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Influence of the Li and M (M = V, Nb, Ta, or Zr) Composition Ratio on the Piezoelectric Properties of LiM-doped AlN Films

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This paper describes the piezoelectric properties of LiM-doped (M = V, Nb, Ta, or Zr) aluminum nitride ($(Li_yM_{1-y})_xAl_{1-x}N$) films with respect to the composition ratio of Li and M. Films of $(Li_yM_{1-y})_xAl_{1-x}N$ were prepared by a radio frequency magnetron sputtering method and characterized by crystal structure, as well as electrical properties such as the piezoelectric coefficient d_{33} and resistivity ρ. The films for M = Nb with x = 0.13-0.20 and y = 0.41-0.49 showed $|d_{33}|$ = 8.26-9.54 pC/N, which were 21-38% larger than non-doped AlN. On the other hand, the films for M = V, Ta, and Zr exhibited a decrease in piezoelectricity. The piezoelectric properties in $(Li_yM_{1-y})_xAl_{1-x}N$ films against M can be mainly explained by the combination of the following factors: crystallinity, lattice parameter ratio c/a, ρ, orientation degree, and polarity inversion. This study revealed that the composition ratio of Li and M gives $(Li_yM_{1-y})_xAl_{1-x}N$ films different behaviors on physical properties and the films for M = Nb with similar stoichiometric compositions ($y \sim 0.5$) are promising candidates as piezoelectric materials for micro-electro-mechanical systems.

Keywords : Piezoelectric material, Doped aluminum nitride, Films, Crystal structure, Sputtering