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CASE STUDY

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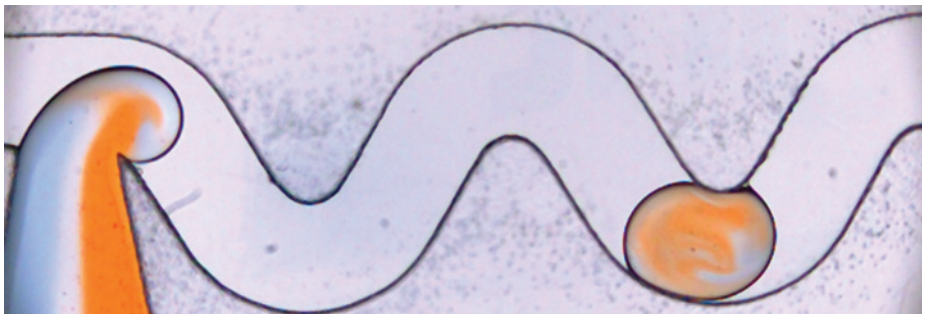
VISION RESEARCH HIGH-SPEED DIGITAL CAMERAS ENABLE ADVANCED RESEARCH IN THE BEHAVIOR OF FLUIDS AT MICROSCALE LEVEL



Images provided by: Fraunhofer Institute for Chemical Technology

WHEN IT'S TOO FAST TO SEE, AND TOO IMPORTANT NOT TO®

Looking through the microscope, a scientist takes a deep breath, and holds it. Random and jerky droplets appear, but move too quickly to be studied accurately. Using a high-speed digital camera, the scientist freezes the droplets in a series of images that can later be properly analyzed. This scientist could be studying the mixable properties of new paint colors, or he could be working on a revolutionary new vaccine.

Welcome to the world of microfluidics.

Introduced in the 1980s, microfluidics is an offshoot of the more commonly known lab-on-a-chip technology. It is applied in the fields of chemistry, physics, biotechnology, and engineering in which small volumes of fluids are analyzed. Microfluidics technology exists in many everyday objects, including liquid pumps, gas valves, and consumer inkjet printers. Have you ever wondered how an inkjet printer manages to accurately place millions of miniscule droplets of ink on a glossy sheet of photo paper? The printhead is finely calibrated to deliver the

"The lab-on-a-chip field is increasingly using high-speed cameras. High-speed cameras with short exposures allow us to visualize dynamics of fast-moving objects on a microscope without blur, such as a sample of micro-particles in water, a sample of blood, or a mixture of different fluid phases such as oil and water, or water and gas. Without these cameras, all we see is still images or blur. They are extremely useful in helping us figure out if the research we're doing is working at all."

– Jon Edd
Ph.D., Assistant Professor of Mechanical Engineering
Vanderbilt University in Nashville, Tenn.

BEHAVIOR OF FLUIDS AT MICROSCALE LEVEL

"The primary use of high-speed cameras in my field right now is for research and testing of prototype designs. Without them, it would be difficult to understand how my network of microfluidic channels is being experienced by the cells, particles, and droplets which flow through except in an average sense"

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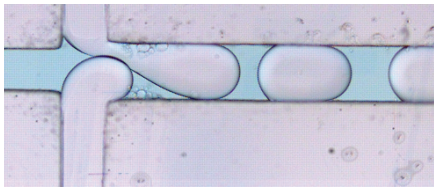

same tiny amount of ink in the correct place, over and over again. Microfluidics technology is also used in the development of DNA chips, micro-propulsion, and micro-thermal imaging.

Gaining momentum as a viable research tool, microfluidics is proving to be particularly useful for scientists researching cell structure and function. Since all living things are made of cells and almost all cells are microscopic, the study of human, plant, and animal cells in the past century has become vital to our continued survival on Earth. For more detailed analysis of their work, cell researchers are combining microfluidics with the use of high-speed cameras. High-speed imaging is already being used in the lab-on-a-chip field, which is the integration of several lab functions on a chip, where it has significantly helped advance the discovery of new scientific data.

"The lab-on-a-chip field is increasingly using high-speed cameras," said Jon Edd, Ph.D., Assistant Professor of Mechanical Engineering at Vanderbilt University in Nashville, Tenn. "High-speed cameras with short exposures allow us to visualize dynamics of fast-moving objects on a microscope without blur, such as a sample of micro-particles in water, a sample of blood, or a mixture of different fluid phases such as oil and water, or water and gas. Without these cameras, all we see is still images or blur. They are extremely useful in helping us figure out if the research we're doing is working at all," he explained.

