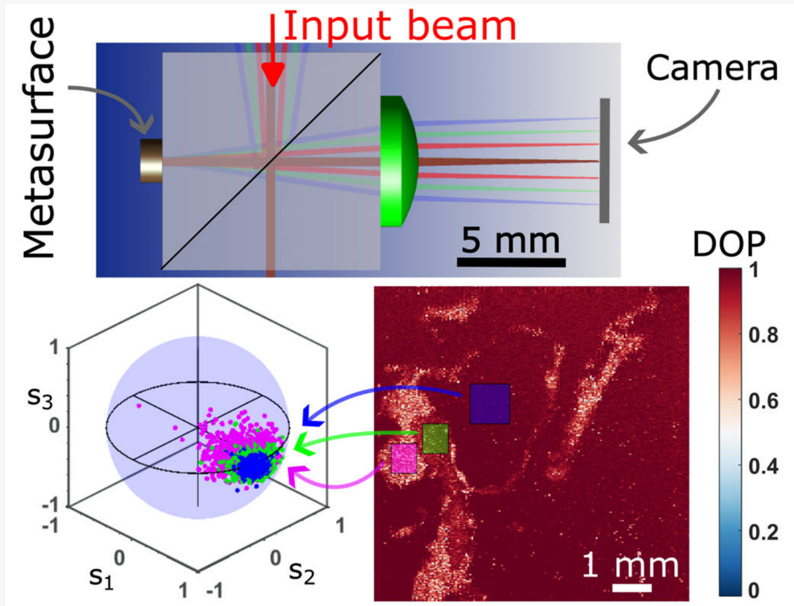
A Step Toward 7D Pathology: Metasurface Polarimetry Enables Next-Generation Tissue Diagnostics

GA, UNITED STATES, April 20, 2026 /EINPresswire.com/ -- Traditional histopathological tissue analysis depends on staining, which translates biological structures into colors. By instead studying how the polarization state of light is altered, it is possible to extract information about the tissue without staining, while additionally gathering data suitable for automated analysis. In the published paper we present a metasurface polarimeter designed for such measurements and benchmark it against a commercially available system.



Metasurface polarimeter and experimental results.

A decade-long journey from laboratory discovery to clinical-ready technology has reached a significant milestone with the development of a miniaturized metasurface polarimeter for cancer tissue analysis, published in Light: Advanced Manufacturing.

The story begins with the Aston-Oulu research team, who pioneered the use of polarization-based imaging for histopathological analysis of tissue samples. Their approach exploits how cancerous and healthy tissues scatter light differently, altering its polarization state in characteristic ways. This label-free technique eliminates the need for conventional staining and sectioning procedures, offering faster, more objective tissue assessment with reduced inter-observer variability.

Polarimetric mapping can reveal structural alterations associated with cancer that are invisible to conventional microscopy. The challenge has been translating this capability from bulky laboratory setups into devices practical for clinical environments.

That translation has now taken a major step forward through collaboration with metasurface specialists at the University of Southern Denmark's Centre for Nano Optics and SINTEF Digital in Norway. The Danish-Norwegian team designed and fabricated a plasmonic metasurface polarimeter, drawing on their world-leading expertise in gap-surface-plasmon metasurfaces and system integration. Working together with the Aston-Oulu team, they have created a device compact enough to serve as the foundation for portable polarization-based confocal microscopy.

The metasurface, a precisely engineered array of gold nanobricks, splits incoming light into six diffraction orders, each filtered to a specific polarization state. A single camera acquisition captures all the information needed to reconstruct the complete Stokes vector and degree of polarization, replacing the rotating waveplates and sequential measurements of conventional polarimeters.

The current prototype has an optical path of around 2 cm, but an optimized design could reduce this to approximately 5 mm. This miniaturization opens the door to handheld diagnostic instruments and potentially even polarimetric endoscopes for in vivo tissue assessment.

Validation using tissue phantoms, designed by the Aston-Oulu team to mimic biopsies with cancerous inclusions, demonstrated clear differentiation between regions simulating healthy and malignant tissue, with Stokes parameter accuracy within ±2% after calibration.

Jointly the researchers outline a clear path toward clinical deployment: replacing the camera sensor with photodiode arrays would boost dynamic range and enable kilohertz-range scanning speeds, while wide-field imaging configurations could eliminate point-by-point acquisition entirely. Such advances would make polarization-based portable confocal microscopy a practical reality for routine histopathology screening.

The work represents a convergence of complementary expertise: the Aston-Oulu team's deep knowledge of tissue polarimetry and tissue phantom development, combined with the Danish-Norwegian collaboration's mastery of metasurface design and nanofabrication. Funding from the European Union's Horizon 2020 program, including the ATTRACT initiative and the OPTIPATH Pathfinder project, supported this international effort.

This development moves forward the OPTIPATH EIC Pathfinder project toward its ambitious goal of 7D Pathology – a comprehensive imaging framework that integrates spatial, spectral, temporal, and polarimetric dimensions to deliver unprecedented diagnostic power for tissue characterization.

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