# International team visualizes properties of plant cell walls at nanoscale

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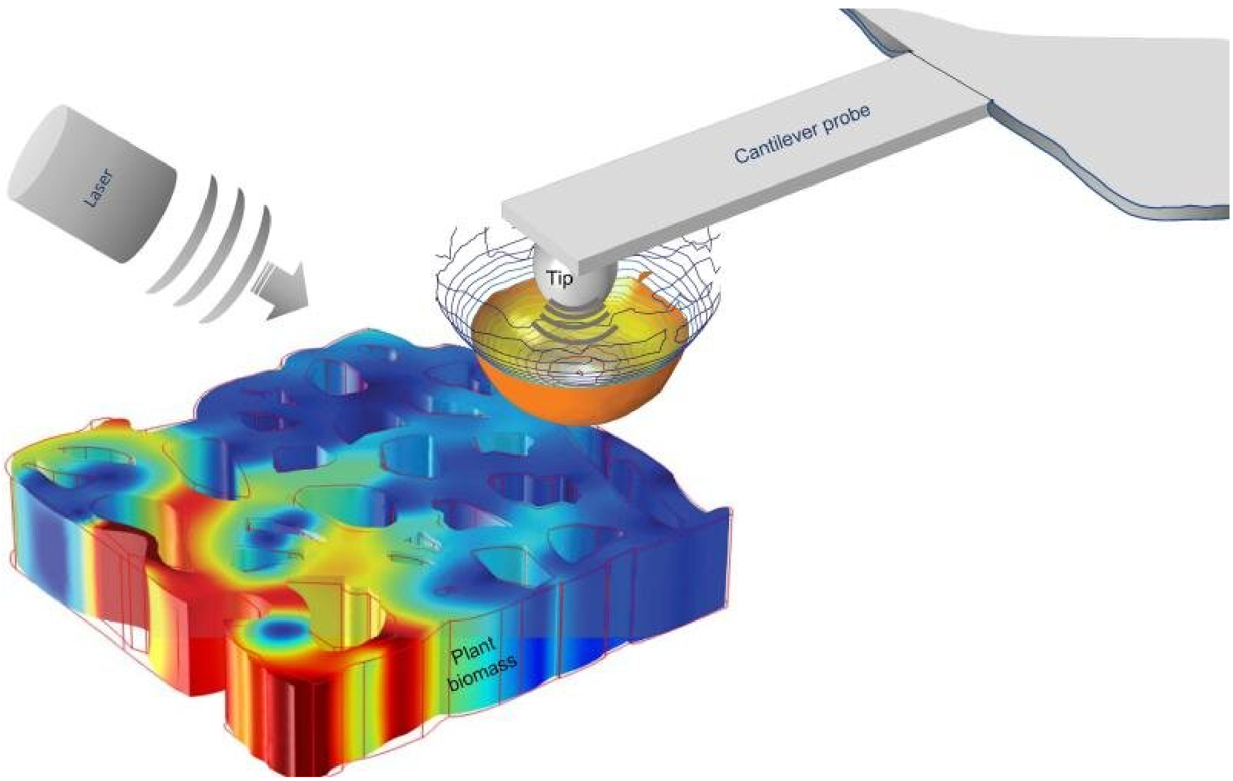


Scattering-type scanning near-field optical microscopy, a nondestructive technique in which the tip of the probe of a microscope scatters pulses of light to generate a picture of a sample, allowed the team to obtain insights into the composition of plant cell walls. Credit: Ali Passian/ORNL, U.S. Dept. of Energy

To optimize biomaterials for reliable, cost-effective paper production, building construction, and biofuel development, researchers often study the structure of plant cells using techniques such as freezing plant samples or placing them in a vacuum. These methods provide valuable data but often cause permanent damage to the samples.

A team of physicists including Ali Passian, a research scientist at the Department of Energy's Oak Ridge National Laboratory, and researchers from the French National Centre for Scientific Research, or CNRS, used state-of-the-art microscopy and spectroscopy methods to provide nondestructive alternatives. Using a technique called scattering-type scanning near-field optical microscopy, the team examined the composition of cell walls from young poplar trees without damaging the samples.

But the team still had other obstacles to overcome. Although plant cell walls are notoriously difficult to navigate due to the presence of complex polymers such as microfibrils—thin threads of biomass that Passian describes as a maze of intertwined spaghetti strings—the team reached a resolution better than 20 nanometers, or about a thousand times smaller than a strand of human hair. This detailed view allowed the researchers to detect optical properties of plant cell materials for the first time across regions large and small, even down to the width of a single microfibril. Their results were published in *Communications Materials*.

"Our technique allowed us to look at the sample's morphology and optical and chemical properties at the nanometric scale—all within the same measurement," Passian said.

Along with ORNL and CNRS, the team included researchers from Aix-Marseille University, the Interdisciplinary Nanoscience Center of Marseille and the Fresnel Institute and Germany's Neaspec GmbH.

"Until now, these optical properties were not measured in situ but merely from extracted components, which do not provide information in the context of structural and chemical properties," said Fresnel Institute researcher Aude Lereu.

By using their measurement technique to obtain a series of detailed images in one region of the poplar wood cell wall, the team also observed the distribution of structural polymers such as lignin and cellulose, which are hard substances that serve as the "bones" of biological systems and can be extracted and converted into biofuels and bioproducts.

This data could be used to improve chemical treatments that use acids or enzymes to increase polymer yields and prevent biomaterials from degrading when exposed to external factors, such as fungi or humidity. Because the poplar samples had already been through a delignification process, the researchers were able to pinpoint both harmless and potentially harmful compositional changes.

"When altering a material, it's important to monitor exactly how it changes at the molecular level," Passian said. "By applying our technique to a pretreated poplar tree specimen, we were able to study the sample while keeping track of any changes that might affect its viability."

The researchers selected poplar as a representative system because these trees grow quickly and require little maintenance, but the technique used on poplar could provide similarly detailed data on many other plants, which researchers could use to improve the efficiency of treatments and engineer ideal biomaterials.

"Our technique revealed that some types of lignin were not fully removed during delignification, and this data could help optimize the process and contribute to a better understanding of lignin recalcitrance," Lereu said.

The technique could also prove beneficial to the field of additive manufacturing, or 3D printing, which involves stacking layers of materials to create a wide variety of objects, from fake fish to spacecraft components. During the printing process, which Passian describes as a more complex version of piping frosting onto a cake with a pastry bag, the measurement technique could add a layer of quality control to minimize human errors, correct material distribution and remove any contaminants in real time.

Gaining a front row seat to subtle changes in plant cells posed a challenge, but Passian anticipates that incorporating quantum-mechanical principles into microscopy experiments might allow researchers to secure an even closer view without damaging delicate biological samples.

"Down the road, quantum science could help bypass the barriers of classical techniques to further improve the resolution of these measurements," he said.

**More information:** Anne M. Charrier et al, In situ plant materials hyperspectral imaging by multimodal scattering near-field optical microscopy, *Communications Materials* (2021). DOI: 10.1038/s43246-021-00166-7

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