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Design and modelling of High Sensitivity Dual Gate MOSFET Integrated MEMS Microphone

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Abstract: ***We proposed double gate (DG) design for microphone by using MEMS technology where diaphragm acts as the sliding gate of transistor and it is existed and used for some applications. The main purpose of using the dual gate (DG-MOSFET) is to integrated MEMS microphone. The analysis is to increase the electrical and mechanical sensitivity of MEMS microphone by using dual gate FET. In single gate we can improve the sensitivity's like electrical and mechanical but in designing they implemented only electrical sensitivity . We actualized a technique for expanding the general affectability of the receiver by expanding its electrical affectability. FET can be used to heighten the flag or to change over yield impedance .In subthreshold locale the channel current relies upon the distinction between entryway to source voltage and subthreshold voltage in the proposed mouthpiece.The design had made more reactive by including mechanical design to the main terminal .***

Index Terms: Microphone , FET field effective transistor, sensitivity, DG_MOSFET .

I. INTRODUCTION

High sensitivity amplifiers are the transducers that which can change over acoustic vitality into electrical vitality. A significant number of the transduction standards and inductions have been created, including the electrodynamic and piezoelectric the capacitive and to the contact receiver. Royer et al. is the one who displayed the main mouthpiece to be created utilizing silicon micromachining strategies in 1983. The silicon innovation permits precise control of the measurements and high level of scaling down and cluster creation of amplifiers requiring little to no effort, high dependability and with great reproducibility.

Microphone:

An amplifier is a sound electric changing over gadget. The plan of electret condenser receivers depends on the hypothesis that we use charging and releasing movement between electric limit channels. At the point when the Electro-plating reaction to the sound weight level, it changes the friction based electricity between the transmitters into electric flag specifically. At that point we can pick up a legitimate yield of impedance and affectability by the electrical circuit coupling. Omni-directional type has the same sensitivity at different angle at the same distance and uni-directional type can receive sound at particular angle and no sound is received from the back of receiving hole. Omni-directional microphones that can take sound with the equal gain from all sides or different directions of the microphone. That means weather the user speaks into microphone from the front, right, left, back side the microphone will record the signals with equal gain. The MEMS sensors are activated in characterization through optical and dielectric force gradient excitation techniques. In optical excitation LAZER beam was used and in dielectric force gradient scheme combination of A.C and D.C signals was used [14].The FEM simulation were performed for different structures and compared performance analysis for different parameters[15].

1.1 Polar Pattern of different types of microphone:

The three different types of polar patterns omnidirectional, unidirectional, noise cancelling.

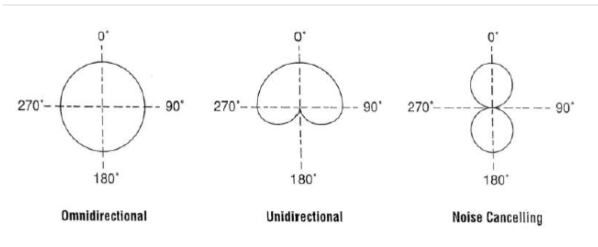

Fig 1: Polar Patterns of Microphone

1.2 SG and DG MOSFET:

Double Gate MOSFETs utilizing softly doped ultrathin layers is by all accounts promising alternative for extreme scaling of CMOS innovation. Fantastic short-channel impact (SCE) invulnerability, high Trans conductance, and impeccable sub limit factor have been represented by various theoretical and preliminary considers on this device. This structure utilizes a thin body to murder sub-surface spillage ways between the source and channel, what's more, along these lines gives excellent undoped body is attractive to resistance against dopant fluctuation effects which offer ascent to

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limit voltage variety, and furthermore for diminished channel to-body capacitance and higher carrier portability which accommodate improved circuit execution. The edge voltage of a delicately doped DGMOSFET is can be balanced by tuning the work capacity of the door material.The structure includes a flexible diaphragm which diverts because of the occurrence sound effect, there by changing and the air distance between the moving gate terminal and the fixed substrate. The adjustment in the hole changes the channel current which shapes the sensor reaction. For a consistent vgs <vt, when the hole changes, the V changes and this prompts an adjustment in channel current. The back voltage is accepted zero and the source is thought to be grounded in the examination.

