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Low Actuation Radio Frequency Micro Electro-Mechanical Shunt Switch

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Abstract— The research work has been done on RF MEMS Switch. High switching speed and very low actuation voltage switch is designed. The switch is designed on substrate of hafnium oxide material which has high dielectric constant. The serpentine flexures are added to provide switch higher flexibility. To get low actuation voltages, low switching speed and remove the problems of stiction ,by adding cylindrical perforation .The Fixed –Fixed RF MEMS switch is designed by adding perforation and supported with various shapes of meanders .The Fixed –Fixed RF MEMS switch is Shunt switch which is employ for high frequency application. The Proposed switch is provides low actuation voltage, high switching speed and remove fringing filed effect.

Keywords—fixed fixed beam; cylindrical perforation; actuation,; stiction; material

INTRODUCTION

MEMS are the Micro Electronic mechanical system or in general terms it is also known as Microelectronic mechanical switch. RF MEMS Switch is further divides in two categories of switch Shunt RF MEMS Switch and Series RF MEMS Switch. For low frequency application Series RF MEMS Switch is used i.e. Cantilever Beam while for high frequency application Shunt RF MEMS Switch is used i.e. Fixed-Fixed Beam. A beam which both anchors ends are fixed is known as Fixed-Fixed Beam [1]. RF MEMS switch is a probable substitute of PIN diode, varactor diode and the mechanical switches for RF applications due to its extremely a lesser amount of power consumption and enhanced high frequency performance [2]. This is due to their high electrical isolation, low insertion loss, excellent linearity, ultra wide band frequency, low noise performance and no bias current need [3]. The Radio Frequency MEMS switch design has been optimized through advance in beam design with serpentine flexures and perforated Fixed Foxed beam. The RF MEMS Switch model is designed and simulated it to measure spring constant of switch, pull in voltage and capacitance of switch. The concept of perforation is used to remove sacrificial layer and reduce effect fringing field. Its reduced switching time and also affects the capacitance of the switch [2]. RF MEMS switch have different actuation methods to represent their characteristics such as actuation method are electromagnetic, electrothermal , piezoelectric and electrostatic .Similarly it is classified on base of electrical configuration series and shunt and mechanical structures configuration as cantilever beam and fixed Fixed beam and flat by their material as metallic and carbon allotropes. These switches from a contact outlook are classified in capacitive contacts and DC contact. DC contacts are used for DC up to a few GHz applications. The stiction problem is created in between metal and metal due to increasing ohmic resistance in DC contact switch. This predicament can be shortening by using a lean layer of dielectric between the makes a capacitive contact and metallic contact layers [4].

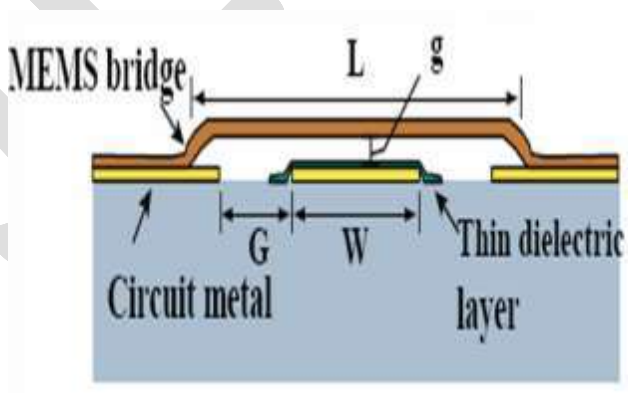

Fig.1 Fixed-Fixed Beam Structure

PRINCIPLE OF MEMS SWITCH

Micro electro mechanical switches work based on mechanical movement and electrical force both to attain ON state and OFF states. The Fixed-Fixed beam or shunt switch consists of a thin metal membrane perched over the center conductor of a Coplanar Waveguide (CPW) and fixed at both ends to the ground conductor by anchors. The center electrode provides RF capacitance and electrostatic actuation between the ground electrode and beam. The transmission line will not affect on signal when switch capacitance is low. The

