Development of Hydrogen-free EP and Hydrogen Absorption Phenomena

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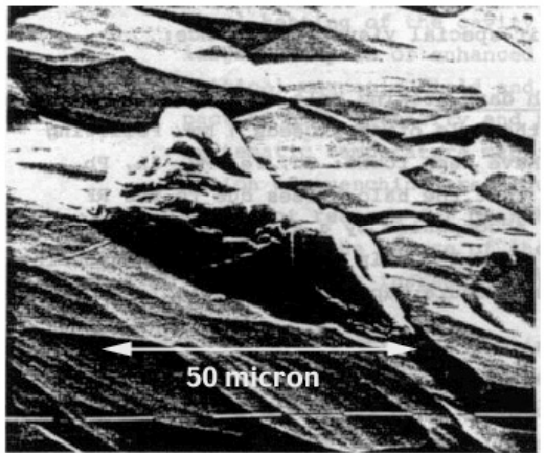
Contents

Introduction

Requirements on Surface Treatment for Superconducting(SC) RF Cavities

1) High Performance: High Gradient & High Q
2) High Reliability
3) Cost-effective

Purpose of mechanical grinding



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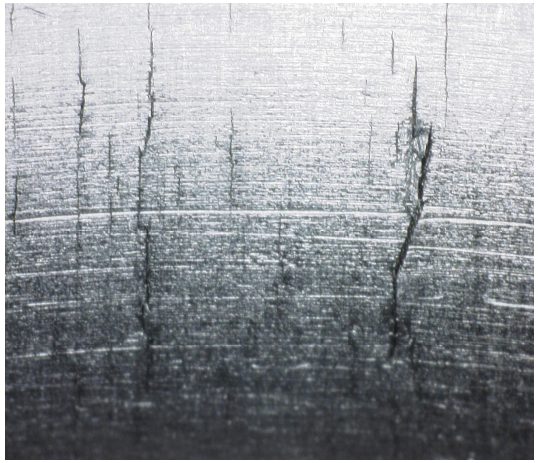
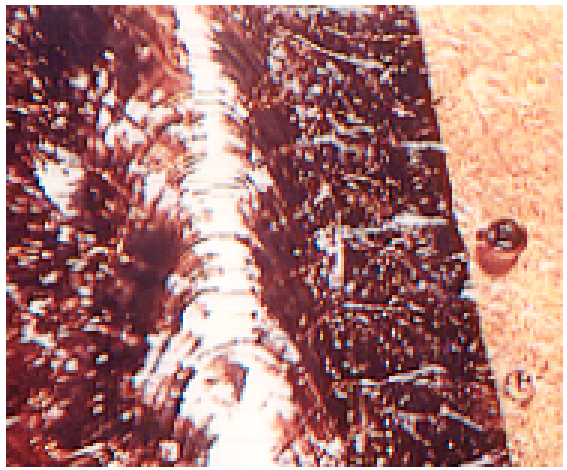


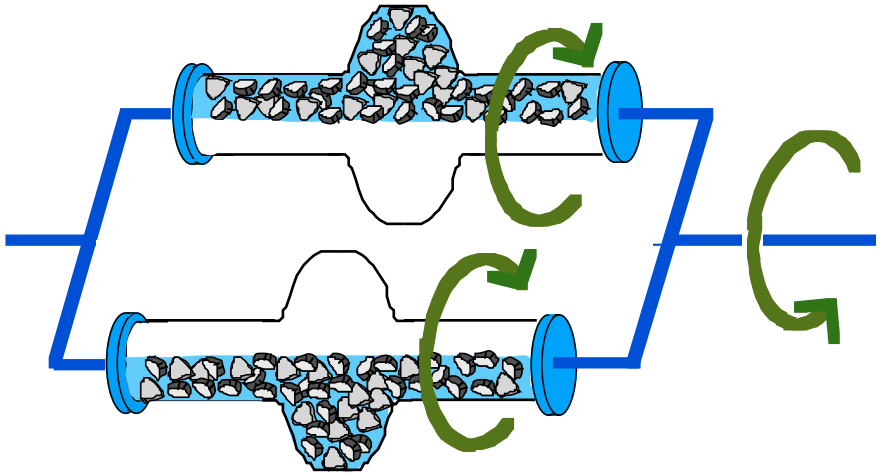
Cracks

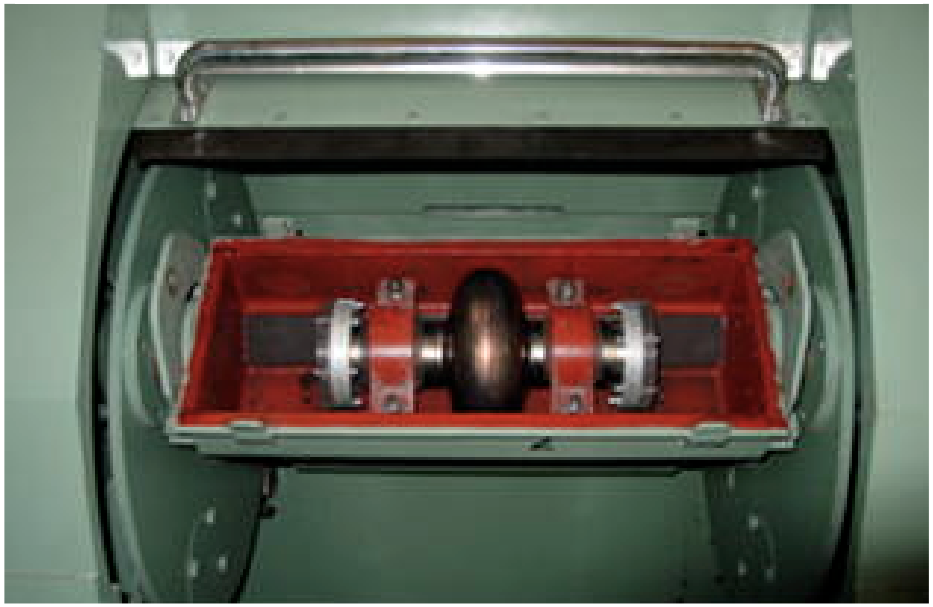


Sputter balls

Mechanical grinding is a powerful method to remove surface defects

Centrifugal Barrel Polishing (CBP)



