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A Study on the Resonator Plating Method of Ceramic Resonator Filter

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Abstract

5th generation telecommunication is expected to be served with Internet of Things (IoT). And those services would cause the architecture of mobile networks. Consequently the distribution of base station should be changed toward dense deployment. In that environment the part for the base station should be altered totally considering the size and output. This paper deals with the method to reduce the filter that would be used in the small base station and introduces the optimization method for conductive coating of the ceramic resonator

Keywords: *IoT, Base Station, filter, conductive coating*

1. Introduction

With the development of communication technology and the rapid increase of users, the distribution of base stations has been changed. In addition, the development of the Internet of Things (IoT) is expected to increase the number of devices with built-in communication chip, which will cause the data traffic to be increased even further. Therefore, it is projected that the 5th generation (5G) telecommunication, which is expected to be commercialized by 2020, and IoT will increase data transmission by 1,000 times than the conventional 4th generation telecommunication and the rate of contact per base station per time more than 1,000 times. Various technologies have been developed to transfer and process more data.

Long ago mobile users used to be in an environment where only high-power base stations have been installed. However, now it is changing toward that middle- and small-power base stations are installed together to configure the communication coverage area more closely. As a result, specifications of parts used in the base station also need to be changed.

As mentioned, initial base stations were comprised of high power and high-performance products to maintain communication wider and farther. As a result, filters that are used in that base station are large-sized product made of metal or a high-performance filter using Dielectric Resonator with low loss. However, due to the development of technology and changes in the communication environment, base station has been changed from a single base station that communicate wider and more distant distance to more base stations that increase density and communication capacity. As a result, parts used in the base station are required to be small-sized parts with medium and small output from parts that withstands high characteristics and high power regardless of size.

In order to use the existing metal filter, it has a problem that it should be reduced in terms of size because it was too big and heavy to be adopted in the medium and small output system. In the case of the existing LTCC filter, even if the size of Monoblock filter or array filter is small, there is a problem that output and characteristics are not enough.

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Also, if a Dielectric Resonator (DR) filter is made to satisfy the characteristics, the size would be too big to be fit into a base station with medium and small output [1, 2].

In order to solve these problems, lots of research works are ongoing in the area of changing the internal and external structure and material of the filter. In order to reduce the size of the filter, in some cases the material of resonator was changed into ceramic. And the size of resonator was reduced by conducting a ceramic conductive coating and forming the TEM 01 delta mode like existing resonator of the metal filter. However, although the method of plating the conductive terminal of the ceramic resonator [3] has been introduced, method for applying a conductive coating on the whole surface of the ceramic material is not concretely specified and many problems occur in adhesion strength and burning according to the condition.

As a result, this paper introduces the optimization method for conductive coating of the ceramic resonator.

2. Material and Methods

2.1. Plating Technique

2.1.1. Inkjet Printing Method

The inkjet printing method is a process technology of patterning fine ink droplets at positions desired to be ejected from the head. In the inkjet printing process, fine ink droplets which ejected through a nozzle adhere to a ceramic surface by flying in the air, and pattern is formed when the solvent is quickly dried to fix the solid component. The size of the droplet is about dozens of pl, and the diameter is around dozens of micrometers. In this method, since phenomena such as photolithography / etching etc are unnecessary, there is no case that the characteristics of the substrate and the material deteriorate due to chemical influences, but also there is no damage as because it is a non-contact type printing method.

2.1.2. Screen Printing Method

The screen printing method is a process in which an ink paste is placed on a screen pulled with a strong tension and the squeegee (a squeegee, a printing tool in the form of a pedestal) is moved down while pushing the paste onto the ceramic surface through the mesh of the screen. Fabrics such as original silk were used as screen, but the material of the mesh is changed to stainless steel due to fine patterning. Ink paste which is used is in a form of resin or solvent that are dispersed in basic materials such as metals, ceramics, and semiconductors to ensure the suitable viscosity for printing. The thickness of the printed film is affected by the concentration and viscosity of the ink paste and the thickness, size, materials of the screen mesh, and generally film can be realized its thickness ranges from submicron to micrometers.

2.1.3. Gravure and Gravure-Offset Printing

Gravure printing is a kind of intaglio printing, in which ink that adhered to a cylindrical plate having irregularities and scratch ink adhered to convex portions. Then ink that has entered the concave portion is transferred to the substrate. A gravure offset printing method which is combination of Gravure printing method and an offset printing method has recently been applied to displays such as LCD color filters and electronic circuits, and the possibility is examined as an important manufacturing process of a flexible electronic element by using a transfer method that ink is transferred from a printing plate to a rubber blanket, and then transfer the ink of the blanket to substrate [4].

