§33. ICRF Feedthrough Ceramics Development for Steady State Heating of LHD

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To complete the steady state ICRF heating system, feedthrough ceramics are one of the most difficult R&D items to develop. Through the ceramics vacuum seal, RF power is put into the LHD discharge chamber from the outside transmission line which is filled with insulating gas. Therefore, the ceramics separate the vacuum and insulation gas of 3 atmosphere while standing the high RF voltage of over several tens of kilovolts. In LHD, it is planned that more than 1 MW of ICRF power will be injected through one feedthrough to the plasma for more than 30 minutes. Therefore the ceramic feedthrough has to stand over 32kV(o-peak) steady state.

We tested five different kinds of ceramic feedthroughs which are designed for LHD steady state operation. The outer diameter of the feedthrough is 240 mm and that of the inner conductor is 102 mm. This size is quite large for the ICRF feedthroughs. The drawings of the cross sectional view of the tested feedthroughs are shown in Fig.1. The crank type and the disk type have cylindrical inner conductors. For the disk type, we made and tested two types. One has cooling channels inside the ceramics and the other has no cooling channels. The cone type is similar to the Princeton(PPPL) type which is popular in ICRF heating systems. This cone type feedthrough has forced gas cooling channels which inject the insulation gas into the ceramics from eight outside nozzles. The ceramic material of the above three types is alumina (> 99%) and brazed with Kovar alloy. On the other hand the cylindrical type feedthrough is made of silicon nitride composite ceramics and the vacuum seal is O-ring and not brazed. This silicon nitride composite ceramic is the same as used in the windows of ECH in LHD.

The RF tests of the ceramics have been done in the test chamber of the R&D antenna. The ceramics are located near the position of the highest voltage between the antenna and the tuners. The test results are shown in Fig.2. The crank type and the two disk types do not have good results in comparison with the other two types. The crank and the disk dypes had serious damage and vacuum leaks through the bazed parts. The troubles happened at the times shown by asterisks in the figure.

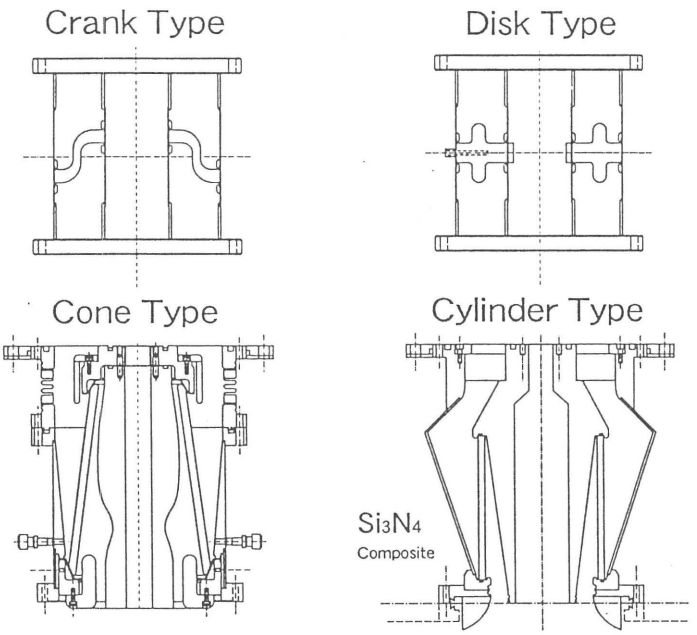

Fig. 1 Drawings of the tested feedthrough ceramics. Alumina ceramics and silicon nitride composite ceramics(cylinder type) are used.

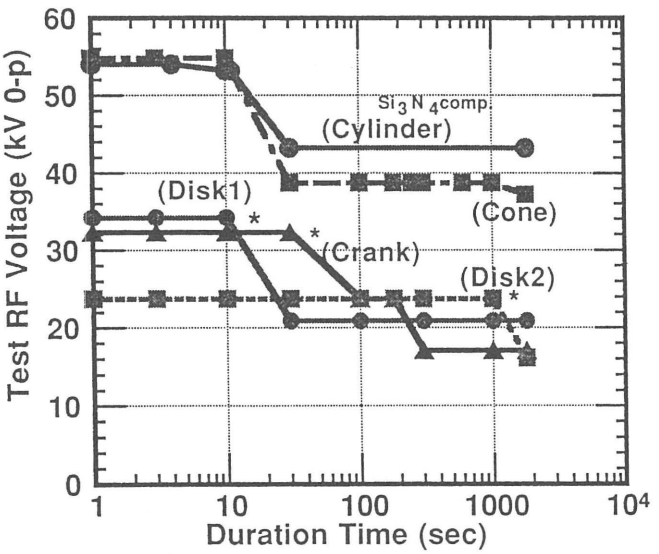

Fig.2 Tested RF voltage and duration time on the feedthrough ceramics. Cone and cylinder types are still not damaged.