Buckled Cantilever Plate for Transducer Applications

Armando Arpys Arevalo Carreno[1], David Conchouso Gonzalez[1], Ian G. Foulds[1]

[1]King Abdullah University of Science and Technology, Thuwal, Mecca, Kingdom of Saudi Arabia

Abstract

Introduction: This paper reports the polymer-based simulation and analysis of a Buckled Cantilever Plate (BCP) for transducer applications (Figure 1). Assembly of this device is done by external means. The unanchored side of the structure is pushed in the direction of the anchor. The structure will bend and hook behind a mechanical stop. This characteristic gives this design the ability to orient features on top of the device in any angle from 0 to 90 degrees with respect to the substrate (Figure 2a). Moreover, it also has the capability of placing structures at a certain height parallel to the substrate (Figure 2b). In our simulation we present an optimization of the anchor configuration to reduce the peeling force in comparison with the standard anchors (Figure 3). This peeling force is applied to the anchors by the buckled cantilevers during their assembly and in the final locked position of the BCP (Figure 4a, 4c, and 4d). If the peeling force subjected to the anchors is greater than the adhesion force between the structure and the substrate, the device could fail and would no longer be able to achieve its vertical assembly position. Several MEMS devices such as gyroscopes, accelerometers [1] and antennas among others, benefit from having a reliable mechanism to displace them out-of-plane without losing direct connection to the substrate. These active devices need to be electrically connected to a power supply or a sensing circuit, which will allow its interaction and integration with other systems. The buckled cantilever design provides accurate out-of-plane assembly while maintaining the direct connection to the substrate for the routing of electrical lines. Use of COMSOL Multiphysics: In order to reduce the peeling force induced at the anchors, the set of four anchor configurations, shown in Table 1, were evaluated. The simulation was performed using the Structural Mechanics Module in COMSOL 4.2a to calculate the stresses and displacement (Figure 4c) of the assembled microstructure as well as the peeling force acting at the anchors edge (Figure 3). These variables were parametrically evaluated with respect to the "assembly distance" of the free moving bottom edge of the plate. Results: The results revealed a reduction in the induced force at the anchor interface of 83% (Figure 3 and 4a) compared with the standard anchors reported [1,2,3,4]. In addition our simulations match the predicted value of the assembly distance stated in [4], in which the vertical position of the plate is achieved at approximately one third of the cantilever's length. In the "top" and "out" anchor configurations, these distances are bigger due to the deflection of their loop shape connection and material's properties. Conclusion: The simulation results for the optimization of the anchors configuration provides important information to increase the yield of the BCP devices that can be used as a base structure for several transducer applications. Due to COMSOL simulations, we were able to fabricate and successfully assemble BCP's structures using the most appropriate anchor configuration design (Figure 1, 4a, and 4d).

Reference

1. Abdul Haseeb Ma, Albert M. Leung. "Three-axis Thermal Accelerometer Based on Buckled Cantiliver Microstrusture." IEEE SENSORS 2008 Conference (2008): 1492-1495.
2. Johnstone, R W, et al. "Buckled cantilverers for out-of-plane platforms." Journal of Micromechanics and Microengineering (2008): 1-7.
3. Ma, Abdul Haseeb Shui Ching. BUCKLED CANTILEVER 3D MICROSTRUCTURES FOR TRANDUCER APPLICATIONS. Burnaby: SIMON FRASER UNIVERSITY, 2008.
4. Sameoto, Dan, et al. "Assembly and Characterization of Buckled Cantilever Platforms for Thermal Isolation in a Polymer Micromachining Process." Canadian Conference on Electrical and Computer Engineering (2007): 296-299.

Figures used in the abstract

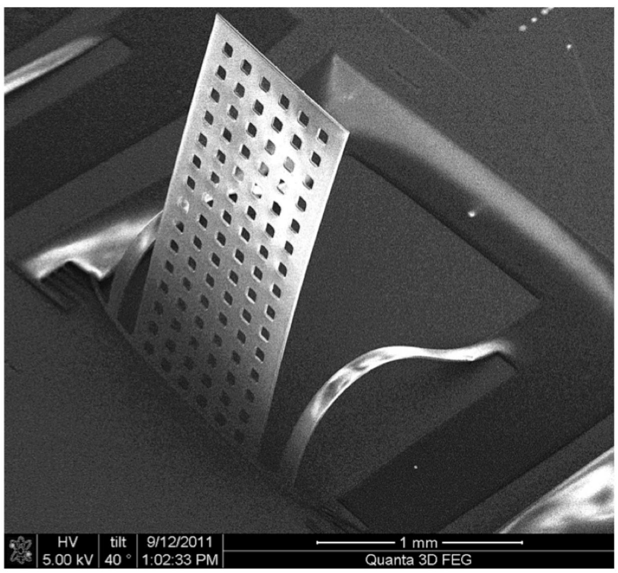

Figure 1: SEM image of an assembled Buckled Cantilever Plate with etch holes.

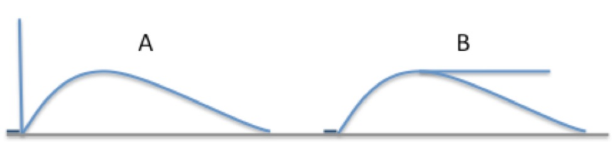

Figure 2: A) Lateral layout view of a vertical assembled BCP; B) Lateral layout view Assembled BCP with plate parallel to the substrate.

Anchor Configuration Types	Finite Element Simulation of the Anchor Geometry			
	Standard "Bottom"	"In"	"Top"	"Out"
Assembly Distance	650µm	650µm	830µm	850µm
Simulated Pealing Force at 90°	$-1.4558e^{-4}$ N·m	$-2.4498e^{-5}$ N·m	$-3.236e^{-5}$ N·m	$-3.825e^{-5}$ N·m
Reduction	Reference	83%	78%	74%

Figure 3: Comparison table of the anchor configurations for the Buckled Cantilever Plates.

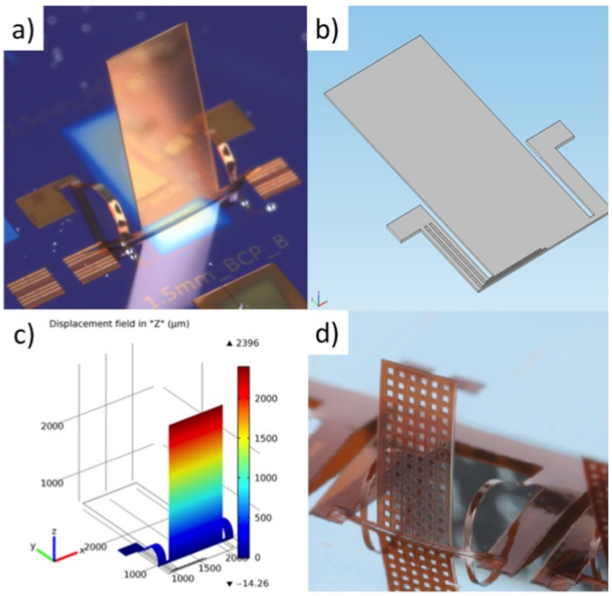

Figure 4: a) Photo of an assembled BCP (Note: "In" anchor configuration); b) Perspective view of a BCP 3D model in rest position; c) Simulation of an assembled BCP showing "Z" Displacement; d) Photo of an assembled BCP with Etch Holes (Note: Anchors are failing using the "Standard" Anchor configuration).