Parametric Study of Polyimide – Lead Zirconate Titanate Thin Film Cantilevers for Transducer Applications

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Introduction

We investigate the deflection of micro cantilevers using the piezoelectric actuation mechanism. The piezoelectric effect is a reversible process, which exhibits the so-called direct effect (internal generation of electrical charges resulting from an applied mechanical force) and its reverse effect (internal generation of a mechanical strain when an electrical field is applied).

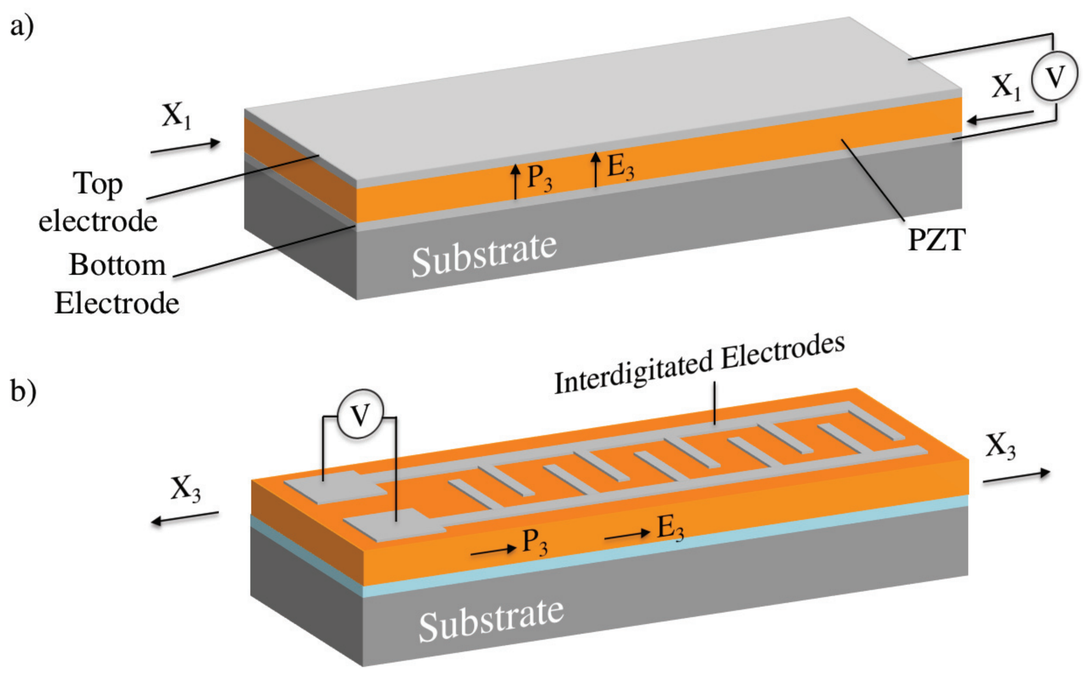

Figure 1. A schematic diagram of a cantilever actuated by a) d31 mode and b) d33 mode.

a) Use of the d31 piezoelectric coefficient (transverse strain constant). The in-plane strain X1 in the piezoelectric film is induced by an external electric field E3 normal to the plane. When a voltage is applied to the electrodes, the piezoelectric film contracts laterally for E3 parallel to the remnant polarization (Pr) of the film, which makes the beam bend up.

b) Interdigitated electrodes can be used for a larger electric field and polarization in plane with the ferroelectric film. The induced strain X3 results from an in plane electrical field E3. Mode in use is the d33 (extensional strain constant).

Design Parameters

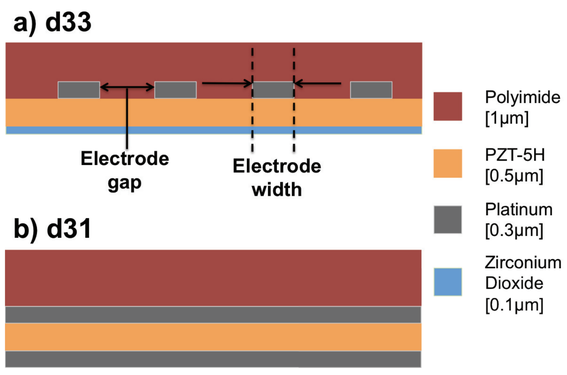

Figure 2 shows the parameters of the geometry that were used in the parametric sweep to modify the model features in the simulation.

