Water-Immersible micromachined $Pb(ZrTi)O_3$ thin film actuator

Personnel

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Sponsorship

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Concept and Key Idea

There have been many efforts to overcome two major problems in SPM technologies: slow scanning speed and inability to measure living cells underwater. We demonstrate the water-immersible thin film PZT actuator, the whole PZT is sandwiched between the top and bottom metal electrodes to prevent water permeation, which can be used for in vivo or in vitro SPM measurements of living cells under water or biological fluid. This can also be used for the direct actuation of microfluidic devices in various wet applications.

Design and Fabrication

In order to be water-immersible, the electrodes need to be electrically insulated as well as the piezoelectric layer needs to be waterproofed. This paper describes our design solution and process for a water-immersible piezoelectric device, which separates the bottom electrode from the top electrode by having a narrow ditch covered with PZT film. The whole PZT film is then encapsulated with the top metal electrode, which seals envelopes together with the metal layer left outside ditch of the lower electrode. In this structure, the whole PZT is sandwiched between the top and bottom metal electrodes to prevent water permeation. Figure 15 shows the water-immersible PZT cantilever beam designed.

The width of the ditch is the key design parameter for both electrical separation and good microstructure of PZT on top of the ditch. We tested several widths of the ditch, and got good dense PZT microstructure and electrical insulation with the 2 um width of ditch. The surfaces of the PZT film on the 2 μm separated Pt bottom electrode region ("P" region in Fig.1) were observed at three adjacent points by AFM (Fig.16). The piezoelectric constant, d_{31} is about -100pC/N. The dielectric polarization and fatigue properties of the devices were measured in air and water. The spontaneous polarization, remnant polarization, coercive field and dielectric constant are 54 $\mu C/cm^2$, 15 $\mu C/cm^2$, 60 KV/cm and 1200, respectively (Fig. 17(a)) And the polarization property of the device was unchanged whether it was in the air or under the water until $1x10^9$ cycles (Fig. 17(b)).

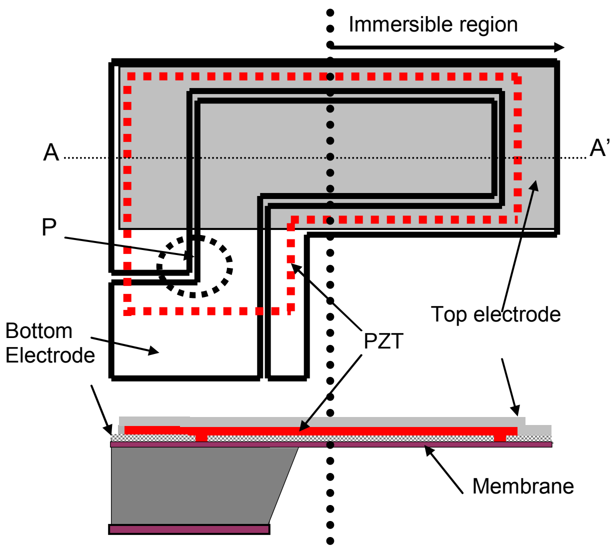

Fig. 15 Device schematic of water-immersible piezoelectric actuator

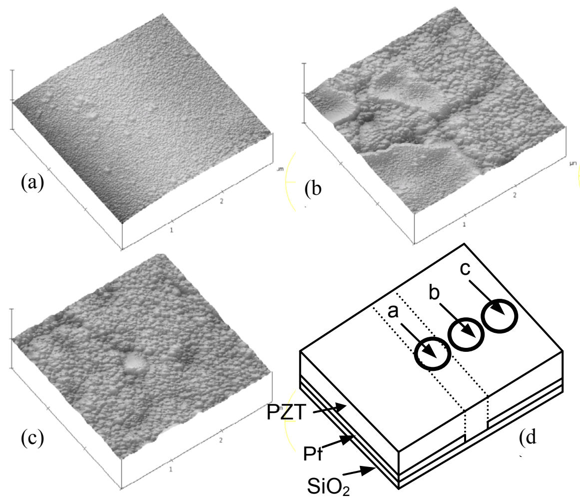

Fig.16 AFM images of the PZT film surface and intersection diagram of the PZT film on the separated Pt bottom electrode region, (a) PZT surface exact on the separated Pt, (b) PZT surface near on the separated Pt, (c) PZT surface on Pt bottom electrode, (d) Schematic diagram of the region "P" in Figure 1(a) which was observed by AFM

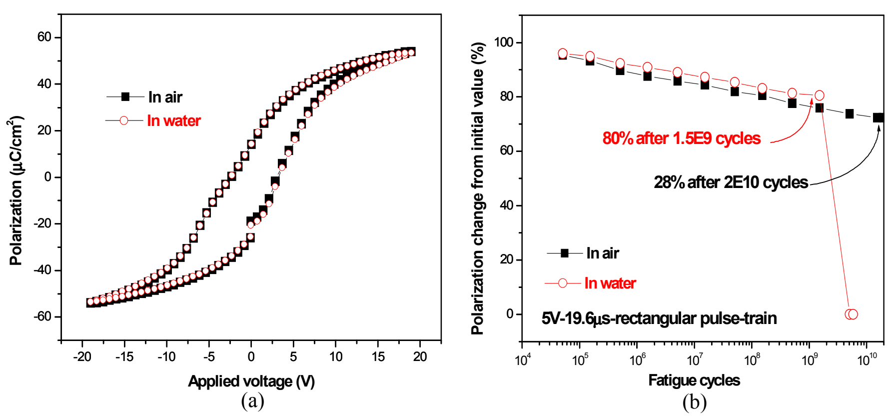

Fig.17 Polarization property changes of the PZT films (a) P-E hysteresis curve as deposition, (b) Fatigue properties against number of cycles in air or water