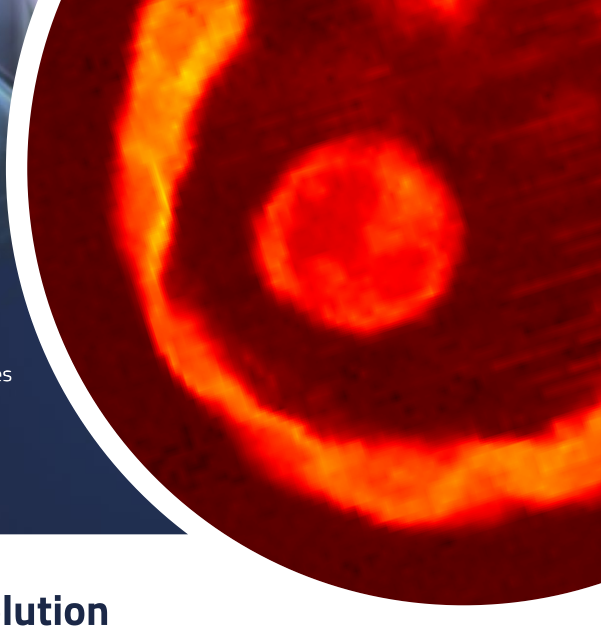
ApplicationNote

Live cells
Organoids · Spheroids 3D cell culture
Organisms and Tissues
Plant science
Biomaterials · hydrogels soft materials
Other cool topics



A Scalable, Turnkey Brillouin Microscopy Solution from CellSense and Teledyne

Brillouin microscopy has emerged as a transformative technology for non-invasive, high-resolution imaging of a sample's mechanical properties in life sciences[1]. It enables to map viscoelastic properties in living cells. tissues, and engineered materials in a fully label free and contact free manner. Brillouin microscopy is a promising tool to stride towards new discoveries in the fields of mechanobiology, developmental biology, disease diagnostics, and advanced materials characterization.

The potential of this technology can be seen in one of its recent and first commercial integrations: The Discoverer from CellSense Technologies. This pioneer in Brillouin imaging instrumentation accelerates the adoption and availability of Brillouin microscopy, by combining CellSense's proprietary Brillouin optical platform with high sensitivity scientific detectors provided by Teledyne, a global leader in high performance scientific imaging solutions. The result is a Brillouin imaging solution that is fast, sensitive, and robust – enabling researchers to extract richer mechanical information with unprecedented precision and throughput.

Introduction

Understanding the mechanical properties of biological systems is essential for fields such as mechanobiology, cancer research, developmental biology, and tissue engineering[2,3]. Established mechanical probing techniques – such as atomic force microscopy (AFM) or micro indentation – are inherently contact based and often incompatible with delicate or dynamic samples.

Brillouin microscopy overcomes these limitations by measuring frequency shifts of light scattered by thermally generated acoustic phonons inside the sample[1]. This frequency shift correlates with the local longitudinal modulus. Scanning the sample thus provides a direct, label-free mean of mapping local viscoelasticity in three dimensions[4,5] with subcellular resolution.

Implementing Brillouin microscopy at scale is challenging, requiring narrow-linewidth lasers, advanced optics, and exceptionally high spectral resolution to resolve small frequency shifts. Because the collected signal is extremely weak, the detection device must combine efficient photon collection with low noise and scientific-grade accuracy.

Background / Context

CellSense has developed a turnkey VIPA-based Brillouin system offering sub pm-scale spectral resolution, strong stray-light suppression, and real-time spectral fitting. For biological applications, the platform includes low-phototoxicity illumination, environmental control for live-cell work (temperature and CO_2), and immersion objectives optimized for cellular imaging. User-friendly software enables automated Brillouin shift extraction and 2D/3D mechanical mapping. While these elements define the optical core, overall performance depends on fast, sensitive, and reliable detection hardware.

The Teledyne Prime BSI Express ideally complements the Brillouin hardware thanks to its >95 % QE, low read noise, and correlated multi-sampling, enabling precise detection of GHz-range frequency shifts. Its high frame rates support rapid viscoelastic mapping, and the 6.5 µm pixels match standard Brillouin magnifications for optimal sampling. The compact, thermally stable design further simplifies integration into microscope-spectrometer setups.