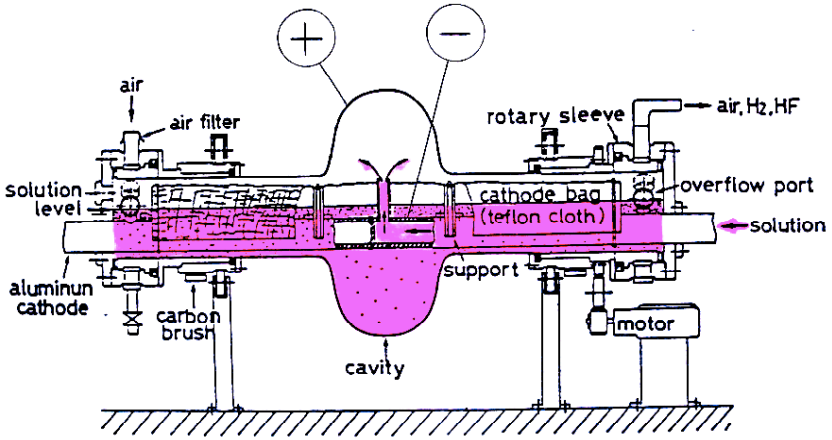


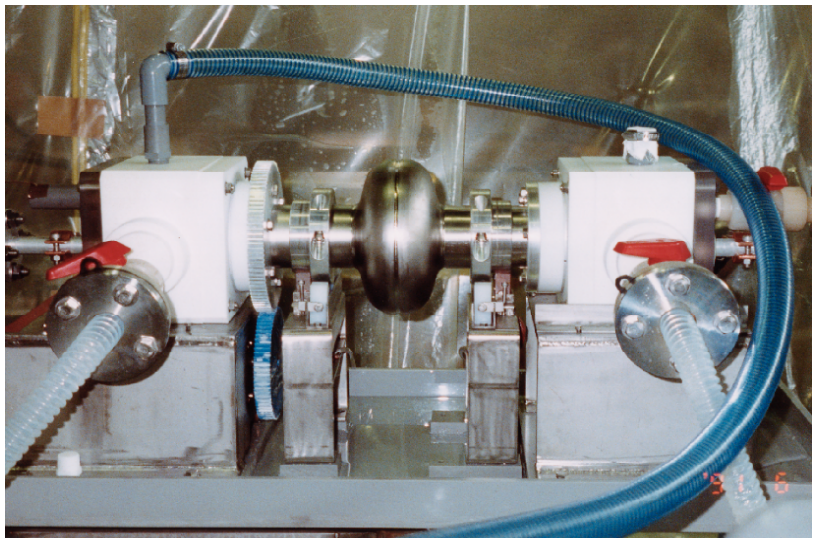
Chemical Polishing (CP)

CP solution: Equal mixture of $HF(46\%)$, $HNO_3(60\%)$ and $H_3PO_4(85\%)$

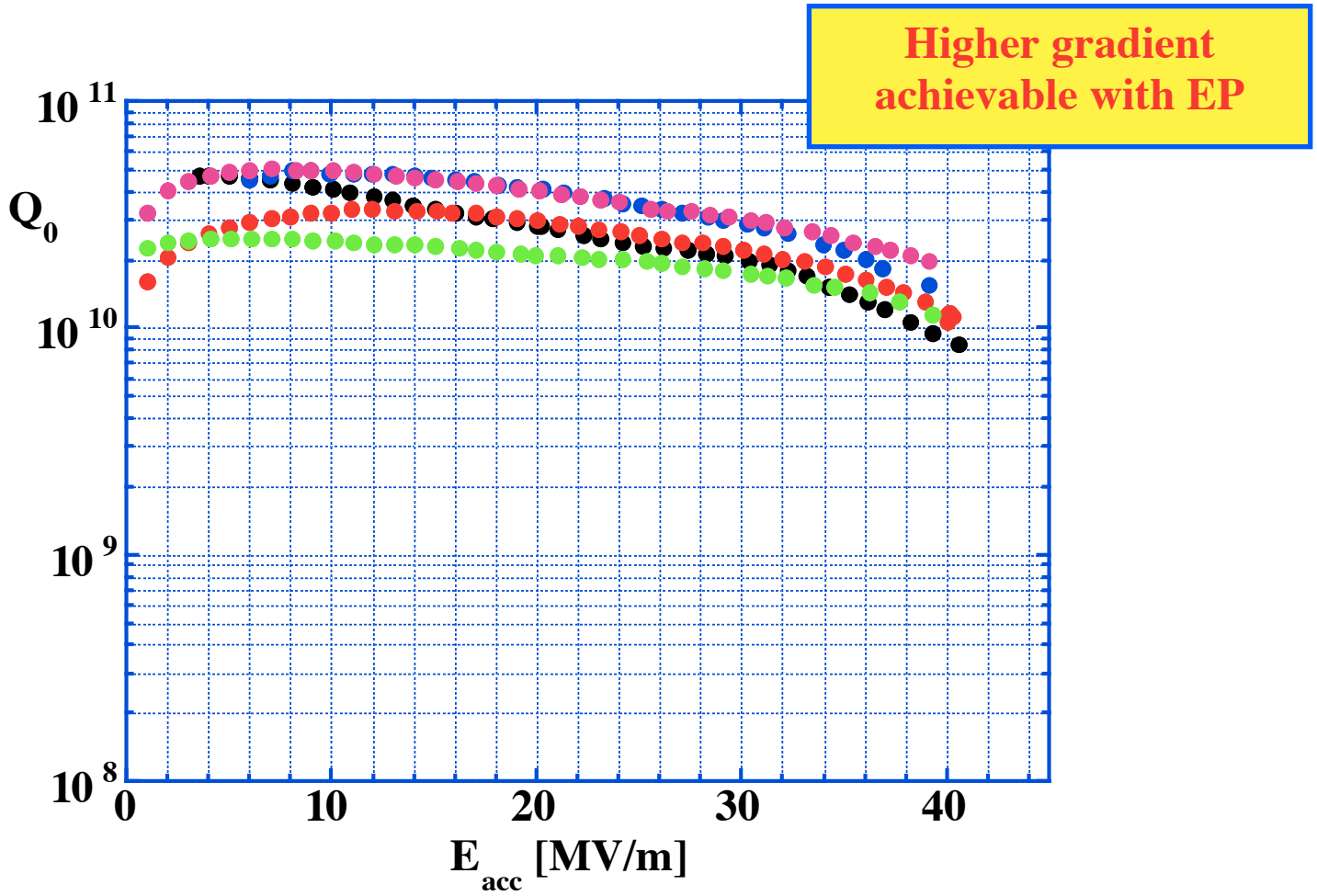
Horizontal Continuous Electropolishing (EP) TRISTAN

