# Recent results of N-infusion at KEK/J-PARC

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# <u>Outline</u>

- N-infusion system at J-PARC furnace
- Table of N-infusion results at KEK/J-PARC
- N-infusion results; good and bad examples
- KEK new furnace
- Summary

#### J-PARC Furnace

#### **Clean furnace & clean procedure is essential**

- Oil-free vacuum pump system.
  - Turbo pump 3unints: SIMADZU TMP3202M (3000L/sec x3)
    - + Scroll pump 3unints: ANEST IWATA ISP500 (500L/min x3)
  - Cryopump 1unint: ANELVA CAP220 (10000L/sec)
- J PARC furnace has been used for SUS and Ti chambers degassing.
- Small samples for surface analysis were set beside with cavity.



#### N-infusion system

- A nitrogen introduction line was added for nitrogen infusion.
- Pumping system during nitrogen infusion.
  - ➤ First, portable pump was used. → Poor background pressure
  - > Later, three TMPs of the main pumps were used with reduced speed.
- The chamber pressure during N-infusion was monitored with a capacitance gauge and adjusted with a variable valve controller.



#### <u>History of N-infusion at J-PARC</u>

- After 1<sup>st</sup> N-infusion was failed, pumping unit during N-injection was improved.
- 6 times N-infusion was tried at J-PARC furnace to total of 8 cavities.

#	Month	Result	# of Cells	Series	Treatment	N2 pumping unit	Cavity material
0	2017.3	Success	Single	R-6	800C Anneal		FG (TD)
1	2017.4	Fail	Single	R-2	N-Infusion(800x3h+120x48h)	Portable pump unit	FG(TD)
1'	2017.6	Fail	Single	R-2	N-Infusion(800x3h+120x48h) w/o N2	Portable pump unit	FG(TD)
2	2017.1 1	Success	Single	R-8c	N-Infusion(800x3h+120x48h)	<b>TMP50%</b>	FG(TD)
First successful case! Q value and gradient were improved.							
3	2018.1	Success	Single	R-9b	N-Infusion(800x3h+125x48h)	<b>TMP50%</b>	FG(TD)
Q value was improved. Q value at high gradient was degraded by Field Emission.							
4	2018.2	Fail	Single	R-2	N-Infusion(800x3h+160x48h)	<b>TMP50%</b>	FG(TD)
5	2018.3	Fail	Single	R-9	N-Infusion(800x3h+120x48h)	<b>TMP50%</b>	FG(TD)
5	2018.3	Success	Three	R-10b			LG(CBMM)
First successful case of LG! Q value was improved. Q value at high gradient was degraded.							
6	2018.4	Fail	Single	<b>R-2</b>	N-Infusion(800x3h+120x48h)	<b>TMP50%</b>	FG(TD)
6	2018.4	Fail	Single	R-9b			FG(TD)

#### Typical N-infusion procedure

- Typical N-infusion parameters:
  - 800C, 8h + 120C, 48h (once tried 160C)
  - 3.3 Pa (~25mTorr) Nitrogen during 120 C
- From 2<sup>nd</sup> Trial, we used main 3 TMPs during N-infusion.



#### Successful examples of N-infusion

- Both 2<sup>nd</sup> and 3<sup>rd</sup> trial N-infusion was succeeded.
- 2<sup>nd</sup> trial (120 °C N-infusion): Gradient was improved 5% and Q<sub>o</sub> was improved 30%.
- 3<sup>rd</sup> trial (125 °C N-infusion): Unfortunately Q value at high gradient was degrader by field emission.
- Both residual resistance were lowered than reference and BCS resistance of 2<sup>nd</sup> trial was slightly lower than reference.



#### Failed example of N-infusion

- Failed 5 cavity tests are shown as right figure.
- Even for different parameters, different cavities, degraded Qslope is very well reproduced.
- Most probably, contamination(carbon?) caused by the furnace.

Why always very similar degradation curve?

#### **Q-E curves for failed 5 cavities**



#### N-infusion applied to LG cavity

- N-infusion was applied to LG 3-cell and FG single-cell cavities, at the same time.
- N-infusion for LG was successful.
- N-infusion for FG was failed with degradation.



LG is strong against contamination?? Other reasons??



#### New clean furnace at KEK



#### Completed at the end of last fiscal year





## <u>Summary</u>

- KEK continues N-infusion studies.
- There were some successful results. But not reproducible.
- Q-degradations were observed for some trials.
- New furnace will boost up the N-infusion study.

#### **Questions**

- Why results are not reproducible even for same furnace parameters?
- Does LG have some merit against N-infusion procedure?
- What does limit performance of N-infusion cavities? (Eacc decreased at KEK/J-PARC N-infusion. What's wrong?)

Thank you very much for your attention !

Cavity preparation for heat treatment

- HPR(flange open) > 1 hours, dried one night and double-packed inside class-1000.
- Nb cap and foil were polished by CP and ultrasonic cleaned with degreasing, dried inside class-10. Then packed inside class-1000.
- These were prepared at KEK-Tsukuba campus. And Transport to J-PARC. Setup into J-PARC furnace.



Requirement for furnace

- What is "clean furnace"?
  - ⇒ Excellent reachable vacuum pressure
  - ⇒ Less contamination, especially from Carbon
- All heaters and reflectors(6 layers) are made of Mo.
- Clean and less material inside furnace.
- Main pump is cryo-pump.
- TMP can be used during N-injection.
- Target vacuum pressure
  ▶RT:1e-6 Pa, 600C: 1e-5 Pa, 1000C: 1e-4 Pa
- Furnace is built in clean-booth.

### 800C heat treatment test with

cavity





### **Condition for N-injection**





- TMP(700 litter/sec) can be used during N-injection.
- 2~3e-5 Pa can be reached.
  - ⇒Background during N-injection
- ~3Pa can be kept while pumping by this TMP.
- Nitrogen flow is controlled by mass flow controller.