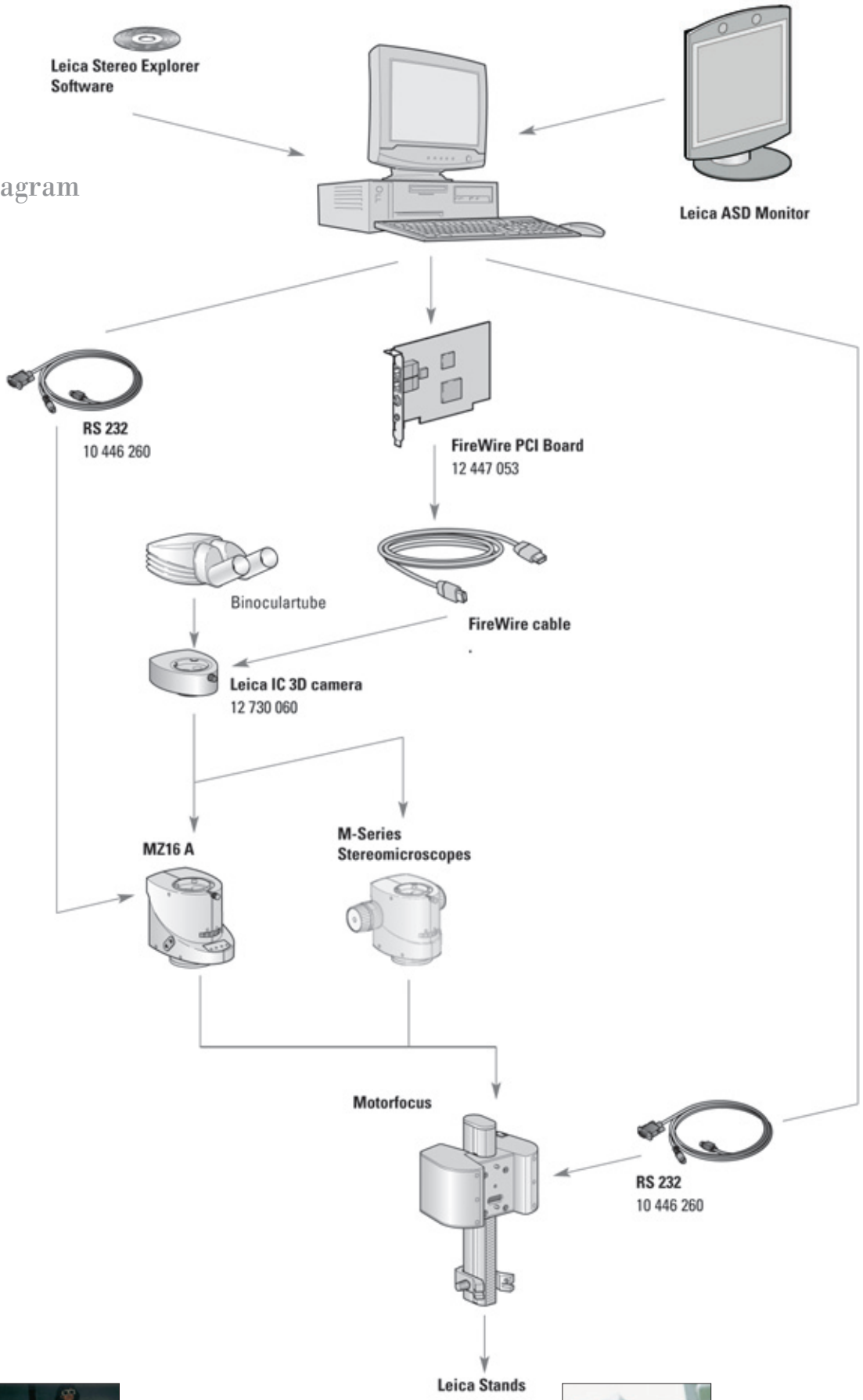
The IMAX Corporation is founded and the first IMAX 3-D theaters are built. Today, 235 theaters are in operation.

1971



Dr.-Ing. Dennis Gabor is awarded the Nobel Prize for the invention of laser holography.

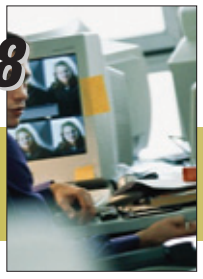
Assembly diagram



1979

Stereoscopy development stagnates; with few exceptions, further development takes place for IMAX 3-D theaters only.

1988



With the introduction of powerful desktop PCs, real-time simulations become increasingly popular.

