TEST RESULTS OF PLASMA IN-SITU CLEANING ON LOW BETA HWR CAVITY

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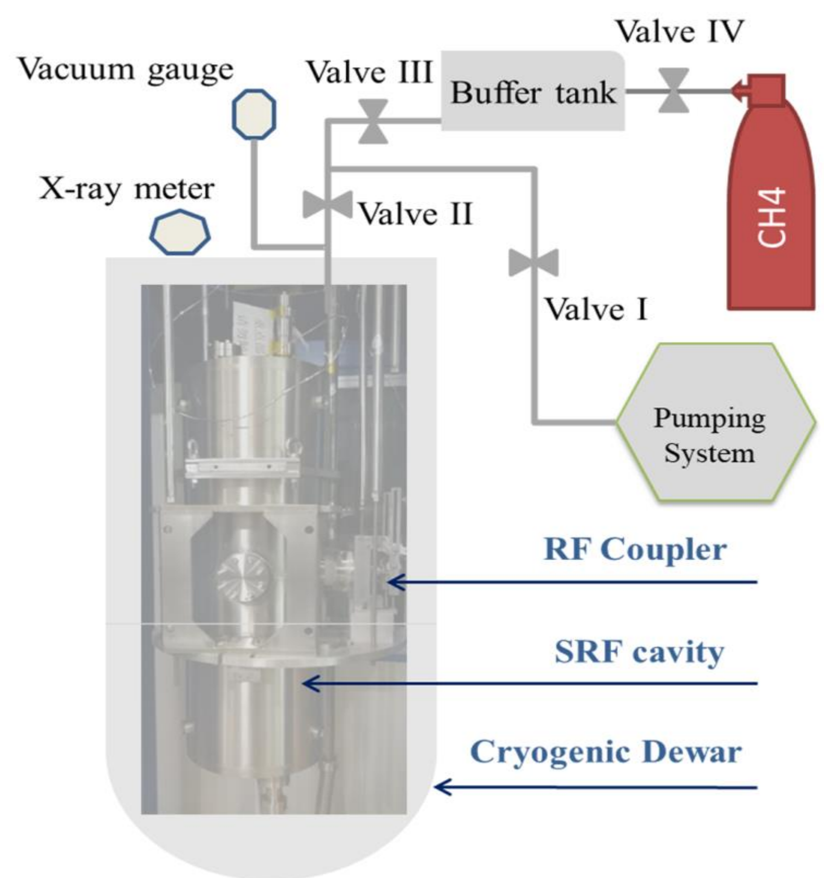
ABSTRACT

Field emission occurred in SRF cavity is the major limitation to operate at high gradient with stability. The plasma in-situ cleaning for the low beta HWR cavity was carried out to remove the hydrocarbons contaminants on the inner cavity surface. And the vertical test results indicated that the field emission effect was relieved with the increasing of the quench point and emission set-on point. Thus, oxygen active plasma processing can be an effective method to solve the field emission issues for the low beta HWR cavity.

Variety of carbon contaminants

- Carbon contamination on the SRF cavity decrease the work function of niobium surface and induced the FE effect.
- The contamination was clarified into weak and strong strength of the binding energy between the niobium surface.
- The weak strength, due to the cryogenic adsorption at 4K.
- The strong strength, carbon deposited into niobium surface and it was hardly to removed by the physical conditioning.

Cryogenic adsorption



- First test of standard treatment cavity as the baseline.
- CH_4 was fed the HWR at room temperature and cooling down 4K for cryogenic adsorption.
- Warming up to 300K and pumping CH_4 out to remove contaminant adsorption and then cryogenic test .

Fig.1 Residual gas analysis during the in-situ plasma cleaning.

