C-15

Development of Multilayer Ceramic Magnetic Circuit for MEMS Three-Phase AC Generator

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Abstract: This paper proposes multilayer ceramic magnetic circuits used for MEMS three-phase alternating current generator. The ceramic magnetic circuits are fabricated by a multilayer ceramic technology. In addition, two type circuits such as the separated coils type and the integrated coils type are designed. Two type circuits are compared by the power generation experiment. Moreover, the magnetic flux of ceramic magnetic circuits is analyzed by finite element method (FEM). The four-pole magnet and spindle machine are used for the power generation evaluation. The output power of the integrated coil type magnetic circuit is 0.63mVA. And then, the separated coil type magnetic circuit is 3.3 mVA.

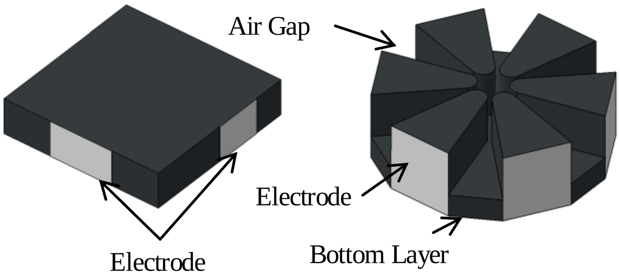
1. Introduction

With the increase in power consumption of electronic devices such as mobile devices, small and high dencity power supply is required. However, secondary battery have confronted a theoretical limit in power dencity. Ultra Micro Gas Turbine (UMGT) was introduced by MIT group as a new small power supply to replace the secondary battery of existing [1]. Therefore, Micro Electro Mechanical Systems (MEMS) turbine type generators have been studied widely. Usually, electrostatic type using electrets have adopted in MEMS turbine type generator. On the other hand, electromagnetic induction type has been adopted in MEMS turbine type generator because it shows low output impedance. However, microfabrication of winding structur and magnetic materials used in electromagnetic induction type generator is difficult to MEMS technology.

In this study, this paper proposes two type multilayer ceramic magnetic circuits used for MEMS generator. The multilayer ceramic technology realize the miniature herical coil structure because it can form the three dimensions windings. Three-phase electromagnetic induction type suitable to generation high current is adopted the generator. Moreover, the magnetic circuits were compared by the power generation experiment and the analyzed magnetic flux by finite element method FEM.

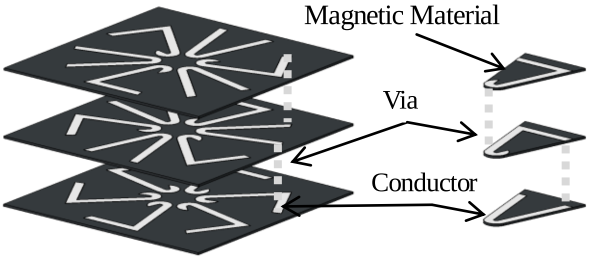
2. Design and Fabrication Process

The ceramic magnetic circuits are fabricated by the green sheet process. The magnetic ceramic material is nickel cupper zinc ferrite with the parmiability of 900. Moreover, silver as conductor paste is used for coil patterns. The ceramic magnetic circuits are designed two types such as the integrated type shown in Fig.1 (a) and the separate type shown in Fig.1 (b). Both ceramic magnetic circuits are designed as six helical coils of twelve-turn placed inside the magnetic ceramic structure. In addition, an axial gap type generation with four-pole magnet is used for generation experiment. The pattern of the coil is shown in Fig.2. The integrated type is designed as a part of all colis placed inside a ceramic structur. Although, the separated type is designed to remove magnetic material from the structure between the coil.



