DESIGN OF COLD BPM FEEDTHROUGH

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Abstract

We have designed many BPM feedthrough used metallized ceramic components.

We select the best material of ceramic and metal adjusted for magnetism and the material of chamber.

The request for low temperature and RF property in accelerator application has increased in recent years.

In this presentation, we report on the design of the BPM feedthrough for low temperature and for the RF up to 20GHz.

INTRODUCTION

We Kyocera have been producing metallized products from Semiconductor Equipment to Medical, Avionics and Space Industry.

Especially our UHV products which are participating with particle physics research had begun since "Tristan project "in Japan.

Our UHV production technology has been evolving day by day with accelerator history, during producing UHV products for Japan, Europe and U.S.A.

The requirement for low temperature in accelerator application has increased according to development of cryogenic instruments in recent years.

On the other hand we have manufactured hermetic feedthroug by using metallized ceramic brazed with metal parts.

Difference of electrical constant between organic material and ceramic make RF throughput design of feedthrough difficult.

We have designed RF feedthrough with not only matching to 50 ohm but also S parameter influenced by signal frequency.

THE BRAZING STRENGTH AT LOW TEMPERATURE

Sample

Fig.1 shows metallized ceramic samples for tensile strength test in low temperature by using brazed ceramic sample in the condition indicated in Table1.

Fig.2 shows structure of sample.

Mo/Mn metallized ceramic is brazed between Fe-Ni-Co alloy metal components using Ag-Cu brazing material.
Fe-Ni-Co alloy is used for brazing material to bond with ceramic because it has Coefficient of Linear Thermal Expansion 5.7-6.2 close to one of alumina ceramic 7.0-8.0.
Ceramics are 7mm diameter and 99% alumina which is commonly used for UHV application.

Figure 1. Look of tensile strength test samples

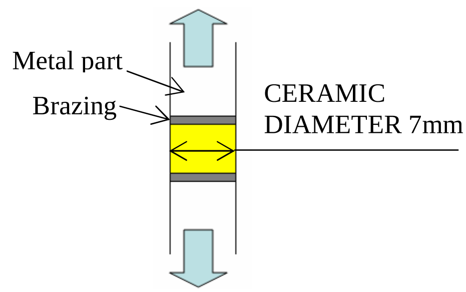


Fig.2 Structure of sample

Table 1.Condition of tensile test sample

Ceramic	99%Al_2O_3(KYOCERA A479)
Metal	Fe-Ni-Co Alloy
Metallizaion	Mo/Mn
Plating on Metallized surface	Ni
Brazing Material	Ag-Cu Alloy
Brazing Temperature	800 degree C

Test Stand

We tested tensile strength of samples of Fig.1 by using the tensile test stand in Japan Atomic Energy Agency.

This test sample was immersed in Liq. N2 or Liq. He.
Then, those two brazed metal components were pulled towards top and bottom direction respectively.
We tested 3-5 pieces of samples in 4K, 77K and 300K (room temperature).

Result

Fig.3 shows result of tensile test in 4K, 77K and 300K.

The tensile strength in low temperature is smaller than in R.T. approximately 10%, but the dispersion affected by brazing flow condition is bigger than this temperature effect.

The influence of low temperature is less than condition of brazing flow, therefore the bonding strength of metallized ceramic is enough for UHV application at 4K.

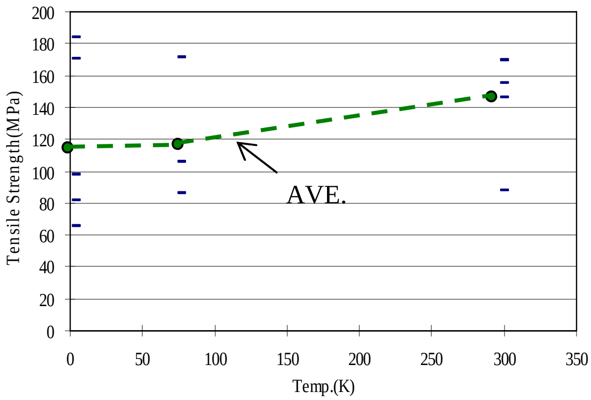


Figure 3 Tensile strength of metallised ceramic

Fig.4 shows braking surface picture after tensile test in 4K.

