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Triple-write One-lens Optical Pickup for Blu-ray Disc/DVD/CD Supporting 4x Blu-ray Read/Write

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Abstract—A Blu-ray Disc (BD) / Digital Versatile Disc (DVD) / Compact Disc (CD) compatible optical pickup supporting Blu-ray 4x read/write has been developed. To achieve 4x speed for BD, a one-lens-type objective lens was adopted to ensure stability for high-speed tracking servo control. Optical system, signal characteristics, and actuator vibration characteristics of the developed pickup are presented.

I. INTRODUCTION

Read/write speed is one of the most important items for optical disc drives with large data capacity. Blu-ray [1] is a format that has 25-Gbyte capacity per layer and its track pitch is reduced to 0.32 μm compared with that of Digital Versatile Disc (DVD) of 0.615-0.74 μm [2]. The 1x scanning linear velocity of on a Blu-ray Disc (BD) is, typically, $74.5 \text{ nm} \times 66 \text{ MHz} = 4.917 \text{ m/s}$ [1], which is faster than that of DVD of 3.49-3.84 m/s [2]. The tracking servo control for 4x BD is, therefore, as severe as 10-12x DVD ($4 \times (0.74/0.32) \times (4.917/3.84) = 11.8$), if we suppose the same replication accuracy and amount of track deviations on the discs. The stability of the servo control is, then, a problem with the increased capacity.

Meanwhile, there is strong demand from consumers for 'triple-write' compatibility of the optical disc drive which has

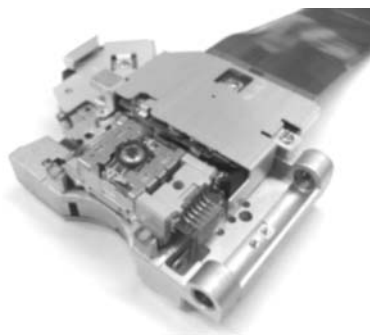


Fig. 1. Appearance of triple-write optical pickup for Blu-ray Disc (BD)/DVD/CD. Objective lens is one-lens-type triple-compatible lens. Lens actuator supports focus, tracking, and tilt control. Laser diode is under the metal cover for electric shield.

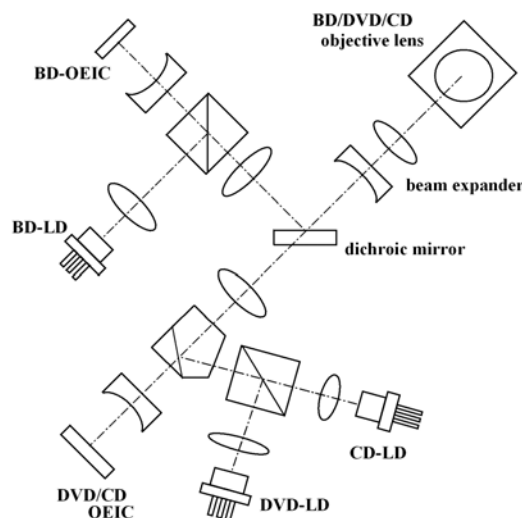


Fig. 2. Optical system for compatible BD/DVD/CD read/write. Light from three laser diodes (LDs) are mixed at the dichroic mirror, and then irradiated to objective lens through a beam expander, which is a pair of spherical aberration correcting lens, one of which position is controlled with stepping motor.

availability corresponding to three formats (Blue (405 nm)/DVD/Compact Disc (CD)) [3]-[5]. In view of tracking and focusing servo control, one-objective-lens pickup with triple-compatibility [4] has an advantage in that symmetric one-lens actuator structure is free from low-frequency mechanical vibration accompanied with rolling/pitching motion that often exists in asymmetric actuator structure. That helps to increase higher-order resonance frequency of the actuator up to 40-50kHz, which is almost the native limit of resonance frequency determined with material stiffness of the actuator.