Microfluidics Welcomes High-Speed Cameras

Jon Edd's areas of research include inertial and drop-based microfluidics (BioMEMS), fluid mechanics, heat transfer, non-equilibrium thermodynamics, cryopreservation, and cryosurgery. "The primary use of high-speed cameras in my field right now is for research and testing of prototype designs. Without them, it would be difficult to understand how my network of microfluidic channels is being experienced by the cells, particles, and droplets which flow through except in an average sense," he said.

Vision Research came to Edd's attention during his postdoctoral fellowship at the BioMEMS Resource Center in Massachusetts. "I had never used a high-speed camera, though I knew we needed one for my lab, and I wanted to find the right set of specifications for our purposes of tracking individual cells or particles in flow," he explained. Some of Edd's counterparts had already tapped the advantages of high-speed cameras for cell study. After assessing digital imaging needs, Edd recommended the purchase of the Phantom v4.2 high-speed camera from Vision Research to better facilitate the research efforts of the BioMEMS

Resource Center. On starting his own lab at Vanderbilt University, Edd purchased the Phantom v310 high-speed camera from Vision Research for studying cells traveling within a high aspect ratio microchannel for example.

With the Phantom v310, Vision Research has set an unmatched standard in the world of high-speed imaging. This is part of the v-Series high-performance line. The v310 is a one megapixel high-speed digital camera with a custom-built 1280 x 800 CMOS sensor. All of Vision Research's digital cameras utilize the company's own proprietary CMOS sensors, which have been exclusively designed for high-speed use. The custom CMOS sensor provides the best balance of sensitivity, speed, and resolution supporting high-speed applications. Additionally, unlike a CCD sensor, CMOS will not "bloom" (creating fringes of light around very bright objects in an image).

Being able to set the v310's exposure to as little as one microsecond was a key factor in Edd's choice of camera. "In doing my research, I needed a camera with a short exposure time, something like one microsecond in most cases, especially when there are particles that are moving quickly relative to their size. This brings up another problem; the signal-to-noise ratio must still be high enough to capture a clear image, and sometimes a short exposure will work against this."

"I've found the solution is to increase the intensity of the transmitted light source and/or reduce the bit-depth of the images from the software interface. This was easy with the v310 since it supports 8- and 12-bit pixel depth." The camera's wide aspect ratio further underscores its importance in scientific research and study. This feature allows moving subjects to stay in frame longer than is possible with other cameras on the market, which in turn allows more time to view the event being recorded.

Phantom® v310 High-Speed Digital Camera with CineMag® interface.

A High-Speed Application with Speedy Results

As a high-throughput camera with the ability to record at 500,000 frames per second, the Phantom v310 offers the largest resolution for a fixed frame rate and enabled Edd to reveal detail unseen to the human eye. The camera's active pixel size of 20 microns also exceeded his expectations.

"I'm very impressed with the fast frame rate and high pixel count of this camera, especially over its predecessor, the v4.2. Frame rate is very important when using a high-speed camera to track individual cells or particles in flow. It is necessary

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to capture several video frames as they transit the microscopic field of view, and this can sometimes be tens or hundreds of microseconds. Frame rate isn't something that can be compromised."

The Phantom v310 from Vision Research allowed Edd to dramatically improve the quality of his research and discern the high-speed motions of cells and particles.

"In particular, we've been able to better understand flow conditions, which result in pattern formations in microchannels. This is when cells or particles evenly space themselves, allowing single-cell encapsulation in picoliter droplets at some kHz frequency. It would have been much more difficult to see what was occurring without using a high-speed camera" Edd said.

"As an alternative, we could have looked at still frames with short exposures, but it wouldn't have been as efficient. It helps immensely to see how the behavior of a particular group of cells or particles evolves with passing through the view region," he noted.

About Vision Research:

Vision Research designs and manufactures high-speed digital imaging systems used in applications including defense, automotive, engineering, science, medical research, industrial manufacturing and packaging, sports and entertainment, and digital cinematography for television and movie production.

The Wayne, N.J.-based company prides itself on the sensitivity, high-resolution and image quality produced by its systems, robust software interfaces, and reliability and versatility of its camera family – all which continue to stand as benchmarks for the high-speed digital imaging industry.

Vision Research digital high-speed cameras add a new dimension to the sense of sight, allowing the user to see details of an event *when it's too fast to see, and too important not to®*. For additional information regarding Vision Research, please visit *www.visionresearch.com.*

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VISION RESEARCH
An AMETEK® Company

100 Dey Road
Wayne, NJ 07470 USA
+1.973.696.4500
phantom@visionresearch.com

www.**vision**research.com