Cu Co-fired (Na, K)NbO_3 Multilayer Structure Toward Piezoelectric Applications

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Recently, we successfully co-fired Cu metal electrode with (Na, K)NbO_3 (NKN) based lead-free piezoelectric ceramics for actuator applications.[1] It is widely known that the Pb(Zr, Ti)O_3 (PZT) based piezoelectric materials possess superior piezoelectric properties.[2,3] However, the concern on both healthy and environmental issues, which were brought up by the lead containing materials, have been raised. RoHS (Restriction of Hazardous Substances Directive) set the maximum amount of lead to 1000 ppm in a homogeneous material used in electrical and electronic equipment (EEE).[4] The piezoelectric industry has continually existed as an exemption under RoHS, and there is no actuator material that matches the properties of soft PZT materials.

Although NKN has excellent piezoelectric properties among most known lead-free piezoelectric materials,[3] it is still inferior to the lead-based piezoelectric materials. Base metal co-fired multilayer structure can be a possible engineer solution to make NKN have comparable performance as PZT by providing both large overall displacement and low manufacturing costs.

In this work, prototyped Cu co-fired NKN multilayer actuators were fabricated through using a poly(propylene carbonate) based binder system, which enabled clean burnout under a low oxygen partial pressure (low pO_2) atmosphere at a low temperature (below 275°C). Highly dense NKN ceramic (4.64g/cm^3, >95%) were obtained by sintering the samples under low pO_2 atmosphere. Detailed transmission electron microscopy (TEM) analysis was performed; no interdiffusion of copper, chemical reactions, or carbon residues were observed in the grains, grain boundaries, or at electrode-ceramic interfaces. Furthermore, dielectric and piezoelectric properties were characterized from the prototyped multilayer samples. Classic ferroelectric switching with minimum space charge contribution and reasonable normalized piezoelectric coefficient (d_{33}^*>200pm/V) were obtained.

Reference

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