Reliability Characterization of MEMS Cantilever Switch

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Research Project at Indian Institute of Technology Bombay under Indian Nanoelectronics User Program (INUP) sponsored by DIT, MCIT Government of India.

2012-14

1. Introduction

Microcantilever switches have demonstrated superior characteristics compared to FET and diode based structures. The long-term reliability of microcantilever switches is of major concern and is currently the subject of investigation. One of the factors limiting implementation of MEMS switches is the limited switch lifetime. Several problems reported to affect the lifetime of MEMS switches are creep in the metal cantilever , distortion in the nominal air gap, stiction of the metal membrane to the dielectric layer is major cause of failure. It depends on dielectric charging that evolves the concept of charge tunneling into the dielectric which in term affect the actuation voltage of the switch. The performance of the switch is affected by surface roughness of the deposited dielectric due to which the nominal air gap height get distorted so the on/off capacitance ratio degrades and the pull-down voltage increases. To study all these effects, fabrication and characterization of Metal-Insulator- Metal capacitor(MIM) test structure is carried out followed by the microcantilever fabrication.

2. Characterization of MIM test structure

A. Physical

Type of Film	Scan Area	RMS Roughness
HWCVD 100 °C Deposition	3µm	4.495 nm
HWCVD 200 °C Deposition	3µm	7.603 nm
HWCVD 300 °C Deposition	3µm	10.136 nm
ICPCVD Room Temp Deposition	5µm	4.458 nm

Table 1. Effect of Deposition conditions on the value of surface roughness

B. Electrical

Sr. No.	Type of Film	Breakdown Voltage (V)
1	HWCVD 300 °C Deposition	21V
2	HWCVD 200 °C Deposition	26V
3	HWCVD 100 °C Deposition	29V
4	ICPCVD Room Temp Deposition	37V

Fig. 3. . Breakdown Voltage for HWCVD and ICPCVD films

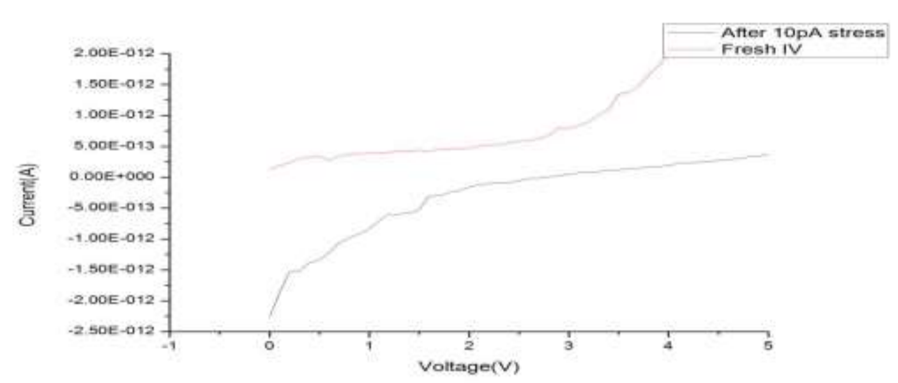

Fig. 2. Constant Current Stress and Corresponding IV shift.

