MGB_2 THIN FILMS ON NB CAVITY BY PULSE LASER DEPOSITION

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Abstract

The large efforts have been concentrated on Nb cavities for International Linear Collider (ILC). The maximum accelerating field gradient of Nb cavities is limited about 50 MV/m due to Hcsh. MgB_2 (MgB_2) have higher Tc than Nb and expected to have higher Hcsh. Thin films of MgB_2 on Nb is useful to increase future ILC energy upgrading.

At KEK, the preliminary test of thin films on Nb by Pulse Laser Deposition(PLD) method have been started and initially the direct deposition of MgB_2 film on Nb discs and single cell cavity was studied.

INTRODUCTION

The maximum accelerating field gradient of Nb cavities is limited about 50 MV/m due to Hcsh. To decrease magnetic field on Nb, recently magnetic shield using thin films superconductor is proposed.(1) MgB_2 is one of such high Hcsh materials.

Not only perfect thin films, thin films with uniformly distributed small particles of superconducting materials possibly partially shielding magnetic field, so we start experiment to form MgB_2 thin films on Nb substrate. After TE mode cavity experiment, TM mode cavity experiment started.

MGB2 FILM PREPERATION

DC Measurements Sample

Basically the film forming methods of pulse laser deposition(PLD) is same as described by Inagaki et al(2) and dimension of samples are 10x20x2.5mm. Initially, to fix condition of film forming on Nb, we studied DC resistance measurement. But the resistance was not vanish to 9 K. The post annealing temperature was fixed by 620 deg C which almost same as best value of sapphire and SiC substrate cases.

RF Measurements Samples

Substrate of RF measurement samples is a Nb disc of 37 mm diameter and 2.5 mm thickness. The surface of samples polished by #2000 diamond polishing past and degreased by acetone. MgB_2 films of about 1 micron meter formed by PLD method and post annealed 620 Deg. C.

RF MEASURMENTS

The samples set on host cavity made from copper as shown in Fig 1.

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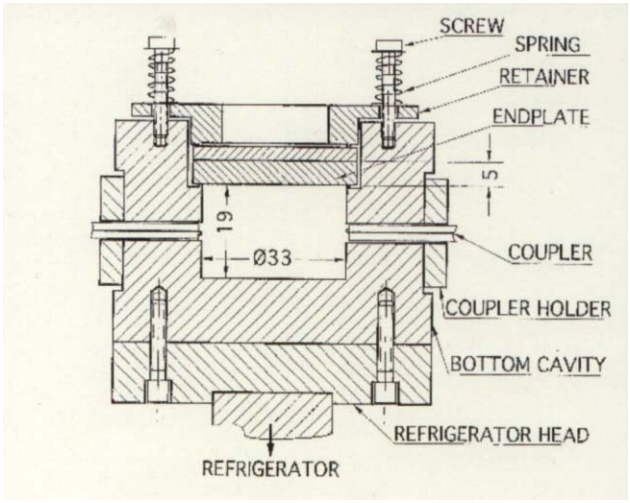

F1g. 1 RF measurement cavity made from copper and samples set as endplate.

The surface resistances Rs were measured for MgB_2 film deposited Nb disc and bare Nb disk.

Fig.2 shows the measured QL and Q_0 of Nb and Fig.3 shows those of MgB_2 film.

