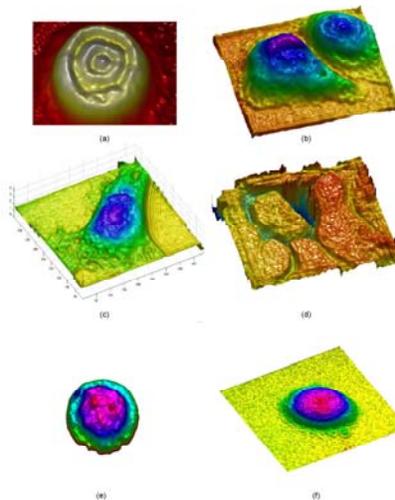


## Digital Holographic Microscopy for 3-D Optical Metrology with Real-Time, Full-Field Nanometer Resolution

### High-Resolution Surface Imaging Using Optical Phase Information

Measurement Science and Systems Engineering researchers at Oak Ridge National Laboratory have developed and patented a number of prototype microscopic imaging systems based on the technology of *Digital Holographic Microscopy*. These systems provide three-dimensional (3-D) quantitative information on the surface height topology of, for example, biological cells, with nanometer precision. The method involves recording the complex wavefront from a sample directly onto the surface of a charge-coupled-device camera in a single image.



Quantitative height profiles of biological cells.

Unlike phase-shifting profilometry methods, the phase and amplitude of the imaged surface can be determined rapidly from just a single recorded digital image with high throughput using Fourier analysis. The phase information recorded is directly

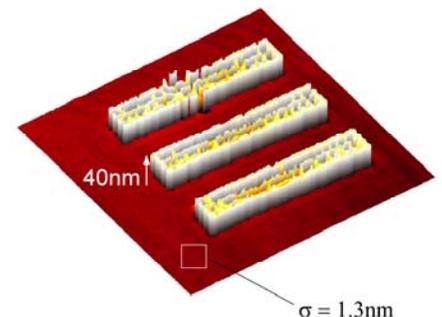
related to both the surface height of the object and the refractive index. A number of other unique capabilities make digital holography very appealing for application in a diverse range of areas, including industrial inspection and biological microscopy.

### Base Technology

Prototype digital holographic instruments have been developed in both reflection and transmission modes. The axial resolution along the vertical (z) axis is on the order of a nanometer. The transverse resolution (in the x-y plane) is determined as in classical microscopy by the numerical aperture of the microscope objective. Video rate acquisition and fast digital reconstruction (30 fps) allow for real-time imaging

### Specifications and Features

- High-speed imaging and throughput (30 fps rate).
- Full-field imaging (no scanning requirements).
- Nanometer precision axial resolution (roughly 1nm).



The current system resolves 1nm axial resolution in the axial direction. Shown is an element from a USAF resolution test target.



Digital Holographic Microscopy

**Purpose:** The Image Science and Machine Vision Group conducts applied computer vision research and development addressing important issues in industrial and economic competitiveness, biomedical measurement science, and national security.

**Sponsors:** Government agencies such as the Department of Energy, nongovernmental agencies, private companies, universities, and various consortia.

**Features:**

- High-speed imaging and throughput.
- Full-field imaging.
- Nanometer precision axial resolution.
- Noninvasive imaging.

**Contact Information:**

Christopher J. Mann, Ph.D.  
Oak Ridge National Laboratory  
Oak Ridge, TN 37831-6075  
Phone: 865-576-5089  
(manncj@ornl.gov)



- Extended depth of focus (3-D volume information).
- Digital image focusing control.
- Complete digital aberration and sample tilt correction.
- Noninvasive imaging.

**Contact Information**

For more information on digital holographic microscopy capabilities and applications, please contact Christopher J. Mann (manncj@ornl.gov) at 865-576-5089.