Advanced linear and nonlinear optical metrology in support of next-generation lithography

We have developed a new concept for improving the resolution capabilities of advanced optical lithography systems, based on using high-index, uniaxial-crystal last lens elements (e.g., sapphire) and transverse polarized illumination. We showed that high-order nonlinear spatial dispersion effects which could compromise this approach, have high symmetries that can be corrected for by standard aberration correction techniques. (See Figure 2.1.) Measurements of these effects are in progress. Our project has generally now turned to investigating these and other types of nonlinear optical effects relevant to advanced 193 nm optical lithography, using a unique pump-and-probe laser system capable of scanning down to 190 nm. One important class of effects is related to high light intensities, which can change the optical properties of materials through changes in the electron band/state occupancies. We are exploring these effects in oxide nanocrystals as a way to create saturable absorbing materials for potential use as lithography image contrast enhancement layers and to create nonlinear resists for multiple-exposure lithography. Another type of nonlinear effect is multi-photon absorption, which causes damage in lens materials, a serious problem in the industry. We are investigating the mechanisms by pump-and-probe measurements, and exploring possible amelioration approaches. A completely uncharacterized class of nonlinear effects we are investigating results from short-wavelength (finite-*k*) combined with high intensities. We anticipate that these effects may impact lithography imaging as laser imaging intensities increase and resolution is extended.

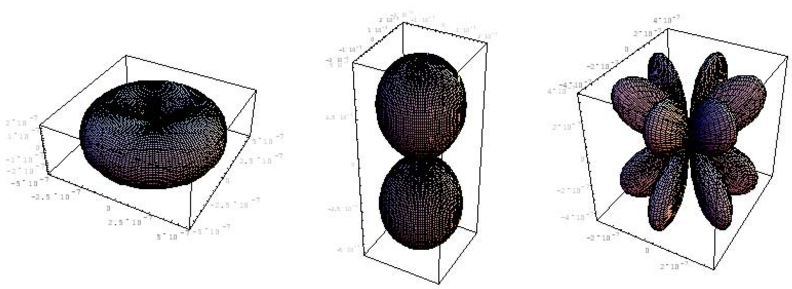

Figure 2.1: The calculated three spatial-dispersion-induced anisotropic index distortions in sapphire, with the sapphire optic axis vertical. The surfaces represent the magnitude of the index deviations in a given direction. Only the third effect represents azimuthal distortions, and due to its high symmetry can be corrected for by lens crystal-axis clocking.

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