2.2. Plating Process

2.2.1. Tumbler

Process for removing foreign substance on the surface for resonator plating. Material used for polishing the surface of the resonator

Table 1. Materials for Tumbler

	Condition	Material
Abrasive Size	2pi	Abrasive, Surfactant, Water, Ceramic Resonator
Speed	200RPM	
Time	30min	

Figure 1. Ceramic Resonator

Figure 2. Tumbler Machine

2.2.2. Hole coating (Ag paste)

Suction after filling AG paste inside the hole

Figure 3. Suction for Resonator

2.2.3. Drying

Dry the page which is stained in the wall in the hall using Dry Oven equipment, 100'C / 30min

Figure 4. Dry Oven

2.2.4. Ag Printing / Drying

Proceed drying after printing the Ag paste on the printing surface (Top / bottom)

Figure 5. Ag Paste Printing

2.2.5. Sintering

Proceed sintering at 900 'C for 15 min using Box Furnace material facility

2.3. Specimen

Manufacturing of dielectric ceramic resonator was performed using ceramic powder with a permittivity of 90 and the size of manufactured resonator is 14.5mm

2.4. Measurement Methods and Standard

The viscosity measurement standard was Brookfield DV-II, spindle # 14/10 rpm, and the adjustment standard of the discharge amount was controlled by the discharge time of discharger, Suction time is over 30 seconds.

Suction time condition was arraying 4 and set suction power as 250 W then worked at the same time

2.5. Resonator Plating Location

A conductive film is formed on the upper surface, the bottom surface, and the through hole except the side surface of the resonator.

Depending on the frequency, the pattern on the top surface may be deformed or not plated depending on the design.

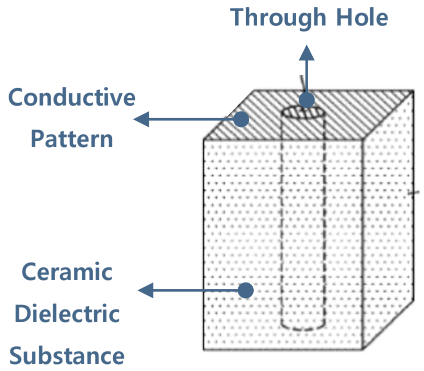


Figure 6. Resonator

3. Result and Discussion

3.1. Coating Effect by Viscosity

To confirm the coating thickness by Viscosity, the change in thickness was measured by changing Viscosity from 80 kcps to 20 kcps as shown in Table 2. The discharge amount was 0.3 g and the suction time was at least 30 seconds during the measuring.

Table 2. Viscosity Value

Viscosity(kcps)	Discharge amount(g)	Suction Time(s)
80	0.3	30.min.
40	0.3	30.min.
20	0.3	30.min.

For the test result, the coated surface is as shown in Figures 7 and 8, and the thickness of the coating by each viscosity is as shown in Table 3.

The coating thickness by paste viscosity was 20 μm at 40 kcps and 15 μm at 20 kcps. Coating thickness was at 10 μm at 10 kcps.

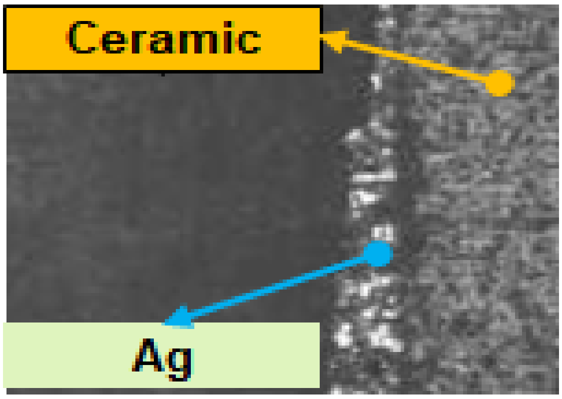
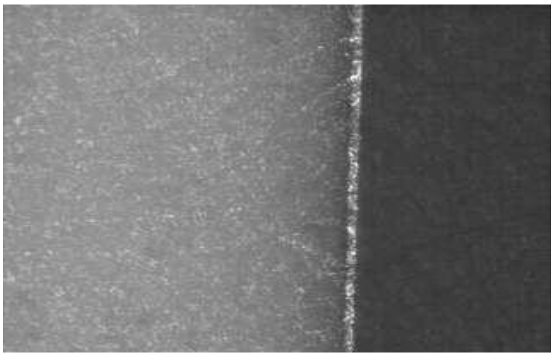
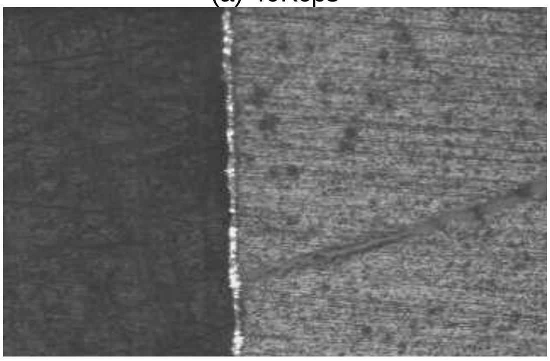


