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Silicon optical MEMS: optical components and sensors

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1　Introduction

Using Micro_Electro_Mechanical System (MEMS) technology, many devices and systems can be miniaturized. Micro pressure sensors and micro accelerometers (air_bag sensor) are examples that are widely commercialized. In the case of optical system, some optical components need to be combined to implement the function desired for optical processing. A micro_optical bench based on a Si surface and bulk micromachining has been proposed in order to integrate optical components on a Si substrate.

In this paper, our recent work on micro_fabrication of optical components and system (switch, scanner etc.) is presented[1-2]. New types of sensors are also included[3]. In the fabrication of three_dimensional structures, deep reactive ion etching and resist spray coating are used. Two examples of optical systems are described below.

2　Integrated laser beam scanner

Figure 1 shows the structure of an integrated optical scanner[2]. A laser diode (LD) is mounted on a terrace fabricated by anisotropic etching. A laser beam emitted from the LD is reflected by the micro mirror fixed at the end of the cantilever_like thermal actuator. The actuator vibrates by feeding a current to a heater of the actuator. The light reflected from the object is monitored by the photodiode on a Si substrate.

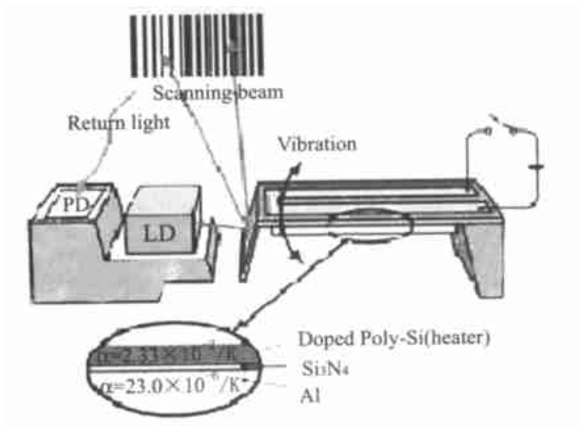

Fig. 1　3D integrated optical scanner.

Figure 2 shows the fabricated Si structure for the micro scanner. As shown in Fig. 2, two V_shaped micro actuators with mirrors are fabricated in front of the terrace for the LD. The cantilevers are about 300 μm long. The depth of the terrace is designed to adjust the height of the laser emission point. The scan angle reaches 30 degrees around 100mW power.

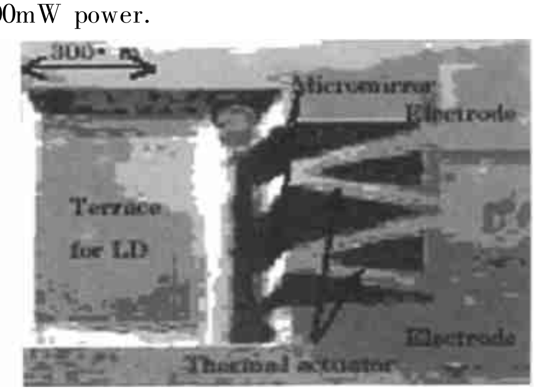

Fig. 2　Fabricated Si structure for micro scanner.

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3 Optical encoder using Si grating

Figure 3 shows the schematic diagram of the encoder using grating imaging[3]. The proposed encoder consists of the two gratings. (Although three gratings are needed in an encoder using a grating imaging, the first grating is simultaneously used as the third grating in a reflection configuration.) Figure 4 shows the schematic diagram of the integrated sensor (index grating part). The light source is a polychromatic incoherent light source.

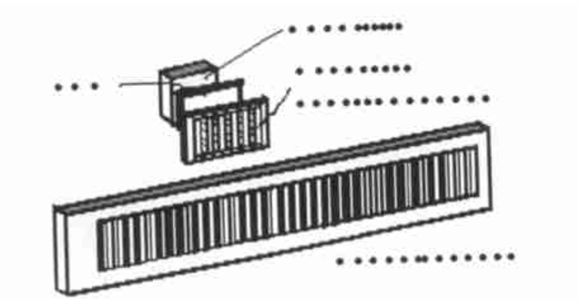

Fig. 3 Encoder using transmission silicon grating.

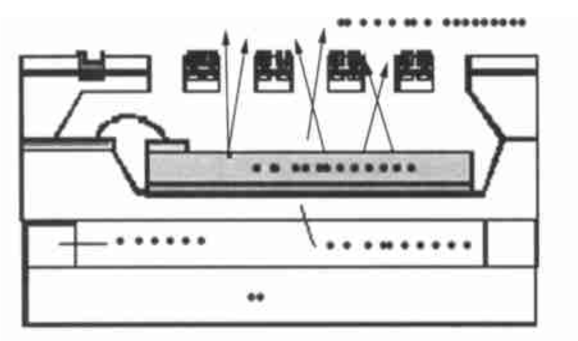

Fig. 4 Integrated encoder sensor.

(LED). The index grating is fabricated from a silicon wafer and consists of the transmission grating. On each grating line, which is a thin silicon beam, two line photodiodes are installed. Therefore, the scale grating is irradiated through the transmission index grating, on which the photodiodes are fabricated.

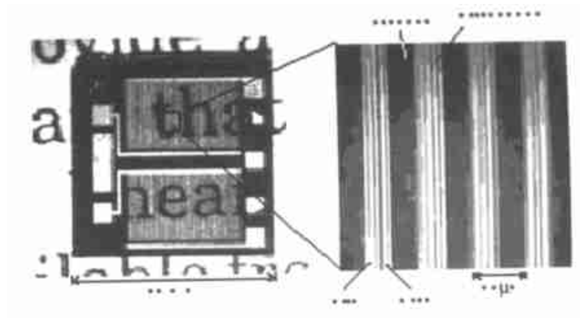

Fig. 5 Index grating with line photodiodes.

Figure 5 shows the optical micrograph of the fabricated index grating (80mm pitch). The silicon substrate is etched through, so as to see the characters on the paper as shown in Fig. 5. The photodiode sensitivity is 21mA/W. Using the fabricated index grating, the displacement signal can be examined. The signal varied sinusoidally as a function of the lateral displacement, which is convenient for obtaining a displacement smaller than a single period by interpolation. The period of the signal was equal to are half of the grating pitch. The fabricated index gratings consist of the two phase shifted gratings. The two signals can be used for distinguishing directon of movement and for interpolating displacement smaller than a single period.

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