MEMS Systems for Biomimetical Applications

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In the past decades, a large body of research on the development of the physical and mathematical models for the human cochlea have been reported extensively. The life-sized construction of an artificial cochlea system using microfabrication technology could serve as a research tool to comprehend the mechanics of cochlea[1-3]. In our research, a new type of microphone based on an array of Resonant Gate Transistor (RGT) with the ability to self-adjust its sensitivity (gain) and selectivity (frequency) is proposed (Fig. 1). The novelty of this device lies in its selective real time adaptive behaviour that promises a model of an active cochlear which mimics the real cochlear mechanism inside the human ear. The electrical component of an RGT is a standard depletion mode n-channel MOSFET while the mechanical part consists of a resonating bridge structure that instantaneously acts as the gate for the MOSFET[4]. Different lengths of bridges (0.36 mm-11.44 mm) in an array of RGT have to be designed to cover the whole range of the audible frequency (20 Hz-20 kHz). The fabrication process has many challenges. One critical step in constructing the RGT device is the development of a clean, reliable and damage-free process for the release of the long bridges. The process should be capable of releasing the long bridges without causing the bridges to collapse or damage the MOSFET device underneath the bridge.

In this work, a release process capable of releasing the aluminium bridge structure from the photoresist sacrificial layer has been developed. The technique employs a downstream plasma configuration[5]. In an oxygen plasma, the process tool is able to generate the reactive monatomic oxygen species of which are extracted downstream to react with the photoresist underneath the bridges. The temperature, gas flow and pressure of the plasma can be controlled and optimised to give a gentle uniform isotropic etch release process. Preliminary results are very promising with bridges of 0.57 mm-1.62 mm length, 9 μm width and 0.5 μm thickness having been released successfully from 6 μm of photoresist sacrificial layer in 30 minutes under an etching condition of 250 °C of temperature, 0.7 Torr of pressure and 1000 SCCM of oxygen flow rate (Fig. 2). Test structures have been designed[6] (Fig. 3) in order to characterise the etching process under different pressures and temperatures. Fig. 4 shows the results obtained for a condition of 190 °C, 0.7 Torr and 1000 SCCM. The undercut length varies nonlinearly with etch time. Within the first 2 minutes, the undercut etch rates are 1.64, 0.57 and 0.28 μm/min respectively for the undercut widths of 5, 10 and 20 μm. In addition, conventional MOSFETs designed for the proposed cochlea model have been fabricated and measured to have a transconductance of 23 mS. Details of the etch release process, characterisation and measurements of the integrated RGT device will be presented.

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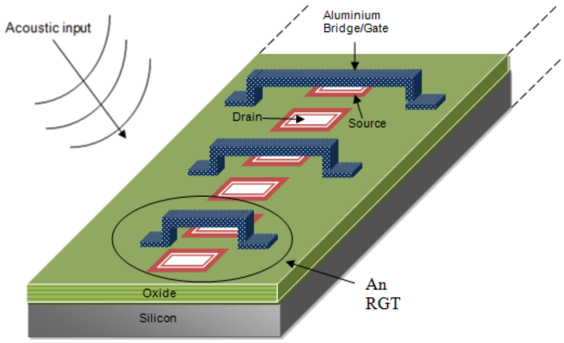
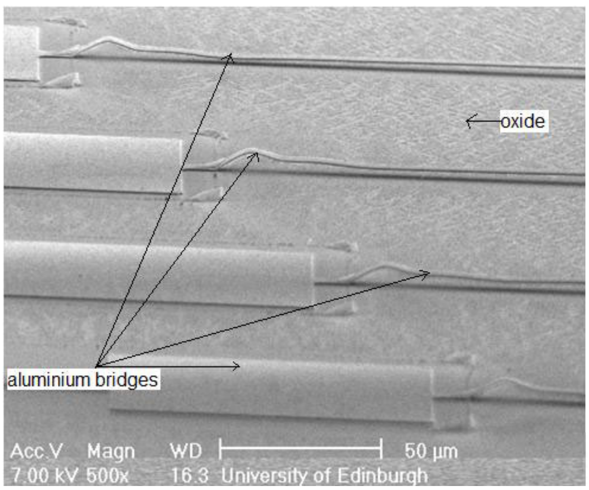
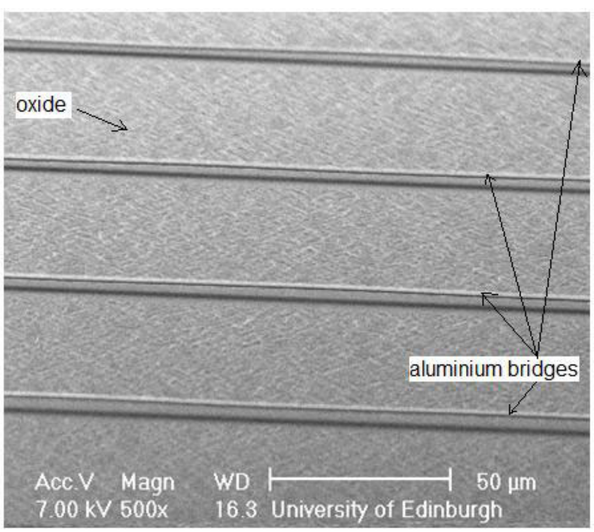


