C-1

Patterning Technology of Different Materials in Multilayer Ceramic Components

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Abstract: A new method which uses photo resist films and doctor blade method to prepare patterning of the different materials inside the same level of multilayer ceramic component is proposed. Conventionally, different materials were stacked each other, and therefore the materials have been placed on each level. On the contrary, the new method that uses the photo resist film can obtain the flat patterned structure of the different materials inside the base material. In this research, multilayer ceramic component which has patterned different material was achieved.

1. Introduction

It is important to combine different materials inside multilayer ceramic devices such in Low Temperature Co-fired Ceramics (LTCC) system. Conventionally, it has been usual that the green sheets of different ceramic materials are formed separately, and then they are stacked each other. The word green sheet means a flexible sheet before firing, which is composed of ceramic powder and binder material. Therefore, the different materials have been placed on each level inside the multilayer device. However, by means of the conventional method, it is difficult to produce more complex structures such that different materials are placed and patterned in the same layer.

The authors previously published a new processing method of the ceramic green sheet by using the photo resist film for forming the through empty areas [1]. Making use of the similar method, we developed more complex structure that the different materials of the magnetic material and insulation material are placed and patterned in the same layer in multilayer ceramic system. For example, it becomes possible to form the nonmagnetic ceramic surround the coil pattern into the magnetic material of the laminated inductor. In this application, the magnetic flux loss due to the minor loop located between the conductors is expected to decrease. Figure 1 shows the schematic illustration of the laminated inductor.

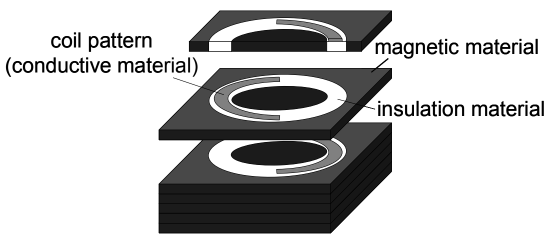

Figure 1. Schematic illustration of the laminated inductor that suppresses the minor magnetic loop.

In this paper, the formation process and the observation of the structure are discussed.

2. Experimental Procedure

The schematic illustration of the objective pattern of the different material and the structure is shown in Figure 2. This structure was composed of two blank layers on the different material layer.

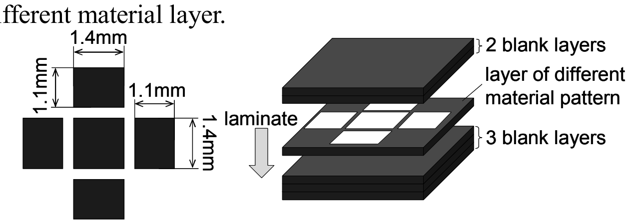

Figure 2. Schematic illustration of the pattern of the different material and structure.

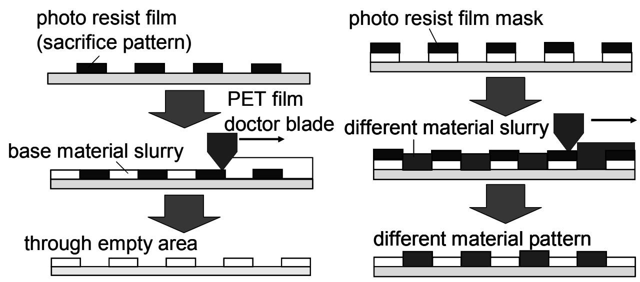

Figure 3. Schematic illustration of process for producing the patterned different material into the green sheet.

Figure 3 shows the schematic illustration of the process for producing the patterned different material into the green sheet. In the first step, the photo resist film was exposed for forming the sacrifice pattern corresponding to the different material. The sacrifice patterns were obtained after developing. In the second steps, the green sheet of the base material was formed using the doctor blade. At the time, the gap between the blade and the surface of the resist film was adjusted to zero. Therefore, the slurry filled the sacrifice pattern surrounding. Then, the specimens were dried. After the sacrifice pattern was dissolved, the green sheet of the base material with the through empty area was achieved. After that, the patterned resist film was covered on the base

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material of the green sheet, and then it was laminated by a heat press. The laminated green sheet was filled with the slurry of the different material using by the doctor blade. After that, the resist film for the mask was dissolved. Through these procedures, the green sheet with the through different material pattern was achieved. The patterned green sheet and the base material green sheet was stacked at designed number and fired.

