Characterisation of microscopical anisotropy of Biological Tissues by Polarization Imaging

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We have characterised anisotropic biological media by performing polarisation imaging. The optical anisotropy degreee can be measured by the images. High resolution on the microscopic and nanoscopic alignement of structured media is characterised.

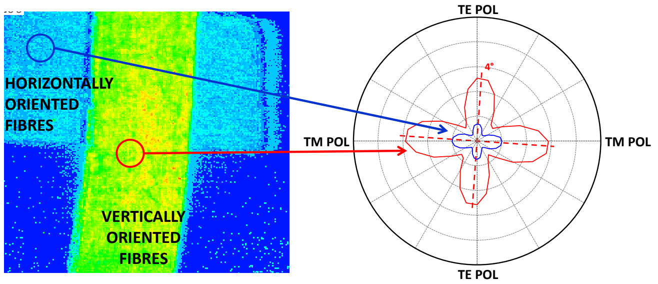
Keywords: Polarisation imaging, optical anisotropy, biological tissues, composite materials, micro-structured, nano-structured

1. Introduction

Biological matter is inherently inhomogeneous, being made up of elementary units, for example cells, or organizations of them, for example fibers. This happens not only in the biological field: materials science has long introduced composite systems to satisfy the engineering of specific physical characteristics not present in natural materials. The best known example is, for example, the realization of light but mechanically highly resistant materials by drowning glass or carbon fibers in resins.
A quick and precise analysis of the alignment of nanostructured systems is of great importance both from a technological point of view, to optimize the alignments in the manufacturing processes, and from a diagnostic point of view, to check the local anisotropy and possibly recognize and discriminate materials similar but different. A technical and rapid solution to this problem is represented by polarized light imaging.
This technique allows to highlight both micro- and nano-structures of the materials, characterizing the anisotropy of the optical properties due precisely to the specific molecular order. Hence, absorption, reflection, refraction and dispersion measures of polarized light by structured materials is a powerful tool for analyzing the morphological order of the organization.

2. Polarisation imaging

The very simple idea is the realisation of images of micro- and nano-structured materials by illuminating the samples with linear polarization light. The wavelength can be chosen from case to case to enhance the contrast of the recorded images. The samples were illuminated orthogonally but observed at large angles in order to highlight the different behavior of the diffused light according to the viewing angle. The images were mathematically treated to determine the depolarization anisotropy of the light diffused towards the observer. Jones matrix analysis and Stoke's vector representation of light [1] through the Mueller matrix [2] have been implemented to characterize the final polarization state and increase the contrast.
The application to wood samples is shown in figure.



Two orthogonal samples were contemporarily imaged using the same polarised light. Consequently the samples had orthogonal fibre orientations. Anisotropic large-angle reflectivities were observed, whose anisotropy can measure the fine allignment [3]: in such a case we were able to follow the curvature of the vertically oriented fibres and measure the otienzation angle.

Such powerful technique can be applied to other biological tissues like human skin, internal organs, connective tissues to discriminate different constituent materials or healthy from diseased tissues.

References

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