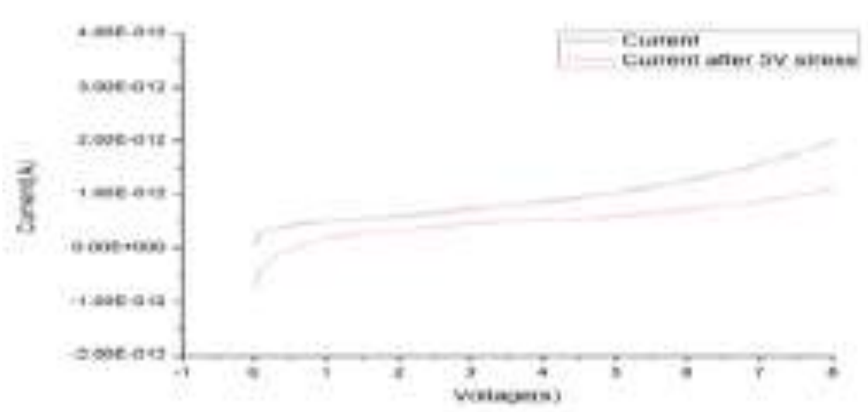

Fig. 5. Constant voltage stress and corresponding I-V Shift

PG students Associated: Mrs. Pallavi Shahapurkar, Mr. Nikhil Mule, Mr. Deepak Khushlani, Miss Divya Shrivastava , Mr. Vaibhav Dubey and Mr. Pratik Bheley

3. Fabrication Of Microcantilever Switch

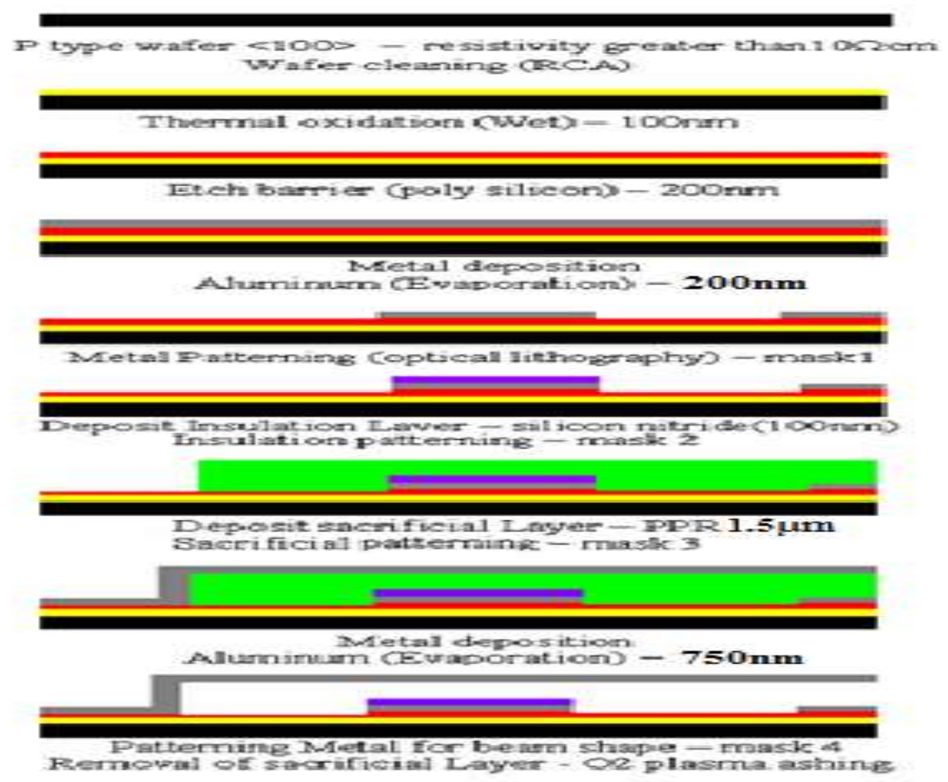

Fig. 4. Fabrication Process Flow.