EP solution: mixture of HF(46%) and H_2SO_4(95%)

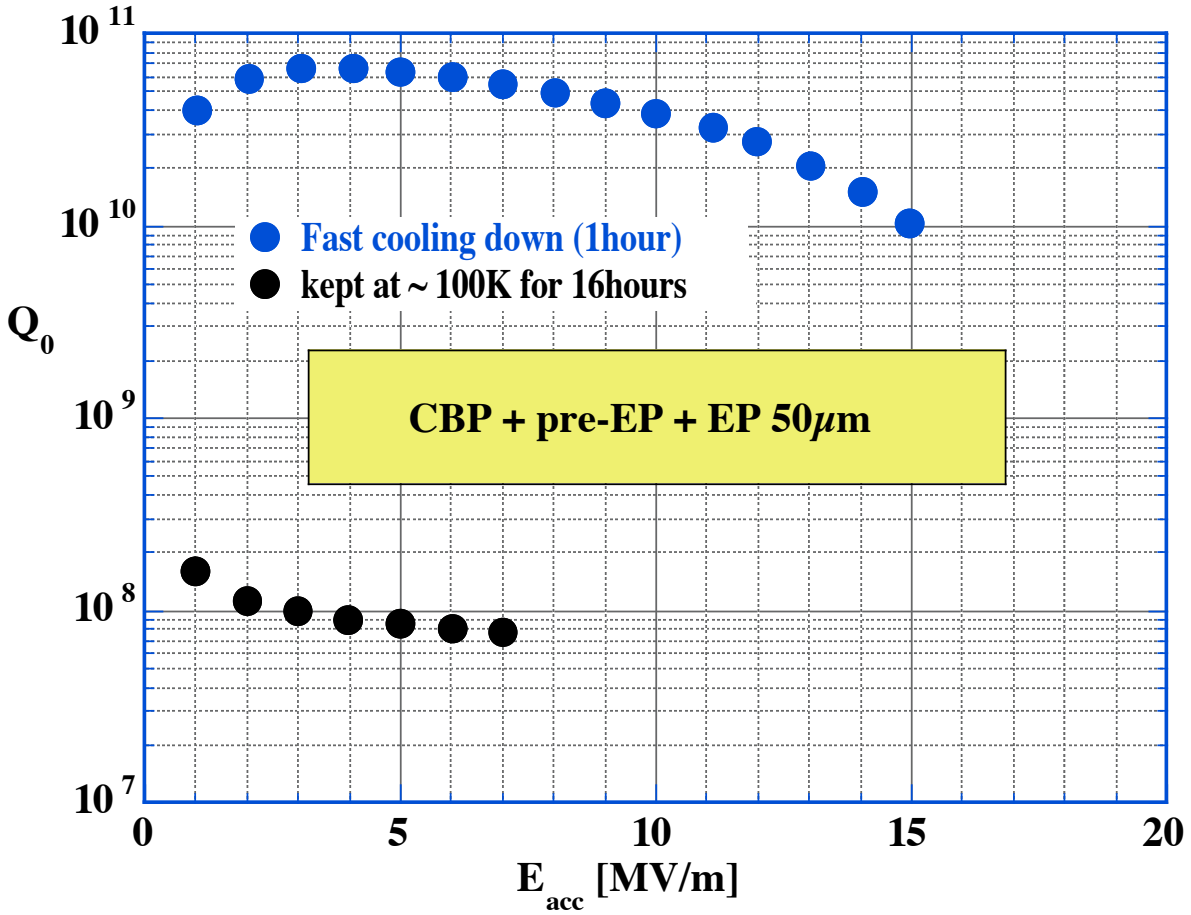




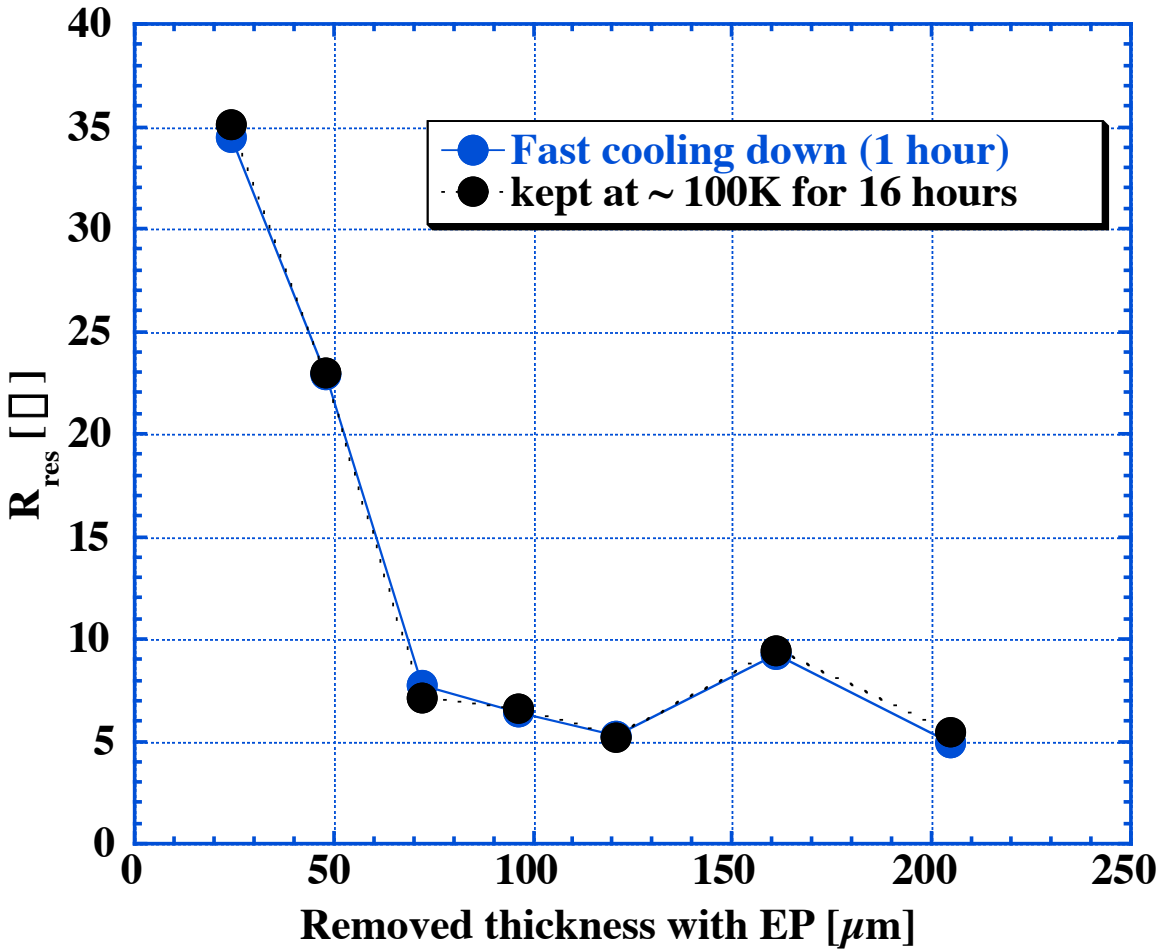
Electropolishing (EP) is the preferred technology in KEK



CBP + pre-EP + EP: Hydrogen Q-disease



Discovered: EP-alone does not cause Hydrogen Q-disease. (KEK 1999)

