Multiphysics Analysis of a Micromirror System

Nkorni Katte[1]
1. Department of Electrical Engineering, Wilberforce University, Wilberforce, OH, USA

INTRODUCTION: The challenge of our current research is to design large aperture MEMS scanning mirrors for Light Detection and Ranging (LIDAR) applications such as in unmanned driving or Unmanned Aerial Vehicle. The current MEMS scanning mirrors have a smaller aperture which limits application, it can only deflect light at small angles. In this research we show how to engineer new designs for MEMS mirrors with larger aperture to increase the deflection angle while also maintaining an optimal scanning rate.

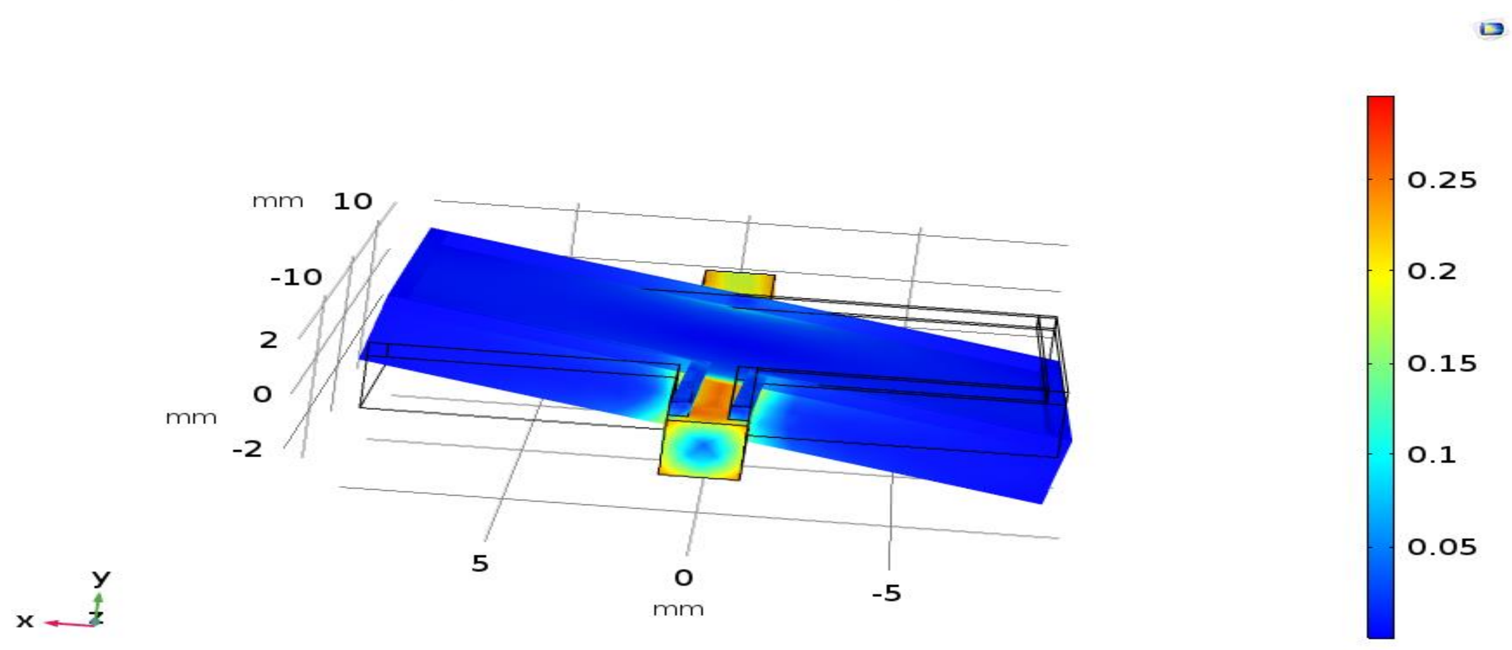

Figure 1. Deflection of micromirror under the action of electromagnetic forces

COMPUTATIONAL METHODS : An electric current is introduced in a coil which sits on the micromirror, in the presence of a magnetic field. This condition creates a Lorentz force ***F*** which will rotate the mirror about an axis.

$$\boldsymbol{F} = I\boldsymbol{L} \times \boldsymbol{B}$$

$$\nabla . \mathrm{S} + \boldsymbol{F}\boldsymbol{v} = 0$$

In the solving this coupled, where the electric currents setting is coupled with the Solid mechanics. A current density, normal to the surface of the Aluminum wire which forms a coil is used to create a body load force term that provides a torque which rotates the entire mirror.