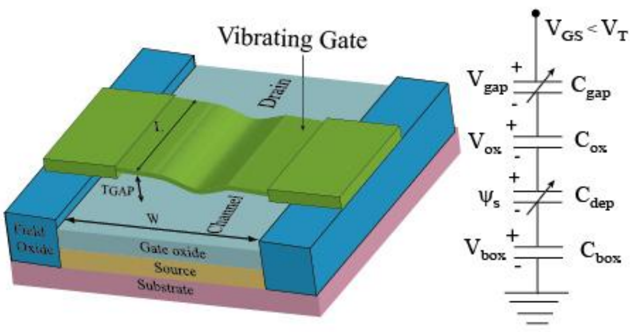

Fig: 2 3D Design for single gate(SG-FET) MEMS microphone

1.3 Simulation and design of single gate :

In this we have designed single gate and dual gate FET integrated MEMS microphone in the software named comsol. In this all the dimensions are in micro meters . Generally, FET consists of source, drain and gate terminals.

This consists of substrate, source and gate oxide these are placed one on another in particular dimensions. Both the sides of substrate have field oxide and at the top of we kept gate

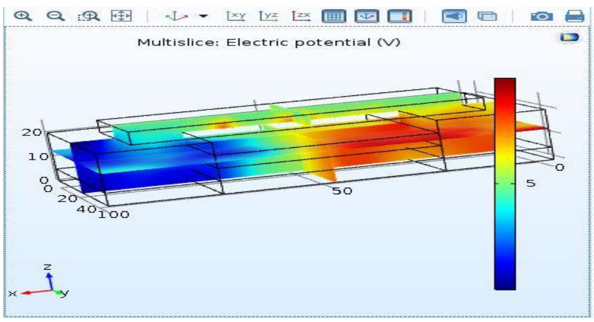

Fig: 3 SG-MOSFET at 5V

Fig: 3 represents the 3D structure of single gate(SG).The length of substrate is 100, width 50 and height 35.And at the top we have vibrating gate when we apply the voltage on gate we can see that the voltage is passing to the entire circuit by this we can not observe how much amount of voltage is dividing for gate and for source .So we went for dual gate FET integrated MEMS microphone. This accommodates an inbuilt intensification in the sensor reaction. The talked about strategy makes the receiver delicate to little redirections, of the request of sub micrometers, for the diaphram. The sensor dependably worked in completely exhausted condition by realizing that the silicon film thickness is not exactly most extreme consumption width.

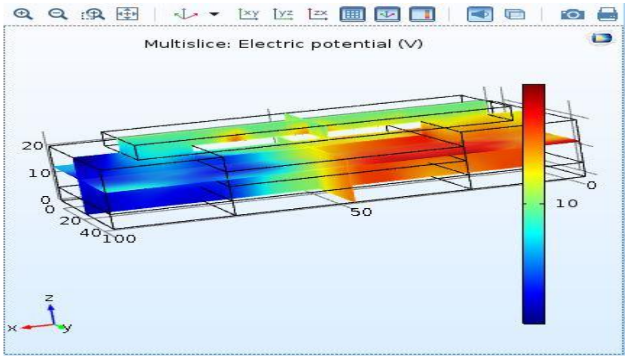

Fig: 4 SG-MOSFET at 10 V

In this we can identify that voltage applied is 10V at gate and total is supplied to the blocks but we can not identify how much amount is send for gate and for source .

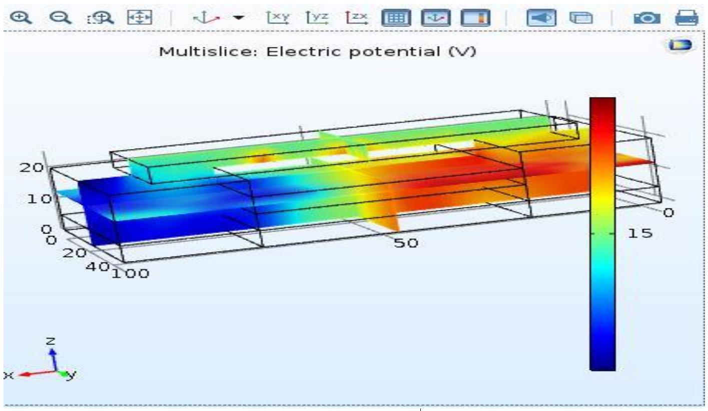

Fig: 5 SG _MOSFET at 15V

The materials used for substrate is single crystal silicon and same for source and gate oxide. Polycrystalline material is used for field oxide and silicon oxide for field oxide.

