First trial of the In-situ Nitrogen Infusion at KEK

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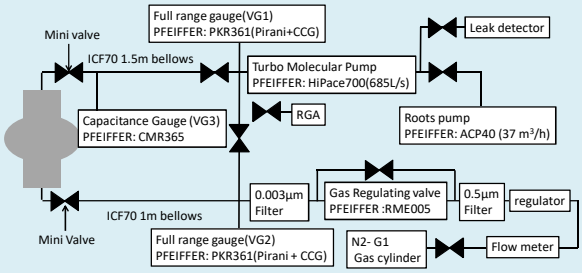
Abstract

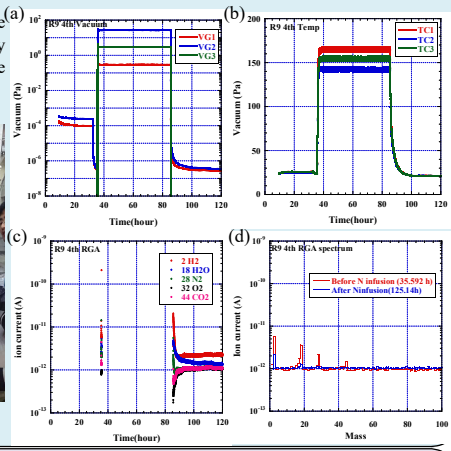
The nitrogen infusion is the new surface treatment technique for improving the RF loss and the maximum accelerating gradient of superconducting cavity. In this process, it is important to be carried out continuously both the 800 °C annealing in vacuum and 120 °C nitrogen infusion without exposure to the atmosphere. The annealing serves activation process by removing the oxide layer. The in-situ nitrogen infusion system was prepared to investigate whether nitrogen infusion effect or something changes happen in the case of applying nitrogen infusion technique without removing the oxide layer. It can only introduce nitrogen into a cavity during 120 °C low temperature baking and transport a cavity to the vertical test system without exposure to the atmosphere. We tried to infuse nitrogen to a single cell by keeping 120 °C and 48 hours with 3 Pa nitrogen. The cavity was annealed in another vacuum furnace and applied high pressure rinsing (HPR) before nitrogen infusion. The vertical test result was same Q value as the normal 120 °C baking without nitrogen. It suggests that oxide layer prevents infusion of nitrogen.

In-situ Nitrogen Infusion Pumping system

Top and bottom flanges of the cavity each have one vacuum port. The system can be baked before injecting nitrogen into the cavity. The vacuum pressure can be controlled by the gas regulating valve (RME005) and the capacitance gauge mounted at pumping side of the cavity during the nitrogen injecting. The cavity can be transported to the vertical test stand without exposing the inner surface of the cavity to the atmosphere.

