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High-power properties of $(Sr,Ca)_2NaNb_5O_{15}$ piezoelectric ceramics in a longitudinal mode

$(Sr,Ca)_2NaNb_5O_{15}$ 圧電セラミックスの縦振動モードにおけるハイパワー特性

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1. Introduction

The piezoelectric actuators are almost always fabricated using $Pb(Zr,Ti)O_3$-based (PZT) ceramics. However PZT ceramics easily experience a large strain and produce a notable degree of nonlinearity under practical use condition as the high-power properties, which increase heat generation with decreasing quality factor and deteriorate the performance of PZT ceramics. On the other hand lead-free piezoelectric ceramics have been actively studied not only from the viewpoint of environmental conservation but also for the possibility of outstanding high-power characteristics. It was previously reported that $(Bi,Na,Ba)(Ti,Mn)O_3$ (BNBTM) and $(Sr,Ca)_2NaNb_5O_{15}$ (SCNN) ceramic disks have good high-power properties, moreover c-axis crystal-oriented SCNN ceramic plate have the effective piezoelectric constant as large as that of hard PZT ceramics and superior high-power characteristics.[1,2] They represented higher output power density than that of PZT ceramics.[3] The high power properties of crystal-oriented SCNN ceramics were considered to originate from decreasing strictly the internal stress induced crystal anisotropy.[4] The ultrasonic motor of a 31-vibration mode using the crystal-oriented SCNN plate showed twotimes higher output power in the previous study.[4]

In this study, we investigated the high-power properties of SCNN ceramics in a longitudinal mode (33-vibration mode) by comparing with those of PZT ceramics.

2. Experimental Procedure

SCNN powder were synthesized by a conventional solid-phase reaction.[1] The power was pressed into cylinder and sintered. After electrodes were formed on the surfaces of cylinder, poling was performed. SCNN ceramics were cut into rectangular columns with dimensions of □2 x L5 mm^3 for the 33-mode resonator. As comparison, we used hard-PZT C-213 and soft-PZT C-64 rectangular columns of □2 x L5, □4 x L10 mm^3 manufactured by Fuji ceramics.

The high-power properties were measured as a resonator in the 33-mode by continuous driving it with constant current driving method.[1,5] Figure 1 shows the picture and schematic of the configuration around in the measurement system.

3. Results and Discussion

At first, we checked the dependence of the dimensions of rectangular columns using PZT ceramics. Figure 2 shows the temperature rise of the resonator as function of the vibration velocity for PZT rectangular columns. Famously hard-PZT restricted the temperature rise than soft-PZT. The temperature rises of PZT rectangular columns with L10 was higher than those with L5. It is considered that the vibration of L10 have lack of stability than that of L5 in our measurement system.

Figure 3 shows the temperature rise of SCNN rectangular column as function of the vibration velocity in comparing with that of hard-PZT rectangular column. The temperature rise of SCNN is linearly increasing with the vibration velocity however that of hard-PZT is abruptly increasing with more than around 0.3 m/s rms. The radial vibration mode of SCNN ceramics shows gradually increasing the temperature rise with the vibration velocity in the previous study.[1] There was the difference of the vibration modes in the SCNN ceramics. The temperature rise of SCNN is lower than that of hard-PZT which the vibration velocity is over about 0.35 m/s rms. It is considered that this behavior is derived from the load of the Cu wire. The details follow on the day.