1.4 parameters for silicon:

Property	Name	Value	Unit
Relative Permittivity	Epsionr	11.7	1
Coefficient of thermal expansion	Alpha	2.6e-6{1..	1/k
Heat capacity of thermal expansion	Cp	700[j/k.]	(j/kg.k)
Density	Rho	2329[kg]	Kg/m^3
Thermal Conductivity	K	130	W/(m)
Young's modulus	E	170e9[Pa]	Pa
Poisson's ratio	nu	0.28	1

Table (A) Single Crystal Silicon parameters

These are the results for SG-MOSFET we can identify that voltage can pass to entire circuit .

II. ARCHITECTURE AND DESIGN

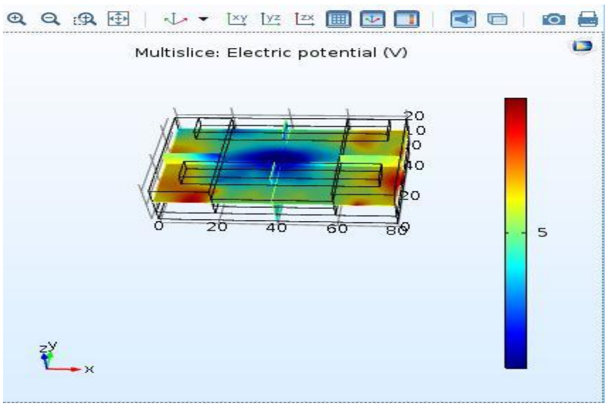

Fig: 6 DG –MOSFET at 5V

Dual Gate MOSFETs' are the type of MOSFET having two gates - they can be used to provide additional isolation between drain and gate. The common mode of operation is to switch both the gates simultaneously and lightly doped channel of dual gate shows in a negligible depletion charge. In this we can identify that the less amount of voltage is applied to the structure but there is no change when compared to single gate(SG) and dual gate (DG-MOSFET).Because the minimum amount of voltage should be applied to the structure. But in dual gate the voltage must be divide to the every block that means every block is having minimum requirement of voltage.

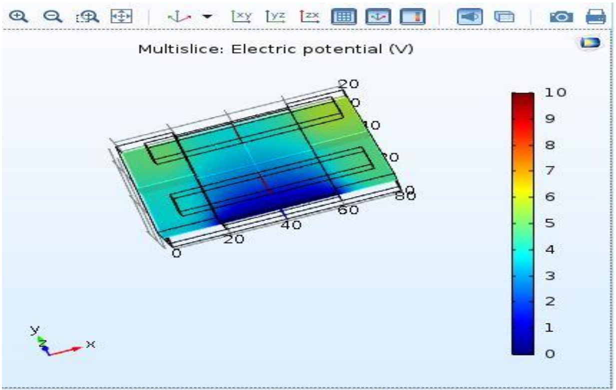

Fig: 7 DG –MOSFET at 10V

In this structure the voltage supplied is 10V among this the required amount is sent to the different blocks .By this we can see that the total voltage supplied is getting utilized efficiently.

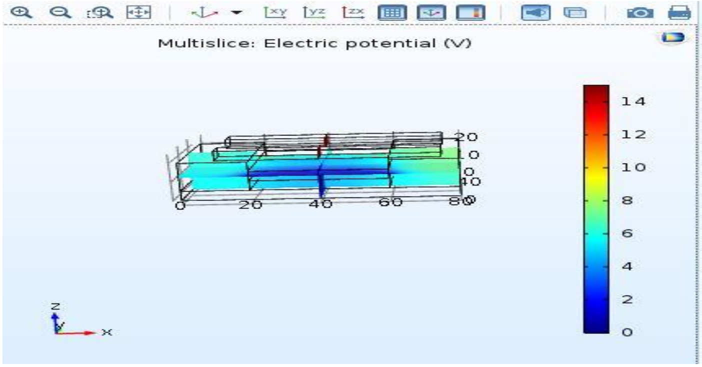

Fig: 8 DG –MOSFET at 14V

Property	Name	Value	Unit
Relative Permittivity	Epsionr	4.5	1
Coefficient of thermal expansion	Alpha	2.6e-6{1..	1/k
Heat capacity of thermal expansion	Cp	678[j/k]	(j/kg.k)
Density	Rho	2320[kg]	Kg/m^3
Thermal Conductivity	K	34[W]	W/(m)
Young's modulus	E	160e9[pa]	Pa
Poisson's ratio	nu	0.22	1

Table (B) Single Crystal Silicon parameters

These are the values for single crystal silicon by default as we want specifiy we can enter manually.