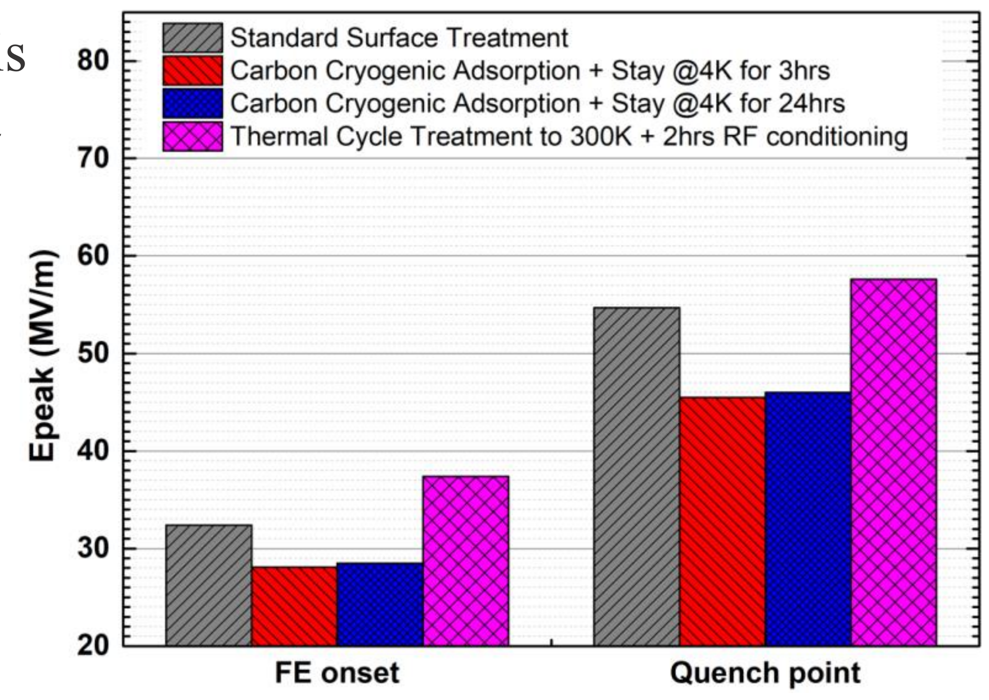


Fig.2 Results of CH_4 adsorption on HWR and performance recovery by thermal cycle.

- Performance degraded by carbon cryogenic adsorption, FE onset and quench point decreased by 12% and 18%.
- The carbon contamination from the cryogenic adsorption can be removed by warming to room temperature.

Plasma ignition in HWR

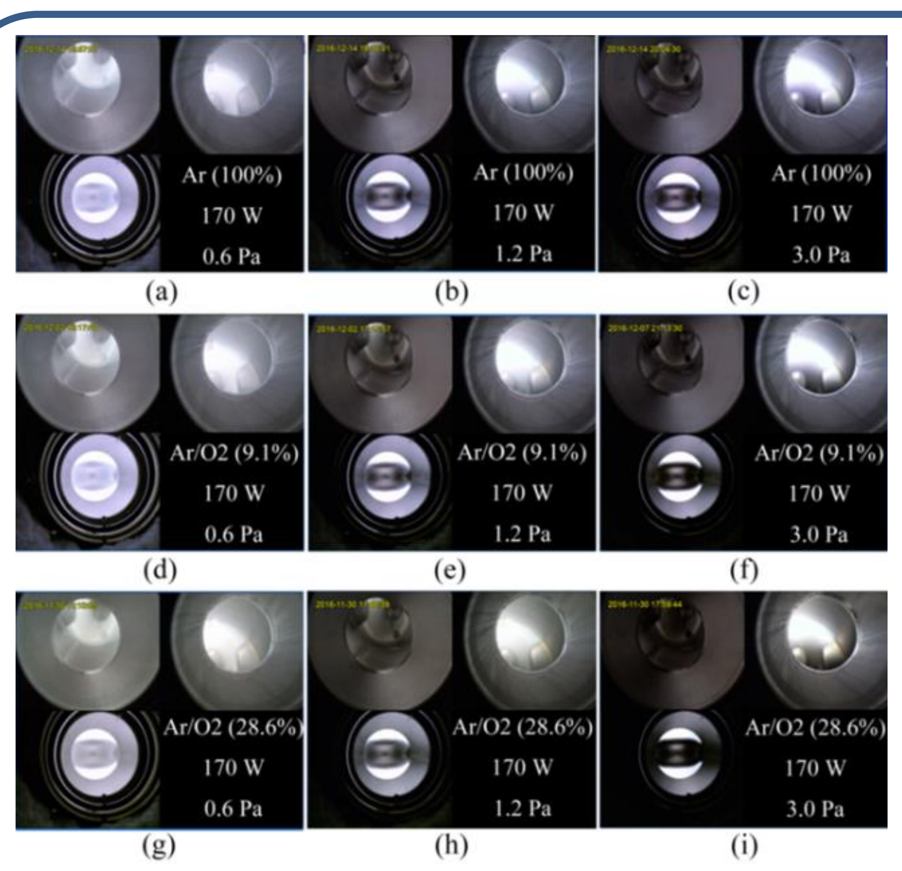


Fig.3 Ar/O2 mixed RF plasma ignition on HWR cavity.

