Supplementary Materials

Silicon on Insulator Electrostatically Actuated Bistable Cantilevers for Resonant Displacement/Acceleration Sensing

Omer HaLevy, Erez Benjamin, Naftaly Krakover, Yoav Kessler and Slava Krylov

School of Mechanical Engineering, Faculty of Engineering,
Tel Aviv University, Ramat Aviv, 69978, Israel

Our device is a cantilever of the length L, width h and thickness d designed to bend in the vertical, out-of-plane (z) direction, Fig. S1(a). The beam is actuated by two side electrodes of the length L_S and thickness d_S, which are located at the distance g_0 symmetrically at two sides of the beam. The electrode thickness is significantly higher than that of the beam. One of the fabricated devices is shown on Fig. S1 (b). Combination of the electrostatic fringing field force pulling the beam towards the middle of the side electrodes thickness, and of the restoring mechanical forces, may result in an equilibrium curve corresponding to the bistable behavior, Fig. S2.

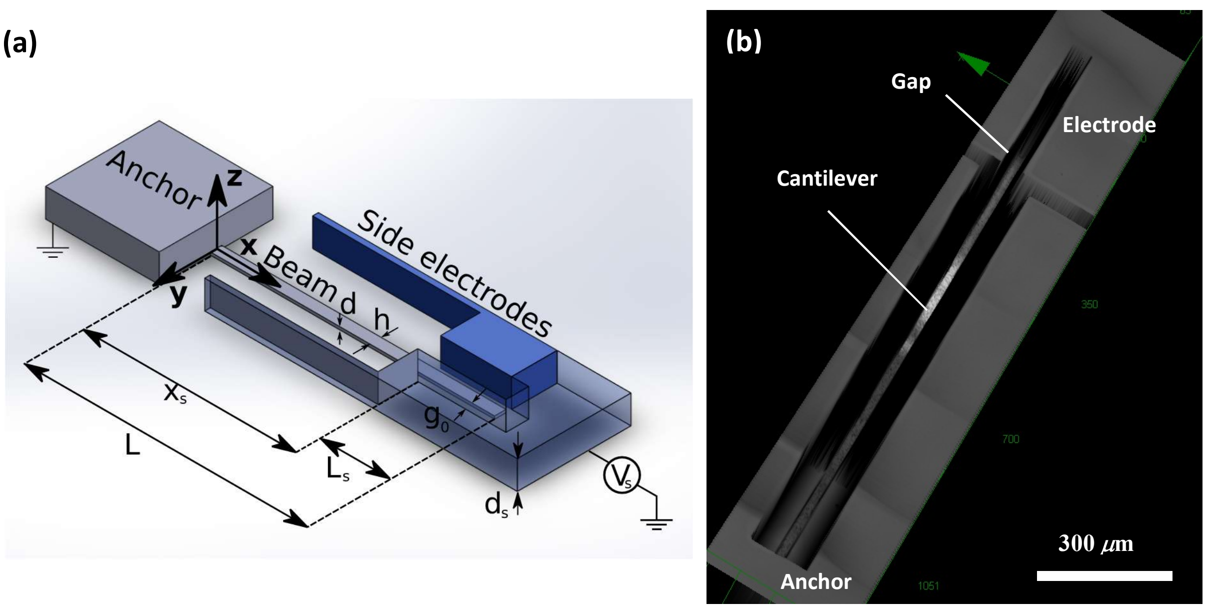

Figure S1. (a) An artist view of the device and the geometric parameters. (b) Confocal microscope (Olympus LEXT OLS3100) image of one of the fabricated devices containing 1300 μm long cantilever.

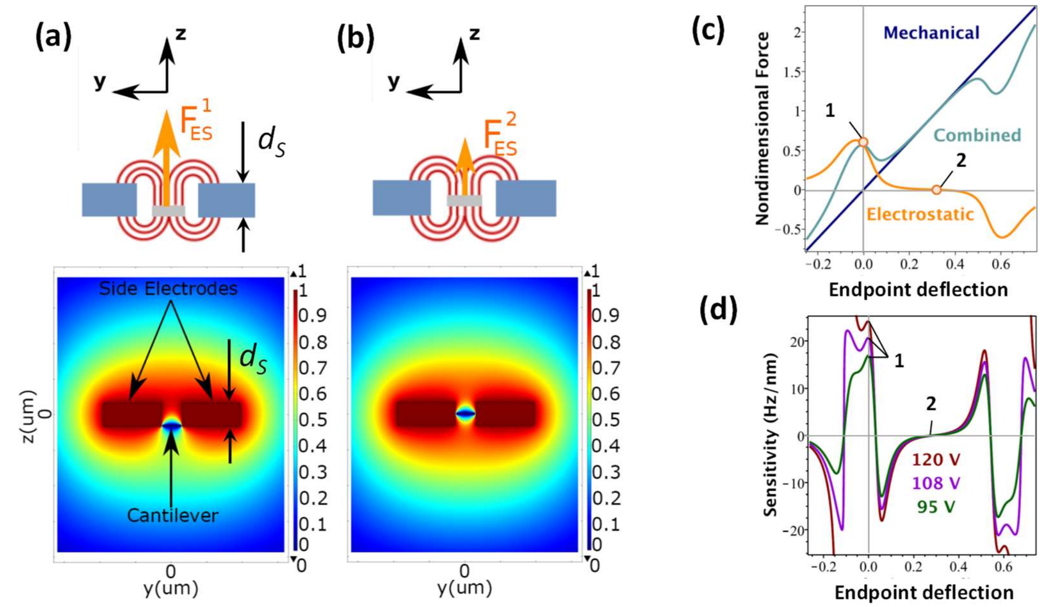

Figure S2. Cross section schematics showing the cantilever and the side electrodes in the initial, "as fabricated" (a) and deformed (b) configurations. Non-symmetric fringing fields emerging from the side electrode is the source of the electrostatic force F_{ES} in the vertical z direction. The results of the numerical finite element (COMSOL) solution of the corresponding electrostatic problems (it terms of the electric potential) are shown in the bottom. (c) Schematic representation of the electrostatic, mechanical and resultant forces as a function of the cantilever's endpoint non-dimensional deflection normalized by the electrode thickness: elastic mechanical (dark blue), electrostatic (orange) and the combined electrostatic and mechanical (light blue) forces. Points 1 and 2 represent the electrostatic force corresponding to the configurations (a) and (b), respectively. (d) Model result for the $L = 150$ μm long, $h = 16$ μm wide and $d = 1$ μm thick cantilever. Different curves, each corresponding to the different voltages V_S (numbers) applied to the side electrode, depict the change in the cantilever frequency as a function of the cantilever's endpoint non-dimensional deflection. The curve corresponding to $V_S = 120$ V is discontinuous and reflects bistable behavior.

Table S1. Nominal geometric parameters of the fabricated devices.

Parameter	Notation	Value	Unit
Cantilever length	L	700-1300	μm
Cantilever width	h	20	μm
Cantilever thickness	d	6	μm
Gap between the cantilever and the side electrode	g_0	10	μm
Side electrode length	L_S	100	μm
Side electrode thickness	d_S	50	μm