Investigation of Dependence of Dielectric Charging on Thickness of Dielectric Layer (Q1 2008 Report)

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During this period a variety of capacitive RF MEMS switches and MIM capacitors were fabricated in order to characterize the dielectric charging effect. The thickness of the SixNy dielectric layer was varied from 200 nm to 500 nm. Figure 1 shows pictures of some of the Georgia Tech fabricated MEMS switches where the membrane consists of gold material.

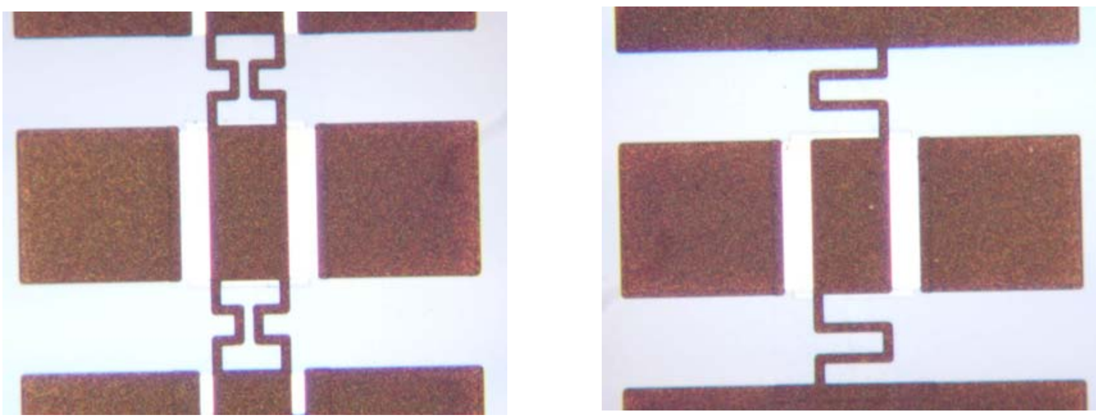

Fig. 1 l) Double meander RF MEMS switch with Au plated membrane and r) single-menader RF MEMS switch with gold plated membrane.

The MIM capacitors were characterized using the Thermally Stimulated Depolarization Current (TSDC) technique and a typical measurement for a SixNy dielectric is shown in Fig. 2.

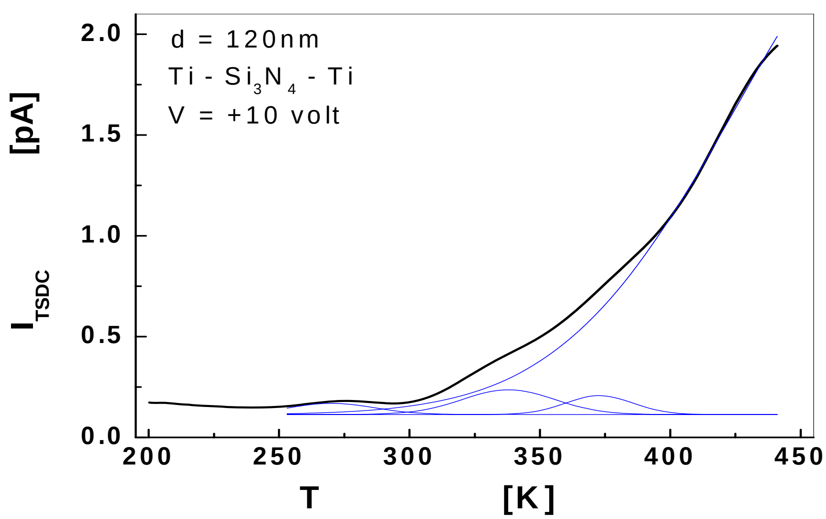

Fig. 2 TSDC measurement for MIM capacitors with Au-nitride-Au.

RF MEMS switches (Fig. 1l) with the same deposition parameters for the nitride dielectric and various thicknesses were also measured in terms of the C-V characteristic at various temperatures. Fig. 3a shows the C-V characrteristic of such a switch for a descending voltage cycle at 450K, and Fig. 3b shows the variation of Vmin (voltage where min capacitance is observed during the C-V measurement) over temperature. These measuremetns were performed for switches with two different nitride thicknesses: 200 nm and 430 nm.

