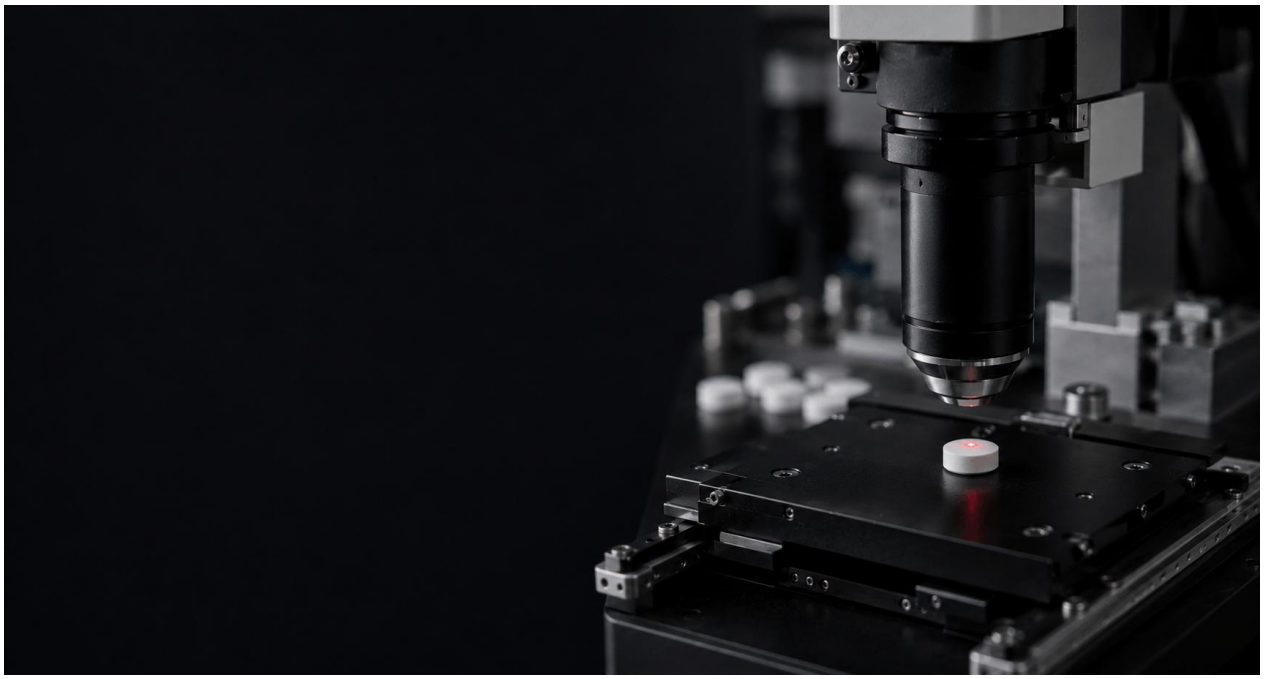
NEW OPTICAL PLATFORM REVEALS WHAT A MATERIAL IS MADE OF, HOW IT IS STRUCTURED, AND HOW IT MECHANICALLY BEHAVES, ALL IN ONE MEASUREMENT

A single multimodal spectroscopy measurement captures a material's chemistry, structure, and mechanics at once, with early impact on pharmaceutical analysis and potential across biomedical research and materials science.



Milan, Italy, 08. July 2026. An international team of researchers has developed an optical technique that measures the chemical, structural, and mechanical properties of a material at the same time, from a single point, and without touching or labeling the sample. The work, published in *Nature Communications*, is led by Milan-based deep-tech company Specto Photonics in collaboration with Politecnico di Milano and other academic partners across Italy, Denmark, and Australia.

One measurement instead of many

Until now, obtaining this combination of information meant using separate instruments and multiple measurements. The new method reads all of it from a single voxel of laser light, offering a faster and more complete way to analyze materials in pharmaceutical development, biomedical research, and materials science.

Three signals hidden in scattered light

The advance rests on capturing the full vibrational spectrum: the complete range of ways light scatters as it interacts with a material's molecular vibrations. Three complementary signals sit within that spectrum. Brillouin scattering reveals mechanical properties, ultra-low-frequency Raman reveals molecular structure and organization, and conventional Raman reveals chemical composition.

The faintest low-frequency signals, which carry the mechanical and structural information, are normally buried under intense scattered laser light, which is why they have been so difficult to capture alongside the rest. Specto Photonics proprietary Birefringence-Induced Phase Delay (BIPD) filter suppresses that background, allowing all three signals to be recorded together from the same spot.

"This approach reveals the significance of the combined information from different modalities which access the stiffness, molecular orientation and the chemical composition of the material by only shining laser light," said **Dr Giuseppe Antonacci**, coordinator of the project.

Proven on everyday medicines

The team tested the platform on widely used active pharmaceutical ingredients, including indomethacin, ibuprofen, and paracetamol. It distinguished between amorphous forms of the same drug produced by different manufacturing routes, a distinction conventional methods often cannot resolve, and mapped the mechanical, structural, and chemical makeup across an ibuprofen tablet.

Why it matters for drug development

A drug's solid-state form, whether crystalline or amorphous, and the way it is processed, directly affects its solubility, stability, shelf life, and how well the body absorbs it. Amorphous formulations are increasingly common yet notoriously difficult to characterize. A single, label-free measurement that captures mechanical, structural, and chemical detail at once could support formulation design, stability testing, and real-time quality control during manufacturing, with minimal sample waste.

Beyond pharmaceuticals

The applications extend well beyond drug development. Because the method is all-optical, non-contact, and works in three dimensions at diffraction-limited resolution, the researchers point to uses in biomedical research, for example in studying the mechanics and organization of structures inside living cells, and in materials science, where the mechanical, structural, and chemical state of a sample can be read together rather than one property at a time.

What comes next

The authors describe the work as a new framework for multimodal vibrational spectroscopy and imaging, and a step toward fully optical instruments that co-register three-dimensional mechanical, structural, and chemical maps of a sample at sub-micron resolution.

Publication

Title: Full vibrational spectroscopy for simultaneous mechanical, structural and chemical analysis **Journal:** *Nature Communications* **DOI:** 10.1038/s41467-026-74558-z **Link:** https://www.nature.com/articles/s41467-026-74558-z

About the research

The study was conducted by researchers from Specto Photonics, University of Milano-Bicocca, Politecnico di Milano, CNR-Istituto di Fotonica e Nanotecnologie (CNR-IFN), the University of Copenhagen, and Monash University.

About Specto Photonics

Specto Photonics is a Milan-based deep-tech company developing advanced Brillouin spectroscopy instrumentation, including integrated spectrometers on silicon chips and high-rejection optical filters. enabling an all-optical mechanical investigation of materials.

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