INTEGRATED ANGLE RESOLVED SPECTROSCOPY WITH NOVEL OPTICS 'CALDERA MIRROR'

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ABSTRACT

This paper reports the integrated angle resolved spectroscopic device with embedded novel optics 'caldera mirror'. We have integrated lithographic lenses, a fluidic channel, light shields, an optical fiber and a caldera mirror. In order to facilitate output of angle resolved signals from micro device, the caldera mirror was developed and embedded. In the device, scattered or emitted lights from fluidic channel were passed through integrated confocal optical systems, and, then, outputted through the caldera mirror. Performance of the device was tested by using fluorescent observation.

KEYWORDS

Angle resolved spectroscopy, optics, optofluidics, microfabrication

INTRODUCTION

Recently, many groups reported optofluidic systems for various applications such as spectrophotometry [1], fluometry [2], and flow cytometry [3]. These devices utilized the lithographic mirrors and lenses for scaling down the analytical systems and/or improvement of the analytical performance. In our previous paper [4], we focused on introduction of the lights by utilizing the embedded prisms, which is suitable for on-chip multi-beam spectroscopy and easy to use. In the present paper, we have investigated an innovative fabrication method for an embedded novel optics 'caldera mirror' and demonstrated its performance in the angle-resolved spectroscopy.

CONCEPTION

Figure 1 illustrates the conception of the integrated angle resolved spectroscopic device, which consists of lithographic optics, fluidics and an embedded caldera mirror. Laser light is injected through the integrated optical fiber. Emitted or scattered light form the fluidic channel is reflected to a vertical direction through the caldera mirror after passing through integrated confocal optical systems consist of two lenses and light shields, and then detected by CCD. By using this device, angle resolved signals can be detected by using just one CCD.

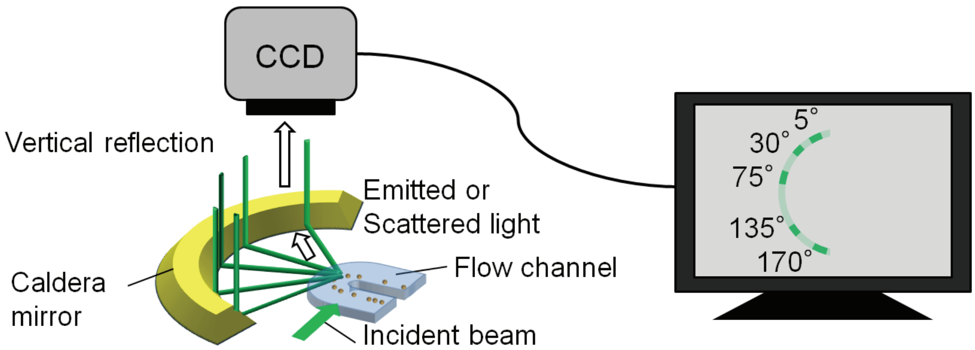

Figure 1 Concept of the integrated angle resolved spectroscopic device that consists of lithography optics, fluidics and embedded novel optics 'caldera mirror'.

RESULTS & DISCUSSION

Figure 2 shows a fabrication process of the caldera mirror. In this study, the caldera mirror was fabricated by molding of thermosetting resin. A circular cone mirror and custom-made mold were utilized as the mold. After peeling off the resin and arranging the shape, Cr membrane was coated on the reflection surface of the mirror by using vacuum deposition equipment.

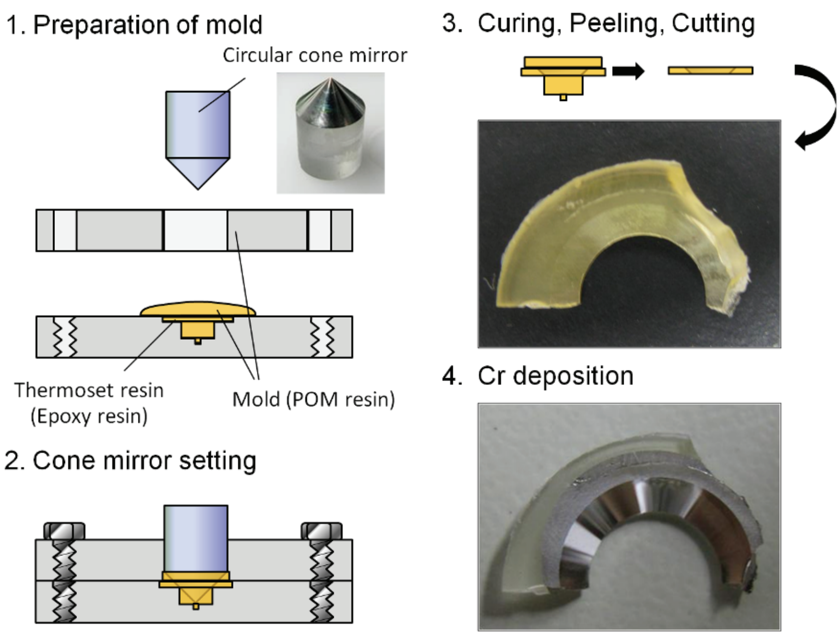

Figure 2 Fabrication process of the caldera mirror.