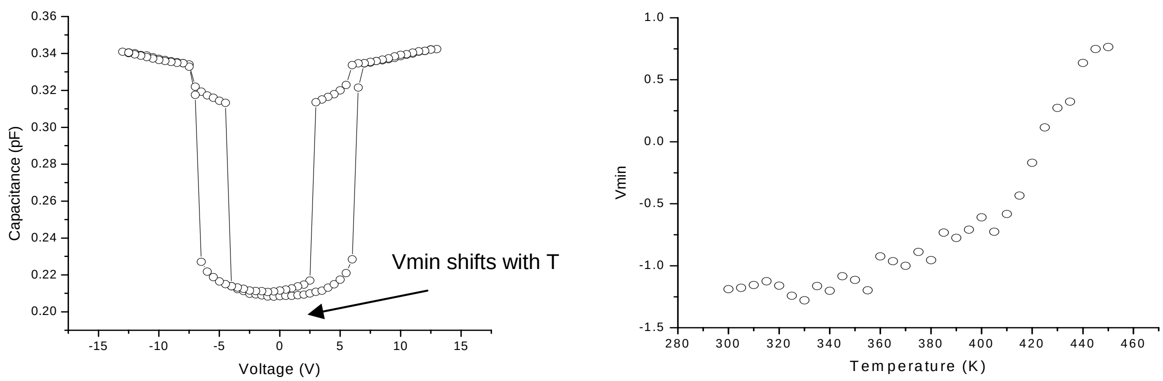

Fig. 3 l) C-V measured data for GT MEMS switch at 445K and r) Vmin vs. temperature variation.

Fig. 4a shows the charge for the MIM capacitors with varying dielectric thickness, indicating an increase in charge with thickness following a square root law. Fig. 4b shows the Vmin vs. temperature variation for MEMS switches with two different dielectric thicknesses. It can be observed that for the thicker nitride the slope of the curve-fitted data is larger than that of the thinner material indicating more charging for the MEMS switch also. The MEMS results agree very well with the MIM ones.