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ellectostatic force is developed when dc voltage is applied between beam and electrodes. The developed electrostatic force and high capacitance attract the beam toward ground electrodes so that the membrane will change it position or deflect downwards by decreasing the gap height between electrodes. The increasing electrostatic pressure on the membrane gives more deflection. The membrane will pull down towards the core conductor with a convinced pull-down voltage and will make short circuit [5]

ELECTROSTATIC ACTUATION

The projected switch is used electrostatic actuation mechanism to design the membrane. As electrostatic actuation mechanism power dissipation is almost zero. The load of membrane shift towards the electrode and it has connected with meanders which bring lower down the spring constant *k*. The load of the voltage is spread on the beam due to ribs are around the edges of the membrane. The residual stress component can be discarded through computation due to the stiffness of the membrane. The actuation voltage V_{in} of a RF MEMS switch is given by [6-7].The switch relies on the elastic recovery force of flexures instead of the force of a membrane to pull it upwards, because the membrane is stiff around the edges [7]. Capacitive switches are two state capacitors. The distinctive switch is a metal bridge suspended above a Co-Planer Waveguide signal line with both ends of the bridge anchored to ground. The switch is snapped down when a voltage more than electrostatic pull-in voltage is applied between beam and electrode. In the down state incident signals are reflected due to the pattern of a low impedance path through the dielectric and the switch beam to ground. The stage of isolation depends on the relative value of the shunt impedance to the characteristic impedance of the transmission line [8].

CONTACT AND MATERIAL

The material for RF MEMS switch depends on properties of material as melting point, resistivity, hardness and process difficulty. The resistivity of a sputtered metal film is about twice its bulk resistivity. A various types of materials are available to be used in RF MEMS switches. Some of the most common materials used for both cantilever and fixed-fixed beam switches are gold, aluminum, platinum, molybdenum, nickel, and copper. [9]

DESIGN OF RF MEMS SWITCH

The Fixed- Fixed RF MEMS switch at both ends is fixed above free gap. The HfO_2 material have a assets of high dielectric constant as compare to other oxide materials .The Fig.2 shows the 3D structure of cylindrical perforated switch A. The dimension of beam is shown in Table.1. The serpentine flexures provide the greater flexibility and high switching speed which supported to join the ground electrode. As membrane width is increases then its decreases the efficiency of actuation switch which will effect on the maximum deflection [10]. The simulation is done by software in 3D axis geometry. When applied voltage reaching the pull-in Voltage levels the gap between ground electrode and beam reduced, collapses to zero thus it forms closed contact and used as a switch [11].

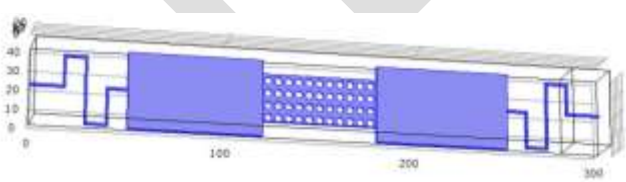

Fig.2 3D structure of switch A

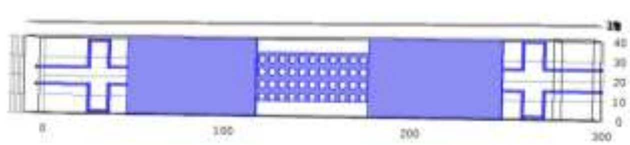

Fig.3 3D Structure of Switch B

SIMULATION OF RF MEMS SWITCH

The simulation is done by using COMSOL MULTIPHYSICS Software. The signal transmission of a switch is controlled by the capacitance value between the movable beam and the transmission line. When the applied electrostatic actuation voltage is zero, the movable beam is suspended over a CPW transmission line and the switch is in the on-state [12]. The pull in voltages of various switches have different . The 24.1 volt is maximum voltage or pull in voltage where it shows maximum deflection or maximum displacement of z- component. The cylindrical perforated MEMS switch with supported various meanders reduces squeeze film switching speed increases flexibility and damping. The maximum displacement of switch A is -0.0399 µm as shown in Fig.4. The Fig.5 represents the 3D structure of simulated switch B -0.1151 µm at 24.1 volt. The each geometry provides various displacements at applied voltage. The graph between capacitance and applied is shown in Fig.6 and Fig.7 respectively switch A and switch B.