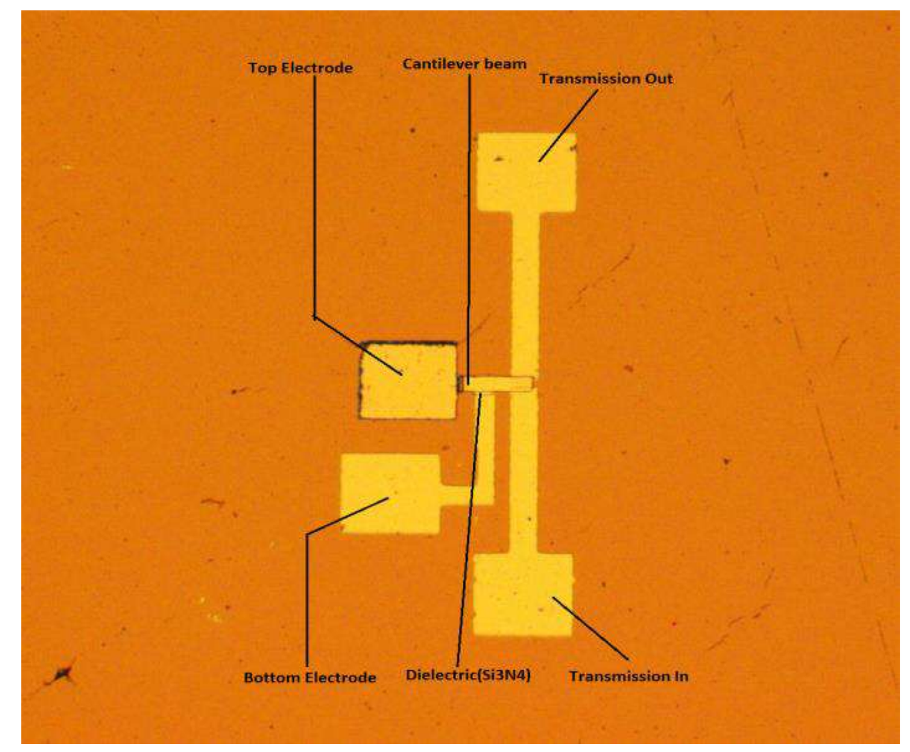

Fig. 4. MEMS cantilever switch

4. Electrical Characterization Of Microcantilever Switch

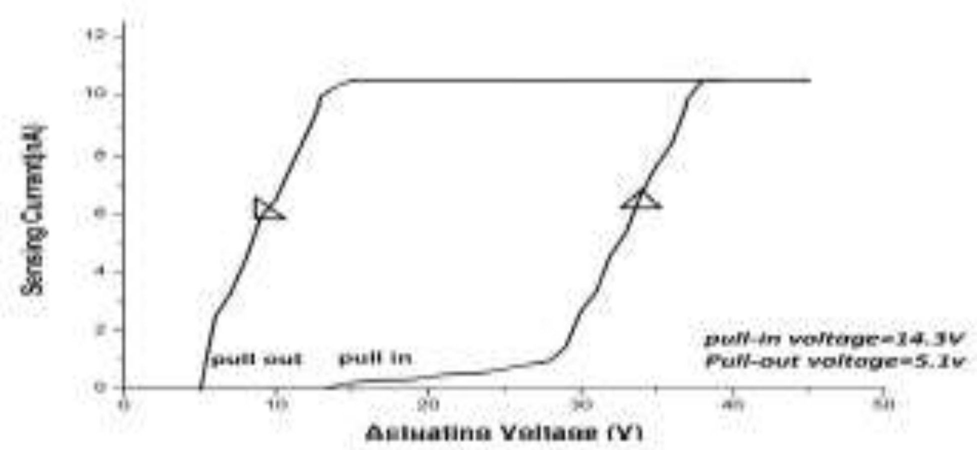

Fig. 6. CV characteristics of MEMS cantilever switch.