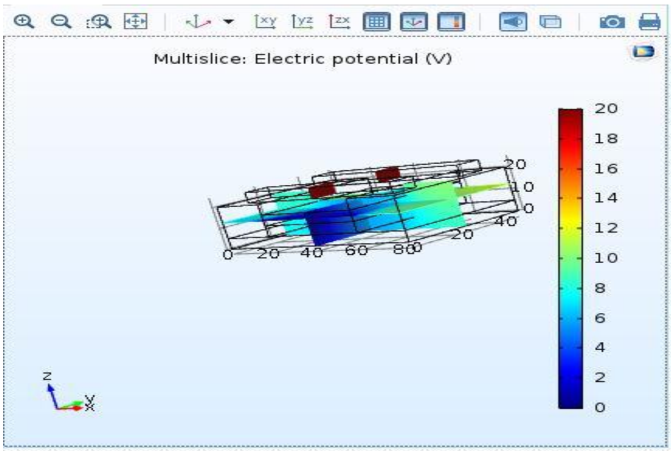

Fig : 9 DG –MOSFET at 20V

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III. SIMULATION AND MEASURED RESULTS

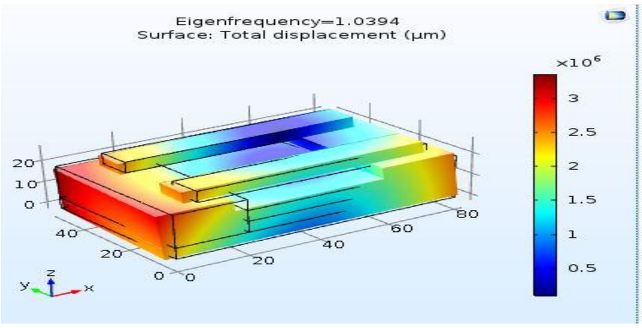

Fig: 10 Dual Gate at Load 0

Fig: 10 represents DGMOSFET that is designed using three materials viz. single crystal silicon, silicon oxide and polycrystalline.various loads (0-16) are applied to gate terminal which causes rapid voltage deviations there by enhancing the variation in eigen frequency and resulting in hgher frequency .

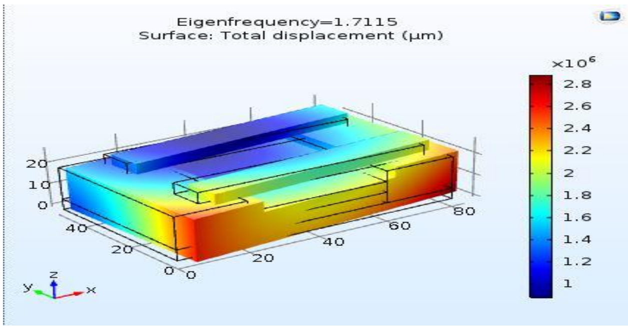

Fig: 11 Dual Gate at Load 10

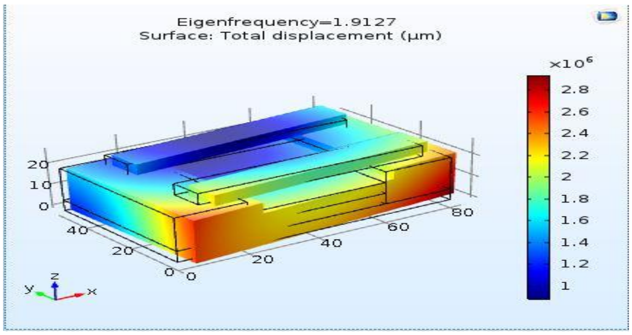

Fig: 12 Dual Gate at Load 14

A load of 14 is applied eventually that which is represented in Fig:12. A peak Eigen value of 1.9127 is obtained when the load applied is 14 .Further increment of load i.e.alters the Eigen value to a lower value of 1.2