DIMENSION OF SWITCH

Parameters	**Block-1**	**Block-2**	**Block-3**
Length	70 µm	90 µm	70 µm
Width	40 µm	25 µm	40 µm
Height	2µm	2 µm	2 µm

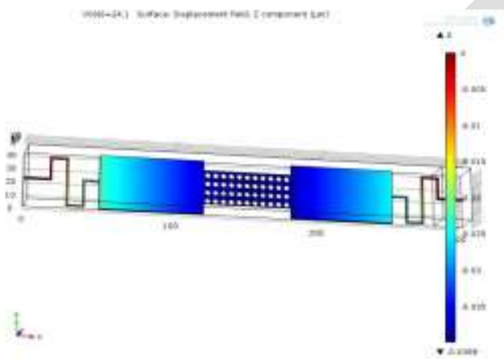

Fig. 4 Simulated Switch A at 24.1 volt

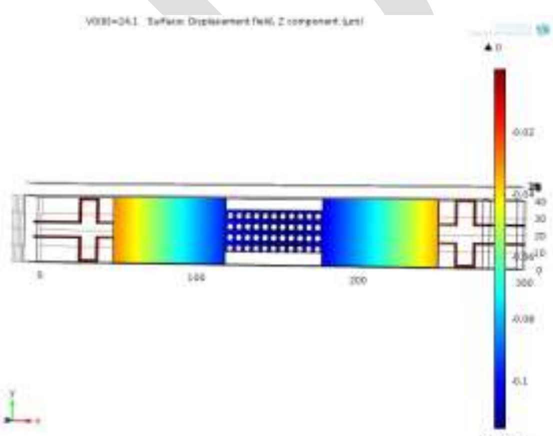

Fig.5 Simulated Switch B at 24.1 volt

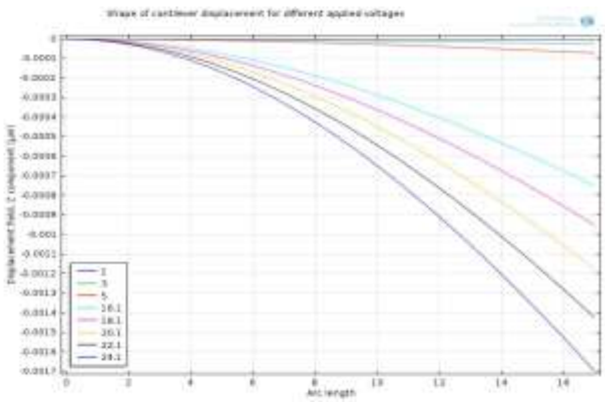

Fig. 6 Graphical representation of Switch A

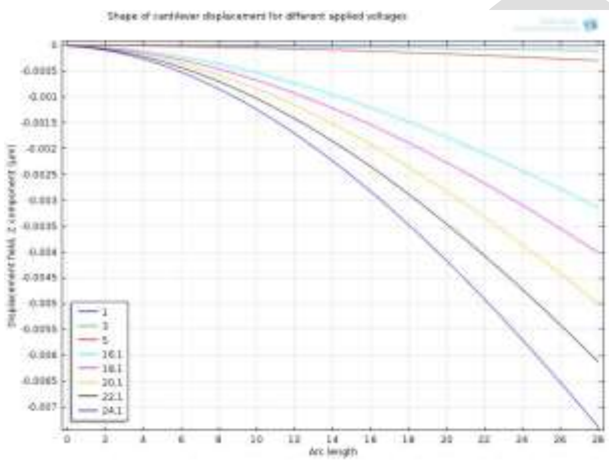

Fig.7 Graphical representation of Switch B

RESULT AND DISCUSSION

In Fixed- Fixed RF MEMS switch is designed to the reduce switching time, increases flexibility, increases switching speed and reduce power dissipation. The various types of supported meanders RF MEMS switches which provides different types of z component displacement at various applied voltages. The comparisons of switches are shown in the Table 2 The perforation increases the switching speed and reduces fringing fields.

