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Thermal expansion coefficient and elastic modulus of reactive pulsed-DC magnetron co sputtered piezoelectric AlScN thin films

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$Al_{1-x}Sc_xN$ is an attractive material for radio frequency microelectromechanical systems (RF-MEMS) due to higher piezoelectric coefficient d_{33}=27.6 pC/N (x=0.43) compared to 6 pC/N in pure AlN [1] and increased electromechanical coupling k_t^2 [2]. Mechanical properties such as elastic modulus and coefficient of thermal expansion (CTE) are important for designing RF-MEMS. However, there are very few experimental or theoretical studies of elastic modulus of $Al_{1-x}Sc_xN$ in a large range of compositions (up to x=0.26) [3] and, the CTE of $Al_{1-x}Sc_xN$ thin films has never been reported until now. In this work, reactive pulsed-DC magnetron sputtering process was optimized [4] to produce 1 µm thick highly c-axis oriented $Al_{1-x}Sc_xN$ thin films (up to x=0.32) on 100 mm Si(001) and Al_2O_3(0001) substrates. X-ray diffraction, scanning electron microscopy, piezoresponse force microscopy, and Berlincourt method were used to analyze the film properties. To simultaneously determine the thermal expansion coefficients and the elastic modulus, a thermal cycling was performed [5] and the temperature dependent film stress was then measured. Based on the stress measurement results, CTE was calculated as a function of Sc concentration. Our measurements show average CTE αf= 5.01×10^{-6}/K, biaxial elastic modulus of 300 GPa, and Young's modulus of 216 GPa for $Al_{0.7}Sc=_{0.3}N$. The average CTE and elastic modulus measured for AlN fits values found in literature [5]. Consequently, the experimentally determined elastic modulus will allow designing RF-MEMS based on $Al_{1-x}Sc_xN$ with various Sc concentrations and the CTE will enable the device performance prediction at elevated temperatures.

[1] M. Akiyama, et al., Adv. Mater. 21(5), 593 (2009)

[2] G. Wingqvist, et al., Appl. Phys. Lett., 97(11), 112902 (2010)

[3] M. A. Caro, et al., J. Phys. Condens. Matter 27, 245901 (2015)

[4] Y. Lu, et al., Phys. Status Solidi A, 1700559 (2017)

[5] R.E. Sah, et al., J. Vac. Sci. Technol. A Vacuum, Surfaces, Film. 28, 394 (2010).

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