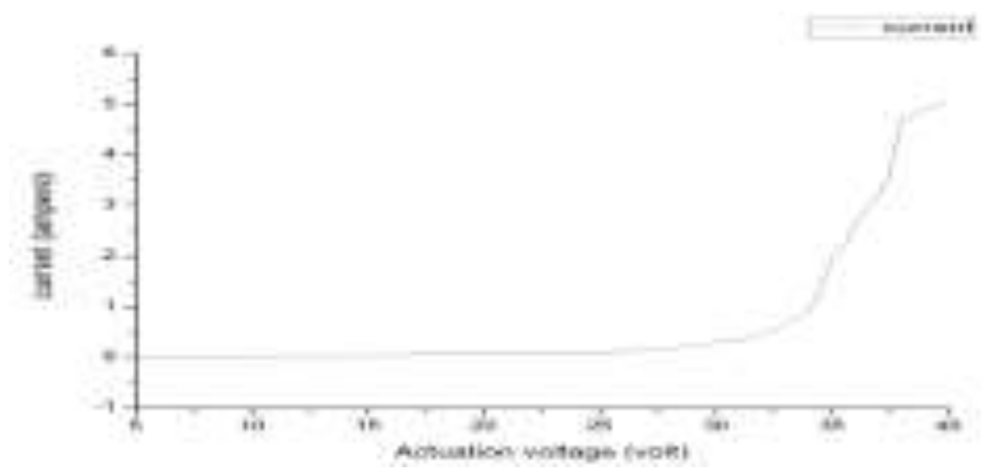

Fig. 7. CV characterization between the transmission pad and actuation voltage

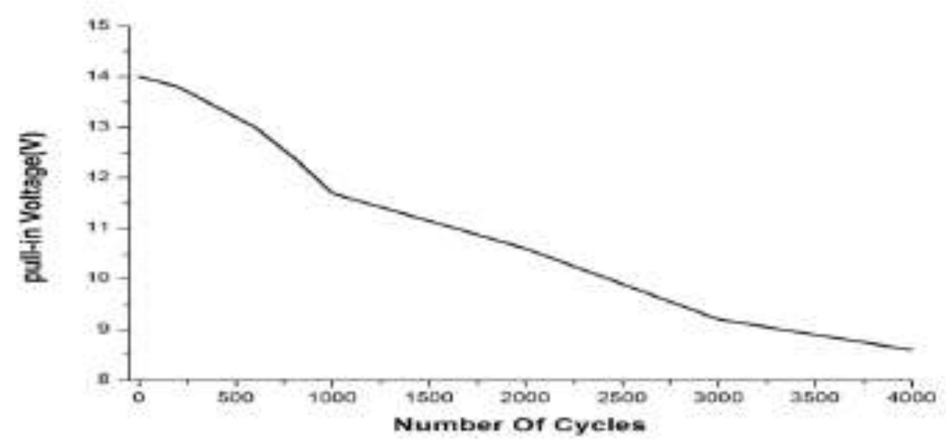

Fig. 9. Pull-in voltage v/s No. of Cycles

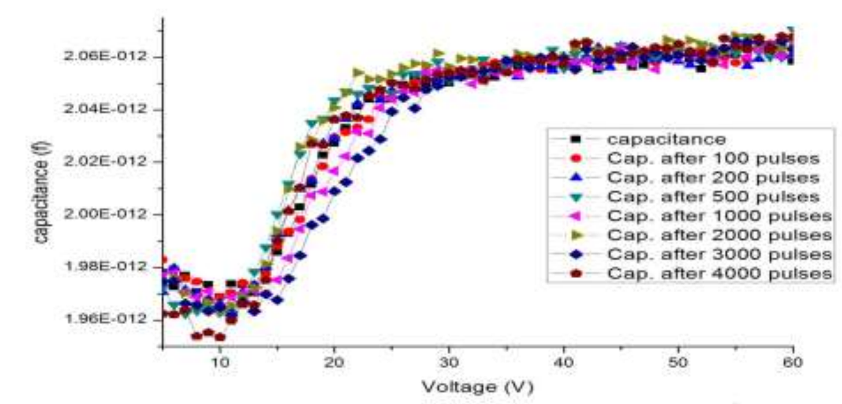

Fig. 8. CV after pulses

Conclusion

In this project, MIM capacitor structure is fabricated with same electrode and dielectric material as that of switch deposited using HWCVD and ICPCVD Methods to study the effect of deposition condition on physical and electrical characterization of the switch. Atomic Force Microscopy show that the ICPCVD films has more uniform surface than HWCVD films. ICPCVD films shows low leakage, high breakdown and considerable performance after stressing. The fabrication of microcantilever switch is done by considering the background of experimental observations in Test structure. Electrical characterization of device shows expected functionality of switch.

Acknowledgement: Centre for Excellence In Nanoelectronics And Nanoelectronics Device Characterization Laboratory (IITB, Powai, Mumbai)