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Microscopic Müller Matrix Analysis

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In the last decade, the miniaturization of optical devices has been one of the main driving forces in the field of nanotechnology, necessitating also the development of novel optical materials. An inevitable ingredient to this development is the in-depth study of the optical properties of the aforementioned material classes.
Here, we discuss an experimental scheme, which can be used to extract the optical properties, such as attenuation, linear and circular retardance, as well as linear and circular dichroism, of microscopic samples. We use a custom-built optical system [1] to focus light onto the sample under investigation using a microscope objective of an effective numerical aperture (NA) of 0.5 [2]. The light transmitted through the sample is collected by an oil-immersion objective (NA = 1.3). The sample is placed on a piezo stage, which can be moved with nanometer precision. A complete analysis of the polarization state of the transmitted light is performed using two electrically controlled liquid crystals. The use of liquid crystals, helps in avoiding opto-mechanical rotation induced errors in the polarization analysis part of the setup. The polarization state of the incident light is controlled using a polarizer and a quarter-wave plate. By sequentially analyzing all six polarization states (linear vertical, horizontal, diagonal, anti-diagonal, left- and right-hand circular) for each input polarization, a complete Müller matrix analysis can be performed. With a computational analysis of the recorded data we link the output polarization state to the corresponding input state and extract the Müller matrix, which describes the optical response of the investigated material or system. The method has been successfully used to analyze nanoparticles and novel hybrid metamaterials [2]. This technique is flexible and easy-to-implement. In contrast to established methods, it also allows for the optical study of small specimens with lateral dimensions on the micrometer scale.

References

[1] P. Banzer, U. Peschel, S. Quabis et G. Leuchs, «On the experimental investigation of the electric and magnetic response of a single nano-structure,» *Optics Express,* vol. 18, 110, pp. 10905–10923, 2010.

[2] A. Butt et a. et, «Investigating the Optical Properties of a Novel 3D Self-Assembled Metamaterial made of Carbon Intercalated with Bimetal Nanoparticles,» in Advanced Photonics 2018 (BGPP, IPR, NP, NOMA, Sensors, Networks, SPPCom, SOF), OSA Technical Digest (online) (Optical Society of America), paper NoTu4J.5, 2018.