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Write-Once Volumetric Optical Disk Using Transparent Recording Material with an Optical Switching Layer

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A volumetric optical disk having multiple transparent films with optical switching layers is proposed as a recordable medium to increase the number of recording layers. In the disk, an optical switching layer is adopted to reduce laser energy decay and increase recording sensitivity for reading and recording, respectively. A well-defined deformation area (mark) with submicron to nanometric dimensions can be yielded precisely on the transparent films by a focused laser beam. The peak writing power of 7 mW for a four-layer recordable medium, fabricated by molding and spin bonding techniques, was demonstrated experimentally as an example. The proposed volumetric disk can achieve a higher recording capacity by using conventional optical pickup units. [DOI: 10.1143/JJAP.43.4937]

KEYWORDS: volumetric optical disk, multilayer optical disk, optical nonlinearity, optical switching layer, silver oxide structure

1. Introduction

As the demand for storage capacity continually grows, data storage technologies are being driven to achieve higher capacity, higher readout and recording bit rate, and faster access time. The recordable optical disk, as a two-dimensional optical storage medium, is currently the most widespread physical format for optical storage. A promising technique has been developed to increase the volumetric data density of optical disks by including a third physical dimension, using a multilayer recording structure, i.e., by axially stacking a number of recording layers. However, issues such as interlayer crosstalk, low laser energy transmittance, and absorption exist in such a disk.[1)] Therefore, the structure with an optical switching layer in a volumetric optical disk was introduced[2,3)] to resolve these issues. In this paper, a disk structure of multiple transparent films with an optical switching layer as recordable media is demonstrated to increase the number of recording layers in a volumetric optical disk.

2. Experiment

In a multilayer optical disk, laser energy is decreased by the presence of out-of-focus recording layers. The total number of recording layers is therefore limited by the fixed laser power of the pickup. An intensity-dependent nonlinear optical structure as an optical switching layer added to each recording layer, as shown in Fig. 1, was proposed to modulate the absorption and transmission of light in the recording layers, depending on whether the laser is focused on it or not. In addition, the conventional low-transmittance recording material was replaced by a transparent one (polycarbonate), as illustrated in Fig. 2, to improve laser energy efficiency, suppress the interlayer crosstalk, and increase the total number of recording layers. Specifically, this simplified structure offers a three-dimensional optical disk with significantly decreased crosstalk, large number of inexpensive recording layers on a substrate, and reduced reading/recording laser power.

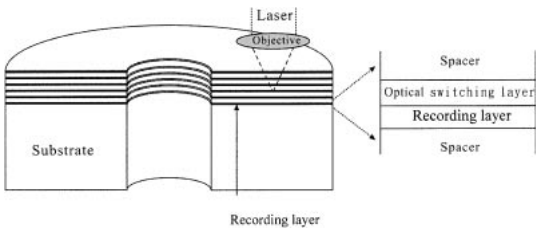

Fig. 1. Schematic diagram of an optical disk with optical switching layers.

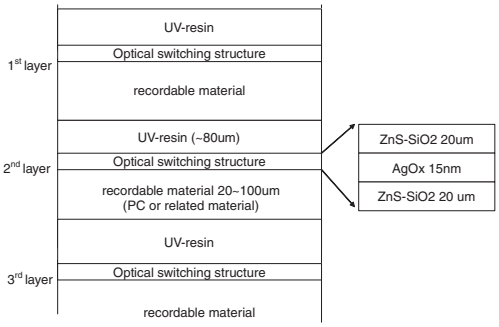

Fig. 2. Schematic of a multilayer disk structure using transparent recordable material with an optical switching layer.

As the disk is accessed by a pickup, the interactions between recording layers and the focused laser spot are divided into three cases: (a) at very low light intensity, (b) reading, and (c) writing modes, as shown in Figs. 3(a)–3(c), respectively. To read or record data marks on the recording layers, optical switching layers should have the following nonlinear characteristics in various modes:

(a) No nonlinear phenomenon occurs as the optical switching layer is illuminated by a very low intensity out-of-focus spot. The recording layers are a high transmittance state to suppress the interlayer crosstalk.
(b) Larger reflected signals (more than 10%) can be obtained because the nonlinear absorption phenomenon occurs and enhances its reflectivity in the focused spot area.
(c) Nonreversible thermally deformed materials, such as polycarbonate (PC) or polymethyl methacrylate (PMMA), are deformed if a higher power is applied.