Fig. 1: A model of MEMS RGT-based microphone. The first three RGTs from an array of RGTs are shown here.



(a)



(b)

Fig. 2: The first four aluminium bridges are shown (a) at the anchor (b) at the middle of the bridge. Beam width= 9 µm, beam thickness= 0.5 µm and distance from bridge to substrate= 6 µm.

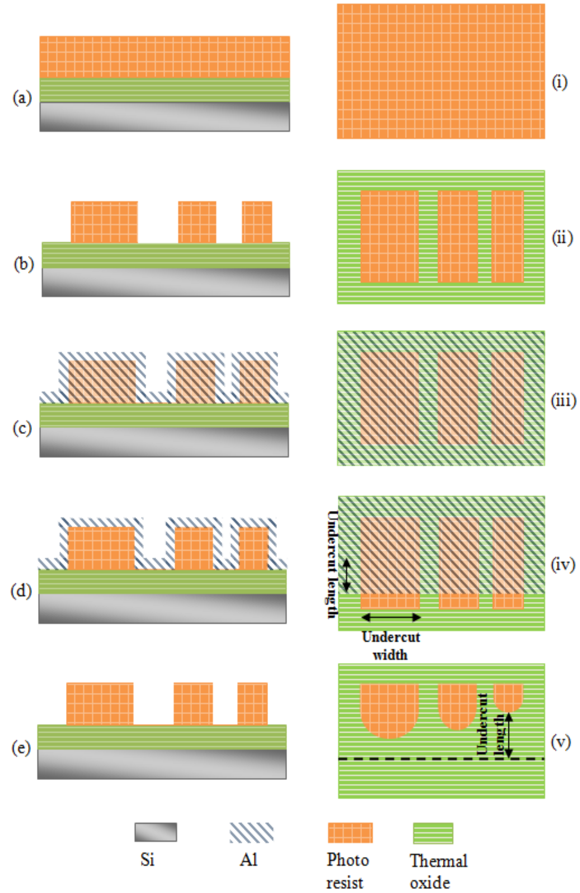


Fig. 3: [(a)-(e)] Cross section of the fabrication and release process steps for the test structures and [(i)-(v)] top view of the process[6].

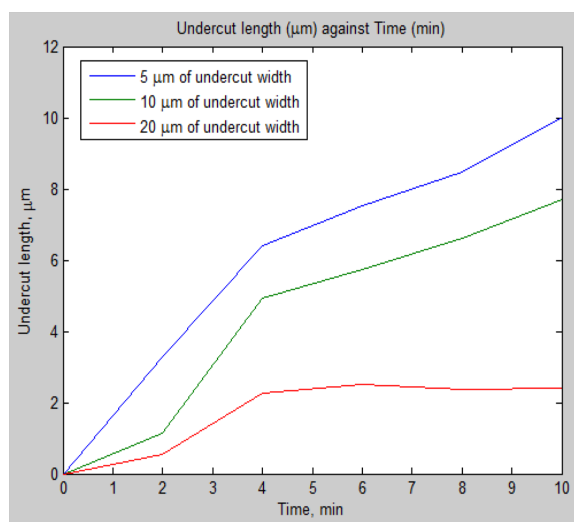


Fig. 4: Undercut length against etch time for etching under condition of 0.7 Torr, 190 °C and 1000 SCCM flow rate.