Experimental Results of Creep Measurement
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The typical creep curve has 3 stages, namely primary creep, secondary creep, and tertiary creep. The primary creep can be characterized by a monotonic decrease in the rate of creep. The initial strain $\varepsilon_0$ is the instant response of the material to the applied stress. The time associated with stage I and III creep is usually much shorter compared to the secondary creep. The viscoelastic process enters a steady-state in the secondary creep stage and the strain rate usually converges to a constant. The tertiary creep is accompanied by cavitations and the formation of micro-cracks on the grain-boundaries. In this stage the strain rate increases over time and eventually leads to the rupture of the material.

The analog RF-MEMS varactor is used to measure the creep of the nanocrystalline nickel film. The nominal thickness and gap are 3 μm, $V_{\text{pull-in}}$ is ~ 50V. The drift of the experimental setup is characterized by measuring the capacitance of a varactor without applying the bias. The drift is less than 4 fF for 1,500 hours.

The measured capacitance-time curve of an RF-MEMS varactor biased under 40 V. The unbiased curve is obtained by periodically removing the bias voltage for 1 min every 60 min. $C_0$ is the original capacitance before any bias voltage is applied.

The error of the capacitance is less than 0.2% (< 0.2 fF). The standard deviation is calculated every 100 data points. The sampling rate of this setup is 5 samples/sec.

The bi-state bias condition used in this experiment. The on-state lasts 60 min and the off-state lasts only 1 min. This special bias condition enables the measurement of time-dependent $C_{\text{off}}$, tuning range, and effective spring constant.

The FEA-extracted gap-time curve of an RF-MEMS varactor biased under 40 V. The unbiased curve shows the actual gap when the bias is removed. The curve is fitted with $y(t) = A_0 + \sum_{i=1}^{n} A_i e^{\alpha i t}$.

The capacitance-gap curve used in gap extraction. The FEA model is more accurate than parallel-plate assumption, $C = \frac{\varepsilon \varepsilon_0 A}{g}$.

The profile of the fixed-fixed beam. The confocal microscopic image shows the beam is slightly buckled-up after releasing. The anchor is designed to enhance the adhesion between nanocrystalline nickel and sputtered gold.

The initial creep measurement on PRISM device. The peak between 0-10 hour is related to residual-stress induced buckling.