RF-MEMS performance and reliability
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Dielectric charging model
Injection: \[ J_\text{in} = A_n (N - n_i) \]
Leakage: \[ J_{\text{out}} = A_{0,w} n_i \]
Emission: \[ J_e = A_e n_i \]

Trapping Occupancy:
\[ n_t(x,t) = \frac{A_0 w(x)}{A_{0,w}(x)} \left( 1 - \exp\left( -\frac{t}{q A_{0,w}(x)} \right) \right) \]

Steady state leakage:
\[ J_s = \sum_i A_n(x) \frac{A_{0,w}(x)}{A_{0,w}(x)} \exp\left( -\frac{t}{q A_{0,w}(x)} \right) \]

Model for charge injection and current leakage through thick and defect-filled dielectrics has been developed.
Results from analytical calculations has been matched with numerical simulations.
Analytical model provides useful insight into various charge transport mechanisms.

Compact model and lifetime prediction

Performance:
\[ V_{\text{PI}}(0) = \frac{483 E L^2}{27 W L e_i} \]
\[ V_{\text{PO}}(0) = \frac{233 E L^2}{27 W L e_i} \]

Dynamics:
\[ v_{\text{PI}} = \frac{y_{\text{PI}}}{V_{\text{PI}}} \]
\[ v_{\text{PO}} = \frac{y_{\text{PO}}}{V_{\text{PO}}} \]

Reliability:
\[ n_t(x,t) = \frac{A_n(x)}{A_{0,w}(x)} \left( 1 - \exp\left( -\frac{t}{q A_{0,w}(x)} \right) \right) \]
\[ V_{\text{PI}}(t) = V_{\text{PI}}(0) - \frac{q x_{\text{PI}}(t,x,t) dx}{e_i e_o} \]

Compact model allows us to estimate both the performance and life time of the switch very quickly.

Dielectric parameter extraction

DFT simulations:

Current transients are used to extract dielectric electronic parameters, which are necessary to estimate device lifetime. Trap depths are estimated using DFT calculations. Other parameters are obtained from least-square fitting.

UQ and sensitivity analysis

Sensitivity defined as:
\[ S(t,O) = \frac{O_{\text{max}} - O_{\text{min}}}{O_{\text{org}}} \times \left| \frac{t_{\text{max}} - t_{\text{min}}}{t_{\text{org}}} \right| \]
Membrane length, membrane width, trap depth, barrier height and effective mass are determined to be the most important parameters affecting performance and lifetime.

Sensitivity studies reveal useful information for device designers towards optimization of process parameters for reducing device variability.