Localized Off-Chip Transduction for MEMS Using 2-D Ultrasonic Arrays

Abstract:
Frequent use of piezoelectric actuators in microsystems brings forward the possibility of using a generic platform to suit some of the applications like microfluidic pumps, ultrasonic motors and inkjet printhead devices. The bulk nature of ceramic Lead Zirconate Titanate (PZT) is the main challenge towards an integrated approach which does not include manual adhesive bonding. To address this, we developed a micromachining process in which diced PZT pillars are sandwiched between a circuit die or possibly PCB at the bottom and a MEMS die on top [1].

Reminiscent of a 2-D ultrasonic imaging array, the device consists of 20 x 20 pixels of PZT-4. The fabrication procedure makes use of flip chip bonding which is already a well accepted packaging solution to chips with large pin-count [2]. After Sn/Pb solder is electroplated on the aluminum pads on the bottom die, 0.5 mm thick PZT pixels with typical pitch size of 250 µm is bonded to pads by reflowing the solder. The top die, which can have surface micromachined structures, is etched by DRIE to leave a silicon dioxide/silicon nitride membrane. This is mainly to increase displacement on the membrane surface. A MEMS die is finally bonded on the pillars, again using solder reflow. The target of the project is to demonstrate a 2-D microfluidic pump based on acoustic streaming by using individual PZT pillars as piston transducers to generate a traveling wave on the membrane.

Summary:
We report on a fabrication/packaging process which enables localized off-chip actuation and also circuit integration in a compact manner. Impedance measurements taken from two pixels reveal an acceptable match; yet a reduced quality factor as compared to unbonded PZT is an issue that needs to be solved in future runs. Future characterization involves optical measurement of transfer function of pillars on different locations on the membrane to enable mode control.

References:
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• Bulk PZT actuation.
• Off-chip actuation.
• 2D transducer array.

Figure 1: Diagram showing the structure of the fabricated device with the stacking of the: 1) VLSI die, 2) PZT pillars, 3) MEMS die.

Figure 2: Fabricated MEMS-die which is a 0.5 mm by 0.5 mm SiN membrane with silicon pillars extruding out to engage the motion of each PZT pixel to the membrane.

Figure 3: Electrical impedance curves of two neighboring pixels from the final device.