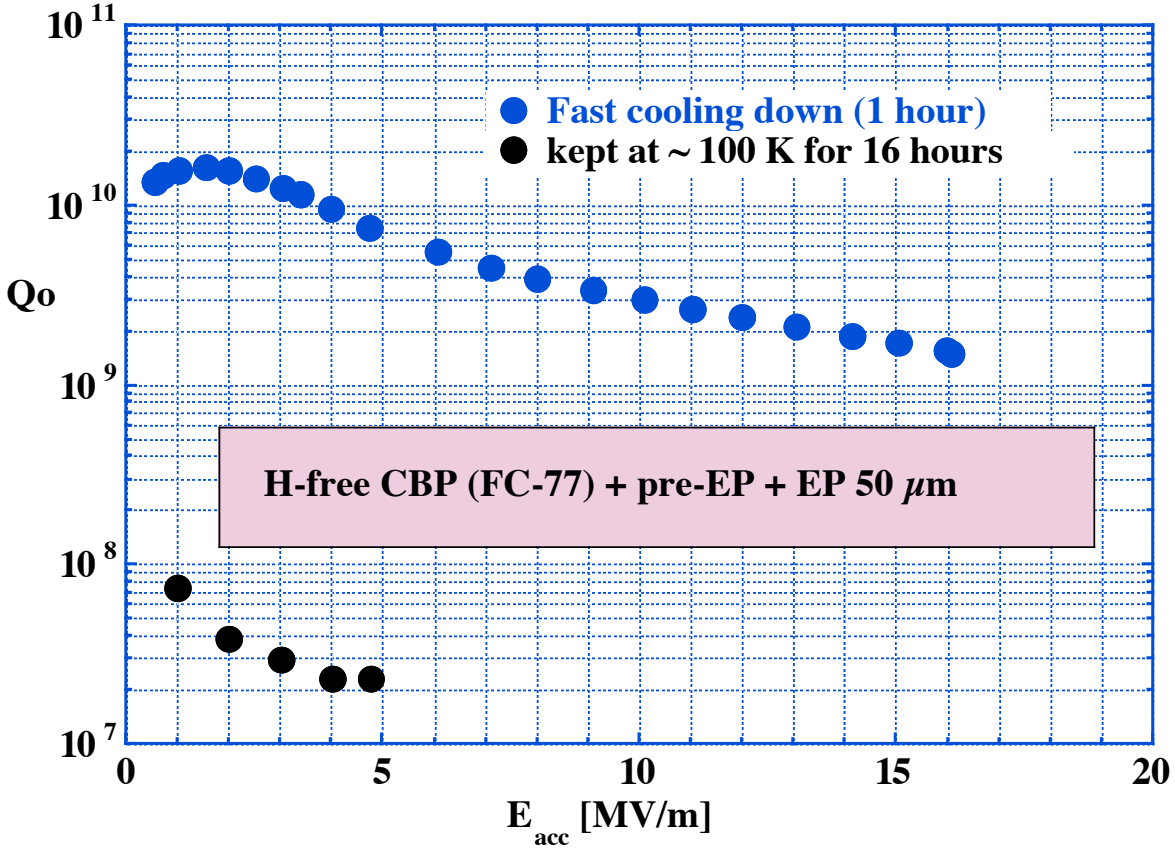


Hydrogen-free CBP

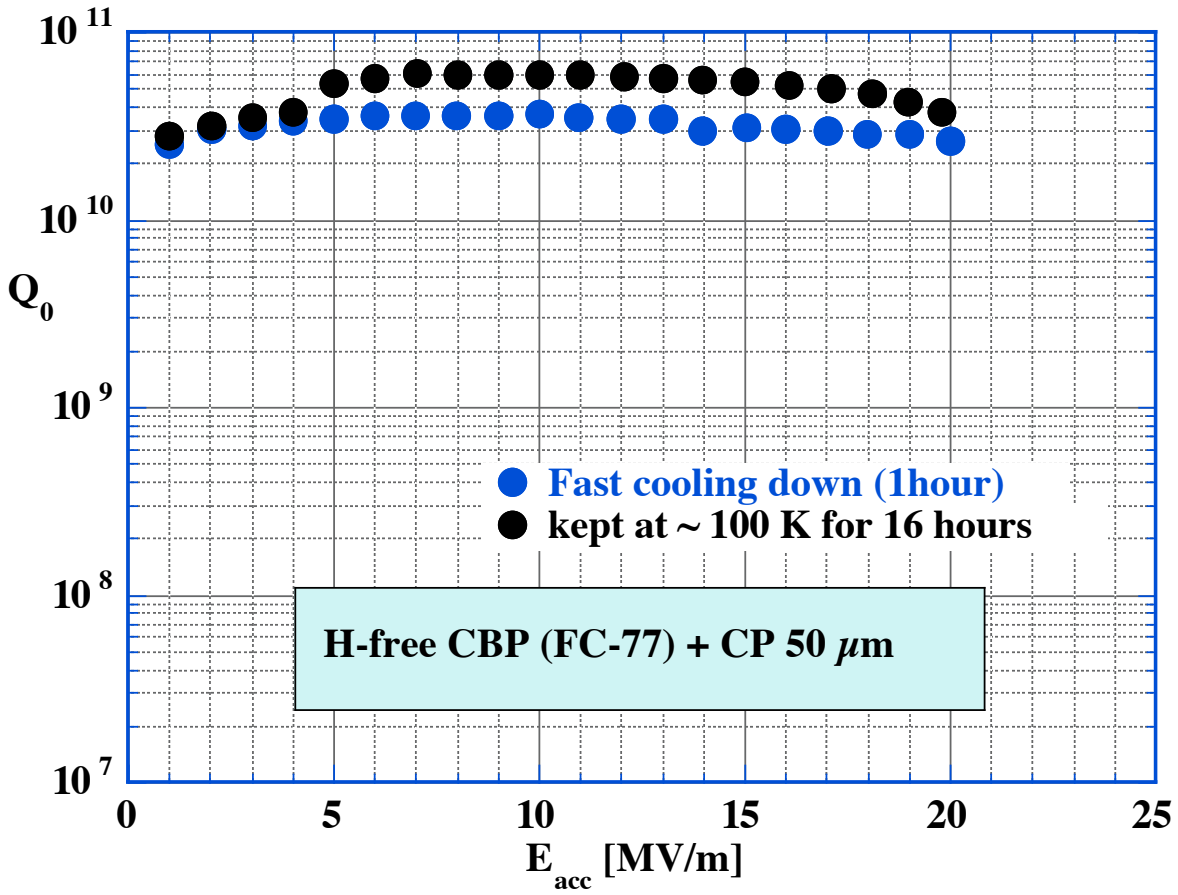
Liquid used for CBP	Hydrogen concentration in the test sample	comments
Annealing	1.0±0.2 [ppm]	sample conditioning
Soapy water (water + compound)	78.0±2.9 [ppm]	Standard composition