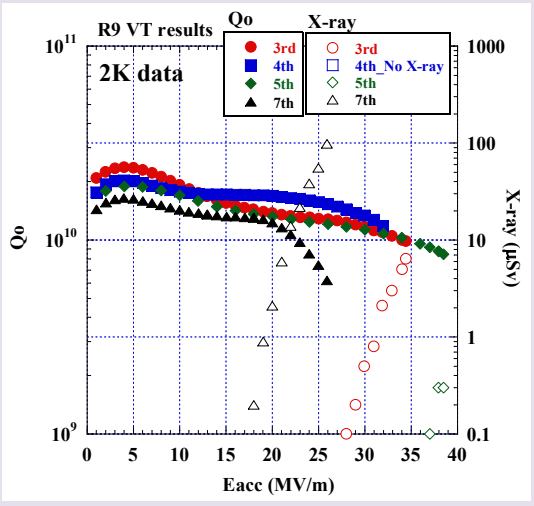


Example: 160 °C Baking with Nitrogen

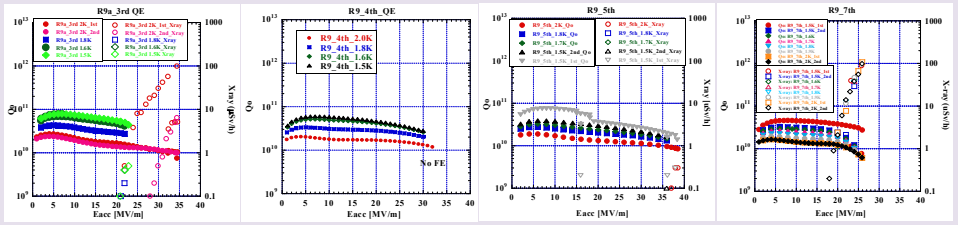


Cavity and process

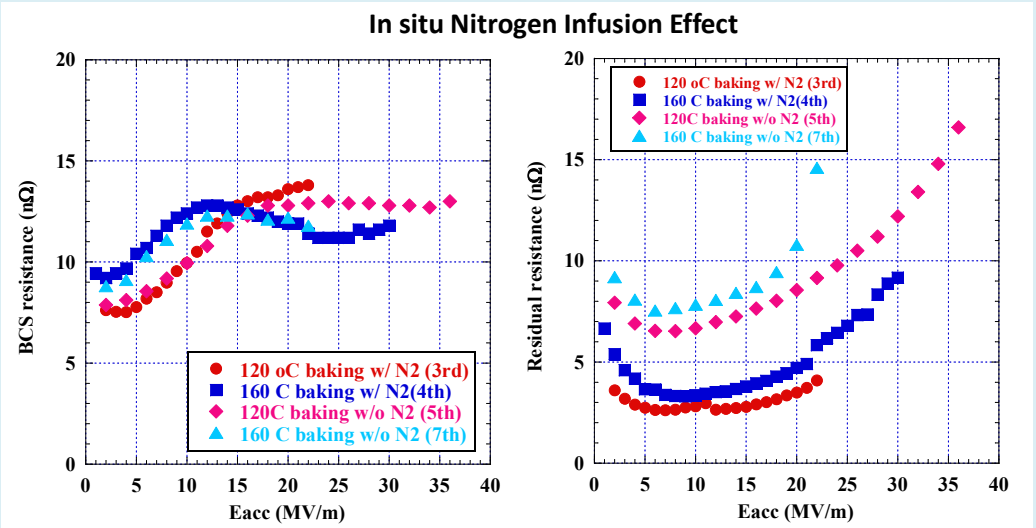
All tests are carried out by using 1.3 GHz single cell cavity (R-9). Nb sheet is fine grain produced by Tokyo Denkai and cavity was fabricated by MiraPro. Nitrogen infusion recipe is considered that nitrogen is infused to the niobium surface after removing the oxidized surface. Therefore, nitrogen is introduced following annealing at 800 °C without exposing to the air. We investigate whether nitrogen infusion effect or something changes happen in the case of applying nitrogen infusion technique without removing the oxide layer with using the in-situ nitrogen infusion system . It can only introduce nitrogen into a cavity during 120 °C low temperature baking and transport a cavity to the vertical test system without exposure to the atmosphere. Standard recipe with 120 °C and 160 °C baking were also carried out for comparison.



#	Surface treatment	Detail
1st	800 °C Annealing at KEK small furnace using oil diffusion pump Final EP (EP2) was omitted to check the furnace cleanness	As received +EP 100 μm +Anneal 800 °C x 3hr +USR 15 min + HPR 3 hr + Baking 120 °C x48 hr, w/o N2
2nd	Standard recipe without baking	+ EP 20 μm + USR 15 min + HPR 3 hr
3rd	**120 °C Baking with Nitrogen**	**+(without opening to the air) +Baking 120 °C x 48 hr, w/ N2 3Pa**
4th	**160 °C Baking with Nitrogen**	**+(without opening to the air) +Baking 160 °C x 48 hr, w/ N2 3Pa**
5th	**Standard recipe (120 °C baking without Nitrogen)**	**+ EP 20 μm +USR 15 min +HPR 3 hr + Baking 120 °C x 48 hr, w/o N2**
6th	Nitrogen infusion (120 °C x 48h)	+ N-infusion (800 °C x 3 hr + 120 °C x 48 h, w/N2 3Pa) +USR 15 min + HPR 3 hr
7th	**160 °C Baking without Nitrogen**	**+ EP 20 μm + USR 15 min + HPR 3 hr + Baking 160 °C x 48 hr, w/o N2**



Results and in-situ nitrogen infusion effect



Q values can be separated to the BCS resistance which depends on the temperature and the residual resistance which is constant part for each accelerating gradient. Since the residual resistance is affected by the magnetic flux by the external magnetic field and field emission. It is difficult to discuss the in situ infusion effect on the residual resistance. The BCS resistance curves shows that the baking temperature is much more influence to the Q value than in-situ nitrogen infusion. Nitrogen is almost no influence. These results shows that high temperature annealing for removing oxidation layer is important for infusing nitrogen into niobium.

Summary

KEK prepared in-situ infusion system that can introduce nitrogen to the cavity during baking and transport to vertical test without exposing to the air. It was found that nitrogen can not infused to the niobium surface without high temperature annealing by the 120 °C and 160 °C baking results. In order to realize the in-situ infusion system that It is necessary to add a system for removing oxidation layer.