Figure 7. Viscosity 80kcps



(a) 40Kcps

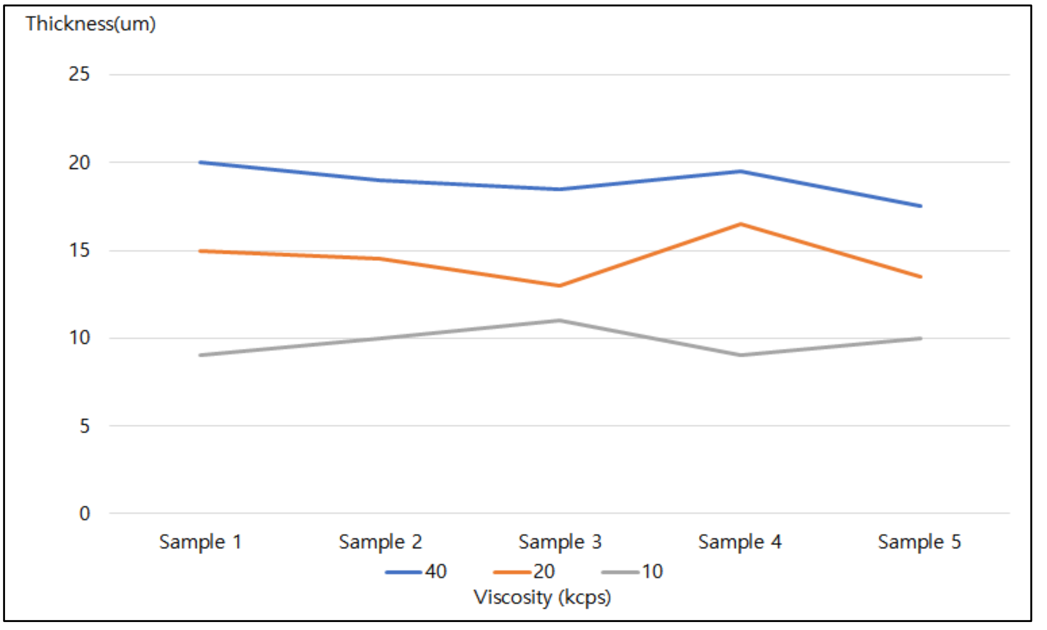


(b)10Kcps

Figure 8. Viscosity Result

Table 3. Coating thickness

Viscosity(kcps)	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
40	20.0um	19.0 um	18.5 um	19.5 um	17.5 um
20	15.0 um	14.5 um	13.0 um	16.5 um	13.5 um
10	9.0 um	10.0 um	11.0 um	9.0 um	10.0 um



3.2. Coating Effect on Discharge Amount

To confirm the coating by Discharge, the coating state was measured by changing Discharge from 0.1 g to 0.3 g as shown in Table 4. The suction time was at least 30 seconds during measurement.

Table 4. Discharge Amount of Paste

	Discharge amount(g)	Suction time(s)
Sample 1	0.1	30
Sample 2	0.2	30
Sample 3	0.3	30

It is not printed when discharge amount is less than 0.1 g as shown in Figure 9.

Figure 9. Discharge rate Fail Result

There is no failure about printing when the discharge amount was 0.2 g or more.

3.3. Coating effect by Suction Time

To confirm the coating state by Suction Time, the coating state was measured by changing Suction Time from 0.5 s to 20 s as shown in Table 5. The discharge amount was 2 g and the suction power was 250 W during measurement.