Demineralized water	79.1±5.0 [ppm]	No compound
(Stones only)	10.9±0.8 [ppm]	
Propanol (C_3H_7OH)	49.4±2.2 [ppm]	No water
FC-77 (C_8F_{18}、$C_8F_{16}O$)	4.6±2.2 [ppm]	No hydrogen

(test samples: 2.5mm(H) x 1.0mm(W) x 147mm(L), RRR=200)

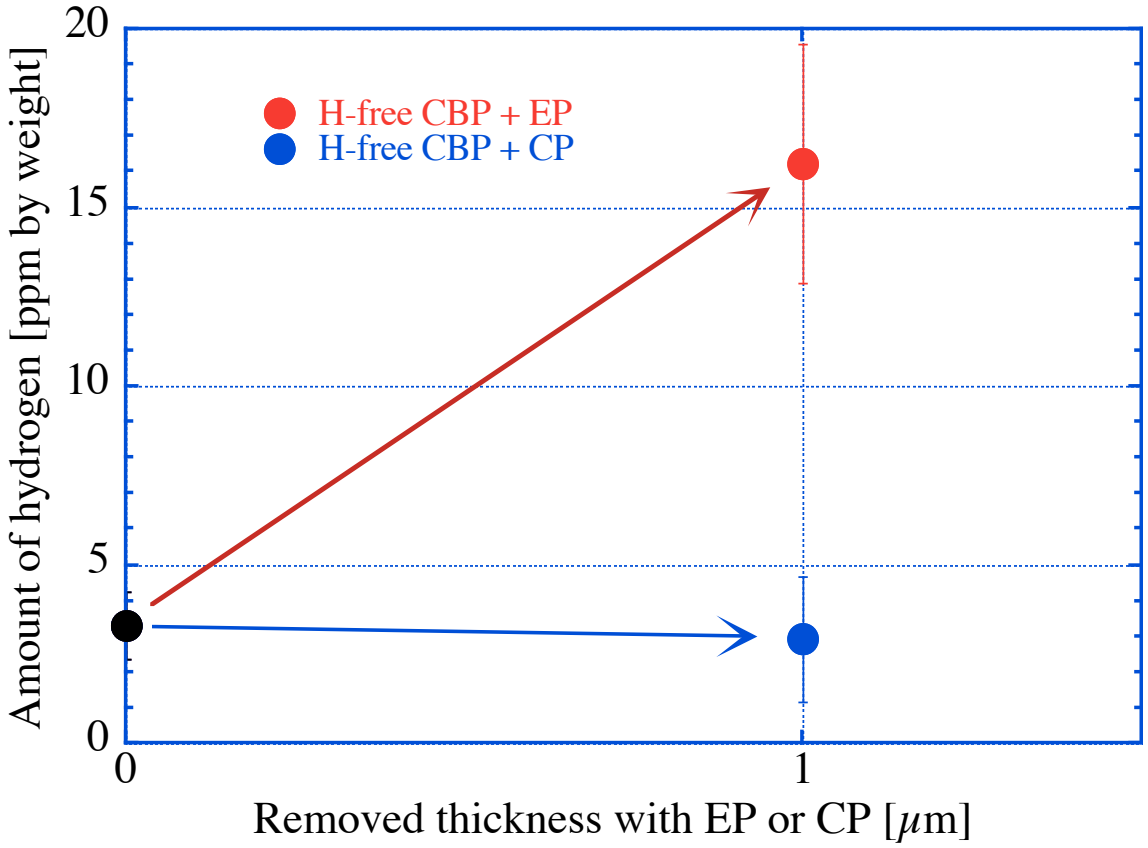
H-free CBP + pre-EP + EP: Hydrogen Q-disease



