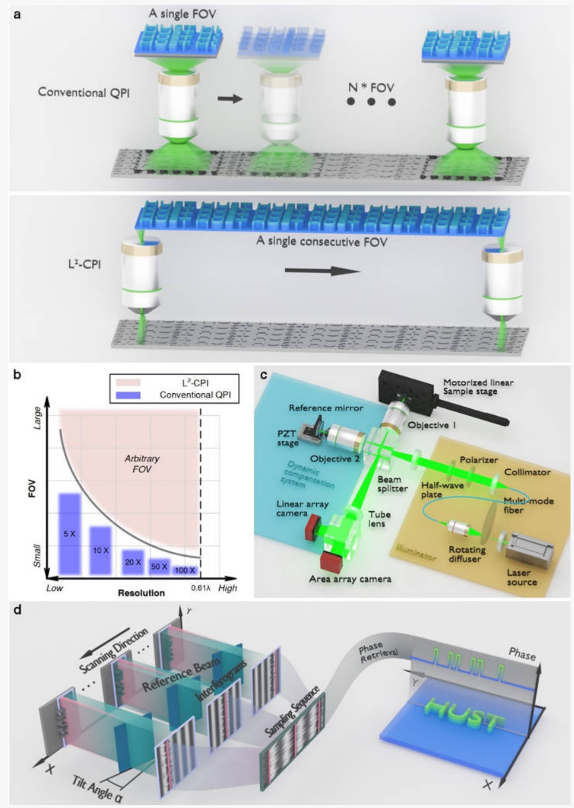
L2-CPI: High-Resolution Computational Phase Imaging with an Arbitrary Field of View

GA, UNITED STATES, June 11, 2026 /EINPresswire.com/ -- High-resolution phase imaging is vital for nanomanufacturing and bioimaging, but is often limited by the trade-off between resolution and field of view. Scientists in China have developed [L2-CPI](), a computational phase imaging technique that achieves an arbitrary field of view with diffraction-limited resolution. By integrating a pixelated acquisition strategy with dynamic vibration compensation, this system enables seamless, high-throughput 3D inspection of semiconductors and biological samples without the errors of traditional image stitching.



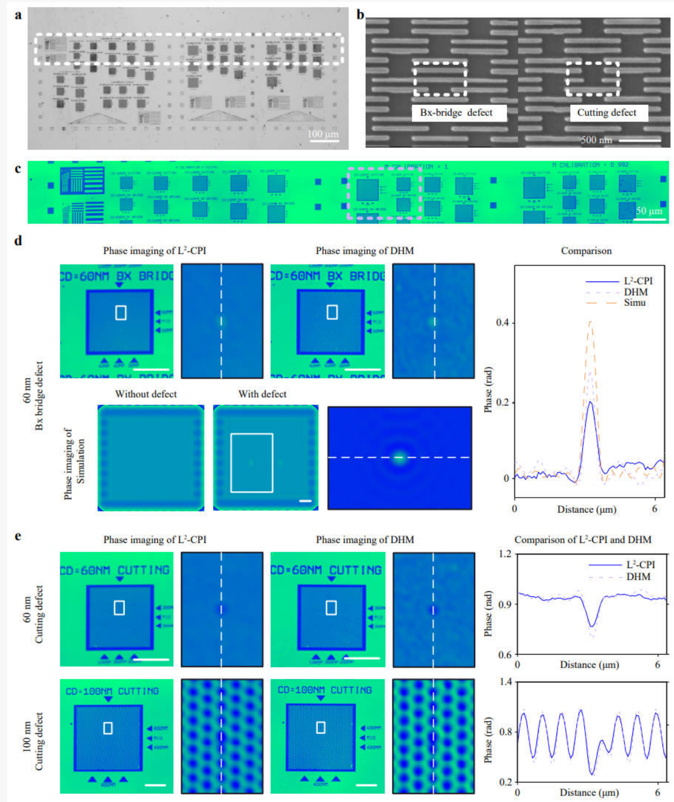
Principle and system configuration of L2-CPI.

The rapid advancement of semiconductor manufacturing and precision medicine demands imaging tools capable of capturing nanometer-scale details across large areas. Quantitative Phase Imaging (QPI) has emerged as a premier solution for observing transparent biological cells and measuring the 3D topography of silicon wafers. However, conventional QPI systems face a fundamental "bottleneck": high-magnification objectives provide high resolution but only a tiny field of view. To image a whole wafer or a large tissue sample, researchers must use "step-and-repeat" stitching, a process prone to mechanical misalignments and phase discontinuities that compromise data integrity.

In a new paper published in Light: Advanced Manufacturing, a team of scientists led by Professor Jinlong Zhu from the School of Mechanical Science and Engineering at Huazhong University of Science and Technology, China, has developed a novel computational imaging architecture called Lateral Line-scan Computational Phase Imaging (L2-CPI). This system extends the conventional limits of optical microscopy by enabling continuous, high-resolution phase imaging across an arbitrarily large field of view, limited only by the travel range of the scanning stage.

The L2-CPI system is centered around a Linnik-type interferometric configuration that utilizes the sample's lateral motion to generate phase shifts. Unlike traditional methods that require the sample to stop for every frame, L2-CPI captures data "on the fly." The team integrated a Dynamic Compensation System (DCS) to suppress mechanical vibrations in real time and employed a robust three-parameter cosine-fitting algorithm to retrieve phase information with high precision. These scientists summarize the operational principle of their system:

"We designed a lateral scanning architecture that serves three purposes in one: (1) to achieve diffraction-limited resolution across an arbitrary field of view without the need for image stitching; (2) to eliminate 'proximal errors' typically found in step-scan systems through a continuous pixelated acquisition strategy; and (3) to ensure high-fidelity 3D reconstruction even in the presence of industrial-level mechanical vibrations."



Patterned wafer defect inspection based on L2-CPI.

"Because our method retrieves phase information from a massive number of data points during the scan, it is significantly more robust against noise and environmental disturbances than traditional phase-shifting techniques," they added.

The researchers demonstrated the power of L2-CPI by inspecting patterned defect array wafer and microlens arrays. The system successfully identified sub-wavelength defects—such as bridge and cutting defects — in an intentionally fabricated defect array on a wafer with a 60 nm critical dimension, which are typically invisible to conventional intensity-based imaging systems. Based on our simulations, L²-CPI is expected to retain detectability even when the critical dimension is scaled down to 15 nm.

"The presented technique provides a high-throughput, non-destructive solution for large-scale nanometrology. It will be particularly transformative for the semiconductor industry, where rapid and accurate defect detection is critical for yield enhancement. Beyond the cleanroom, we foresee L2-CPI opening new avenues in digital pathology and automated biological screening, allowing researchers to 'see' large-scale life processes with unprecedented detail," the scientists forecast.

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