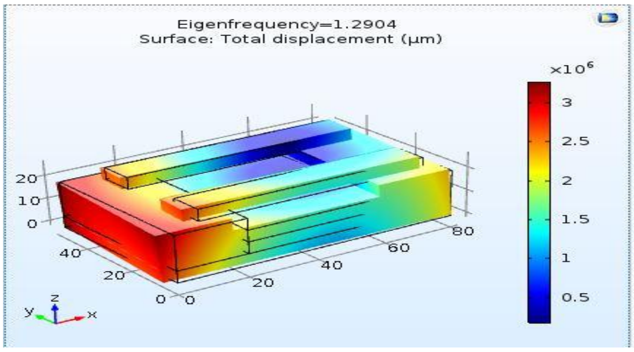

Fig: 13 Dual Gate at Load 16

Property	Name	Value	Unit
Relative Permittivity	Epson	4.2	1
Electrical conductivity	sigma	0[S/m]	s/m
Coefficient of thermal expansions	Alpha	.	1/k
Heat capacity of thermal	Cp	730[j4/k]	(j/kg.k)
Density	Rho	2200[kg]	Kg/m^3
Thermal Conductivity	K	1.4[W]	W/(m)
Young's modulus	E	70e9[pa]	Pa
Poisson's ratio	nu	0.17	1

Table (C) Silicon oxide parameters

Applied Load	Eigen Frequency	Total Displacement
0	1.0394	$3*10^6$
2	1.044	$3*10^6$
4	1.6327	$3*10^6$
10	1.7115	$2.8*10^6$
12	1.8949	$2.8*10^6$
14	1.9127	$2.8*10^6$
16	1.2904	$2.8*10^6$

Table (D) Values of Load,Eigen Freq and Displacement

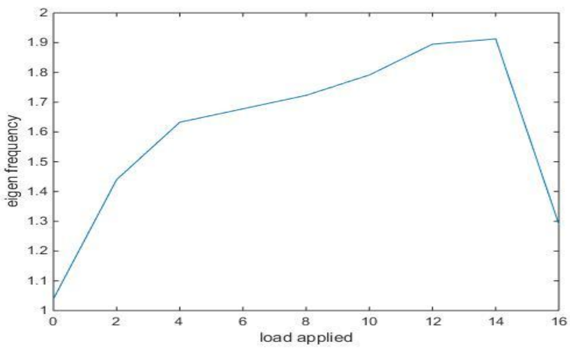

Fig: 14 Load vs Eigen Frequency

Applied Load	Eigen Frequency	Total Displacement
0	1.0394	$3*10^6$
2	1.044	$3*10^6$
4	1.6327	$3*10^6$

10	1.7115	$2.8*10^6$
12	1.8949	$2.8*10^6$
14	1.9127	$2.8*10^6$
16	1.2904	$2.8*10^6$

Table (E) Values of Load,Eigen Freq and Displacement

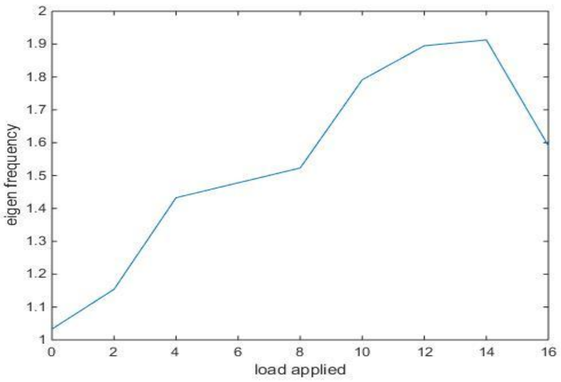

Fig: 15 Dual Gate at Load 14

IV. CONCLUSION

The proposed Dual Gate MOSFET(DG-MOSFET) is designed using single crystal silicon, polycrystalline and silicon oxide. This entire design is done using COMSOL software in the range of micrometers. Simulation work is carried out and values mentioning applied load ,Eigen Frequency's' are obtained and are tabulated in Table(D).A Graph indicating applied vs Eigen Frequency is drawn that is shown in Fig: 14.As the load increases 0-14,it is observed that frequency is increased there by effecting the sensitivity. Frequency gets reduced when peak load is applied. The sub edge one-sided DGFET based MEMS receiver was structured and its execution is reproduced. Here we can observe that frequency increases so that the electrical and mechanical sensitivity of dual gate is high and its reliability is high. The electrical and mechanical sensitivity be tuned by using a few elements like initial air gap and silicon thickness.

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