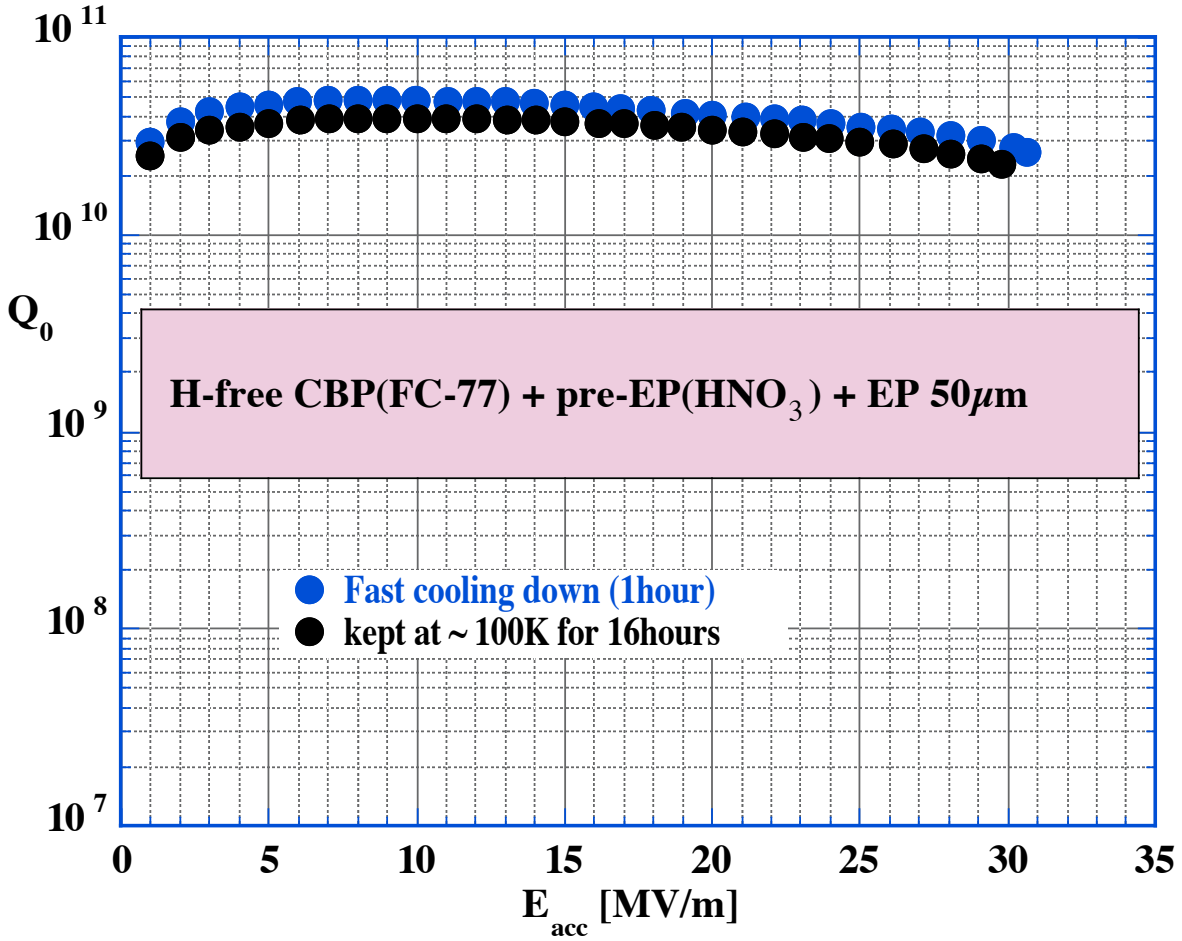
H-free CBP + CP: No Hydrogen Q-disease

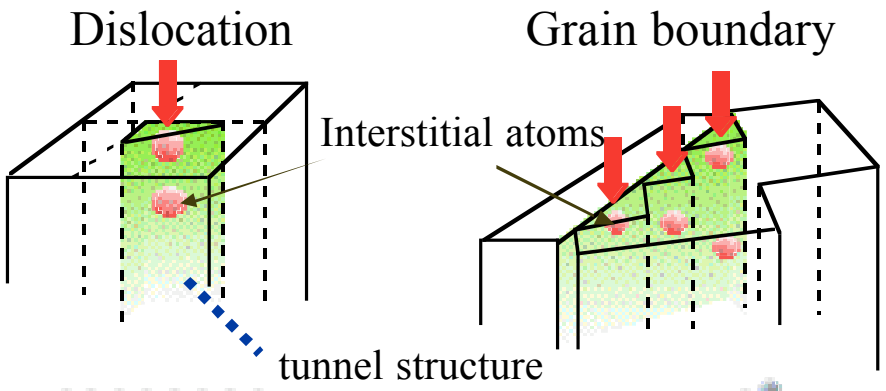


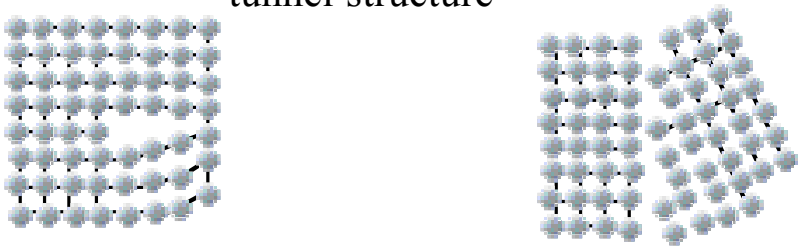
H-free CBP + EP: Hydrogen absorption
H-free CBP + CP: No Hydrogen absorption