References

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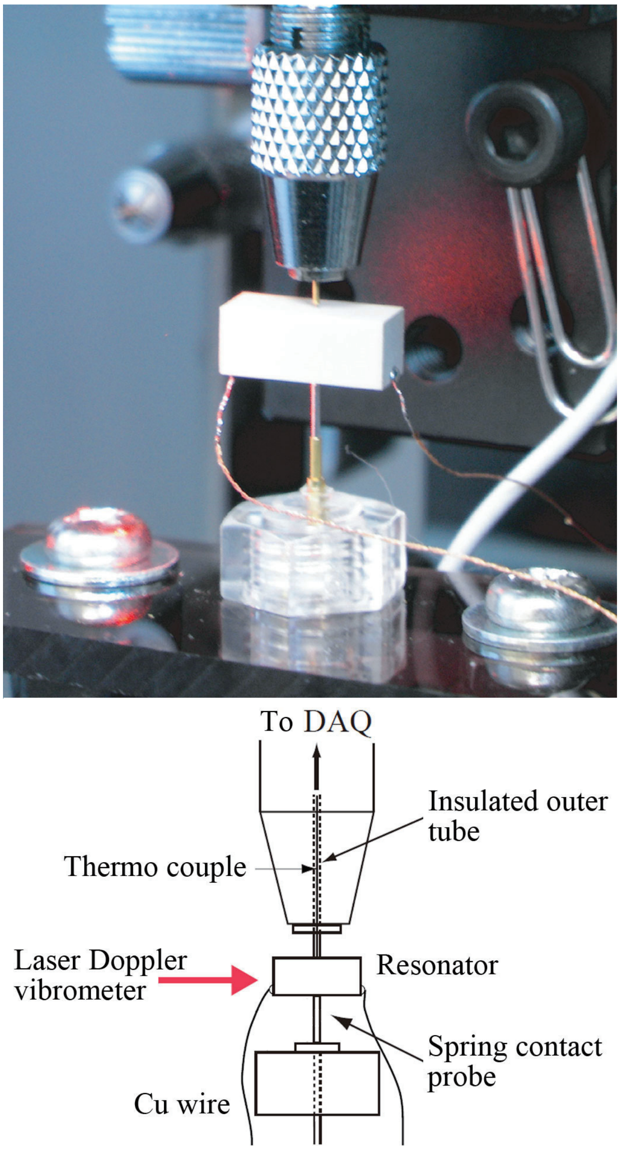

Fig. 1 Picture and schematic diagram of configuration around vibrator in the measurement system.

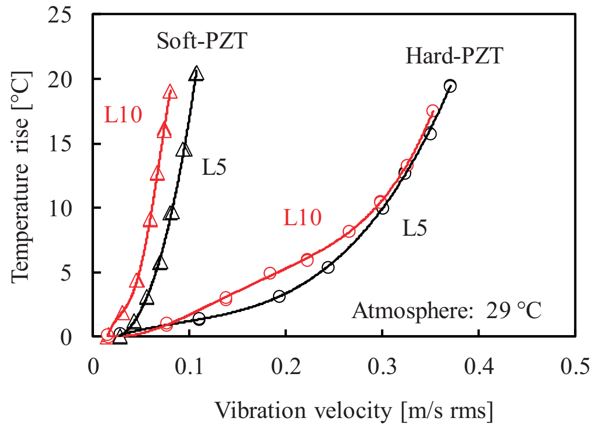

Fig. 2 Vibration velocity dependence of temperature rise of PZT ceramics with difference from dimensions.

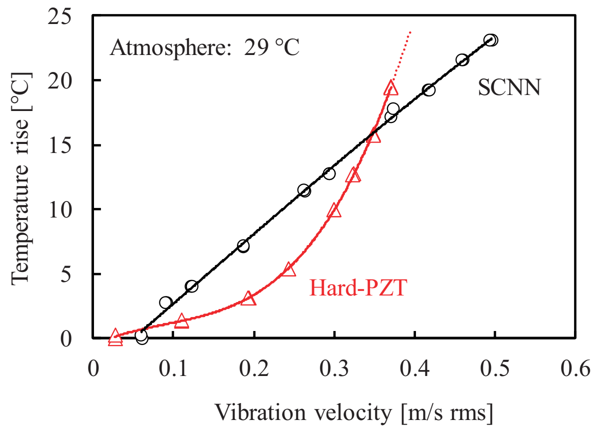

Fig. 3 Vibration velocity dependence of temperature rise of SCNN and hard-PZT ceramics.