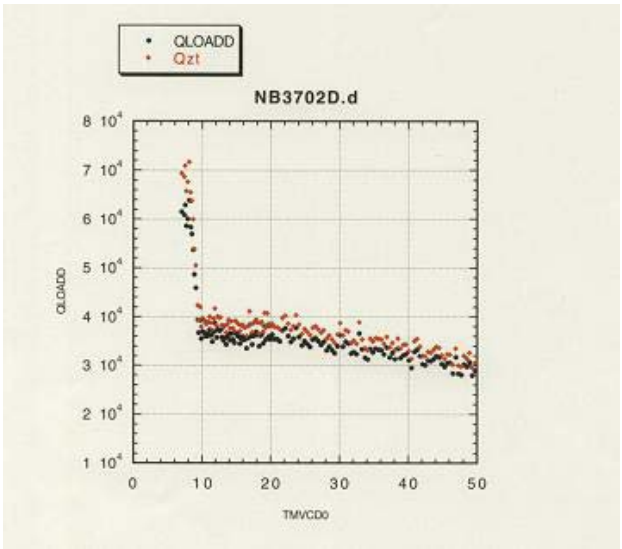

Fig.2 QL and Q_0 for Nb disc

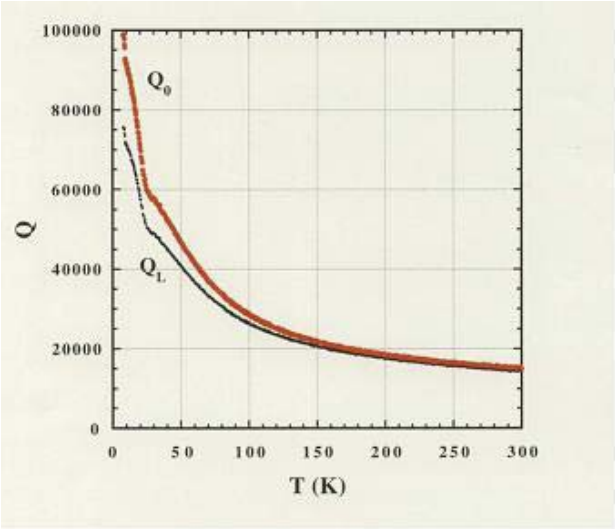

Fig.3 QL and Q_0 for MgB_2 precursor film on Nb

Q_0 of MgB_2 film on Nb data clearly shows suddenly changes at 25 K and 9 K corresponding to critical temperature Tc of MgB_2 and Nb.

The Rs of each materials is calculated using that of copper host cavity .

Fig.4 and Fig.5 show measured Rs of Nb and MgB_2 on Nb.

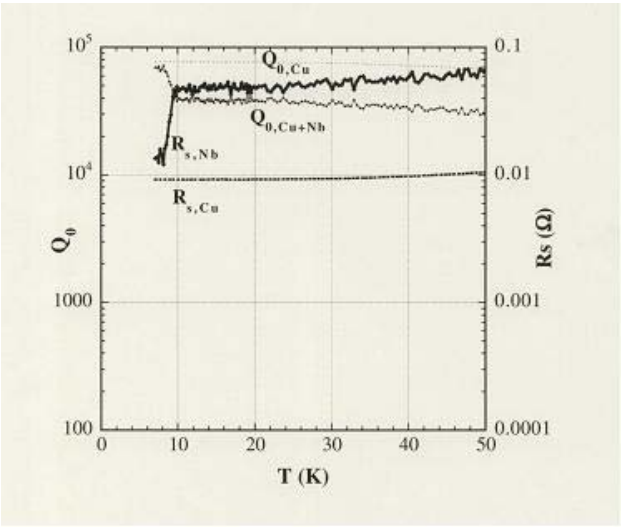

Fig.4 Rs and Q_0 for Nb disc and those of host cavity

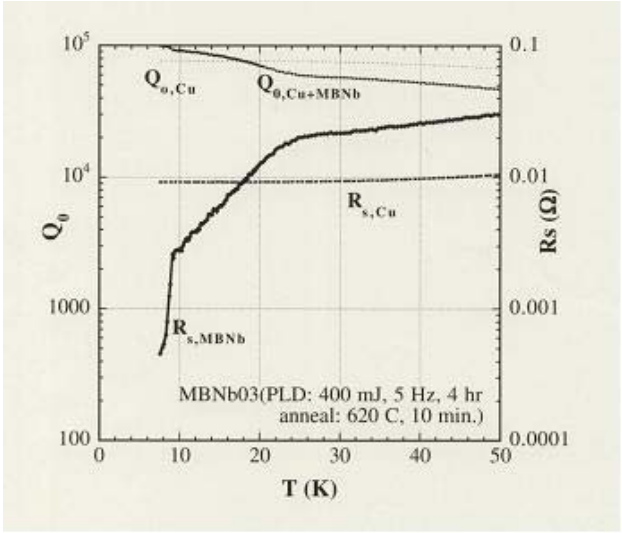

Fig.5 Rs and Q_0 of MgB_2 film on Nb and those of host cavity.

Rs of MgB_2 on Nb also present indication of superconducting transition of MgB_2 at 25 deg K. Superconducting transition also observed at about 9 deg K corresponding Tc of Nb, so, if film is uniform, it seem MgB_2 film partially shielding RF field.

