Electrothermal actuation studies on Silicon Carbide resonators

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Microelectromechanical systems (MEMS) based in Silicon Carbide (SiC) is a good candidate for harsh environment applications[1]. Due to its excellent mechanical and electrical properties, SiC is a promising material for high efficiency MEMS devices[2]. In the last years, different dry etching techniques for SiC with high selectivity and high etch rates have been developed. In particular, a one-step inductively coupled plasma reactive ion etching process has been developed to pattern and release SiC structures on poly-Si sacrificial layers[3]. Among all the actuation methods, the electrothermal technique has started to play an important role in the MEMS field since the required fabrication process is simple[4,5] and the power consumption is comparable to other forms of actuation methods[6]. In this work, we have designed SiC actuator beam devices to investigate, both experimentally and theoretically, the influence of the beam and actuation electrodes dimensions on the resonant frequency and the electrothermal actuation efficiency respectively.

Single crystal SiC beams resonators have been designed, fabricated and tested. The resonators' performance has been compared to theoretical simulations. Aluminium (Al) electrodes on top of the SiC have been patterned photolithographically and dry etched. After, SiC beams have been formed with the one-step etch and release process[3]. Fig. 1 shows one of the released structures. The fabricated devices have been actuated electrothermally by applying an AC voltage across the electrodes. One of the resonant peaks at 150.5 kHz is shown in Fig. 2. A quadratic dependence between the cantilever length and the resonant frequency has been found and fig. 3 shows good agreement between the simulated and theoretical results. For cantilever lengths ranging between 200μm and 50μm, resonant frequencies between 90 kHz and 945 kHz have been obtained. In addition, the electrode dimensions on the resonant bridge structure have been optimised with a view to obtaining efficiently actuated resonators. The influence of the electrode dimensions on the actuation efficiency, together with the simulated temperature gradient for the resonator structures will be presented. Fig. 4 shows a schematic of the bridge structure and the associated electrode dimensions L (10-190μm), S (10-50μm) and W (3-12μm) that have been varied.

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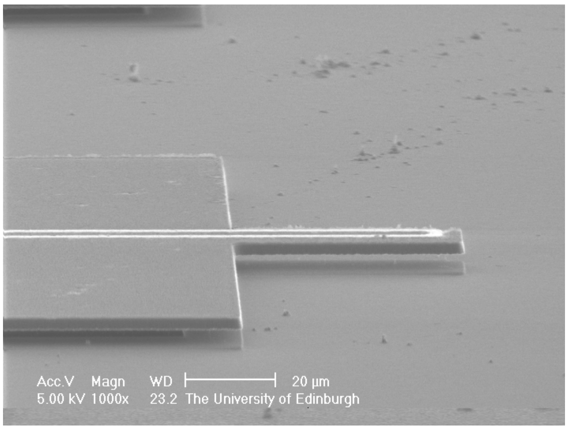

Fig. 1: Scanning electron micrograph of a silicon carbide resonator with aluminium electrodes on top

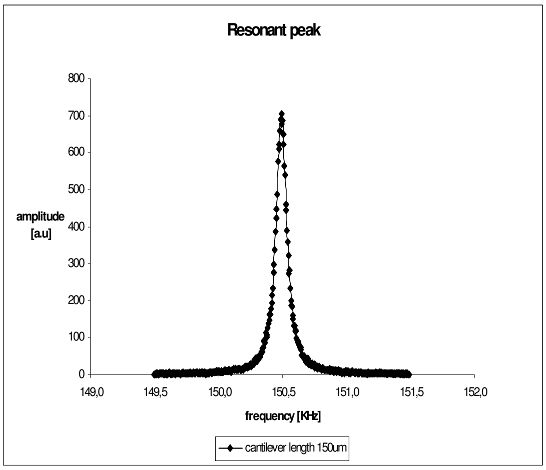

Fig. 2: Resonant peak of a SiC cantilever device

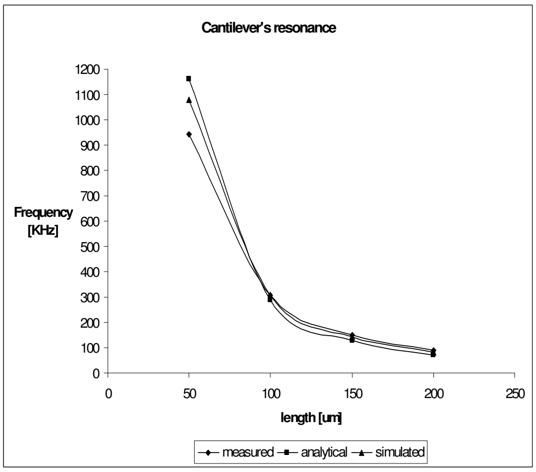

Fig. 3: Frequency versus cantilever length

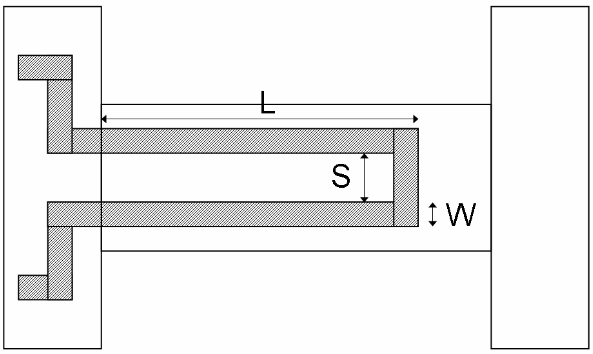

Fig. 4: Bridge design with electrode dimensions