DVD-ROM, -RAM AND CD COMPATIBLE OPTICAL PICKUP WITH A TWO-WAVELENGTH LASER DIODE UNIT

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1. Introduction

In recent years, simple optical systems have adopted a monolithic two-wavelength laser diode (LD) for further reductions in the cost and size of DVD-CD compatible optical pickups. [1][2] With the recent commercialization of DVD-RAM recorders, the capability of DVD-RAM reading has become very important. Specifically, it is necessary to increase the light power efficiency of the optical system and to reduce the so-called track-crossing noise, which is crosstalk to the focus error (FE) signal of the tracking error (TE) signal.

This paper reports a novel optical pickup using a two-wavelength LD unit to meet the above requirements.

2. Optical configuration

Figure 1 shows the optical configuration of the optical pickup, and Table 1 shows its specifications. All of the optical components are arranged along a single optical axis. It is a very simple optical system that is stable against ambient temperature variation.

A grating for three-beam TE signal detection (three-beam grating) and a diffractive optical element (DOE) for FE signal detection are installed on the LD-side and opposite side of the substrate, respectively. The grating has dichroic characteristics that diffract only infrared laser [2]. To reduce track-crossing noise, the spot size detection (SSD) method [3] is adopted for FE detection. We also adopted three types of TE signal detection methods: the differential phase detection (DPD) method for DVD-ROM, the push-pull (PP) method for DVD-RAM, and the three-beam tracking method for CD-ROM, CD-R and CD-RW.

Furthermore, an inner area aberration compensating lens [4] was adopted as the objective lens, and it was redesigned to optimize the lens characteristics for a monolithic two-wavelength LD.

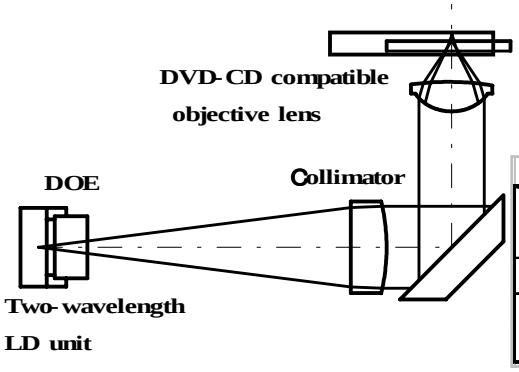

Table 1. Specifications

		DVD		CD
		ROM	RAM	
Laser wavelength		650nm		780nm
Detection method	Focusing	SSD		SSD
	Tracking	DPD	PP	Three-beam

Fig. 1. Configuration of optical system

3. DOE and photo detector pattern

Figure 2 shows the DOE and photo detector (PD) pattern of the optical pickup. A monolithic two-wavelength LD is mounted in a pit which is formed on a surface of a photo detector substrate and has a 45° inclined wall playing a role of mirror. For the DPD method, the DOE pattern is divided into four quadrants, and the center of the DOE pattern coincides with the optical axis of the red laser light source. The DOE diffracts light beams in different directions to detect TE signal. Each quadrant is divided by the lines extending along the x-axis, and each divided region has either positive or negative power to make FE signal by means of SSD method. By utilizing both conjugate diffracted lights which incident on TE detection area and FE detection area to generate a reproduction signal, light power efficiency is greatly improved.

The PD pattern consists of three blocks: TE detection area, DVD-FE detection area, and CD-FE detection area. The signals from the TE3, TE4, TE5, and TE6 areas are utilized to generate the DPD signal for DVD-ROM reproduction and the PP signal for DVD-RAM reading.

The DVD-FE detection area and the CD-FE detection area are separated utilizing the distance between the two light emitting points, and the difference in diffraction angle caused by wavelength difference. By separating the FE detection area into a DVD area and a CD area, it is possible to optimize the focus offsets for DVD and CD independently.

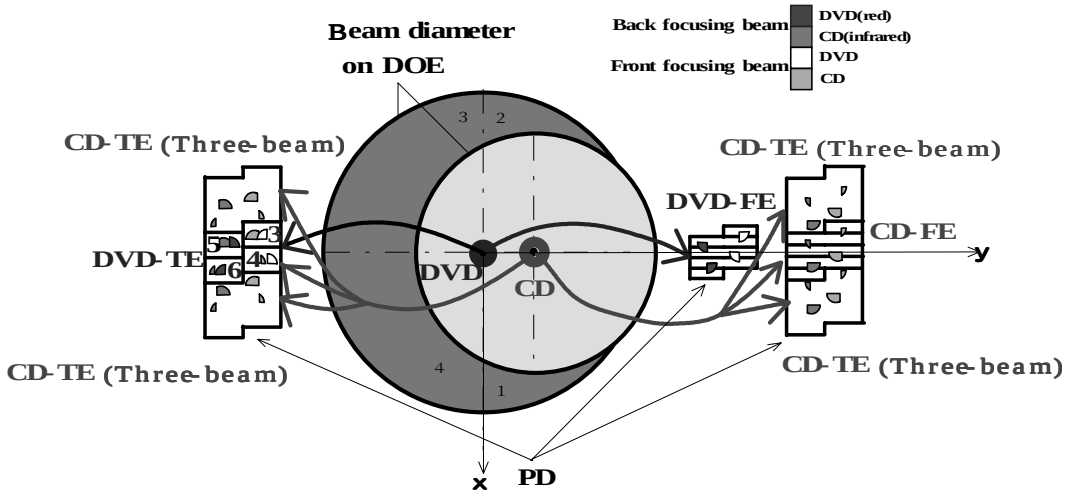

Fig. 2. DOE and PD pattern

4. Transmissivity of red light through three-beam grating

For higher red-light power transmissivity, the grating depth h of the three-beam grating is determined as

