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BioPhotonics spoke with Jim McMahon, a writer covering industrial, manufacturing, and technology topics, about a team from the Beckman Laser Institute at the University of California, Irvine (UC Irvine) that is exploring optical coherence elastography (OCE) to enhance diagnostics by measuring tissue elasticity.

3 Questions with Jim McMahon

How does OCE imaging enhance our understanding of tissue deformation?

OCE, one of the earliest optical elasticity methods, uses **optical coherence tomography** (OCT) to detect depth-resolved deformations in samples subjected to compression. Although traditional OCT provides important diagnostic information, it is often inadequate for early diagnosis when structural deformations are minor. Phase-sensitive detection is a primary method for detecting tissue deformation, similar to phase-based displacement detection in ultrasound imaging. This involves processing the phase-sensitive OCT signal to determine tissue displacement, followed by strain measurement.

Compressional OCE integrates strain data from phase shift with stress applied through compression loading to calculate the elastic modulus, which characterizes the tissue's mechanical properties. One particularly promising application lies in the differentiation between malignant and normal tissues, wherein OCE demonstrates superior contrast compared with conventional structural OCT imaging. By leveraging differences in the Young's modulus — the measure of the ability to withstand changes in length when under tension — of tumor components, OCE can produce images that closely resemble histological images. Unlike traditional histological techniques, OCE can be conducted on freshly resected tissue samples and even performed in vivo.

What has UC Irvine's work revealed about the capabilities of OCE?

Researchers at UC Irvine's Beckman Laser Institute, including Dr. Fengyi Zhang, have focused on two applications of OCE: visualizing local movement and strain in biological tissue, and visualizing tissue elasticity using mechanically produced deformations. Previously, strain and elasticity maps for such materials were obtained through mechanical testing, but OCE enables imaging in real time.

In ophthalmology, OCE could be used to characterize the mechanical properties of the cornea to diagnose related ocular diseases. In dermatology, the elasticity of skin could indicate related pathologies. In oncology, ex vivo imaging of excised tissues from regions with varying stiffness can be visualized in a 2D, depth-resolved elastogram. To improve the management of atherosclerosis, OCE could be used to monitor the stability of plaque by mechanical characterization of the arterial wall.

How have researchers dealt with vibration issues in their experiments?

The micron-level precision required for OCE at the Beckman Laser Institute was compromised due to low-frequency vibrations originating from the building's air-conditioning system, elevator movement, and other facility operations.

An air table helped to reduce high-frequency vibrations, but data sets remained compromised. The problem was resolved, however, when the laboratory was awarded a complimentary Negative-Stiffness vibration isolation platform. Introduced in the early 1990s by Minus K Technology, this technology has been widely accepted for vibration-sensitive applications, largely because of its ability to effectively isolate lower frequencies, both vertically and horizontally.

Negative-Stiffness isolators are unique in that they operate purely in a passive mechanical mode. They do not require electricity or compressed air. They achieve a high level of isolation in multiple directions, with the flexibility of custom-tailoring resonant frequencies to 0.5 Hz vertically and horizontally. When adjusted to 0.5 Hz, the isolators achieve ~93% isolation efficiency at 2 Hz, 99% at 5 Hz, and 99.7% at 10 Hz.