- Plasma discharge was concentrated in the middle of cavity.
- The lower gas pressure and smaller oxygen volume ratio has stronger luminance of the plasma light and a more uniform distribution of discharge will be achieved in the cavity.

Carbon deposited on HWR by PECVD

- Plasma ignition techniques on HWR was used for the PECVD. The pressure of Ar/CH4 mixed gas was 0.8 Pa to obtain a uniform distribution of plasma inside the HWR.
- The volume ratio of CH4 was 2.5% to the generate active species such as C2, C2H2, CH3, CH2 and CH to deposit the carbon on niobium surface.
- Total effective time for PECVD was 5 minutes.

Plasma cleaning on carbon deposited cavity

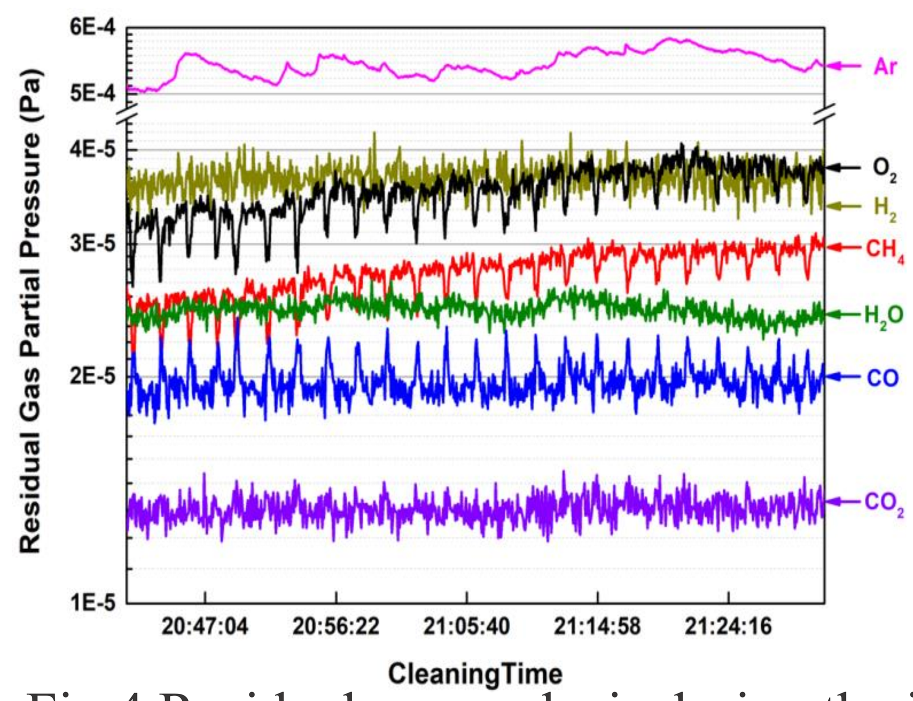


Fig.4 Residual gas analysis during the in-situ plasma cleaning.

- Obviously peaks of the partial pressures appeared when the plasma pulse turning on.
- Oxygen was consumed as the oxidant for burning the carbon contaminants.
- CO is more readily produced that CO2 on the oxidizing of carbon contaminants under the plasma condition of this work..