$$h = \lambda_R / (n - 1) \quad \cdots\cdots\cdots \quad (1)$$

where n is refractive index of the grating substrate and λ_R is the wavelength of red light (650nm). Using a glass material (n = 1.514), h is as deep as 1.3 μm. This depth leads to discrepancies from scalar analysis and a larger influence of the grating side wall taper due to the etching process. As a result, transmissivity of red light is 68% with a 65° side wall taper by vector analysis. To decrease the grating depth and improve transmissivity, a high refractive-index material was adopted. Tantalum oxide (Ta_2O_5, n = 2.1) was evaporated on a glass surface, and the grating depth was set to 0.59 μm. The scanning electron microscope (SEM) photograph of cross section of the grating formed on Ta_2O_5 is shown in Figure 3. Consequently, the measured transmissivity of red light increased to 80%.

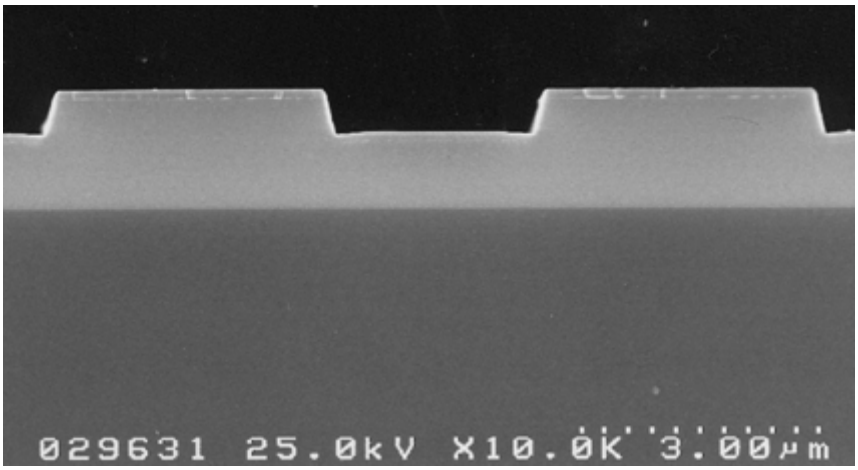

Fig. 3. SEM photograph of the grating formed on Ta_2O_5

5. DVD-CD compatible objective lens [4]

A novel DVD-CD compatible objective lens having a common back focal length suitable for a two-wavelength LD unit was developed by redesigning the inner area aberration compensating lens. The optimal thickness of the disk substrate at the inner area of the lens was redesigned, and the phase step of the inner area boundary was also optimized to improve readout characteristics.

6. Signal evaluation

The data-to-clock jitter for DVD-ROM was 6.9% and that for CD-ROM was 5.6%. These results demonstrate the compatible reading of DVD-ROM and CD by using the newly developed objective lens and by separating the FE detection regions of the PD pattern. The FE signal and PP signal of a 4.7GB DVD-RAM with focusing servo control are shown in Figure 4. The track-crossing noise amplitude was as small as 7.5% of the FE signal amplitude. The eye pattern of DVD-RAM without equalizer is shown in Figure 5. The jitter value of the DVD-RAM was 8.6%, which is sufficiently low for practical use.

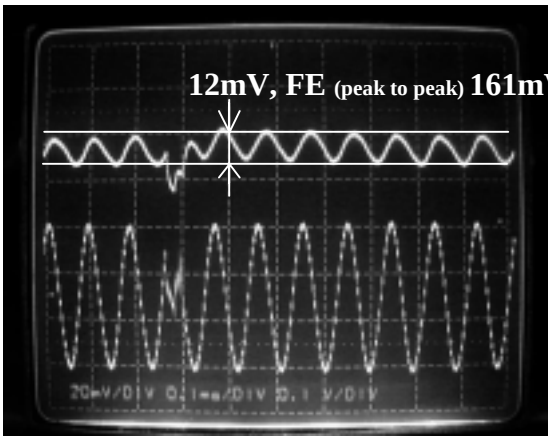

Fig. 4. FE signal with a focusing servo (upper) and PP signal with a focusing servo (lower)

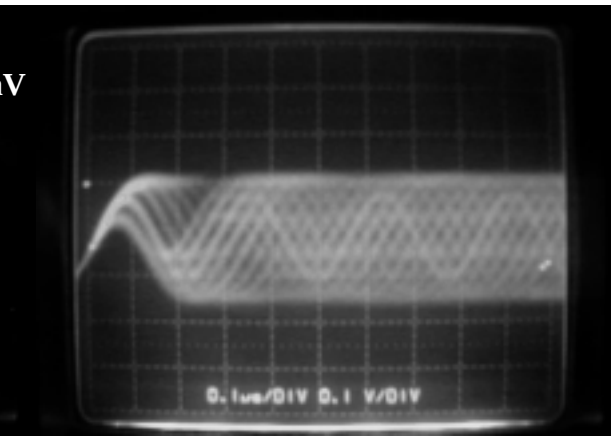

Fig. 5. Eye pattern of DVD-RAM without equalizer

7. Conclusions

A Novel optical pickup with a two-wavelength LD unit that can read DVD-ROM, -RAM, and CD was proposed. Using the SSD method, a stable FE signal with little track-crossing noise was experimentally confirmed. The red-light power efficiency of the optical system was improved by fabricating a three-beam grating on high refractive-index material and utilizing both conjugate diffracted lights from the DOE. Consequently, compatible reading of DVD-ROM, -RAM, and CD was successfully demonstrated.

References

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