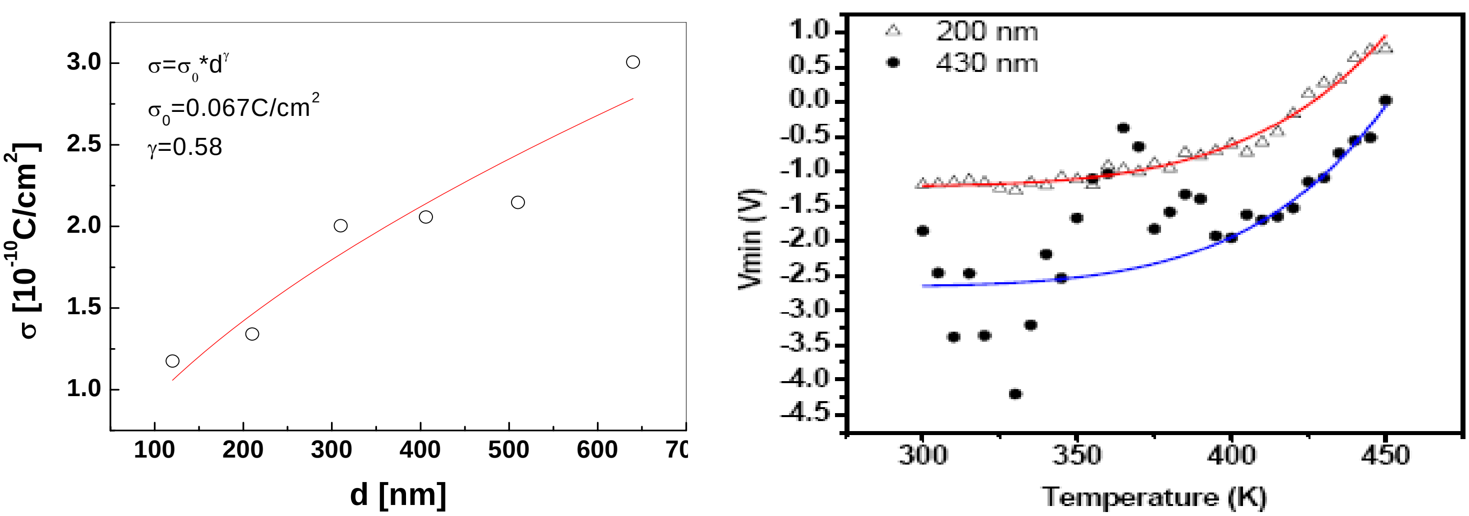

Fig. 4 l) Charge vs. nitride thickness for MIM capacitors and r) Vmin vs. temperature variation for GT switches with 2 different nitride thicknesses.

Similar measurements were performed for MEMtronics switches that consist of oxide dielectric and Aluminum membrane material. Some sample results are shown in Fig. 5. Fig. 6 summarizes the pull-in and pull-out window vs. temperature for the MEMtronics switches indicating an inflection point. The latter is still being investigated. Finally, Raytheon switches with nitride dielectric and Aluminum membrane were also characterized with C-V measurements over temperature. Fig. 7 summarizes the Vmin vs. temperature results for the Raytheon and Memtronics switches. The latter show the least amount of change indicating small dielectric charging, whereas the Raytheon switches show a larger variation indicating more charging. An additional systematic experimental characterization will be performed in the next quarter where the measured C-V data will be mapped to specific nitride deposition conditions.

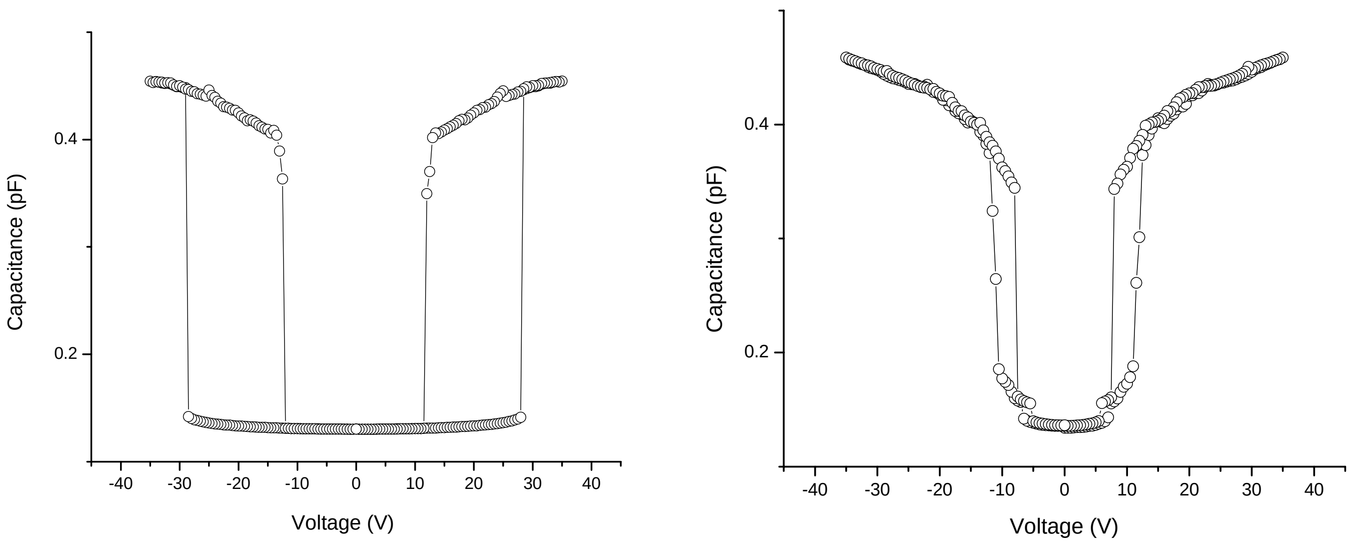

Fig. 5 C-V characteristic of Memtronics switches measured at: l) 300 K and r) 420 K.