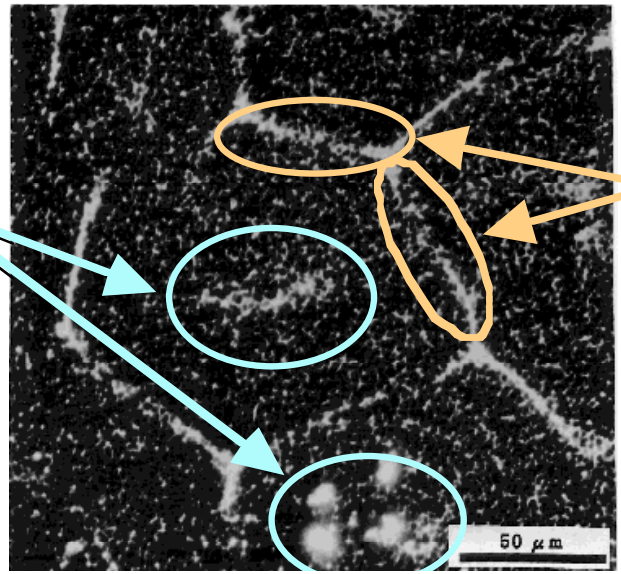
H-free CBP + pre-EP (HNO_3) + EP: No Hydrogen Q-disease