Vertical test results and conclusion

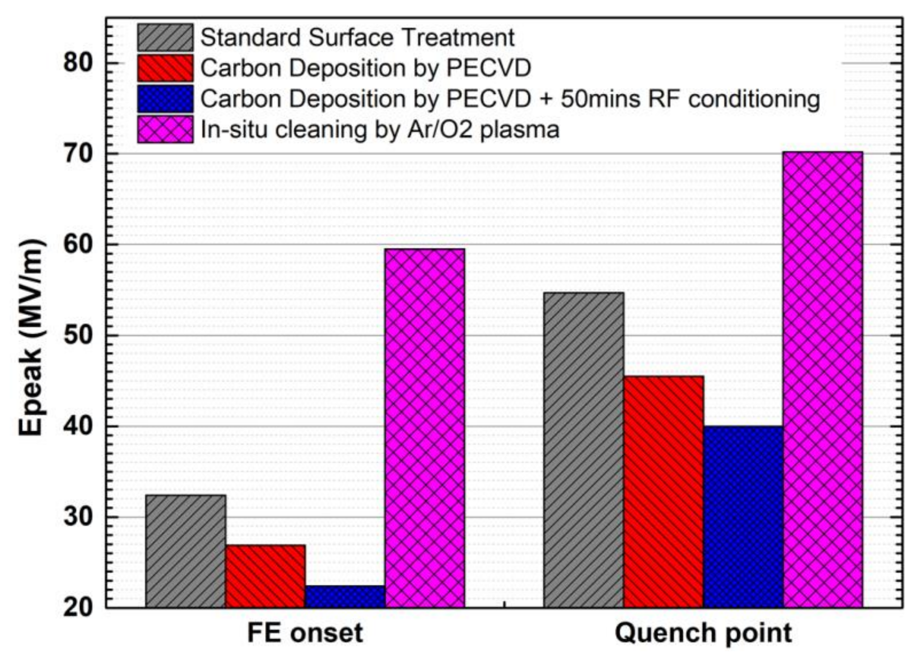


Fig.5 Results of carbon deposition and in-situ plasma cleaning.

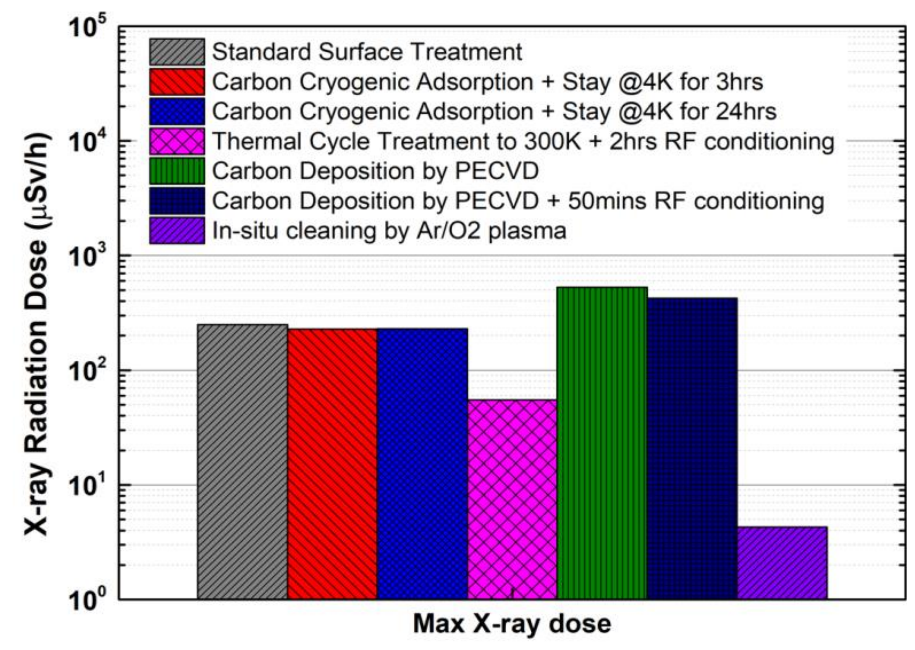


Fig.6 X-ray of HWR under different treatments.

- The performance was deteriorated after the carbon deposition due to the increasing of FE, and the MP was appeared at 16-19 MV/m.
- Additional RF conditioning was conducted to mitigate the multipacting and FE, but the performance decreased further due to that the carbon contaminants was translated to the electric field stronger region.
- Carbon deposited contamination was removed by oxygen active plasma, and the x-ray dose was significantly decreased.

Publication

[1] A.D. Wu, S.C. Huang *et al.,* Vertical test results of plasma in-situ cleaning on low-beta HWR cavity, TUOP036, this conference.

[2] A.D. Wu, L. Yang *et al.*, In-situ plasma cleaning to decrease the field emission effect of half-wave superconducting radio-frequency cavities, Nuclear Inst. and Method, A 905 (2018) 61–70

[3] A.D. Wu *et al.,* Carbon contamination mechanism and performance recovery principle for superconducting radio frequency cavities: in submitting.