Figure 3 shows the embedding process of the caldera mirror. The master mold including a fluidic channel and lenses was fabricated by a photolithographic method utilizing thick negative photoresist such as KMPR-1035. After development of the photoresist, the caldera mirror was placed on the mold, and prepolymer of PDMS was casted and cured. The cured PDMS sheet with the caldera mirror was peeled off from the mold.

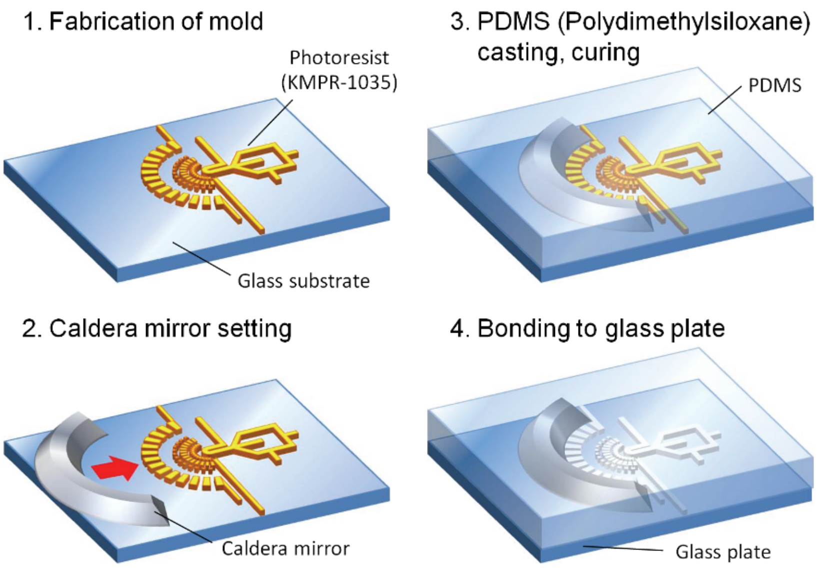

Figure 3 Embedding process of the caldera mirror.

Figure 4a shows the experimental setup for demonstrating the angle-resolved spectroscopy device. In the device, black-colored PDMS block was also embedded on a fluidic channel, in order not to detect emitted or scattered light from the fluidic channel directly. Performance of the caldera mirror was verified by fluorescence observation, where a fluorescent dye solution was introduced to the fluidic channel and the excitation light was introduced through the optical fiber. Figure 4b shows the fluorescent micrograph. The black-colored PDMS block and the caldera mirror worked as expected.

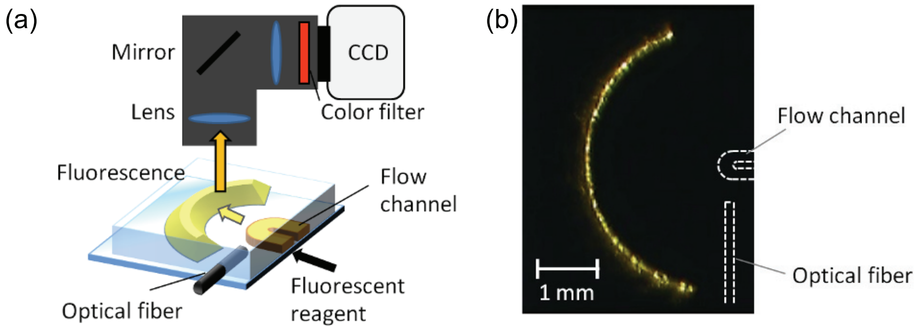

Figure 4 (a) Setup of the angle-resolved spectroscopy device. (b) Microscopic fluorescent image with a CCD. The fluorescence, which is emitted to the in-plane direction, is reflected to the CCD direction by the caldera mirror.

CONCLUSIONS

In this study, we have demonstrated the angle-resolved spectroscopy device embedded the caldera mirror, and other optical components. The technology developed in the present study will be applied to analysis of nanoparticles, microbial, and other nano-sized objects in microfluidic devices.

ACKNOWLEDGEMENTS

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