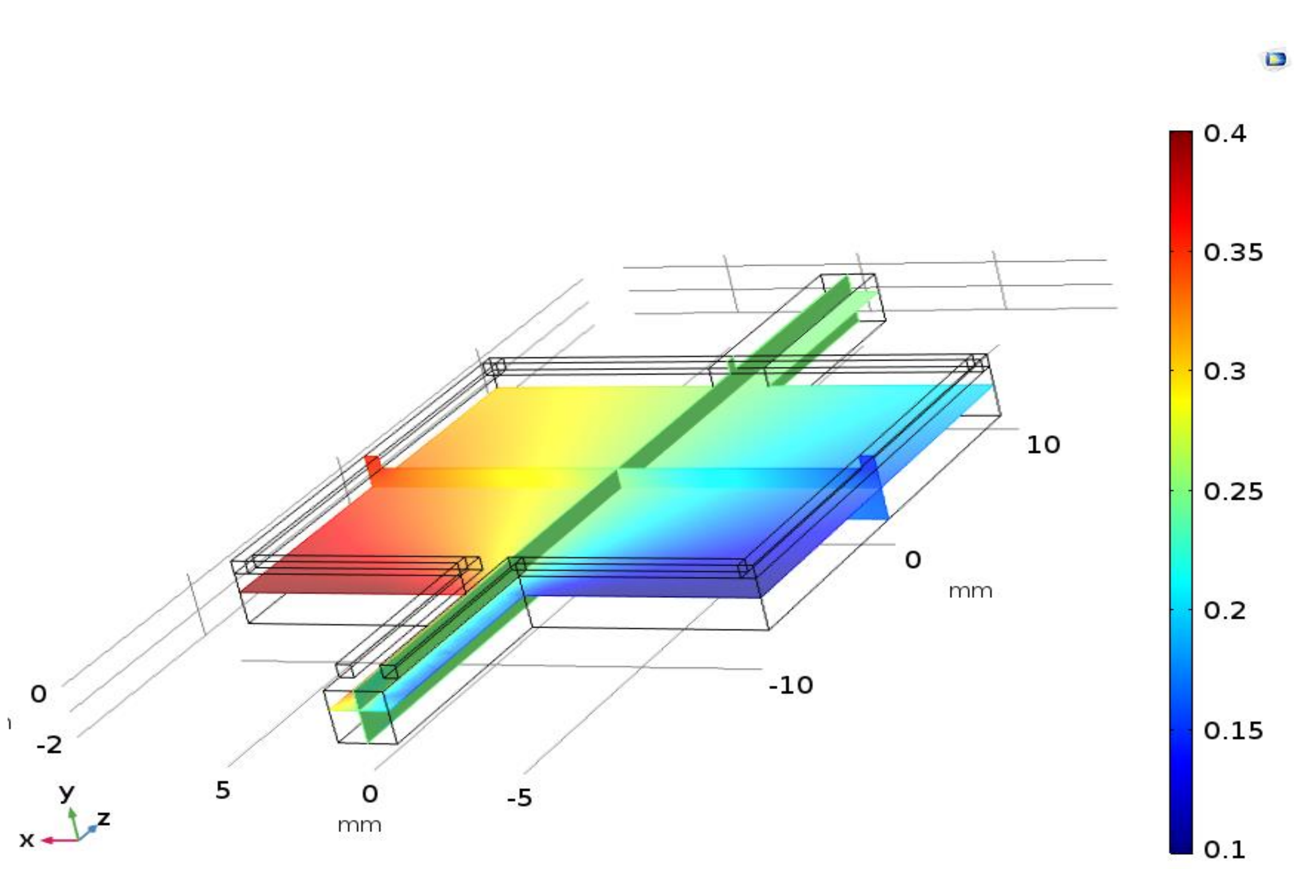

Figure 2. Electric Potential across Micromirror

The Magnetic flux density used was varied between 0.1-0.2T. For practical reasons these devices will also fail for high magnetic flux intensity and high electric current values