(a)　(b)

Fig.1 shematic illustration of ceramic magnetic circuits.
(a) The integrated type　(b)The separated type



(a)　(b)

Fig.2 shematic illustration of internal conductor patterns .
(a) The integrated coil type (b)The separated coil type

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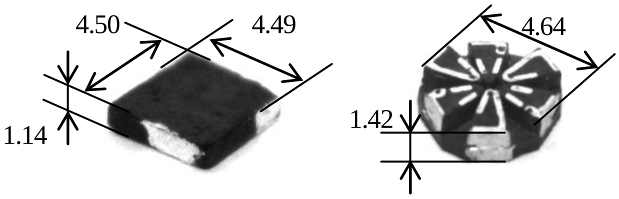
3. Resuts and Discussion

Figure 3 shows the fablicated ceramic magnetic circuits. The size of integrated type magnetic circuit were 4.50 mm× 4.49 mm ×1.14 mm.The size of fabricated separated type ceramic magnetic circuit were 4.64 mm as width, and 1.42 mm in hight.



(a) (b)

Fig.3 Pictureof the fabricated ceramic magnetic circuits .
(a) Integrated type (b) Separated type

Figure 4 shows the schematic illustration of the method for tne generation experiment. The spindle machine rotating at 30,000 rpm and attached the four-pole magnet to the tip was used to demonstrate the generation by the magnetic circuits. The output voltage was measured with an oscilloscope.

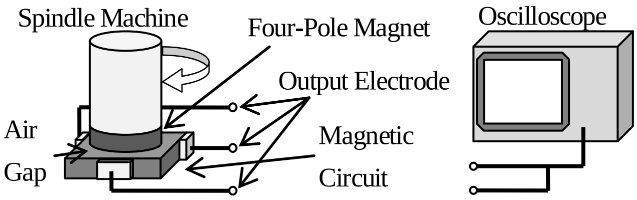
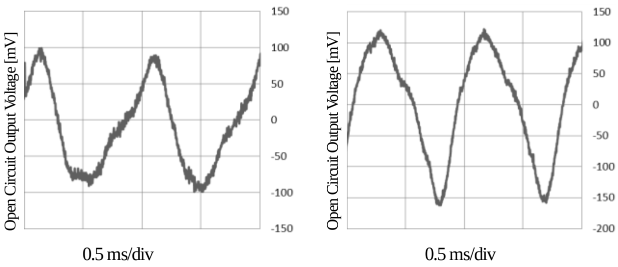


Fig.4 Schematic illustration of generation experiment.

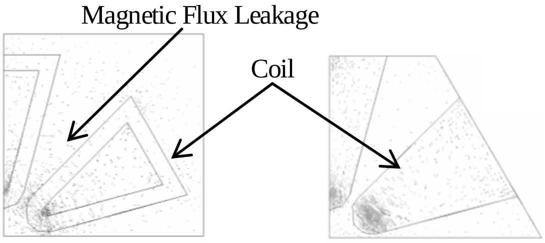
Figure 5 shows the typical output voltage of integrated coil type in the experiment,and the typical output voltage of separated coil type in the experiment.



(a) (b)

Fig.5 Output voltage in generation experiment.
(a) The integrated coil type (b)The separated coil type

The output powers when the load resistance of 1 Ω was used were 0.63 mVA of the integrated coil type and 3.3 mVA of sepalate coil type. In addition, the ceramic magnetic circuits were analyzed by FEM in order to discuss the reason of the difference between the output powers. Figure 6 shows the results of the analyzed magnetic flux of internal ceramic structur. Figure 6 (a) shows a large number of magnetic flux leakage outside the coil. Figure 6 (b) shows that the magnetic flux was guided into the coil more than the integrated type. From these results, the reason why the output power of separated type was five times larger than that of the integrated type is considered that the magnetic flux of separated type is guided into the coil more than that of the integrated type.



(a) (b)

Fig.6 FEM analysis of magnetic flux inside ceramic structurs. (a)The integrated type (b)The separated type

4. Conclusion

Multilayer ceramic magnetic circuits used for MEMS air turbine generator was fabricated. twe types of the magnetic circuits were compared by the power generation experiment moreover, analyzed magnetic flux by FEM. The output powers of magnetic circuits was 0.63m VA and 3.3 mVA. As the results of FEM analysis, the difference between output powers was caused by the difference of magnetic structure.

Acnowledgement

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Reference

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