STATISTICAL INDICATORS IN THE DETERMINATION OF THE NONLINEAR OPTICAL SUSCEPTIBILITY OF THIN FILMS

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In the non-contact study and characterization of surfaces and thin films, one of the most interesting tools is second-order nonlinear optics. The most common second-order effect is second-harmonic generation (SHG), where two photons in a non-linear medium at the fundamental frequency are combined into a single photon at double frequency. Quantitatively, this phenomenon is described by the second-harmonic susceptibility tensor of the medium.

The susceptibility tensor must be known in order to fully understand the SHG effect in each specific case. Unfortunately, the determination of the tensor is not straightforward, especially in low-symmetry cases, since in general several susceptibility tensor components contribute to the response of the medium simultaneously. Therefore, a physical model describing the sample and consistent data from several measurements are needed. In order to construct such a model, several properties of the sample must be either known or assumed. The problem is that usually it is very difficult to verify the consistency of the measurement data or validate the assumptions, both of which may have a large influence on the final results.

We have recently developed a technique to characterize the second-harmonic susceptibility tensor of thin films of low symmetry [1,2]. Our technique not only allows the second-harmonic susceptibility tensor to be determined, but also assesses the consistency of the data and the validity of the model. This is achieved by using a sufficient number of measurements to provide statistical indicators about the problem.

Statistical analysis gives a large number of various indicators and descriptors that can be used in various problems, but not all of them are suitable for our technique. This is partly due to the many idealized assumptions that are common in statistics but more or less lacking in our real-world case. To refine our technique for determining the nonlinear susceptibility tensor, we examined the behavior of several statistical indicators both through simulation and as a function of the amount of available data.

As a result, we are able to select the most useful statistical indicators and make our analysis more robust. In addition, the minimum number of measurements required to perform the determination of the susceptibility reliably was be determined for a specific thin film sample.