Properties of Miniature Ultrasonic Motor using (Sr,Ca)$_2$NaNb$_5$O$_{15}$ Piezoelectric Ceramics Under High-Input Power

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Abstract

There are great demands for microactuators to miniaturize mechanical components and add high functionality in mobile equipment. Piezoelectric actuators using Pb(Zr,Ti)O$_3$ (PZT) ceramics have been partly put to practical use and many studies on ultrasonic micromotors have been carried out. As pioneering work, we succeeded in realizing a double-mode miniature cantilever-type ultrasonic motor using lead-free multilayer piezoelectric ceramics (MLPC) of (Sr,Ca)$_2$NaNb$_5$O$_{15}$ (SCNN) and the motor showed to be able to rotate by a lithium-ion cell used in the mobile equipment without an amplifier circuit. However, these miniature piezoelectric devices easily experience a large strain when subjected to a practical value of displacement. Under such a large strain, these miniature piezoelectric devices easily produce a notable degree of nonlinearity as high-power properties. Recently, SCNN ceramics exhibited the jump phenomena with hard-spring effect shown in Fig. 1 and to posses superior high-power properties than those of PZT ceramics shown in Fig. 2.

In this study, we investigated the driving properties of the motor using SCNN ceramics under high-input power by comparison of their high-power properties.

1. Introduction

2. Motor design

3. Motor characterization

References

Fig. 1. Jump phenomena under constant-voltage driving for SCNN disk.

Fig. 2. Vibration velocity dependence of quality factor for SCNN and hard PZT disks.

Fig. 3. Picture of cantilever-type ultrasonic motor for SCNN-A-MLPC.

Fig. 4. Simulated result of vamplate radius dependence of maximum revolution speed ($\Omega_0$) and torque ($T_0$).

Fig. 5. Revolution speed vs. frequency characteristics for SCNN motor.

Fig. 6. Relationship among revolution speed, efficiency, and torque for SCNN motor.