Table 5. Suction Time

Suction force(W)	Suction Time(s)	Discharge amount(g)	Suction force(W)
Sample 1	5. min	0.2	250
Sample 2	10. min	0.2	250
Sample 3	20. min	0.2	250

When the suction time was 5 sec, partial unprinted and paste agglutination occurred as shown in Figure 10.

When the suction time was 10 sec or more, no failure occurred about unprinted matter.

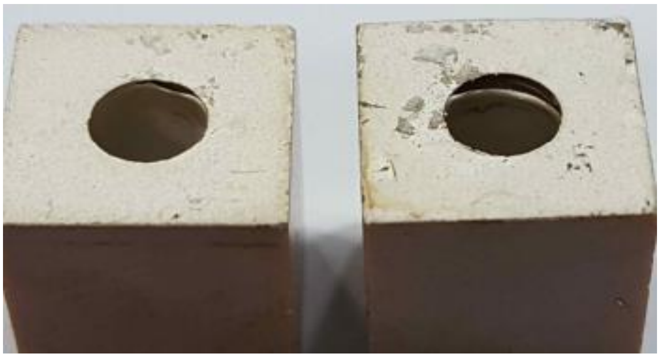


Figure 10. Print Fail Result

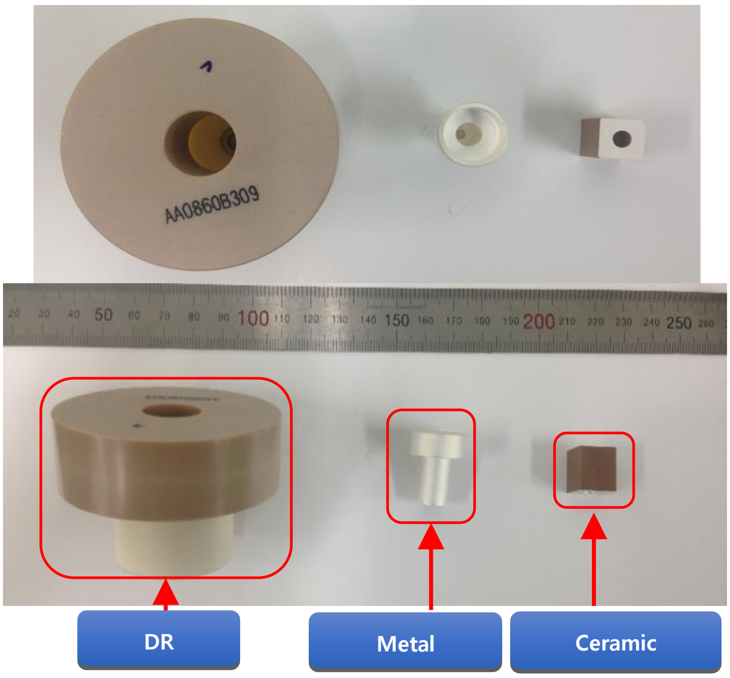


Figure 11. DR vs. Metal Vs. New Ceramic Resonator Comparison

Figure 11 shows Dielectric Resonator, Metal Resonator, and New Ceramic Resonator that used for the 800 MHz filter.

4. Conclusions

It was possible for us to reach the following conclusions through the research on conductive film coating of dielectric ceramic resonator.

We confirmed the results of the conductive film coating according to the discharge amount and the Suction Time when the ceramic with the permittivity of 90 and the resonator with the height of 14 mm. When the viscosity of Paste can have 40 kcps or less, the coating thickness of the resonator is equal and the state of the coated surface shows a good tendency. When the discharge amount was 0.2 g or more, it was confirmed that coating was carried out without occurrence of un-printing failure. When the suction time was 10 sec or more, un-printing failures did not occur and the difference showed a difference in every hour over 10 sec.

We conducted research on conductive film coating of dielectric ceramic resonator, and studied on printing effect of coating by viscosity of paste, discharge amount, suction time.

Through this research that we were able to get the proper value for the conductivity of ceramic resonator with the conduct plating, we could prevent the misprint by printing properly the plating of the conductivity that affects the important characteristics of resonator of the filter. Therefore, we could find the worth of the paper in the fact that we could find the way of minimizing the faults in making filters and keep the RF characteristics.

For the future works, we consider such as optimization method of conjunction between resonator and filter housing for the tight contact.

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