Black color is Mo/Mn metallization and white color is braked ceramic and Ag-Cu brazing material.

Braking modes in 4K and 77K are same as in 300K.

This braking mode is normal.

Final conclusion is that Ceramic brazing strength is enough for UHV application at 4 K.

Figure 4 Braking surface picture after tensile test in 4K

DESIGN FOR RF PROPERTY

Model

We investigated several ceramic models how those will affect to RF performance in ceramic hermetic feedthroughs.

Affecting factors for RF performance are impedance matching and resonance.

Simulated models are coaxial ceramic disc and cylindrical conductor like Fig.5.

We used ANSOFT 3D field simulator; HFSS.

The diameter of center conductor is 1.0mm.

Previous and next transmission lines of ceramic are matched as 50 ohm and insulation medium is air.

We did RF simulation by varying ceramic diameter from 8 to 16 and thickness from 1.0 to 4.

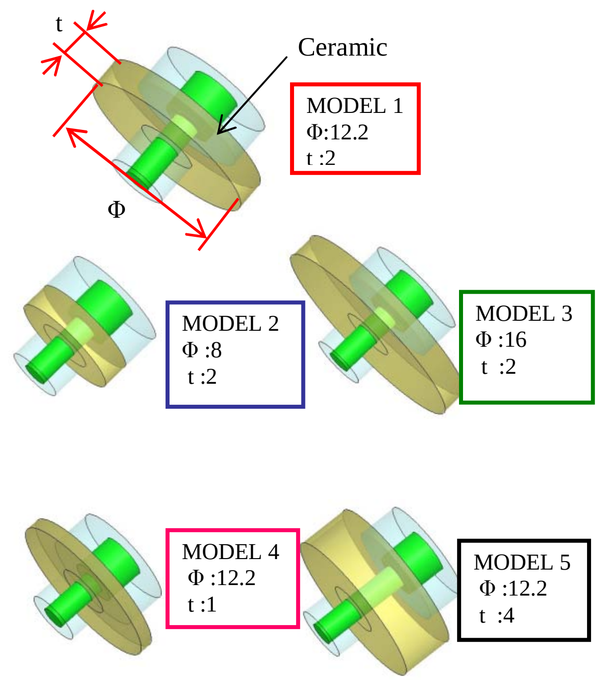


Figure 5 RF simulated models (unit; mm)

Result

Fig.6 shows the result of simulation.

When the diameter of center conductor is 1.0mm and the dielectric constant of insulator medium is 9.0, the diameter of outer conductor is 12.2mm for Impedance 50 ohm.

Therefore MODEL 1 is best at the point of view about impedance matching.

But the big resonance peak appears at 10GHz in insertion loss when the dimensional condition is defined above.

When we design RF feedthrough, we must consider about both of matching for impedance 50 ohm and avoiding the resonance frequency by the simulation in working frequency.

Frequency of resonance shifts to higher frequency by decreasing diameter of ceramic disc, when we compare Model 1,2 and 3.

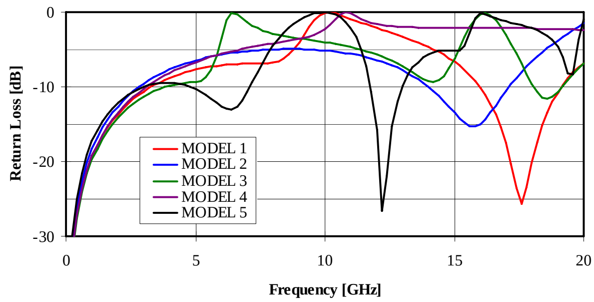
Therefore, we can avoid a resonance phenomenon by designing ceramic outer diameter smaller.

The thickness of the ceramic also influences a resonance phenomenon, when we compare Model 1, 4 and 5.