TM MODE SINGLE CELL CAVITY

The C band scaled ILC shape cavity was machined from Nb rod of 70mm diameter. The separate half cells were assembled by SUS bolts.
MgB_2 film was formed as followings

Q_0 value of the Nb cavity was measured before film forming.

Each half cell is separately formed MgB_2 precursor film by PLD method same as discs. The cavity was assembled by SUS bolts.

Q_0 value of the precursor film was measured.

The additional MgB_2 precursor film for equator region was deposited by PLD with tapered target using CPU controlled laser beam.

The cavity was post annealed to 600 deg.C.

Q_0 measurement.

Fig.6 shows the each half cell surfaces formed MgB_2 precursor films.

Fig.6 Nb half cell with MgB_2 precursor film formed.

Fig.7 shows the tapered target for equator deposition.

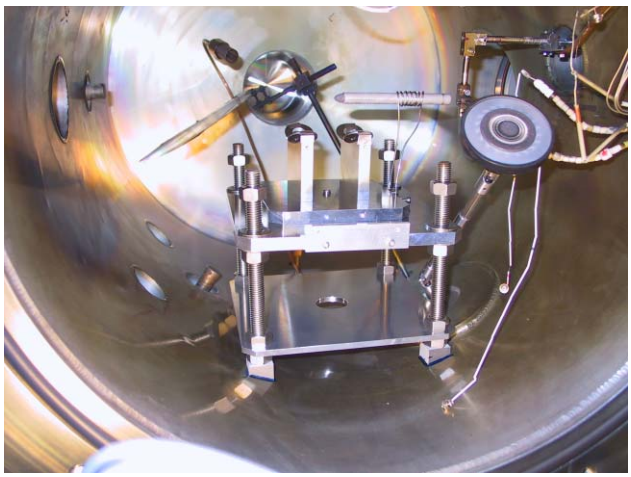

Fig.7 Tapered MgB_2+Mg target set inside PLD vacuum chamber

After heat treatment the cavity performance was measured the results is shown in Fig.8 with bare Nb and precursor case.

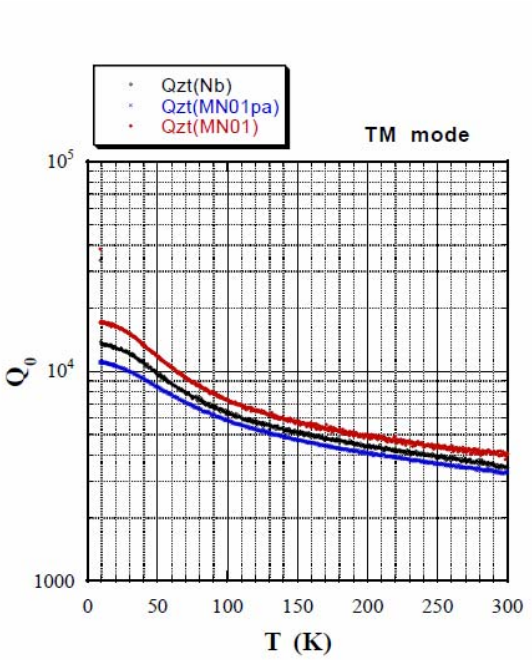

Fig.8 Q_0 for the Nb cavity (middle), MgB_2 precursor (lower) and after anneal (upper)

MgB_2 film shows better Q_0 at low temperature but not clear transition like as Nb disk case.

After this $_{experiment}$ the cavity annealed again up to 750 deg C. The cavity surface covered by white materials, and cavity Q_0 decreasing 200. Nb and Mg compound like as MaNb2O3 expected. So annealing temperature is very sensitive.

SUMARY

MgB_2 film on Nb was studied at low RF field. The film thickness of one micron meter is thicker than magnetic penetration depth of MgB_2, but Nb superconducting transition was observed through MgB_2 film. So the film, seems uniform visibly, have not uniform thickness or partial aria is rest as normal conducting separating small particle superconductor.

Single cell cavity test shows no clear transition at 25 K. Anneal temperature control is sensitive for single cell cavity.

REFERENCES

[1] A. Gurevich, Applied Physics Letter 88, 012511 (2006)

[2] S. Inagaki et al, Proc. of The International Workshop on Thin Films and New Ideas for Pushing the Limits of RF Superconductivity,Padua,Oct.9-12,2006