Figure 2. Cross-section view of d31 and d33 modes.

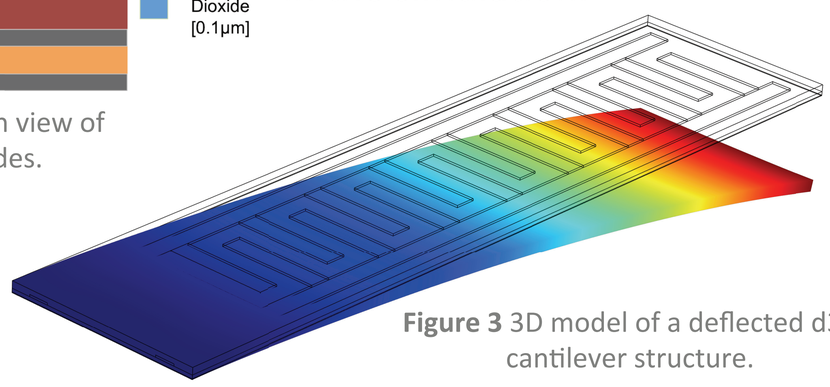

Figure 3 3D model of a deflected d33 cantilever structure.

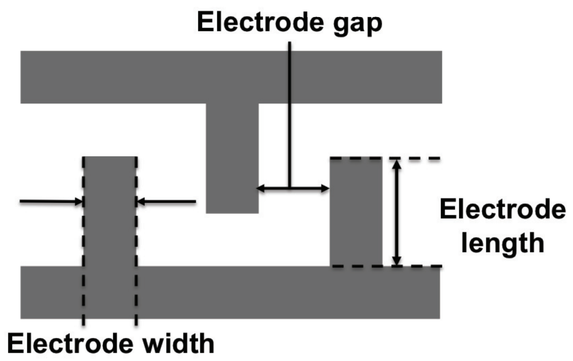

Figure 4 shows the parameters of the geometry that were used in the parametric sweep to modify the model features in the simulation.

Figure 4. Parameterized interdigitated electrodes geometry.

Results & Conclusions

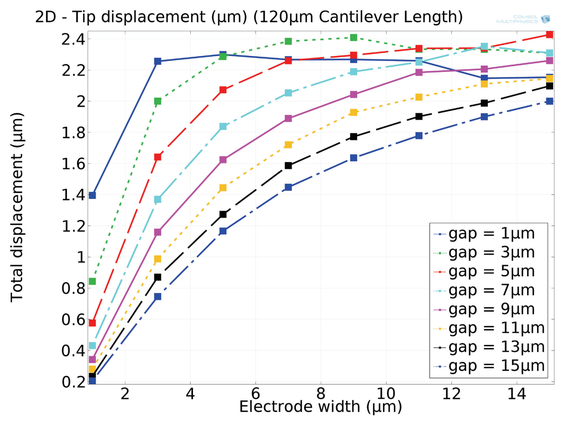

Figure 5. 2D simulation Results

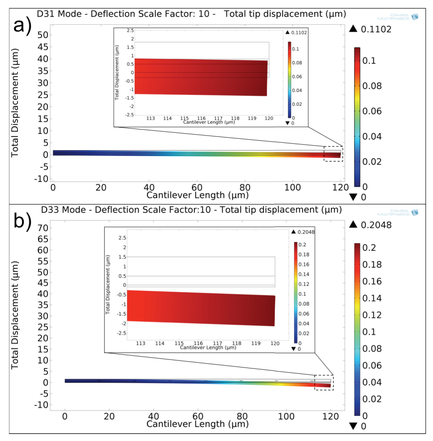

Figure 6. d31 vs d33 modes

The studied structures are currently under fabrication and the experimental measurements will be compared against the numerical models. The fabrication designs are cantilever arrays with a combination of the following parameters: gap (3, 5 and 7µm), electrode width (3 and 5µm) and four cantilever lengths (120, 200, 275 and 350µm). Furthermore, studies regarding the material thicknesses and cantilever lengths will be performed.

The direct piezoelectric effect can also be used for sensing applications (i.e. accelerometers, flow sensors, energy harvesters). The initial results of the presented work are intended to understand the working principle of the presented cantilevers for the development of more complex micro devices.

References

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