

## Master and Slave Beam Servo Technique for Volumetric Bit-Wise Optical Data Storage

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A master and slave servo technique that maintains tracking and focus registration inside a volumetric disk is presented, and the misregistration of the slave beam with respect to the master beam due to disk tilt and beam skew is calculated.

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KEYWORDS: focus servo, track servo, data storage, volumetric media, two-photon media

### 1. Introduction

Conventional optical data storage devices use a closed-loop servo system to keep the laser spot locked onto the data track with pre-existing reference tracks. Since homogeneous volumetric media, like two-photon disks, have no tracks, writing and reading data are not well controlled without precision bearings.<sup>1)</sup> In order to solve the problem of tracking inside homogeneous volumetric disks, external reference tracks are needed. In a recent publication, several servo configurations were considered,<sup>2)</sup> and it was concluded that a common-objective configuration where a master beam, which follows a reference track, and a slave beam, which reads and writes data inside the disk, is the best for generous tolerances. In this paper, a master/slave servo technique that maintains tracking and focus registration inside a volumetric disk is analyzed. The stability of the method is shown experimentally, and the misregistrations of the master and slave beams due to disk tilt and beam skew are calculated.

### 2. Master/Slave Servo Technique

The basic concept of the single-objective master/slave servo is shown in Fig. 1. The tracking beam and the write/read beams are combined through a single objective lens on a single actuator. Using adjustable compensating optics, the write/read beam is focused to different layers in the two-photon disk. The two-photon disk is mounted rigidly to a

master grooved disk, *e.g.* a modified commercial compact disc (CD), so that both disks rotate together on a common axis.

A closed-loop servo system is coupled to the master disk, and a particular track is followed. When track lock is achieved, the tracking beam accurately follows a reference groove as the disk spins. If a position error is sensed by the electronics, the objective lens position is changed with the actuator to correct the error. Since the write/read beam is slaved to the actuator, its focus point inside the volumetric medium follows the same correction path. The write/read beam thus traces a path inside the medium that replicates the track followed by the master servo loop. With this system, any positioning errors in the disk pair as it rotates are tracked by the master feedback system. Since the medium and the master disk are rigidly fixed together and have corresponding position errors, the position of the laser spot in the two-photon disk is well controlled.

The degree to which the slave readout beam holds focus and track relative to the master tracking beam is shown in the experimental diffraction pattern of Fig. 2, where the pupil image of the reflected slave beam is shown. The pattern results from zero and  $\pm$  first diffracted orders overlapping in the pupil. Since the slave beam is slightly out of focus with respect to the grooves, straight-line fringes are observed in the overlap regions. If the fringes drift left or right in the overlap regions, the slave beam is translated horizontally with respect to the reference track, and the slave

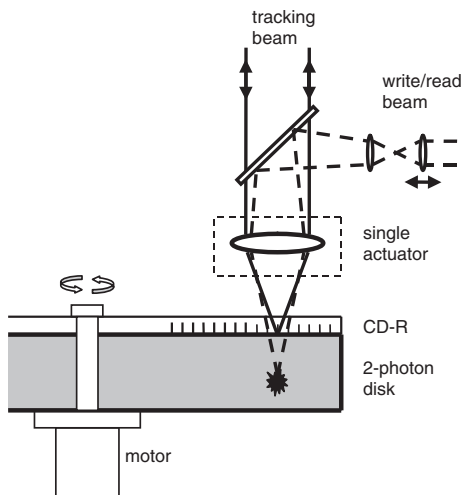


Fig. 1. A master/slave servo technique that combines the tracking beam and the write/read beam into a single path.

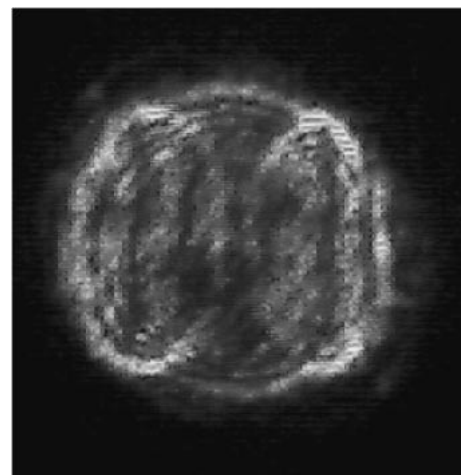


Fig. 2. Diffraction pattern of the out-of-focus slave beam from the reference groove.