RESULTS: A Lorentz force is produced which rotates the mirror and the mirror deflects by some angle. The optical deflection angle is two times the mechanical deflection angle..

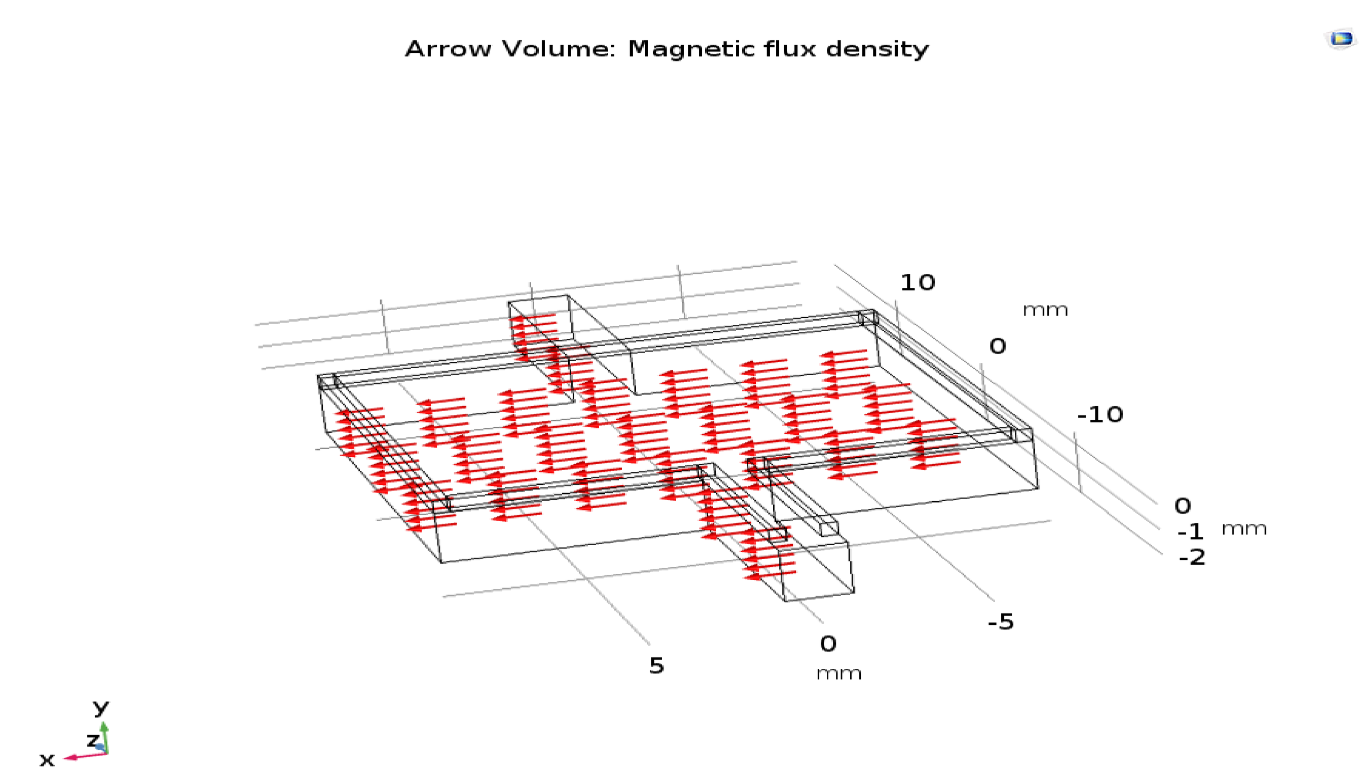

Figure 3. Magnetic flux density acting on the micromirror.