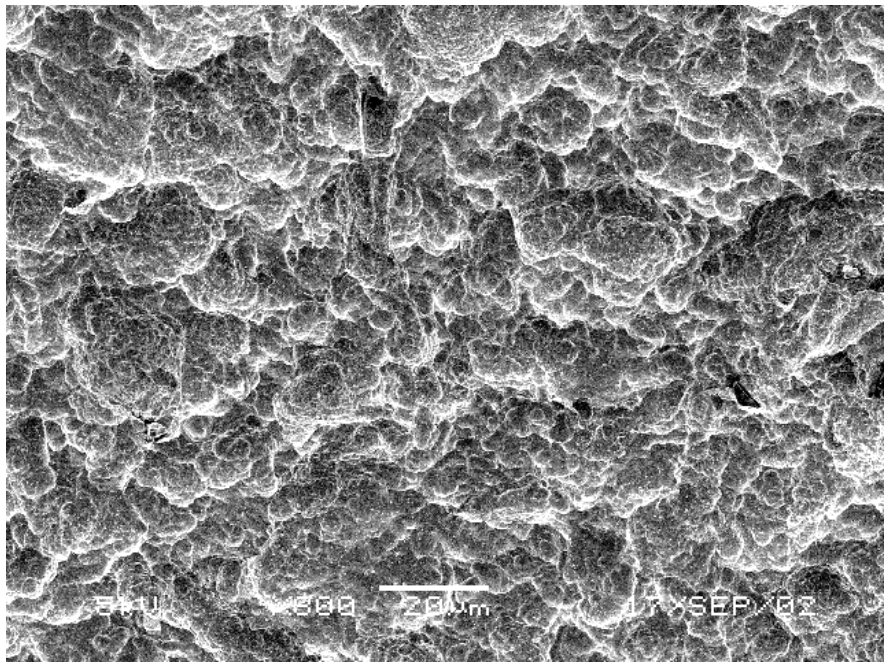


arrangement of atoms at cross section

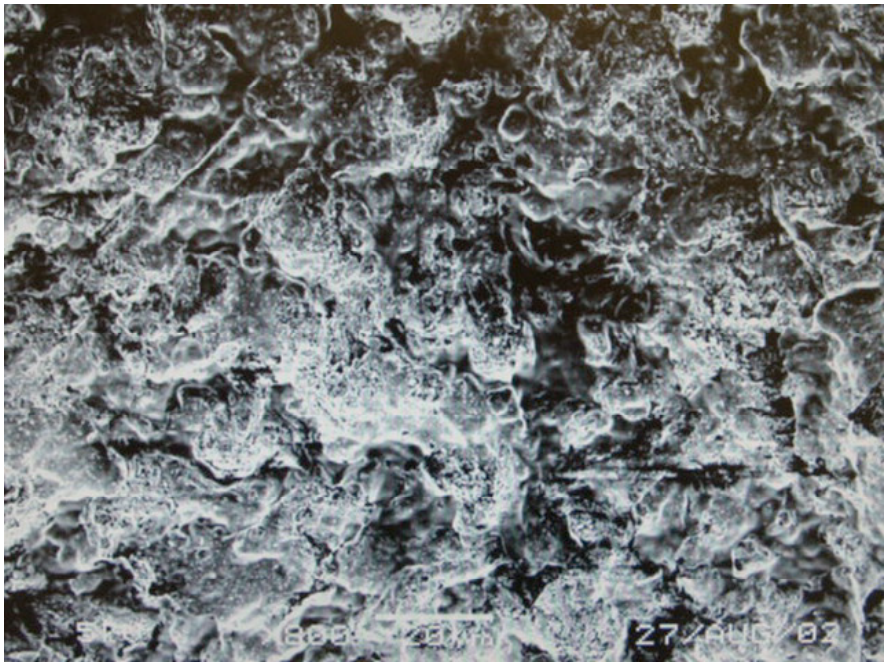


Tritium SEM autoradiography on high-strength steel

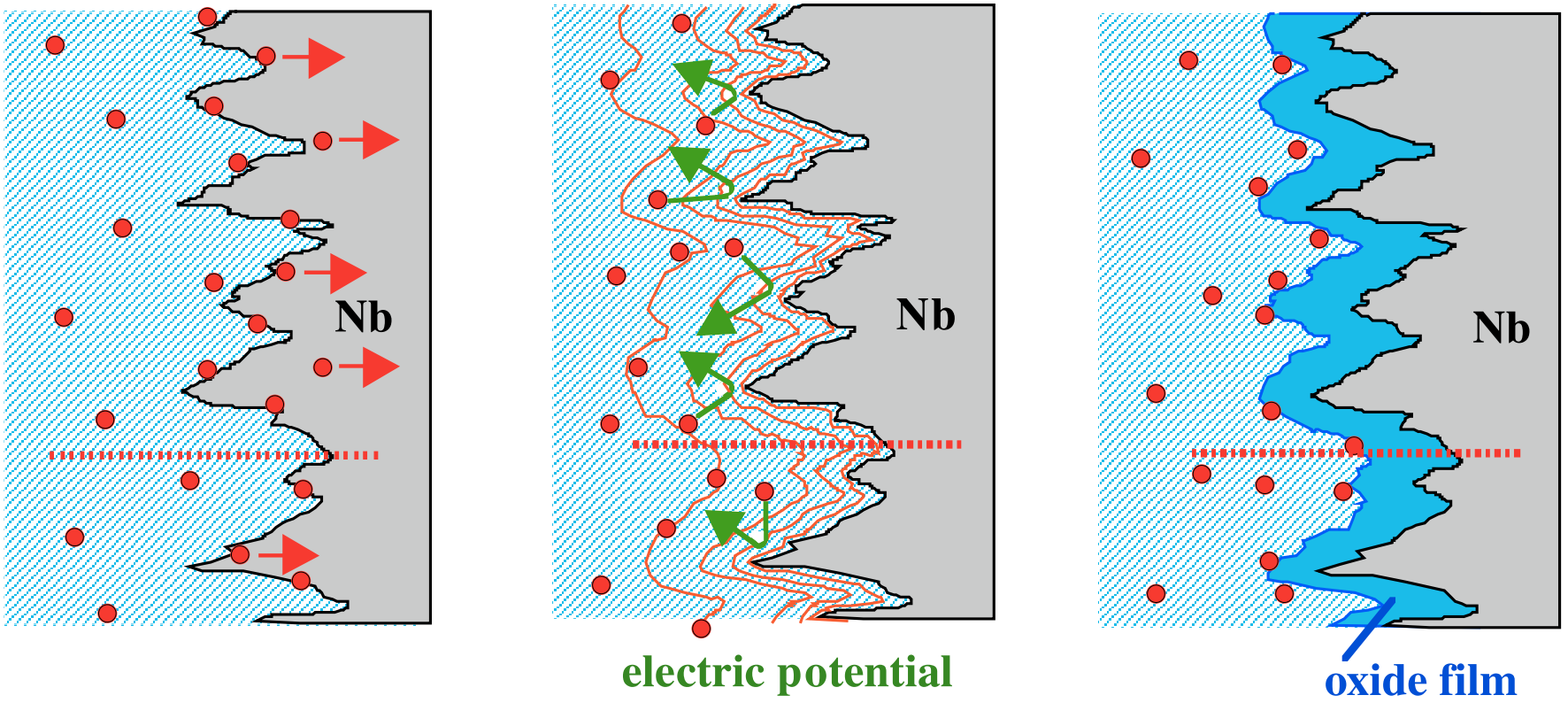
Dr. Gen KATANO

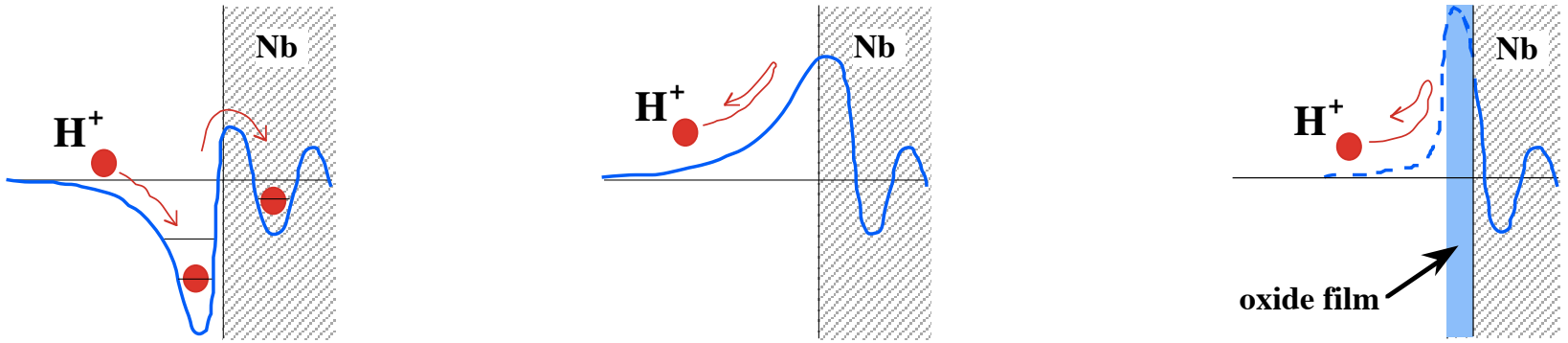


H-free CBP + CP 3 μm SEM



H-free CBP + EP 1 μm SEM


Nb
Nb
electric potential
Nb
oxide film


Nb
H+
Nb
H+
Nb
H+
oxide film

Conclusion

1) Surface defects due to mechanical grinding is the most likely cause of hydrogen absorption.
2) Continuous oxidization process is effective to prevent hydrogen absorption.
3) We innovated H-free mechanical grinding method (CBP) using H-free liquid.
4) We developed H-free EP by adding a little amount of oxidizer into the conventional EP solution. This new H-free EP simplifies the process and reduces the cost dramatically.