APPLIED VOLTAGE WITH DISPLACEMENT

Voltage	**Switch A**	**Switch B**
1	6.7011e-5	0.1151
3	6.0329e-4	1.6168e-3

5	1.6769e-3	4.502e-3
16.1	0.0176	0.0485
18.1	0.0222	0.062
20.1	0.0275	0.0774
22.1	0.0334	0.0951
24.1	0.0399	0.1151

CONCLUSION

The two switches are designed and simulated both it. As result seen the switch B have provide large displacement at 24.1 so that switch is better for low power consumption application. The switch can be used for high frequency application.

REFERENCES:

1. Ankur Saxena, Vimal Kumar Agrawal "Comparative Study of Perforated RF MEMS Switch" Elsevier Procedia Computer Science 57 (2015) 139 – 145.
2. Koushik Guha, Mithlesh Kumar, Saurabh Agarwal, Srimanta Baishya "A modified capacitance model of RF MEMS shunt switch incorporating fringing field effects of perforated beam" Solid-State Electronics 114 (2015) 35–42.
3. Y. Mafinejad, A. Z. Kouzani , K. Mafinezhad H. Nabovatti, "Design and Simulation of a Low VoltageWide Band RF MEMS Switch"(IEEE International Conference on Systems, Man, and Cybernetics San Antonio, TX, USA - October 2009.
4. Yasser Mafinejad,, Majid Zarghami, and Abbas Z. Kouzani , "Design and Simulation of High Isolation RF MEMS Shunt Capacitor Switch for C-K Band" .
5. Haslina Jaafar, Othman Sidek, Azman Miskam and Shukri Korakkottil "Design and Simulation of Microelectromechanical System Capacitive Shunt Switches" American J. of Engineering and Applied Sciences 2 (4): 655-660, 2009 ISSN 1941-7020 © 2009 Science Publications
6. Ankur Saxena and Vimal Kumar Agrawal "Design & Simulation of low actuation voltage perforated RF MEMS switch" ICTACT journal on Microelectronic ,Febrauary 2015, volume: 01, Issue 01.
7. Tejinder Singh "Effective Stress Modeling of Membranes Made of Gold and Aluminum Materials Used in Radio-Frequency Micro electromechanical System Switches" Transactions on Electrical and Electronic Materials,Vol. 14, No. 4, pp. 172-176, August 25, 2013
8. Poonam verma & Surjeet singh " Design & Simulation of RF MEMS Capacitve type shunt switch & its major application " IOSR Journal of Electronics & Communication Engineering , volume4 Issue 5 ,pp 60-68.
9. M.Manivanan , R. Joseph Daniel and K. Sumangala " Low actuation voltage RF MEMS switch using varying section composite Fixed- Fixed beam" Hindawi publishing , Journal of Microwave science & Technlogy Vol. 2014.
10. S.Touati,N.Lorephelin,A.Kanciurzewski, R.Robin,A.S.Rollier,O.Millet,
11. K.Segueni "Low actuation Voltage Totally Free Flexible RF MEMS
12. Switch With Antistiction System" DTIP of MEMS& MOEMS ,April 2008.
13. P.K.Senthil kumar, R.Elavarasi, Paul Branieard Eladi and M.Gopalkrishnan "Pull in volatge Stuady of various structured cantilever and Fixed- Fixed beam models using COMSOL Multiphysics" Indian Journal of Science & Technology, Vol-4, July 2015.
14. Bandhra Mishra , Rajiv Panigrahi, Z.C.Alex " Highly Stablized MEMS Switch with Low Actuation Voltage" International Journal of Recent Trends in Enginering , Vol.2, 2009