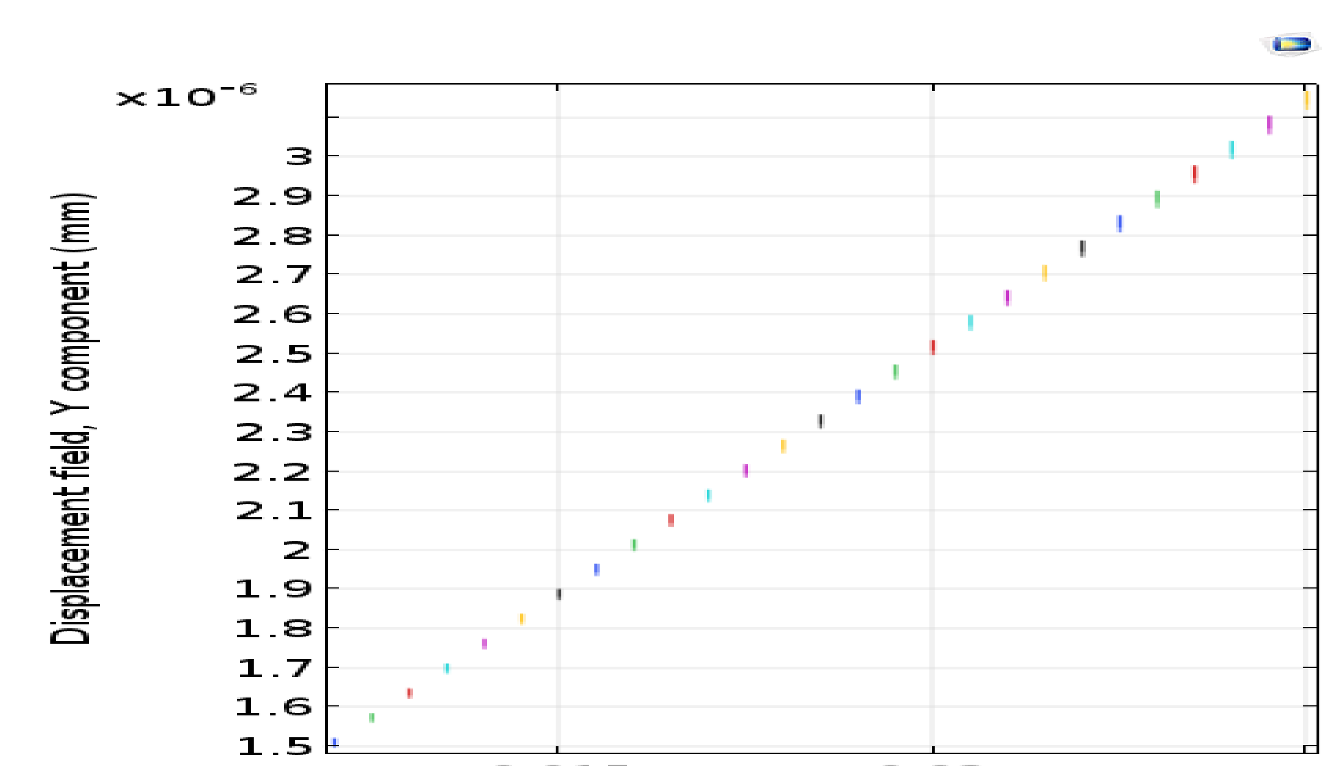

Figure 4. The y-displacement of the lower left edge of the micromirror was calculated as function of the current circulating in the aluminum coil above the mirror
The Current is increased to about 250mA.