Figure 1

Photograph of the setup and the components

CellSense and Teledyne deliver an optimized Brillouin platform. Co-engineered dispersion to pixel matching, low noise detection, and < 10 MHz calibration accuracy improves measurement precision, while high speed acquisition enables faster experiments and multimodal workflows. The partnership combines CellSense's application expertise with Teledyne's manufacturing reliability to provide a scalable and robust solution scale.

Brillouin Imaging Applications

To illustrate the performance of the CellSense-Teledyne platform, we present measurements obtained from 3D breast cancer spheroids embedded in compliant hydrogel matrices (1-2 kPa). Brillouin spectra were acquired across the spheroid volume with subcellular lateral resolution and axial sectioning through the full structure. The system resolves the Stokes and anti-Stokes peaks with spectral precision surpassing the 10 MHz, enabling robust Brillouin frequency shift (BFS) extraction despite the low photon counts. The obtained spectra show well-resolved Brillouin doublets with high suppression of Rayleigh background and completely stable peak positions across repeated acquisitions.

The sensitivity of the Prime BSI Express enables reliable peak fitting at short integration times, thereby reducing the total acquisition time for volumetric datasets while maintaining MHz-scale precision. 3D spatial mapping revealed reduced BFS in spheroids with lumen formation and higher BFS in peripheral proliferative regions. The reconstructed volume clearly distinguished mechanical contrast between the hydrogel matrix and cellular compartments. These findings demonstrate how volumetric reconstructions provide a full 3D mechanical data cube, enabling mechanical heterogeneity to be correlated with morphology or fluorescence-based cell-cycle reporters. A key advantage of this approach is its compatibility with time-lapse acquisition, allowing mechanical evolution during spheroid maturation to be captured without mechanical perturbation or contact-induced artifacts.

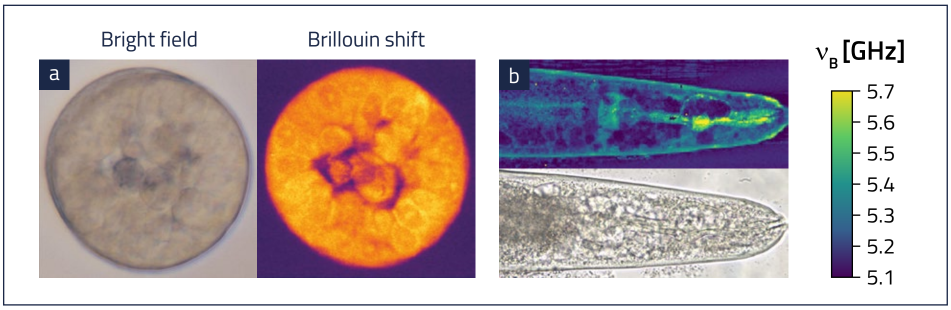


Figure 2

Brillouin microscopy applications.

a. MCF-7 cancer organoid observed by bright field optical imaging and Brillouin microscopy.

b. C. Elegans pharynx region imaged by Brillouin microscopy. Note that the specimen is in its native state and no labeling was applied clearly resolving the internal structure

The integrated CellSense-Teledyne platform supports advanced applications across life sciences, biomedical diagnostics, and materials research. It enables studies of nuclear and chromatin mechanics, stem cell differentiation, cancer progression, developmental biology, and complex cell models such as organoids. In clinical settings, it provides contact-free biomechanical measurements, including corneal evaluation and fibrosis detection. For materials science, the system delivers high-resolution stiffness mapping of hydrogels, polymers, composites, and novel biomaterials used in tissue engineering and soft robotics.

Conclusion

By combining CellSense's optical and spectroscopic innovation with Teledyne's industry leading imaging technologies and systems engineering, the two companies are jointly redefining the performance, reliability, and scientific impact of Brillouin microscopy. This collaboration enables researchers to explore mechanical properties of living systems with unprecedented speed and precision – advancing both fundamental science and real-world biomedical applications.

References

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