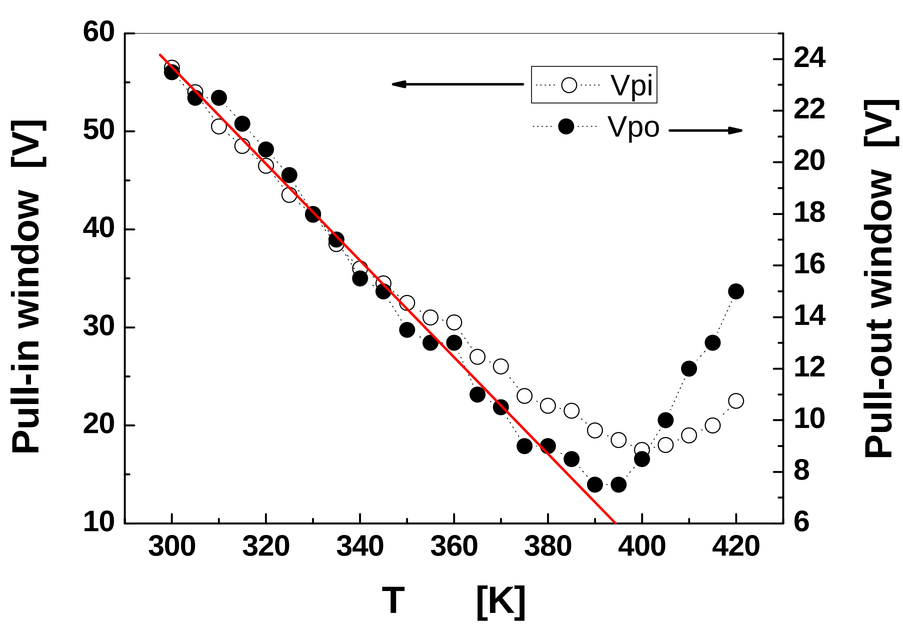

Fig. 6 Pull-in and Pull-out window of Memtronics switches vs. temperature

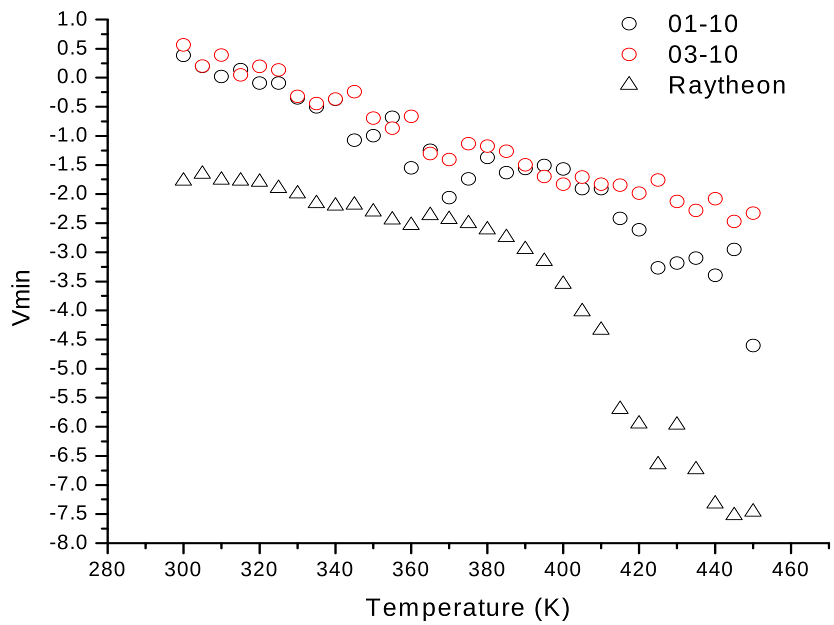

Fig. 7 Vmin change over temperature for Memtronics and Raytheon MEMS switches.