Leica ASD – Technical data, performance characteristics

Stereo camera		
Type	Leica IC 3D	
Interface	PCI FireWire 1394a	
Computer		
Type	Pentium 4 processor, 2.4 GHz, 512 MB RAM, 80 GB hard drive, CD-RW	
Graphics adapter	Nvidia	
Keyboard	Spacesaver keyboard	
2-D monitor	17" flat panel	
3-D camera control system	Leica StereoViewer	
3D display		
LCD technology	a-siTFT/PVA	
Screen size	18.1" (46.0cm)	
Dot mask	0.281mm	
Brightness	250cd/m	
Contrast	500:1	
Response time	25ms	
Frequencies		
Horizontal	Analog: 30–81 kHz, digital: 30–63.3 kHz, vertical 56–85 Hz	
Bandwidth	Analog: 135 MHz, digital: 108 MHz	
Resolution		
Per eye	640–1024	
Total	1280–1024	
Colors	16.7 million	
Signal input		
Synchronization type	Separate H/V, composite H/V, SOG	
Inputs	Dual interface: DVI-D (digital) and RGB D-Sub (analog)* *Analogue input cannot be used for stereo visualization	
Signal output	Headfinder data	RS 232, 19200 baud
Tracking system Eye tracking ASD18 I	Tracking by recognition of the viewer's eye movements within a range of ±20° in front of the monitor	
Tracking system Spot tracking ASD18 S	Tracking by recognition of a reflector spot worn by the user within a range of ±20° in front of the monitor	
Power	Nominal 70 watts Energy management	Standby <5 Watt EPA/NUTEK/EnergyStar
Power supply	Primary AC 90-264 V~, 60/50 Hz, 1.3 A Certification	Secondary DC 12 V, 5.8 A, CE,TÜV-GS
Onscreen Menu (OSM)		
Digital	Horizontal and vertical position, contrast, brightness, synchronization, reset, size (1:1 visualization), filter function, color settings, OSM access, OSM display time, OSM language, OSM position, auto adjustment, switching between analog/digital	
Stereo	Switch tracking on/off, move/save zero parallax plane, swap left/right stereo parts (inverts display of image)	
Dimensions	Product with base	430 × 455 × 245mm (W × H × D)
Weight	Monitor 11.1kg	Base 4.6kg

1993

Shutter glasses, 3-D graphics cards and miniature LCD panels for PC applications and games experience a boom.

2005

Digital cameras and software for stereo-microscopes from Leica Microsystems open up new possibilities.

Leica IC 3D – Technical data, performance characteristics

Digital camera	**Leica IC 3D**		
Camera type	Digital stereo camera for stereomicroscopy with control software		
Sensor	Interline transfer frame readout CCD – ICX252AQ	Sensor grade	Grade Zero
Color filter	RGB Bayer Mosaic	Protective filter	Hoya CM500S (IR cutoff at 650nm)
Shutter control	Electronic global shutter/ Interlaced scan mode	Number of pixels	2× 3.3 Megapixels, 2088 × 1550
Sensitive area	2× 7.2mm × 5.35mm	Pixel size	3.45µm × 3.45µm
Maximum interpolated resolution	2× 7.3 megapixels, 3132 × 2325		
Color depth	36-bit	A/D converter	12-bit
Readout noise	< 6.0 LSB (12-bit) typical	Dynamic range	> 57 dB
Exposure time	230 µsec – 30 sec	Dark current	1.2 LSB/sec at 12-bit typical
Quantum efficiency, relative:	Blue 465nm 98%; green 530nm 100%; red 610nm 94% (sensor only)		
Gain control/offset control	10× / 0-255 LSB (12-bit)		
Live image	On computer screen for all formats		
Shading correction	Yes, stored for all formats	Brightness correction	In all binning modes
Cooling	Passive heat dissipation via metal housing		
Region of Interest (ROI)	User-adjustable in 2-pixel increments from 2×2 up to full resolution		

Image formats		Frames per second Fast / HQ	
	Pixels	Mono	Stereo
Full frame, color or monochrome	2088 × 1550	5 / 2.5	2.5 / 1.25
2 × 2 binning, color or monochrome	1044 × 772	10 / 5	5 / 2.5
3 × 3 binning, color or monochrome	696 × 514	15 / 7.5	7.5 / 3.75
4 × 4 binning, color or monochrome	520 × 384	20 /10	10 / 5
Progressive sub-sample	696 × 516	33 / NA	16.5 / NA
Progressive R or G B monochrome	1044 × 775	10 / 5	5 / 2.5
Modes	Formats in Fast (20 MHz) or High Quality (10 MHz) modes as specified above, triggered or free running		

Computer	
Minimum PC hardware requirements	Pentium 4 with 2 GHz, 512 MB, 24-bit graphics card, 1024 × 768, CD-ROM drive, onboard 1394a FireWire OHCI or available PCI slot for FireWire PCI card
Supported operating systems	Windows 2000, Windows XP
Software	Leica DFC Twain / Leica StereoExplorer / Leica StereoViewer

Interfaces			
Optical	Compatible with M series stereomicroscopes	Video adapter	Not required
Data	Single-cable FireWire - IEEE1394a 6-Pin	Software trigger	

Technical data and operating environment			
Energy consumption	~6 W		
Housing	Die-cast aluminum		
Dimensions	129.5×97.5×40.0mm (W × H × D)	Permitted temperature range	+10 – +35°C
Weight	550g	Relative humidity	10% to 80% non-condensation

Order numbers – Leica IC 3D			
12730060	Leica IC 3D camera kit consisting of 2m 6-Pin/6-Pin FireWire cable, Leica DFC Twain Software and Leica IC 3D camera		
Order numbers – Leica StereoExplorer basic modules			
33007032	Leica Stereo Explorer for non-automated microscopes		
33007033	Leica Stereo Explorer for automated microscopes		
Order numbers – Leica StereoExplorer expansion modules			
33007034	Leica Stereo Explorer autofocus module	33007037	Leica Stereo Explorer volume module
33007035	Leica Stereo Explorer profile module	33007039	Leica Stereo Explorer calibration tool
33007036	Leica Stereo Explorer area module		
Order numbers – Leica ASD systems			
10447426	Leica ASD18 I-system 3D monitor with eye tracking		
10447427	Leica ASD18 S-system 3D monitor with spot tracking		
33007040	Sharp 3D 15" Monitor (2D-3D switchable)		
10447429	Leica StereoViewer software		

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