THE EFFECT OF DC SOURCE TO FABRY-PEROT OPTICAL FILTER

Nguyen Thi Xuan Mai[1], Nguyen Thi Thu Linh[2,*]

[1] *Faculty of Fundamental Science, Thai Nguyen University of Technology, Vietnam*
[2] *Faculty of International Training (FIT), Thai Nguyen University of Technology, Vietnam*
[*] *Email: thulinh@tnut.edu.vn*

This paper presents an actuation method for the Fabry-Perot (FP) optical filter (Micro Electromechanical System) using the electrostatic force to get the desired wavelengths. DC source is used and analyzed to control this force in the experimental results.

Keyword: *MEMS, FP, DC source.*

1. INTRODUCTION

MEMS (Micro Electro-Mechanical System) consists of mechanical actuators, sensors and other devices at micrometer size[1-5]. The principle of operation of these devices is based on physical phenomena such as: thermal expansion, mechanical force, electromagnetic force and electrostatic force [6-8]. MEMS devices based on electrostatic resistivity have many advantages in micrometer and nanometer dimensions.

FP optical filter is one of MEMS devices used in optical communications, medical and analytical engineering. In the field of optical communication, FP optical filter is used to adjust and follow the WDM signal [9]. In this paper, the micro FP optical filter is an actuator and is controlled in order for the light having the desired wavelength to goes through.

2. STRUCTURE AND CONTROL TECHNIQUES FOR FP OPTICAL FILTER

2.1. The structure of the optical filter

A FP optical filter as shown in Fig. -1 consists of two Bragg reflectors (DBRs) with high reflectivity, the distance between the two Bragg reflectors will determine the output wavelength

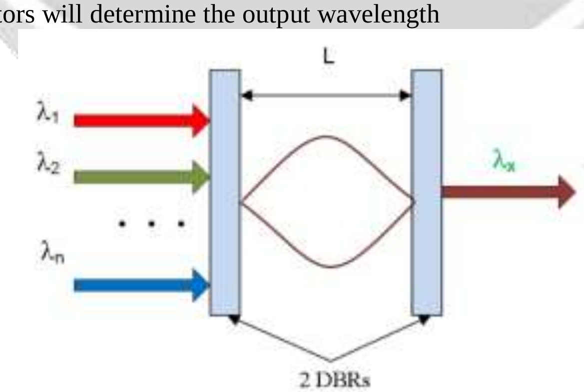


Fig -1: The structure of the FP optical filter

The beams of light to the FP optical filter consist of different wavelengths, but the filter's output only captures the light of a certain wavelength. The electrostatic force will determine the distance between these two reflectors.

The use of electrostatic force for MEMS equipment is appropriate because of the energy density and the feasibility of the electromechanical devices. In many actuators, the balance between the electrostatic attraction and the elastic force will determine the positions of the electrodes. The wide range of electrode placement is extremely useful for various applications of microelectromechanical systems.

An FP optical filter with two reflectors can be considered two electrodes of a parallel capacitor. An electrode is fixed on the base, and the other is movable, as shown in Fig -2.

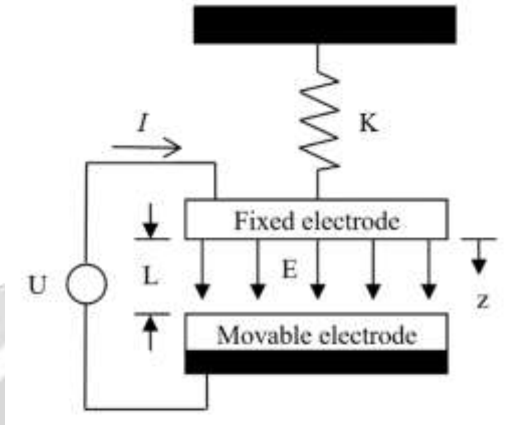


Fig -2: FP optical filter model in the form of two parallel electrodes

2.2. Adjust the distance between two electrodes

As shown in Fig. 2, the movable electrode is connected to a spring with the elastic force F_M, calculated as follows:

$$F_M = Kz \tag{1}$$

z - vertical displacement,

K – elastic coefficient of the spring.

The distance between the two electrodes depends on the elastic force F_M and the electromagnetic force. In order to produce electromagnetic force and to control the distance between these two electrodes, we use a DC power supply.

The electrostatic force F_E is opposite to the elastic force F_M. When the DC voltage is set to the two electrodes, the electrostatic force is determined:

$$F_E = -\frac{d}{dz}\left(\frac{1}{2}CU^2\right) = \frac{\varepsilon\ AU^2}{2(L-z)^2} \tag{2}$$

ε: Dielectric constant

C: Capacitance of the capacitor

A: The area between two electrodes

L: Initial air gap between two electrodes

U- Input voltage set to two electrodes

3. RESULTS AND EXPERIMENTS

Measure the actual displacement of the electrode in the FP optical filter, a white light interferometer made by Zygo company. In this paper, the spectra filtered by the FP were measured by the spectrum analyzer, version HR2000, made by Ocean Optics. The data measured by New View 5000 were analyzed by MetroPro software to produce the results of the measurements.