II. PICKUP CONSTITUTION

A. Optical system

Figure 1 shows an appearance of our prototype pickup for BD/DVD/CD. The objective lens centered on the actuator with symmetric structure is for blue (405 nm), red (660 nm), and infrared (785 nm). The shortest working distance is 0.20 mm (min.) for CD with disc protector. The disc protector is to guard disc surface.

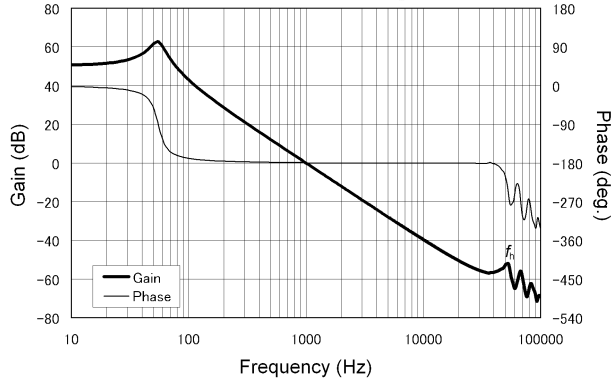


Fig. 3. Bode plot of calculated response of one-lens-type actuator. The thick line shows the gain of the actuator response, whereas the thin line shows the phase. The higher-order resonance frequency f_h is increased up to 40-50kHz.

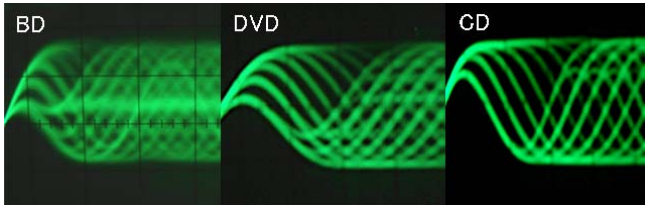


Fig. 4. Eye-pattern of BD-RE 25GB, DVD-ROM, and CD-ROM direct readout signal from the pickup. Typical jitter values are 6% for BD with equalization, 6% for DVD with equalization, and 13 ns for CD.

Figure 2 shows the optical system inside the pickup. The blue/red/infrared light from the three laser diodes (LDs) are mixed at the dichroic combination mirror, and then through a beam expander, irradiated to disc surface by the objective lens. Thickness error of the disc cover layer can be compensated with the lens position control in the beam expander for both BD and DVD.

III. RESULTS

A. Actuator Characteristics

Figure 3 shows the frequency response (Bode plot [6]) of the one-lens actuator. The thick line shows the gain of the actuator response, whereas the thin line shows the phase. The higher-order resonance frequency (f_h) is 52 kHz for the tracking direction.

B. Signal Characteristics

Figure 4 shows the eye-pattern of BD (25GB), DVD, and CD readout signal from the pickup. Typical jitter values of 6%, 6%, and 4% were obtained for BD, DVD, and CD, respectively. A carrier-to-noise ratio of 2T pattern signal on BD-RE 25GB disc was typically 49 dB at 1x speed, which is good value for 4x reading with the limit equalizer [1]. The cut off frequency of the opto-electronic integrated circuit (OEIC) output for BD is typically 115 MHz (-3dB).

C. Read/write Speed

Table 1 shows the list of supported media and read/write

TABLE I MEDIA TYPE AND READ/WRITE SPEED		
Read/Write	Media Type	Support Speed
Read	BD-ROM	4.8x
	DVD-ROM	16x
	CD-ROM	40x
Write	BD-R (SL)	4x

speed values. As a result of improved servo controllability, readout speed up to 4.8x was achieved for BD read-only-memory (BD-ROM), and writing speed of 4x was supported for BD-R.

IV. CONCLUSION

The optical system, signal characteristics, and actuator vibrational properties of our one-lens BD/DVD/CD compatible pickup are presented. With the increased resonance frequency of the one-lens actuator, high-speed tracking and triple-write compatibility for BD/DVD/CD were achieved in 4x BD read/write condition.

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