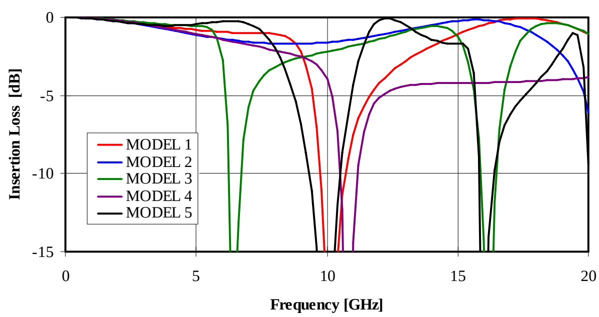
Model 5 has two resonance frequencies to 20 GHz.

We determine reasonable ceramic thickness based on simulation at our design stage and we avoid a resonance phenomenon in usage frequency.

We have the possibility to design the ceramic feedthrough with RF property up to 20GHz by using this simulation method.



(a)



(b)

Figure 6 Result of RF simulation

(a) Return Loss (b) Insertion Loss

Actual design of RF feedthrough

We designed actual products of feedthrough based on above results.

Fig.7 shows the model of actual feedthrough for RF simulation.

Fig.8 shows the result of simulation of RF feedthrough.

We can avoid resonance phenomenon up to 18GHz by designing with 8mm outer diameter of a ceramic.

We manufactured actual BPM feedthrough according to above RF model.

Fig.9 shows the product of Button electrode type of BPM feedthrough.

Fig.10 shows actual measurement result about RF property of BPM feedthrough.

Resonance peek in RF property insertion Loss (S12) appear at 18 GHz same as the RF simulation of Fig.8

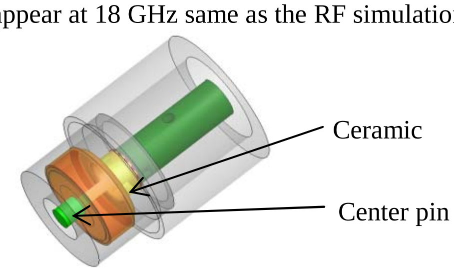


Figure 7 Model of actual feedthrough for RF simulation.

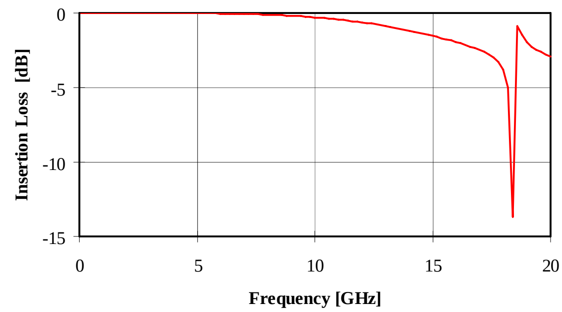


Figure 8 Result of simulation of RF feedthrough

Figure 9 BPM feedthrough

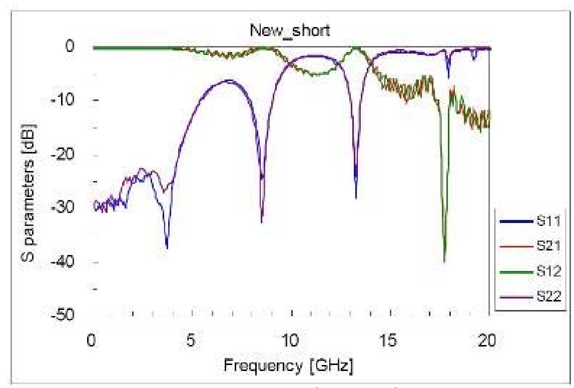


Fig.10 RF property of BPM feedthrough

CONCULSION

We conclude this article with the following summarizing remarks;

1. The bonding strength of metallized ceramic is enough for UHV application at 4K.
2. We have capability of producing BPM withstanding cryogenic environment.
3. We have capability to design considering RF performance by RF simulation [1].

ACKNOWLEDGMENT

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REFERENCES

[1] Hideaki Aoyagi and others, “RF Properties of Coaxial Feed-through Connectors for Design of a Frontend Pulse-by-Pulse SR Beam Monitor”, proceeding in SRI2006, Jun 2006