3.1.Theoretical calculations

The FP optical filter used in experiments has the parameters of this filter given in Table -1.

Table -1: Factual geometric parameters of an FP filter

Bragg reflector: SiO_2/Si_3N_4	9,5 layers
Central wavelength	650 nm
Resonance distance between two reflectors	325 nm

The relationship between the wavelength shift and tuning voltage can be described by equation (3):

$$U = L\sqrt{\frac{2k}{\varepsilon\ A\eta}\Delta\lambda} - \sqrt{\frac{2k}{\varepsilon\ A\eta^3}\Delta\lambda^3} \tag{3}$$

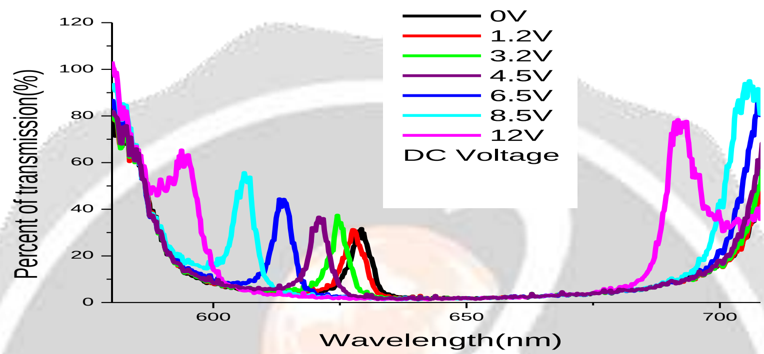
with:

ε – Dielectric constant
A- The area between two electrodes
η - wavelength shift efficiency
k – Elastic coefficient of the spring
L – Air gap between two electrodes

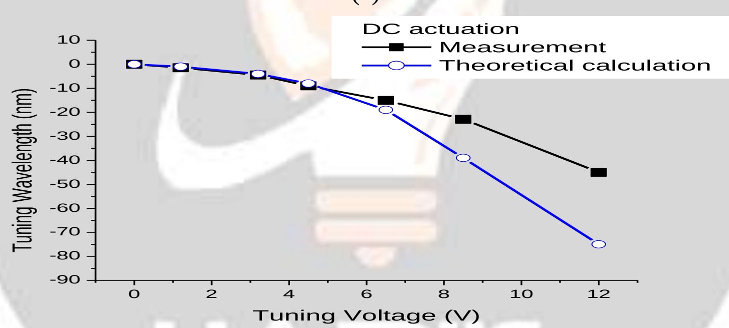
This theoretical result will be compared with experimental spectral measurements later to determine the similarity between them.

3.2. Two optical and mechanical properties

The spectrum obtained from the spectrometer and the movement of Bragg reflector obtained from the interferometer system are shown in Fig. -3.



(a)



(b)

Fig -3: The results of spectrum transmitted through the filter (a. Transmitted spectrum; b. Rate of change of the wavelength matched to the tuning voltages)

The actual displacement of the Bragg reflector when the tuning voltages are increased or decreased (0-19 and vice versa) is obtained from the interferometer system as shown in Fig. -4.

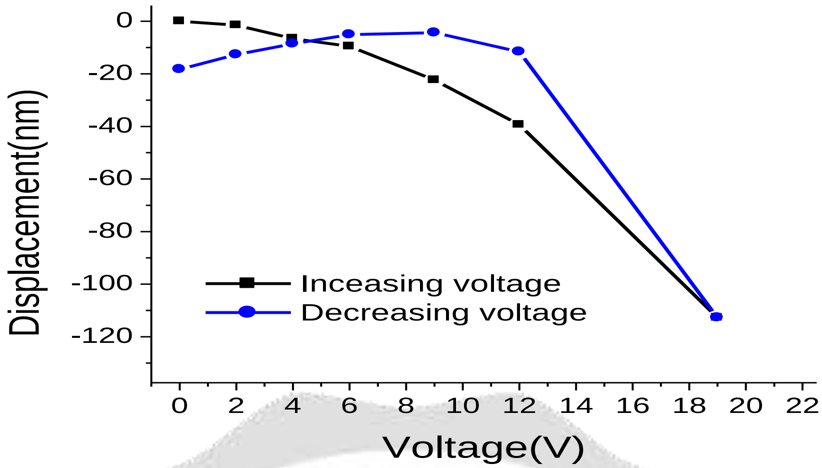


Fig -4: The displacement of the Bragg reflector

4. CONCLUSIONS

The results show that the spectrum transmitted through the filter is shifted from right to left as the voltage changes. When the voltage value varies from 0 to 12v, the filter covers a tuning range of spectrum of 34 nm and a 125 nm band gap. The relationship between the tuned voltages and the displaced wavelength is totally similar to the theory.

5. ACKNOWLEDGEMENT

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