Bimorph Pointer

The piezoelectric bimorph pointer (fig. 1) is a beam made of two uniaxial piezoelectric layers laminated together with opposite polarities. This bimorph pointer can be used for micro-actuation or strain sensing.

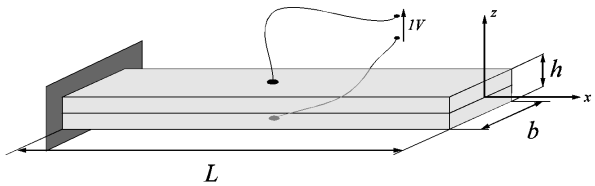


Figure 1: Bimorph pointer

When an external voltage is applied accross the thickness, the induced strain generates moments that bend the bimorph beam. The calculated static deflection of the beam (Mindlin shell finite element *Samcef*) is compared with the analytical solution described hereafter and with the finite element and experimental solutions found in (Hwang and Park, 1993) and (Tzou and Ye, 1996). The bimorph pointer is first considered as an actuator: a unit voltage ($1\ V$) is applied accross the thickness of the beam in $PVDF$ (length $L = 100\ mm$, width $l = 5\ mm$, thickness $h = 1\ mm$). The material properties of $PVDF$ are shown in table 1.

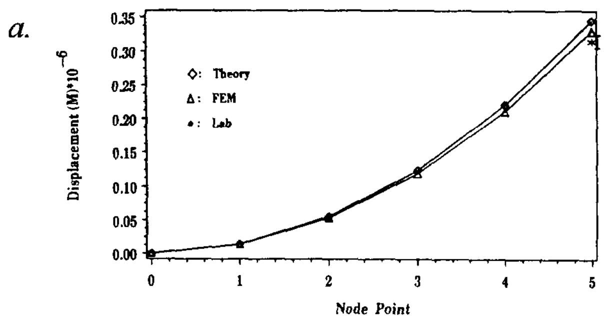
ρ	1800	kg/m^3
E_1	2.0	GPa
E_2	2.0	GPa
G_{12}	0.775	GPa
ν	0.29	
ε	$1.062\ 10^{-10}$	F/m
d_{31}	$2.2\ 10^{-11}$	Cb/N

Table 1: PVDF properties

Using the classical theory of beams (Bernoulli-Euler) and the linear piezoelectricity constitutive equations, an analytical solution for the deflection z along the length of the beam can be found:

$$z\left(x\right) = -\frac{3}{2}\frac{d_{31}\phi}{h^2}x^2 \tag{1}$$

The bimorph pointer was meshed with 10 identical rectangular shell elements along the length and clamped at one end. One should note that the use of shell elements will induce unwanted stress concentration near the clamping points due to the *Poisson*'s effect. The piezoelectric coefficient d_{32} has been taken as zero. Figure 2 shows the comparison between the analytical, finite element, and experimental results found in (Tzou and Ye, 1996) and the analytical and finite element results of the present study.



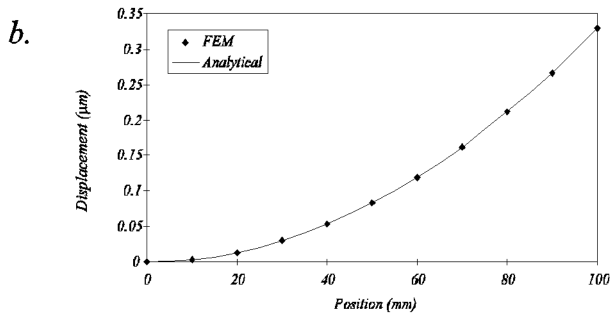


Figure 2: Results;
a. Ref (Tzou and Ye, 1996)
b. Present study

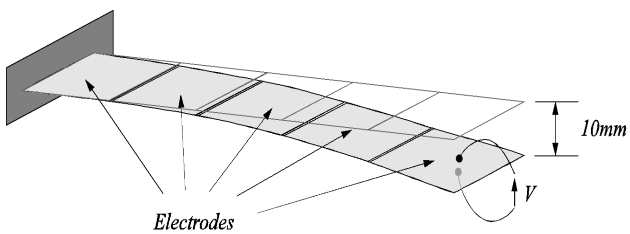


Figure 3: Bimorph sensor

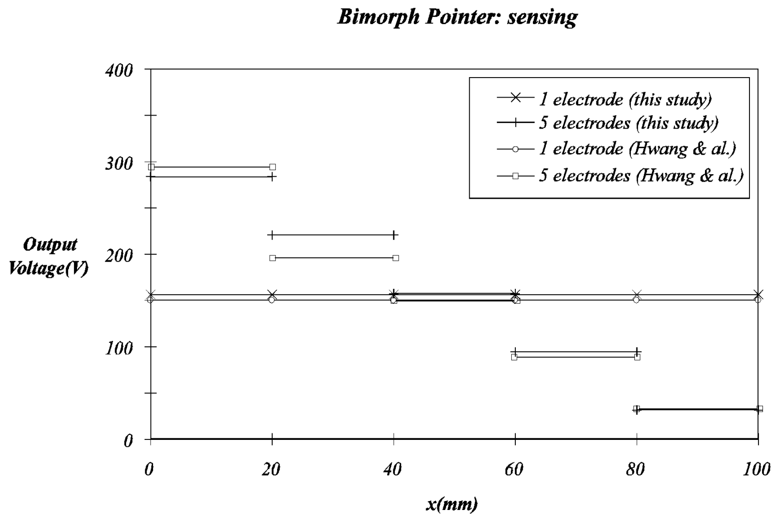


Figure 4: Results

The piezoelectric bimorph beam is also used for sensing: a tip deflection of 10 mm is imposed and the output voltage accross the thickness is calculated (voltage between electrodes, the circuit beung left open). Two models of the sensor electrodes are considered in this study: the first is one pair of electrodes for the all beam and the second is 5 identical pairs of electrodes along the length, figure 3). The results are compared to those found in (Hwang and Park, 1993) using a quadrangular pure bending plate element neglecting the transverse shear, in figure 4.

References

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