Effect of oxygen partial pressure and Al content on langasite $Ca_3TaGa_{3-x}Al_xSi_2O_{14}$ single crystals for high temperature piezoelectric sensors

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Piezoelectric langasite $Ca_3TaGa_{3-x}Al_xSi_2O_{14}$ (CTGAS) single crystals are attracting much attention for high temperature sensor applications. However, the growth of CTGAS with high Al concentration has been reported to be difficult. In this work, CTGAS (x=0~3) single crystals are successfully grown by the Czochralski method. The temperature dependence of resistivity and piezoelectric properties are systematically investigated for the first time as a function of the Al content and the oxygen partial pressure during growth [1, 2].

Figure 1 shows an example growth of fully Al-substituted $Ca_3TaAl_3Si_2O_{14}$ (CTAS) single crystal. It is colorless, crack-free and strongly faceted. The growth of CTGAS under various oxygen partial pressures indicated that, although the piezoelectric properties were invariant, the resistivity was remarkably higher the lower the oxygen partial pressure. Figure 2 shows the piezoelectric constant d_{11} and resistivity as a function of the Al content at 400°C. Al-free $Ca_3TaGa_3Si_2O_{14}$ (CTGS) exhibits the lowest values for the d_{11} and the resistivity. By the gradual substitution of Ga by Al, both parameters tend to enhance continuously, reaching the highest values for the fully substituted CTAS. In conclusion, the current high resistive CTAS is the most promising single crystal among the langasite family for high temperature piezoelectric applications.

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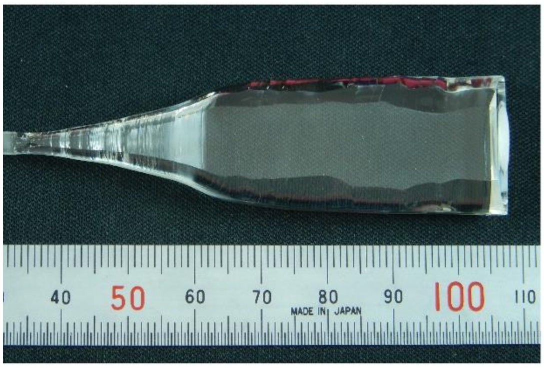

Fig. 1: Photograph of CTAS single crystal grown under N_2+1%O_2 using a Pt crucible.

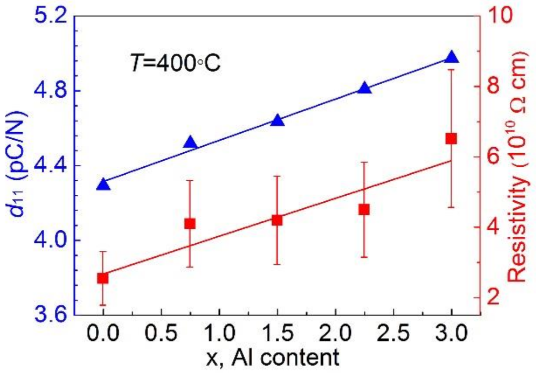

Fig. 2: Piezoelectric coefficient d_{11} and resistivity as a function of Al content at 400 °C.

References

[1] X. W. Fu, E. G. Víllora, K. Shimamura, et al, Cryst. Growth Des., 16 (2016) 2151-2156.

[2] X. W. Fu, E. G. Víllora, K. Shimamura, et al, J. Alloys Compd. 687 (2016) 797-803.