Topics

Processing and Thermoelectric Properties of Highly Textured Na-Co-O Ceramics Fabricated by the Reactive Template Grain Growth (RTGG) Method

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The $NaCo_2O_4$ system has been a p-type candidate material for thermoelectric applications[1-3]. The single crystal shows large in-plane thermoelectric power due to the layered structure[1], and thus attains a dimensionless figure of merit ($ZT = S^2\sigma T/\kappa$) greater than 1[3], where S is the Seebeck coefficient, σ is the electrical conductivity, κ is the thermal conductivity, and T is the absolute temperature. $NaCo_2O_4$ polycrystalline ceramics with a preferred c-axis orientation would have in-plane thermoelectric properties as good as the single crystal.

Tani developed a RTGG method for highly-textured polycrystalline ceramics using reactive template particles with an anisotropic shape and lattice matching with a product material[4]. Co_3O_4 has a similar crystal structure to $NaCo_2O_4$ and thus it is a candidate material as a reactive template. Therefore, c-axis oriented $NaCo_2O_4$ ceramics could be synthesized by the RTGG method if plate-like Co_3O_4 particles were obtained[5].

Plate-like Co_3O_4 particles were prepared by a precipitation method. The Co_3O_4 template particles were mixed with Na_2CO_3 powder, a binder and a plasticizer. The slurry was tape-cast by a doctor-blade technique, and then the dried monolayer sheet was cut and laminated to produce a multilayer sheet. The multilayer sheets were heat-treated and then sintered.

Figure 1 shows the XRD profiles of $NaCo_2O_4$ ceramics prepared by the RTGG method and the JCPDS card. The in-situ reaction was completed during the sintering, and the sintered specimen was identified as $NaCo_2O_4$ as designed. The parallel surface of the RTGG-processed specimen exhibited strong diffraction peaks from the {00l} planes. This result indicates that oriented $NaCo_2O_4$ grains were formed through a topotaxy or topotaxy-like reaction on the oriented Co_3O_4 particles, and highly textured $NaCo_2O_4$ ceramics were eventually fabricated by the RTGG method. **Figure 2** shows a SEM photograph of the oriented $NaCo_2O_4$ ceramics for a section perpendicular to the preferred {00l}-oriented plane. The textured ceramics exhibited a unique microstructure in which plate-like grains with a 1μm thickness and 10μm width were aligned parallel to the casting plane. The σ was larger than that of conventionally sintered ceramics[2] due to the texture (600S/cm at 300K). However, the σ values were smaller than expected from the high conductivity of a single crystal (5000S/cm at 300K[1]). The power factor ($S^2\sigma$, 4-5 $\times$ 10^{-4} W/mK^2 above 600K) was not as great as the value reported for conventionally sintered ceramics[2, 3], because the S was not high enough (60-120 μV/K). The thermoelectric properties of the c-axis oriented $NaCo_2O_4$ ceramics could be improved with a more precisely controlled composition.

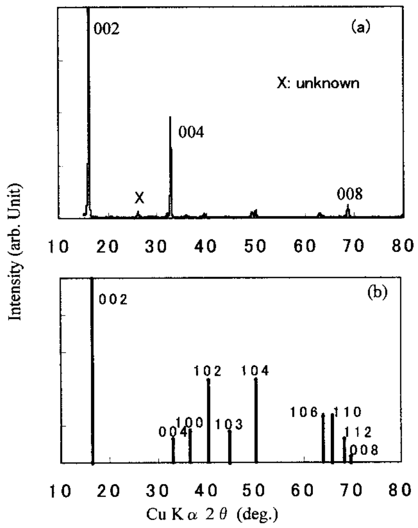

Fig. 1 XRD patterns for (a) $NaCo_2O_4$ ceramics prepared by RTGG method and (b) JCPDS card of $NaCo_2O_4$.

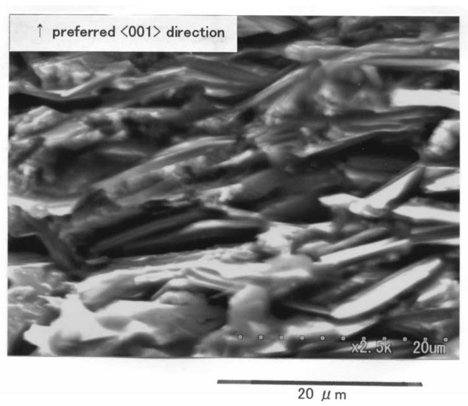

Fig. 2 SEM photograph of $NaCo_2O_4$ ceramics prepared by RTGG method for perpendicular fracture surface to the original sheet plane.

References

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