Proceedings of ASME 2009 4th Frontiers in Biomedical Devices Conference
BioMed2009
June 8-9, 2009, Irvine, California, USA

BioMed2009-83051

PARAFFIN ACTUATED MICROMIRROR FOR ENDOSCOPIC OCT

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ABSTRACT

Microelectromechanical systems (MEMS) have great potential for use in gastrointestinal (GI) imaging. Ultrasound and magnetic resonant imaging can provide useful information about the GI tract, but only optical coherence tomography (OCT) delivered endoscopically can be used to perform an optical biopsy of the GI tissue. In monitoring a condition such as Barrett's esophagus, which typically requires regular random biopsies, the ability to achieve an optical biopsy is indispensible. While the existing method for obtaining an optical biopsy of the GI tract tissue produces functional images, there are drawbacks that could be improved upon. The gear-and-shaft assembly used to couple force from the motor at the proximal end to the distal imaging end requires a complex design [1]. By introducing a rotational MEMS device into the distal imaging end, a rotating optical coupling joint is no longer required at the proximal end, there is no need to precisely align the fixed fiber with the rotational drive shaft, and the metallic reinforcement sleeve can be eliminated leaving a simpler, more flexible delivery method [2]. In order to produce 3D OCT images, displacement in the z-direction needs to be coupled with rotation. A MEMS device that can achieve both vertical displacement and rotation further increases the simplicity of the device and decreases potential alignment and coupling errors. Our MEMS devices needs to be able to bend an OCT beam of light 90°, rotate that beam of light 360°, and simultaneously scan in the z-direction in order to produce 3D OCT images. Also, the device must fit inside the 1 mm diameter available in the endoscope. To accomplish this, we have designed, and are continuing to develop, a paraffin actuated micro mirror.

The thermal expansion properties of paraffin wax have often been utilized in MEMS devices [3, 4]. We have made use of these properties in designing a piston like actuator. Heat is applied to a reservoir of paraffin enclosed by a parylene membrane. The paraffin expands and pushes the post above it upward with the developed force from its expansion. The amount of paraffin in each reservoir is controlled by the reservoir's geometry and so by controlling the amount of heat applied, we can control how far the post above it moves in the vertical direction. Each device has three heaters, three reservoirs, and three posts. All three posts are attached to a single mirror. By appropriately cycling the applied heat to each reservoir, we expect to be able to move the mirror in a spiral like fashion. This will bend an applied beam of light 90° and rotate it 360° while achieving displacement in the z-direction.

ACKNOWLEDGMENTS

The authors wish to thank Jake Hes and the staff at the UC Irvine Integrated Nanosystems Research Facilities (INRF), Wyman Wong, and Shawn Hsu for their invaluable suggestions and assistance. This work is partially supported by NIH Grant #CA91717

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FIGURE 1: CONCEPTUAL DRAWING OF PARAFFIN ACTUATED MICROMIRROR

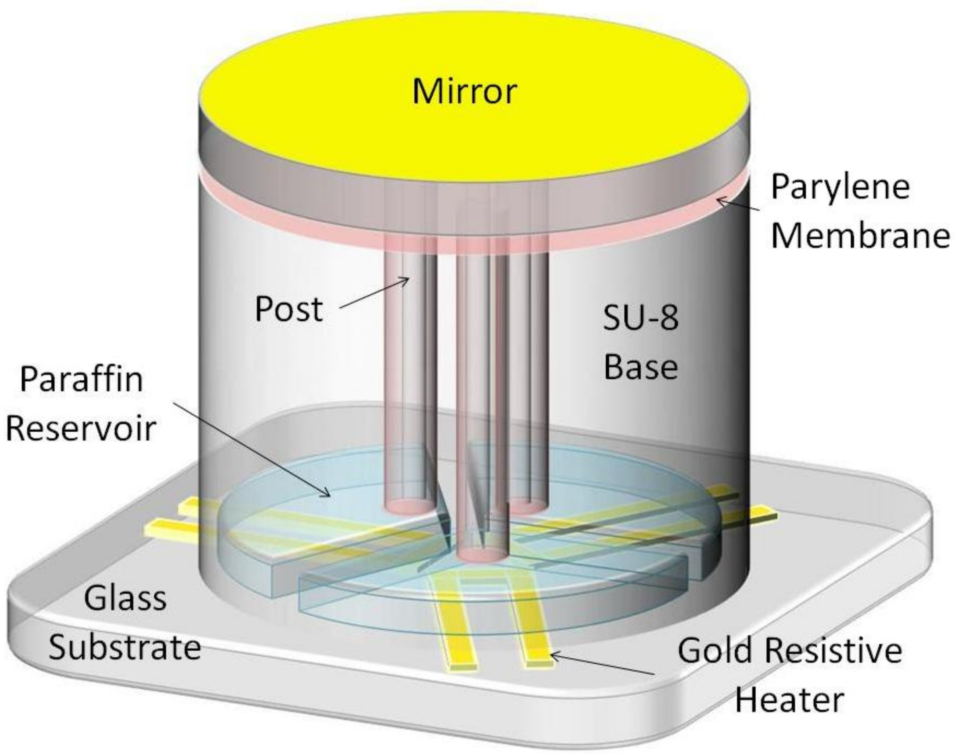

FIGURE 2: CONCEPTUAL DRAWING OF ENDOSCOPE WITH PARAFFIN ACTUATED MICROMIRROR IN PLACE