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Center aperture detection on magnetically induced super resolution magneto-optical disks

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Abstract

A vector diffraction model has been applied to analyze CAD readout of MSR disks. Numerical results indicate that the read power is optimized with an aperture of the same size as the recorded mark. CNR decreases as recorded density increases even by using optimized aperture. CAD MSR disks applications are limited by the aperture-to-spot ratio of 34%. Also, CNR decreases as the track pitch becomes narrower. The vector model presents a higher sensitivity than the scalar model in analyzing the optical readout characteristics of sub-μm disk structure and 'below-diffraction-limit' aperture of the readout spot.

1. Introduction

Reducing recording mark size and having proper readout schemes to detect sub-μm marks with adequate carrier-to-noise ratio (CNR) are among the key techniques to increase recording density in magneto-optical (MO) disks. Magnetically induced super resolution (MSR) [1,2] is a 'below-diffraction-limit' readout scheme. A 'below-diffraction-limit' aperture can be formed to readout sub-μm marks by using currently available laser diodes as a light source to enable exchange-coupling at the heated readout region. The recently proposed center-aperture-detection (CAD) scheme, using exchange-coupling to form a readout aperture between in-plane readout layer and perpendicular oriented storage layer, seems to be more practical among MSR schemes [3,4].

Sub-μm marks can be easily recorded by the thermo-magnetic effect in a suitable MO disk medium. Likewise, readout of MSR disks can also use the thermo-magnetic effect to create a 'below-diffraction-limit' aperture where recorded marks on the storage layer are duplicated onto the readout layer by exchange-coupling of the two layers. The duplication excludes recorded marks beyond the aperture from contributing in readout. Consequently, the readout signal is sensitive to the aperture size. CNRs of MSR disks have been analyzed by a scalar model as functions of aperture size and jitter of the recorded marks [5]. However, the scalar diffraction theory is only valid as long as the wavelength of incident light is smaller than the characteristic transverse dimensions of the scattering structure. In this study, a vector model based on vector diffraction theory [6] is used to analyze CNR in MO disks readout by CAD scheme.

2. Vector model in CAD disks readout

A readout system using conventional MO optical pick-up is one of the advantages of MSR CAD disks. A typical readout system of MO disks is shown in Fig. 1. A light source is emitted from a laser diode passing through collimating and beam-shaping optics to form collimated light. The objective lens then focuses the collimated polarized light onto a diffraction-limited spot on the MO disk. The diffraction-limited spot 'reads out' the recorded marks on the disk based on the polar Kerr effect. The reflected light from the magnetization orientations passes through the half waveplate and beam splitting optics, and is detected by the differential detection scheme.

To simulate the readout signal, the vector model is adopted to calculate the interaction of light on CAD disks. The complex vector electromagnetic field of incident diffraction-limited spot can be written as

$$E_i(x,y) = \hat{x}p(x,y)e^{jk\cdot r} \tag{1}$$

where $\hat{x}$ denotes the polarization of the electric field and $p(x,y)$ is the point spread function of the diffraction-limited spot.

The complex field of the reflected light is then calculated by the following two steps. First, the Kerr effect is obtained by solving the wave equation that propagates in

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