Nonlinear Optical Studies of Photoelastic Effect and Magneto-Plasmonics

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College of William & Mary, Department of Applied Science, 2014
Field: Lasers and Optics, Degree: Ph.D.

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Abstract

Nonlinear optical (NLO) processes are optical phenomena involving a nonlinear response to an applied light field. Two kinds of nonlinearities are studied in this dissertation: magnetic-induced second-harmonic generation (MSHG) interacting with surface plasmon, called "nonlinear magnetoplasmonics" (NMP), and the nonlinear index induced by a strong pump beam in Titanium doped sapphire crystal, referred to as population-induced nonlinear index effect.The fundamentals of the major effects involved are discussed, which include: surface plasmon and its field enhancement effect, MSHG technique and phenomenological calculations, the contrast ratio of magnetic switching, the calculation of lensing effects, population induced strain, and photoelastic effect. Furthermore, the experimental techniques and setup are presented. Two ultrafast laser systems and the design of a spatially and temporally homogenized chirped pulse amplifier are also elaborated, because these are the most important devices in the experiments. In the study of population-induced nonlinear index effect, a fast measurement system is developed and one of the photoelastic constants of Ti:sapphire is obtained, which is useful to optimize Ti:sapphire lasers and amplifiers. In the study of NMP, the MSHG signal enhancement effect and the magnetic contrast tuning effect are discovered in a single crystal iron film. The two jump switching process induced by the cubic magnetic anisotropy of the iron film opens the way for simultaneously investigating both longitudinal and transverse magnetization components regardless of the external magnetic field. This study has potential usage in quaternary magnetic storage systems because it enables the read-out of all four magnetization states from crystalline iron with high contrast ratio, and it is also of interest for bio-chemical sensor applications due to its very high surface sensitivity and simple structure.