OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

FACT SHEET

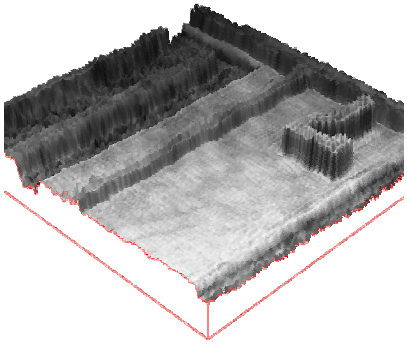
ESTD
Engineering Science & Technology Division

Industrial Inspection

Digital Holographic Microscopy for Industrial Inspection and Metrology

High-Resolution Surface Imaging Using Optical Phase

Researchers at ORNL have developed and patented a direct-to-digital holographic imaging technology and prototype system for the inspection and metrology of surface topology and structure. This method records the complex wave-front of an object directly on the surface of a charge coupled device (CCD) camera in a single digital image. Unlike phase-shifting profilometry methods, the phase and amplitude of the imaged object surface can be determined rapidly from a single digital image at high throughput using side-band (heterodyned) analysis. The phase information is directly proportional to the structural topology (e.g., surface height) and the index of refraction of the various materials composing the surface.



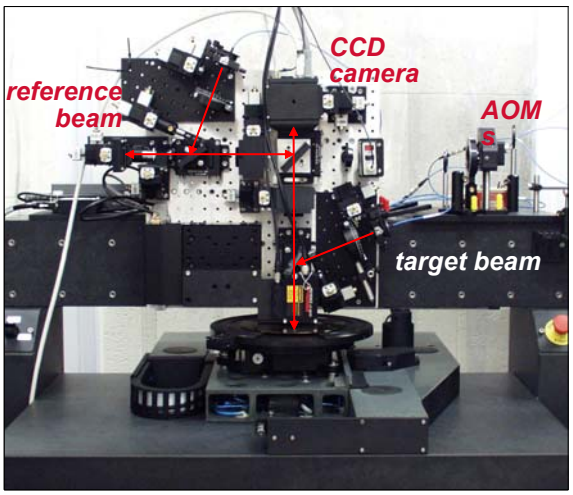
The current system resolves 220-nm in the plane of the surface and 10-nm in the normal direction. Shown is phase image of a semiconductor device.

Base Technology

The prototype ORNL inspection tool uses a 532-nm laser and can resolve 266-nm in the plane of the object surface while resolving 5-nm to 10-nm in the direction of the surface normal (i.e., approximately $\lambda/100$). The system can detect height differences from pixel-to-pixel on the order of 266-nm (i.e., approximately $\lambda/2$). The prototype tool currently processes approximately 3 frames per second (fps) at 1024x1024 pixels x 12 bits on a standard dual 850-MHz processor Pentium PC (~240Mflops) but could achieve 5 GFlops (15fps) to 10 Gflops (30fps) at 2048x2048 pixels using a dedicated array processing architecture.

Specifications and Features

- Source, 532-nm laser
- Windows OS, Visual C++ software library
- Precision Newport stage (20-nm accuracy)
- Automation software to facilitate large area, referential scans



The prototype microscope uses a 532-nm source and is computer controlled to perform automated large area scans and analysis.

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