Fabrication and Characterization of Mechanical Resonators Integrating Microcontact Printed PZT films

D. Saya[1 *], D. Dezest[1], A.J. Welsh[2], O. Thomas[3], F. Mathieu[1], T. Leichle[1], L. Nicu[1] and S. Trolier-McKinstry[2]
[1]Laboratoire d'Analyse et d'Architecture des Systèmes, Université de Toulouse
7 avenue du Colonel Roche, 31031 Toulouse, France
[2]Materials Science and Engineering Department and Materials Research Institute, The Pennsylvania State University,
N-227 Millennium Science Complex, University Park, PA 16802 USA
[3]Laboratoire des Sciences de l'Information et des Systèmes
8 bd. Louis XIV 59000 Lille, France
*Daisuke Saya: dsaya@laas.fr

Down-scaling of piezoelectric resonating devices to enable integrating actuation and detection capabilities is an important subject for the transition from MEMS (micro electro-mechanical system) to NEMS (nano electro-mechanical system) [1]. In order to realize it, degradation of piezoelectric characteristics on miniaturization should be overcome. In this paper, we report fabrication of lead zirconate titanate (PZT) resonators integrating piezoelectric actuation and sensing based on thin PZT. The PZT film is patterned by microcontact printing, which enables retention of the piezoelectric characteristics with reduced size [2].
Fabrication starts with a silicon-on-insulator (SOI) wafer with a device Si thickness of 340nm. Fabrication is based on ultraviolet (UV) stepper photo repeater and micromachining. We fabricated cantilever structures with two sizes: a short version of 35 µm long and 5µm wide and a long version of 150 µm long and 30µm wide. Each of the resonators is composed of Si 300nm, SiO_2 100nm, HfO_2 60nm for isolation, Ti/Pt 20nm/100nm bottom electrode, microcontact printed PZT 200nm, Pt 100nm top electrode as shown in Figure 1.
Electrical testing [3] of the resonators was conducted. Figure 2 shows the piezoelectric response of the 1st mode resonance frequency for the shorter cantilever resonator in air. Excitation voltage was 700mV. The measured 1st mode resonance frequency of the shorter cantilever is 467kHz, which is consistent with simulation result 455kHz, a difference of just 2.6%. In the case of the longer cantilever, the measured 1st mode resonance frequency was 19.1kHz while simulation result is 24.8kHz, a difference of 29%. This discrepancy is believed to be a result of the longer cantilevers suffering overetching during the cantilever release, such that its thickness decreased.
Hence, capability of actuation and detection of mechanical resonators with microcontact printed PZT film was validated making such processed ultrathin PZT films promising for piezoelectric NEMS with integrated actuation and sensing capabilities.

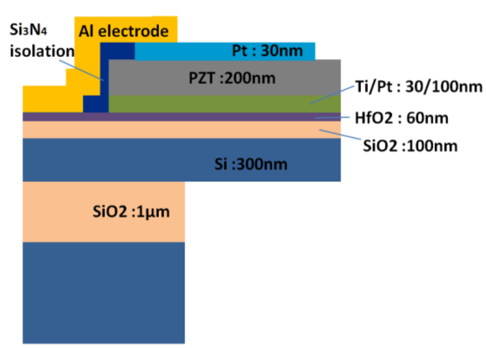

Figure 1: Structure of the resonator with PZT

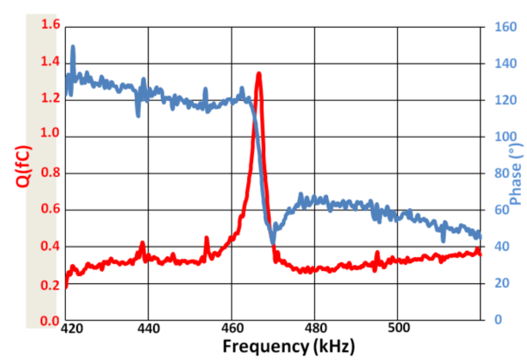

Figure 2: Piezoelectric response of the shorter resonator

[1] D. Dezest, O. Thomas, F. Mathieu, L. Mazenq, C. Soyer, J. Costecalde, D. Remiens, J.F. Deü and L. Nicu, Journal of Micromechanics and Microengineering, 25 (2015) 035002.
[2] A.J. Welsh, R.H.T. Wilke, M.A. Hickner, and S. Trolier-McKinstry, Journal of the American Ceramic Society, Vol. 96, Issue 9, Pages 2799-2805, September, 2013.
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