

New VEP System with Novel Cathode and Fundamental Investigation of Inhomogeneous Removal in VEP

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- Designing of our VEP systems started in Mid 2013 in KEK and MGI.
 One system are in operation.
- Novel cathode "Ninja" developed by MGI was adopted to MGI VEP systems.

However, remarkable inhomogeneous removal was found in our VEP.

Fundamental study of VEP using coupon cavity was carried out.

KEK Vertical EP Facility in New Building KEK Superconducting Accelerator Development Hall (2014) Clean-room outside 15t crane area equipment •• coupler process stand cryomodule ... Cryomodule Test Area 17m Klystron, Modulate 1次洗净损水貯槽 Class-10 connected SC-cavities Class 1000 cryostat space cryomodule assembly tools 30m access clean-room EP スクラバー装置建屋 cavity outside HPR Cryomodule assembly - 伊克装置 wash equipment クッション槽 cryostat EP area 11所 リザーブル Center control room **F**7-286914 (open area) 有意液 藏入總出 communication Cryogenics 超純木製造業) 2774 Vertical test area overhang roof lounge stairwell Helium cryogenics VT preparation area oom3 room2 room1 ----7.5t crane area 2nd floor ヘリウムタンク space for チラーユニッ 液体窒素タンク future air-conditionner ヘリウムガス future cooling water コンプレッサー建屋 outside equipment ヘリウムガスボンベ および ガードル置場 80m

VEP facility for nine cell cavity will be launched in early 2015.



VEP Facilities in MGI





VEP facility for single cell cavity is being used.

VEP facility for nine cell cavity will be launched in coming May

WKEK Patented Agitation Wings "Ninja" by MGI



 Foldable agitation wings are hidden for cathode insertion and expand in use.



Nb Coupon Cavity for VEP Optimization



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Obviously for Surface
 Analysis

Capability of EP Current Measurement of Each Coupon Sample

- 6 Sample Coupons :Top Beam Pipe, Top Iris,
 2 x Equator, Bottom Iris, Bottom Beam Pipe
- 4 View Ports : Top Iris, 2xEquator, Bottom Iris

Recent VEP Conditions for Coupon Cavity

- EP time : 2.5 hours
- Voltage: 9-11V
- Air Cooling

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- Ninja cathode rotational speed: 1, 5, 10 rpm
- Flow rate of EP Solution : 5 L/min

(Stopped for a few minutes for some study)

Movie during VEP at Top Iris

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- Large quantity of H₂ bubbles at top iris but much less H₂ at bottom iris.
 This would be significant especially for Ninja.
- Existence of H₂ gas bubbles to cause "micro agitation" is the key to understand rough topography and large EP current, that is, large removal rate on the surface where H₂ attack strongly occurs especially at the top iris.

Current oscillation seems to be determined by H₂ bubble attack.



1 min Movie during VEP at Top Iris



1 rpm with EP flow of 5L/min



Removal Thickness

Removal Thickness (µm) 100 120 6 8 8 Top_BF Top Equator left Equator Right Bottom Iris Bottom_BP

with Weight Loss

with US Thickness Gauge



- Relatively good agreement in two methods.
- Difference in removal thickness
- Removal thickness seems to follow distribution of H₂ bubble attack. 26, 2014 9



Rougher surface at the top surface due to H₂ attack.

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Typical Surface Roughness



Overall Coupon Current Profile for 2.5h



Top iris showed the highest current density and bottom iris did the lowest.

• Top iris always showed the largest oscillation.

1 rpm Coupon Current Profile for 2min



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Saw-tooth like current peaks at the top iris match the wing rotation.

 \diamond A large quantity of H₂ gas bubbles mildly concentrate on the top iris.

KEK 5 rpm Coupon Current Profile for 2min



Rotation does not match with the large current spikes.

The small current peaks do match with the wing motion.

10 rpm Coupon Current for 1min



Rotation does not match with the current spikes.

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- Less oscillation at the top iris but large oscillation at the others.
- Higher rotation speed causes mixing H₂ gas bubbles in EP acid and makes the bubbles approach to allover the cavity inner surface.

1 rpm Coupon Current Profile for 1 min without EP Solution Flow



Rotation does not match with the current spikes.

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- Many of small current peaks at different coupons synchronize.
- Aggressive EP enhancement occurs because of sudden increase of H₂.



Schematic Model of Explanation



Strong H₂ attack, that is, micro agitation that may make local damage of viscous layer causes rougher surface and high removal rate.

Many current spikes might be because of the local damaging.

 Concerning MGI VEP system, I need to recommend MGI to use a limited size of Al cathode with the same wings to mitigate direct H₂ attack to the top iris.