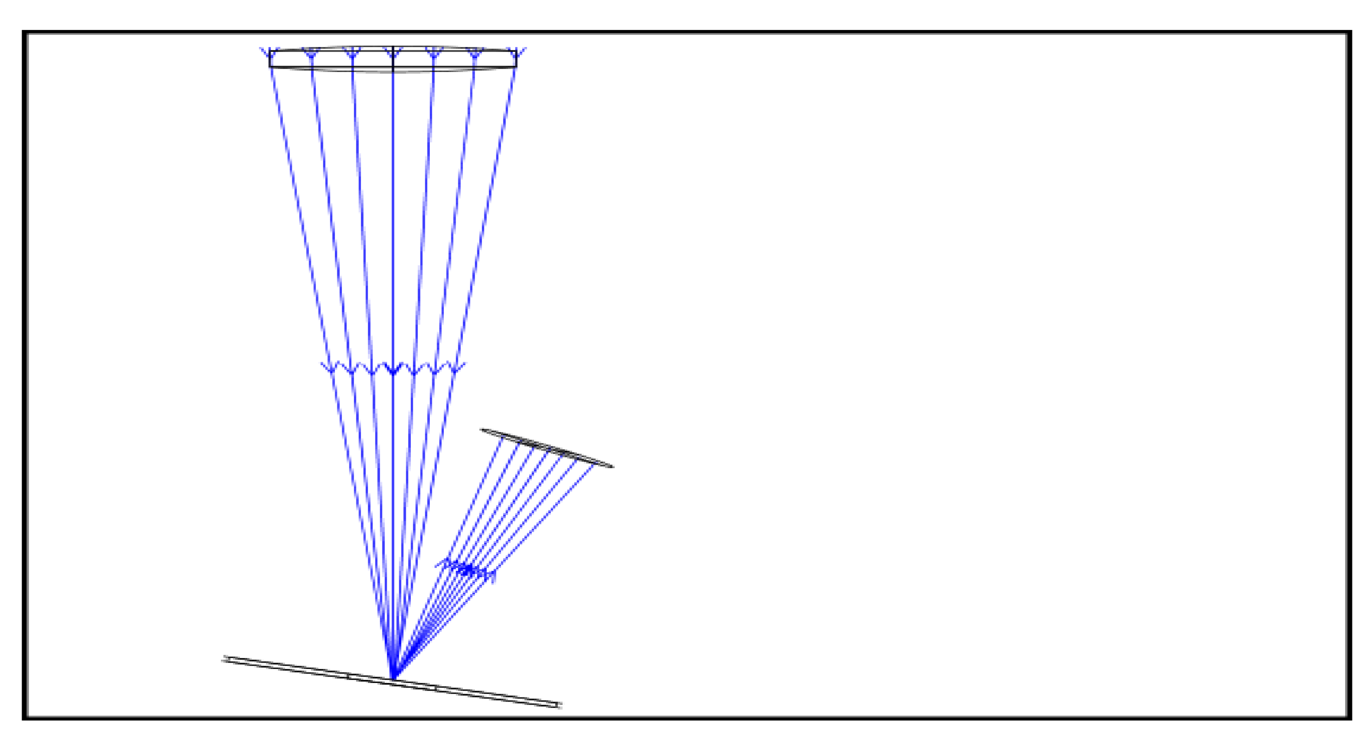

Figure 5. Reflection of light by a micromirror, after it has been deflected by Lorentz force. A 50mm lens is used to focus light at a mirror deflected by 12º. This Ray diagram was produced Optic studio Zemax software

CONCLUSIONS: This work demonstrates how larger Micromirrors needed for modern Lidar systems can be designed to function in a fully integrated environment. This work should be supplemented by experimental work in order to arrive at adequate conclusions. A material study should be performed in order to select the materials with the best mechanical and electrical properties. A Resonance study is also necessary to completely understand the mechanical oscillations of the mirror. A thermal study which examines, the heat deposited by the laser light and one due to electrical current in the loop will also be important. A much more critical study will examine a typical scenario in the presence of factors that contribute to EMI.

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