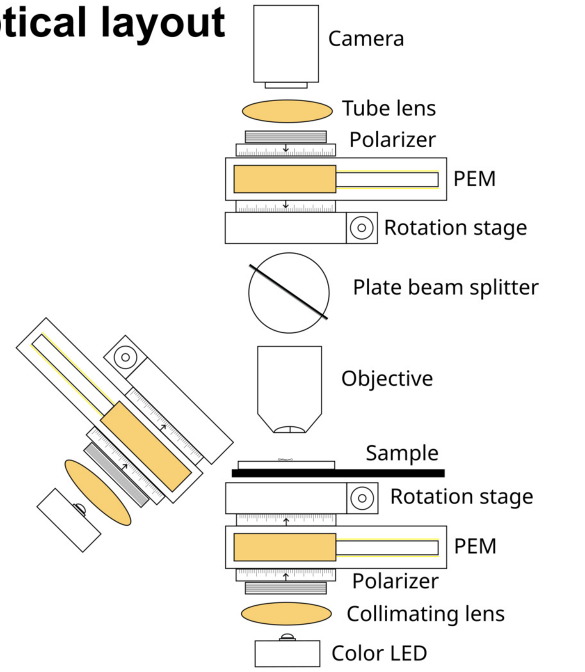
Photoelastic Modulator Transmission Reflection Imaging

John Freudenthal, Hinds Instruments
jfreudenthal@hindsinstruments.com

Introduction

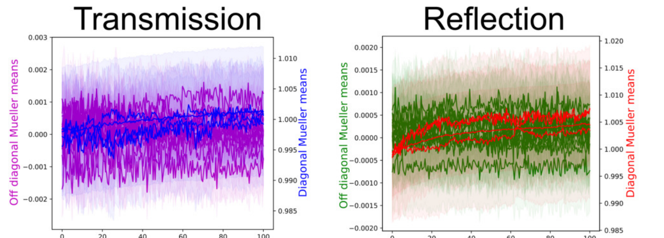
We demonstrate a wide field reflection/transmission microscope capable of measuring the whole Mueller matrix of a sample. By pulsing the light source at various harmonic combinations of the PEM frequency, individual Mueller matrix elements can be measured. To minimize the noise floor, we implement a specialized high power LED driver capable of producing full modulation depth from DC to 500kHz with near ideal pulse-to-pulse behavior.

Optical layout

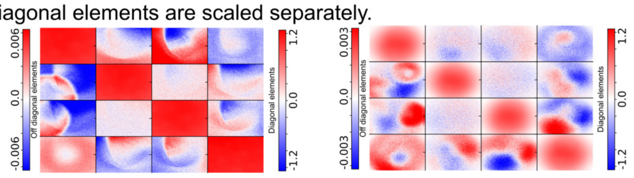


Optical layout of reflection transmission Mueller matrix microscope. Light from a high power pulsed LED passes through a polarization state generator composed of a polarizer and photoelastic modulator mounted on a rotation stage. In the reflection arm, the polarized beam reflects off a rotatable plate beam splitter and into the objective. The polarization state analyzer is likewise composed of a photoelastic modulator and polarizer on a rotation stage.

System noise and stability



The average Mueller element value over time. Off diagonal and diagonal elements are scaled separately.

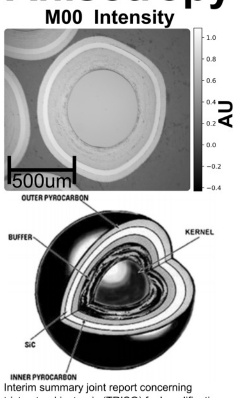


The Mueller matrix elements for an uncalibrated optical path illustrating the artifactual background induced by system optics.

