A Micromachined Free-Space Integrated Optical Disk Pickup Head

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Recently, there is great interest in monolithically integrated free-space micro-optics using micromachining techniques [1]. Monolithic integration of the whole micro-optical system can drastically reduce its size, weight, and cost. In addition, the expensive packaging process of individual optical elements can also be eliminated. An example of the newly micromachined integrated micro-optical system is the optical disk pickup head which plays an important role in the performance of optical data storage systems. Because the data transfer rate is inversely proportional to the square of the mass of the pickup head, this micromichined device not only reduces the assembly cost but also enhances its performance to higher data access rate.

Fabrication of this pickup head using surface-micromachining has been described in detail elsewhere [2]. Figure 1 shows the schematic drawing of the free-space integrated optical disk pickup head. All optical components are built monolithically on a Si substrate with the optical axis parallel to the substrate. Light emitted from the laser is first collimated by a micro-Fresnel lens. The collimated beam passes through the beam splitter and is focused by the second micro-Fresnel lens. The focused light is further bent upward by an integrated 45° mirror, which enables the pickup-head chip to be mounted in parallel to the optical disk. The reflected light from the disk is collected by the same focusing lens, and then reflected again by the beam splitter which directs the light to a planar quadrant photodetector built on the Si substrate via a downward 45° mirror.

The optical beam profiles at various locations are characterized by a charge-coupled device (CCD) camera accompanied with a microscope. The spot size of the beam at the position around the optical disk is measured by varying the focus of the microscope. Figure 2 shows the CCD image and the beam profile of the beam spot at the focal plane. The full width at half maximum (FWHM) of the focused spot size is 2.6 μm and 6.7 μm in the directions perpendicular (X direction) and parallel (Y direction) to the laser junction, respectively (see Fig.1) . The relative large spot size is due to the small numerical aperture (NA~ 0.17) of the focusing lens and the long wavelength (.98 μm) of the semiconductor laser source in our initial demonstration, and is not a fundamental limit of this approach. The 1/e field beam-width versus longitudinal displacement is shown in Fig. 3 in both X and Y directions. The different focal lengths in X and Y directions are attributed to the astigmatism of the ridge-waveguide edge-emitting laser which is weakly index-guided in the lateral direction. We also find that the focal depth of the beam is rather large, which is also due to the small NA of the micro-Fresnel focusing lens.

In summary, a novel free-space integrated micro-optical disk pickup head has been realized using surface-micromachining techniques. A focal spot with the FWHM equal to 2.6 μm × 6.7 μm is obtained. This new integrated optical disk pickup head can significantly reduce its size and weight as well as improve the transfer rate of optical data storage systems. The free-space micro-optical bench technology can be extended to many other micro-optics systems.

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References:

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2. L. Y. Lin, S. S. Lee, and M. C. Wu, "Fabrication of Free-Space Integrated Optical Disk Pickup Heads by Surface-Micromachining Technology", IEEE CLEO/Pacific Rim '95, Chiba, Japan, July 11-14,1995.

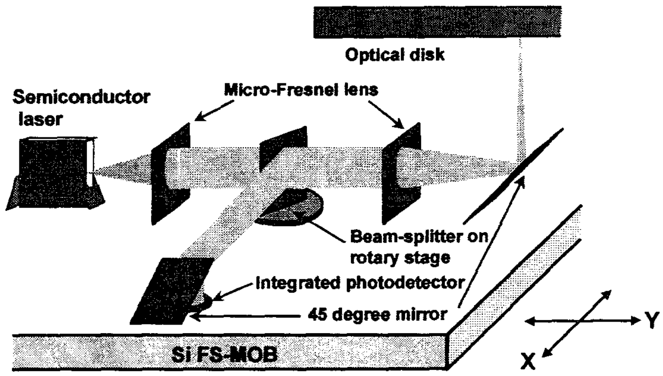

Fig. 1 The schematic drawing of the free-space integrated optical disk pickup head.

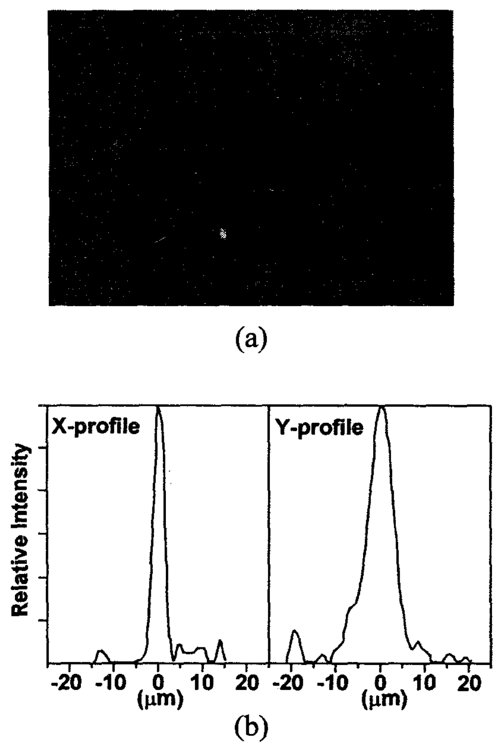

Fig. 2 (a)The CCD image and (b) Beam profiles of the laser beam spot on the focal plane. The FWHM beam-widths are 2.6 μm and 6.7 μm in the X and Y directions, respectively.

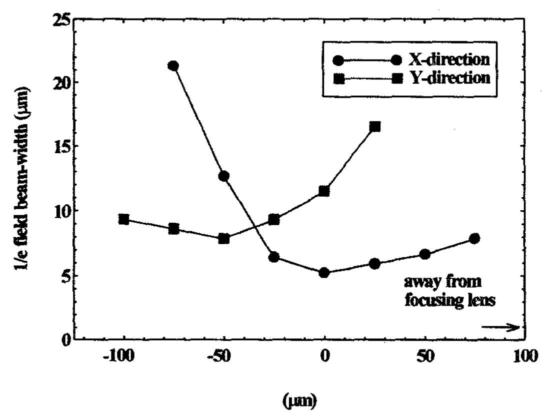

Fig. 3 The 1/e field beam-widths versus the longitudinal displacement near the focal plane. The different focal lengths in X and Y directions come from the intrinsic astigmatism of the edge-emitting laser.