鏡面可調式內視鏡的研究-子計畫二：
內視鏡用熱動式多自由度微致動器的設計與製作

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作An inclined Micromirror with Rotating Motion作

計畫編號：**NSC 88-2218-E-009-008**

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授.授中文摘要

本計畫提出一可作旋轉運動的傾斜微鏡面結構。其構造乃是將作爲鏡面的平板，在其上塗上聚醯胺 (Polyimide)，利用聚醯胺 加熱產生收縮的現象，將鏡面抬起而傾斜。而此鏡面是設置在一個空心圓盤中。利用電熱式側向致動器加以驅動此圓盤時，則此傾斜鏡面將可做三百六十度之旋轉運動。而採用的電熱式側向致動器，則是將已經發展出來的舊有設計加以改良，並採用分析軟體 ANSIS 5.3 加以分析，證實能夠獲得較以往設計往加 0.6 倍的位移量。

量文摘要

In this project, an inclined micromirror with rotating motion was designed and fabricated. Firstly, polyimide was spun on the plate used as the micromirror. After being heated, the polyimide shrunk and tilted the micromirror. The micromirror was constructed on a hollow disk, and the hollow was actuated by a laterally driven mircoactuator. If the hollow disk was actuated, the inclined micromirror rotated up to 360 degrees. The used microactuator was improved from the old design. Through the use of numerical finite-element program ANSIS53, the microactuator was analyzed. From the simulation, that the improved microactuator had a displacement larger than the old design by 0.6 time was observed.

二.計畫緣由與目的作**Introduction**作

Micromirrors attract lots of attentions in Micro-Electro-Mechanical Systems (MEMS) for possible application in minimizing optical device. Different types of micromirrors have different applications. For example, a stationary micromirror can be used as a light or wave guide in optical instruments by reflecting light or wave to the desired direction. Moreover, a movable micromirror can act as an optical switch. For a moving micromirror with high frequency, it can be used as an optical signal modulator. When lots of torsional mircromirrors are set in an array, they can be applied to a printing or projection display device.

A stationary micromirror usually contains a reflecting surface which can be easily made by anisotropic wet etching of silicon. For a movable micromirror, it needs some actuation mechanisms. Selecting proper actuation mechanisms depends on its application. Here we are interested in designing a micromirror with large rotating angle to reflect light into a wide range at low frequency.

In this project, a micro mechanism for a micromirror to rotate a full circle (up to 360 degrees) at a low frequency is proposed. The rotating axis of the mirror is inclined to the mirror surface. When the micromirror rotates, the light injected along the rotating axis to the micromirror can be reflected to the periphery of the micromirror. The micromirror can be used in the endoscope or other optical scanning applications.

The micromirror is originally constructed in the same layer with a hollow disk. By applying the techniques for bending 3-D structures out of silicon wafer plane, the micromirror is then set to be inclined to the hollow disk. An improved thermally driven actuator is employed to rotate the hollow disk. Four masks will be used and no additional assembling process is needed in the fabrication of the micromirror.

目.研究方法

Concept Design

The schematic diagram of the proposed micromorror is shown in fig.1. As the diagram shown, the inclined micromirror with rotating motion is based on the vibrimotor structure. A thermally driven actuator with lateral motion is employed to rotate the hollow disk. As the hollow disk rotates, so the inclined micromirror on the disk.

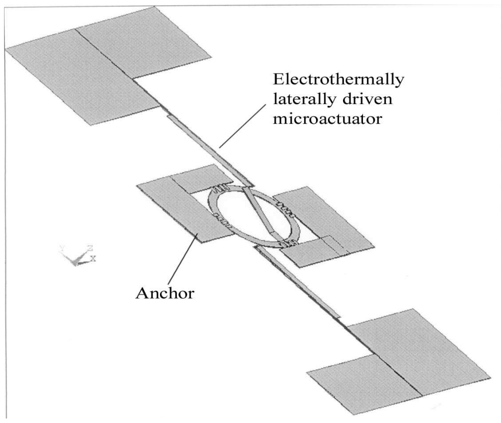


Fig.1.illustration of the inclined micromirror with rotating motion

In order to incline the micromirror, the technology of bend 3D structure out of silicon wafer plane is adopted. The polyimide is employed in our design. The ployimide is put on the plate between the micromirror and the hollow disk. When the polyimide is heated, it shrinks to tilt the micromirror. No additional hand assembly is needed and batch fabrication is possible. The schematic diagram shown below illustrates the principle.

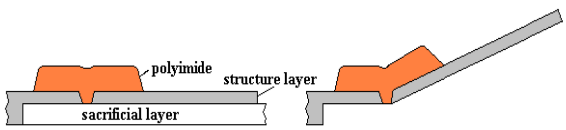
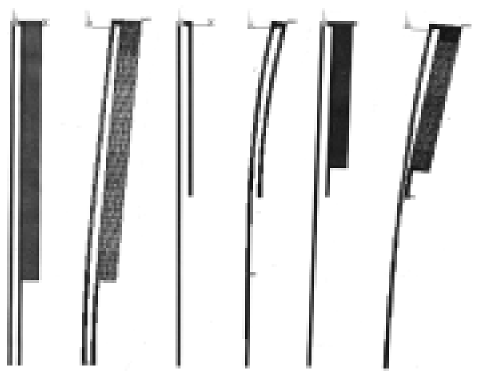


Fig.2.The polyimide is heated and tiles the beam used for micromirror up

An improved thermally driven microactuator with lateral motion

For activating the micromirror proposed in this project, the thermally driven microactuator is employed because of its large output force. In past years, two types of thermal laterally driven microactuators had been presented. One type of the microactuator which could produce motion via the asymmetrical thermal expansion of a microstucture with variable cross sections was proposed by Guckel et al in 1992 [11]. The other type of the microactuator due to the asymmetrical thermal expansion of the microstructure with different lengths of two beams was presented by Pan and Hsu in 1997 [12]. Combining the operation principles of two microactuators mentioned above, an improved thermally driven microacutator is proposed here.



(a)by Guckel (b)by Pan (c)improved design

Fig.3. The models for FEM analysis

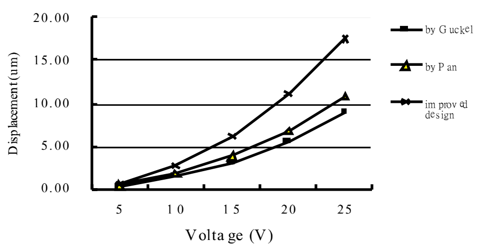


Fig.4.The analysis of comparing three kinds of microactuators

一.結果與討論

Sticking is serious problem in the surface micromaching. After removing the sacrificial layer, the microactuator sticks with the silicon substrate easily. But only a few voltages are applied, the microactuator is actuated and released from the substrate. The microactuator was tested in air by applying an ac triangular voltage. The frequency of the input voltage was between 1~10 Hz. The measured results is shown in table.1.

Table.1.The displacement of the microactuator with difference voltages

Voltage	4	5	8	10	12
Displacement (um)	2	4	6	10	18

In order to set an inclined micromirror, how the polyimide tilts the beam used for micromirror should be investigated. For the reason, several beams with spun-on polyimide were made up. A sample of micrograph of the inclined beams was shown in figure.5. The Detailed results are shown in table.2.

Fig.5. The micrograph of inclined beams

Table.2.The inclined degrees of the test beam (unit degrees)

Polyimide (7.5um thick)			Az4620 (3.2um thick)		
2grooves	1grooves		2grooves	1grooves	
45	23	32	33	39	39
38	24	30	32	51	51
42	36	32	40	40	41
44	30	32	31	42	50

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