3. Result and discussion

Figure 4 and Figure 5 are observed image of the different material pattern inside the base material green sheet before laminating. In Figure 4, the base material is LTCC, the patterned material is ferrite. In Figure 5, reversal pattern of the previous one.

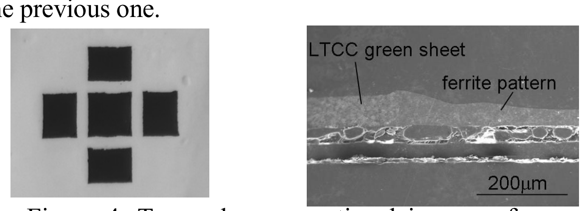

Figure 4. Top and cross sectional images of green sheet composed of the different material.

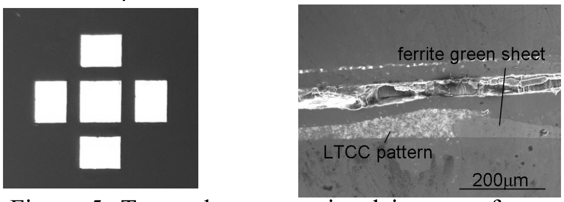

Figure 5. Top and cross sectional images of green sheet composed of the different material.

In these images of the cross-section, it is observed that the thickness of the interface of the base material and different material was not flat. The reason of this phenomenon is the alignment error of the cover mask. Moreover, the difference of the thickness between LTCC green sheet and ferrite green sheet was 20 μm. This reason is that the particle diameter of the ferrite was smaller than the particle diameter of the LTCC. Therefore, the volume ratio of the ferrite in the slurry is smaller than the volume ratio of the LTCC because of the difference of the particle weight. It is necessary to adjust the composite weight ratio of the slurry to solve this problem.

Figure6 is the observed cross sectional images of fired specimen by SEM.

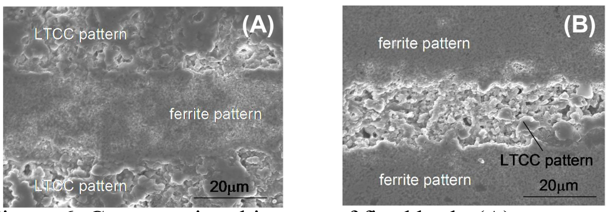

Figure 6. Cross sectional images of fired body (A) patterned material was ferrite; (B) patterned material was LTCC.

In these results, the shrinkage of the surface direction of the specimen which was patterned the ferrite was 4.5 %, the shrinkage of the height direction was 12.7 % and the coplanarity was 4.5 μm. In addition, the shrinkage of the surface direction of the specimen which was patterned the LTCC was 4.4 %, the shrinkage of the height direction was 4.9 % and the coplanarity was 3.7 μm. From these result, the shrinkage of the surface direction was almost same value.

Moreover, it was found that the dispersant of the LTCC slurry that contained phosphoric ester suppressed the sintering of the ferrite. Figure 7 shows the cross sectional image of SEM when phosphoric ester dispersant is used in LTCC slurry. The porosity inside ferrite between the LTCC sintered layers is observed. By changing the phosphoric ester to non-phosphoric dispersant, the sufficient densification of the ferrite was achieved.

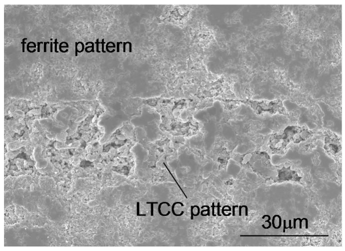

Figure 7. Cross sectional image of fired body, LTCC slurry contains phosphoric ester as dispersant.

4. Conclusion

The different material patterned inside the multilayer ceramic components was achieved. The used materials were LTCC and ferrite. In addition, the difference of the thickness between LTCC green sheet and ferrite green sheet was observed and the difference was 20μm. It is necessary to adjust the composite weight ratio of the slurry to solve this problem. Also, it was found that the dispersant of the LTCC slurry that contained phosphoric ester suppressed the sintering of the ferrite. This problem was avoided by changing the phosphoric ester to non-phosphoric dispersant, showing the sufficient densification of the ferrite.

Acknowledgments

This study was supported by KAKENHI 22560254. And this study was supported by Research Center for Micro Functional Devices, Nihon University.

Reference

[1] F. Uchikoba, J. Tane, S. Park and K. Yamashita, Proc. of International Conference on Electronics Packaging 2007 ICEP, pp. 318-322, 2007.