Strongly {001} Oiented Bimorph Thick PZT Films Grown by High Temperature *rf*-Magnetron Sputtering for a Non-resonant Piezoelectric Energy Harvester

Hong Goo Yeo[1], Tiancheng Xue[2], Shad Roundy[2] and Susan Trolier-McKinstry[1]
[1]Department of Materials Science and Engineering, The Pennsylvania State University, University Park, Pennsylvania, 16802, USA
[2]Department of Mechanical Engineering, University of Utah, Salt Lake City, Utah, 84112, USA
*Hong Goo Yeo: hxy162@psu.edu

Harvesting energy from human motion using piezoelectric elements is a promising approach to extend the working hours of wearable electronic devices without recharging or replacing batteries. Typical designs for resonant piezoelectric energy harvesters are not suitable to extract electrical energy from human motion. Thus, non-resonant piezoelectric energy harvesters such as frequency-up conversion design have been proposed for wearable harvesters. They are required to have large volume of flexible piezoelectric. {001} oriented PZT thin films on flexible Ni foil are an excellent candidate for this application. Especially, the growth of thicker (>5um) bimorph PZT films by in-situ crystallization *rf* magnetron sputtering should provide larger output power with high area efficiency.

In this study, bimorph PZT films were sputtered at 550 ~ 585 °C with 10% Pb excess $Pb(Zr_{0.52},Ti_{0.48})O_3$ target using an *rf* power of 88 Watt onto {001} PZT seeded $LaNiO_3/HfO_2$/Ni foils prepared as described elsewhere.[1] Strong {001} orientation of the PT films was confirmed by X-ray diffraction patterns. No pyrochlore phase was detected in as-grown films by either XRD or FESEM micrographs. Both PZT films were dense with columnar grains. Following growth of thick PZT film by high temperature sputtering, one CSD PZT capping layer was used to decrease surface roughness. The PZT films had low dielectric permittivity values near 450, with low loss tangents < 0.04 at 10 kHz. Highly {001} oriented PZT films show well-saturated PE hysteresis loops with large remanent polarization (42 $\mu C/cm^2$) at 100 Hz. The performance of in-plane plucking designed piezoelectric energy harvester using six rectangular piezoelectric beams (10 mm by 3 mm) will be described.

[1] H. G. Yeo, S. Trolier-McKinstry, J. Appl. Phys. 116 (2014) 014105.