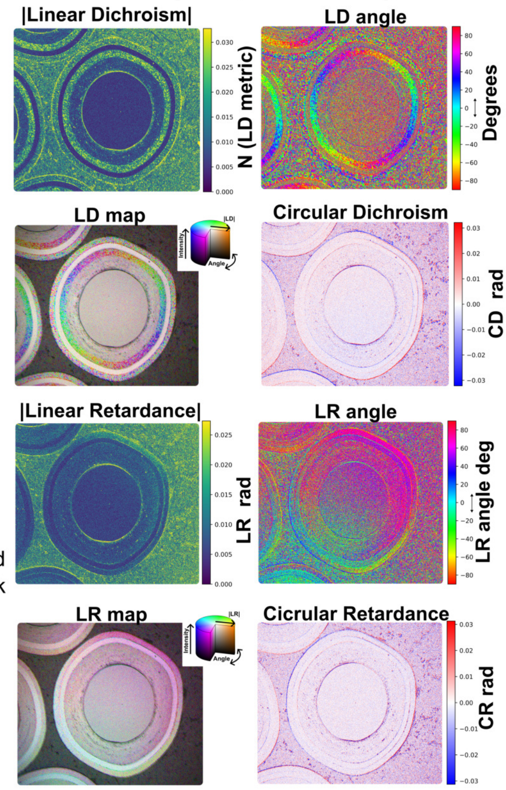
$$M_T = M_{pol}(\theta_{pol1})M_{ret}(\delta_{PEM1},\theta_{PEM1})M_{obj}(\delta_{obj},\theta_{obj})M_{ret}(\delta_{PEM0},\theta_{PEM0})M_{pol}(\theta_{pol0})$$

$$M_R = M_{pol}(\theta_{pol1})M_{ret}(\delta_{PEM1},\theta_{PEM1})M_{BS}(N_{BS},\delta_{BS},\theta_{BS})M_{ret}(\delta_{PEM0},\theta_{PEM0})M_{pol}(\theta_{pol0})$$

Anisotropy in TRISO graphite layers

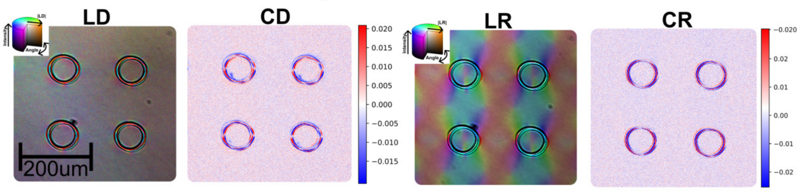


Interim summary joint report concerning tristructural isotropic (TRISO) fuel qualification



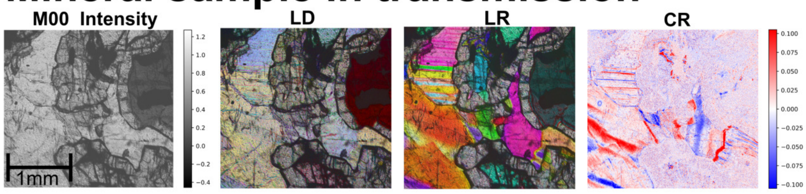
Tri-structural isotropic fuel particles are nuclear fuel particles with a kernel of radioactive fuel surrounded by layers of pyrolytic carbon and silicon carbide. The specialized ceramic layers capture the bulk of radionuclides and offer mechanical robustness. In order for these particles to maintain integrity within high temperature gas reactors, the layers of graphite must exhibit very low anisotropy.

Vortex retarder plate in transmission



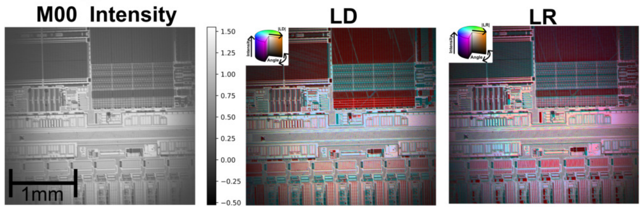
Polarization micrographs of the dichroism and retardance induced by vortex ring retarders laser written into glass with stress birefringence from fabrication.

Mineral sample in transmission



Polarization micrographs of the dichroism and retardance of dichroic and anisotropic mineral samples. CR originating from overlapped layers.

Integrated circuit in reflection



Polarization micrographs of failed integrated circuits. Damage to the deposited layers is easily visible in the linear diattentuation and retardance maps.

References

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[2] S. Nichols, J. Freudenthal, O. Arteaga, and B. Kahr, “Imaging with photoelastic modulators,” presented at the SPIE Sensing Technology + Applications, D. B. Chenault and D. H. Goldstein, Eds., Baltimore, Maryland, USA, May 2014, p. 909912. doi: 10.1117/12.2053459.

[3] G. E. Jellison and F. A. Modine, “Two-modulator generalized ellipsometry: experiment and calibration,” Appl. Opt., vol. 36, no. 31, p. 8184, Nov. 1997, doi: 10.1364/AO.36.008184.