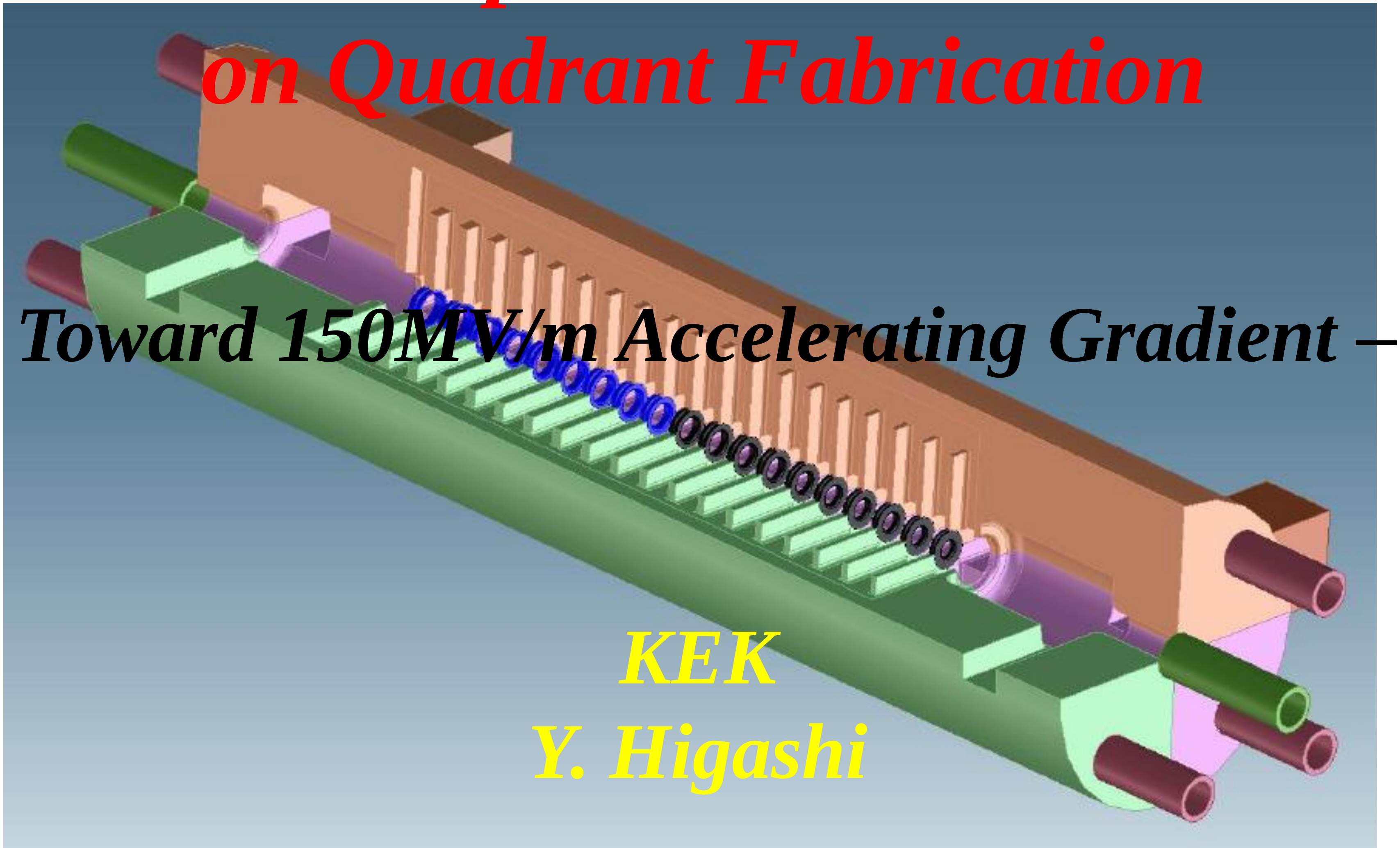
Material Preparation and New ideas on Quadrant Fabrication



- Toward 150MV/m Accelerating Gradient –

KEK
Y. Higashi

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Fabrication procedure on NLC/GLC and Single cell structures

NLC/GLC	*Single cell structures*
Rough cutting	*Rough cutting*
D.T	*D.T*
Chemical etching	*Chemical etching*
Diffusion bonding	*Diffusion bonding*
Brazing	*Brazing*
Baking at 650degC.	*Megasonic water rinsing/light etching*
Installation	*Baking at 400degC.*
In-situ baking	*Installation in simple clean bench*

Materials

NLC/GLC	*Single cell structure*
OFHC ~4N	*OFHC ~4N*
	OFHC ~6N
	OFHC ~7N
	CuZr
	Molly
	CuAg

Surface roughness and vacuum characteristics

- ***Vacuum***

$10^{-6} \sim 10^{-8}$ Pa

- ***Surface roughness***

~ 1~3 μm Ra (depend on etching conditions)

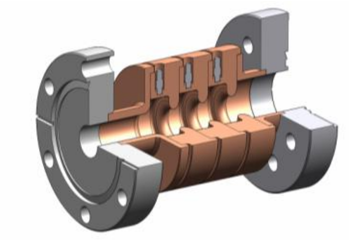
High Power Tests of Single Cell Standing Wave Structures Tested

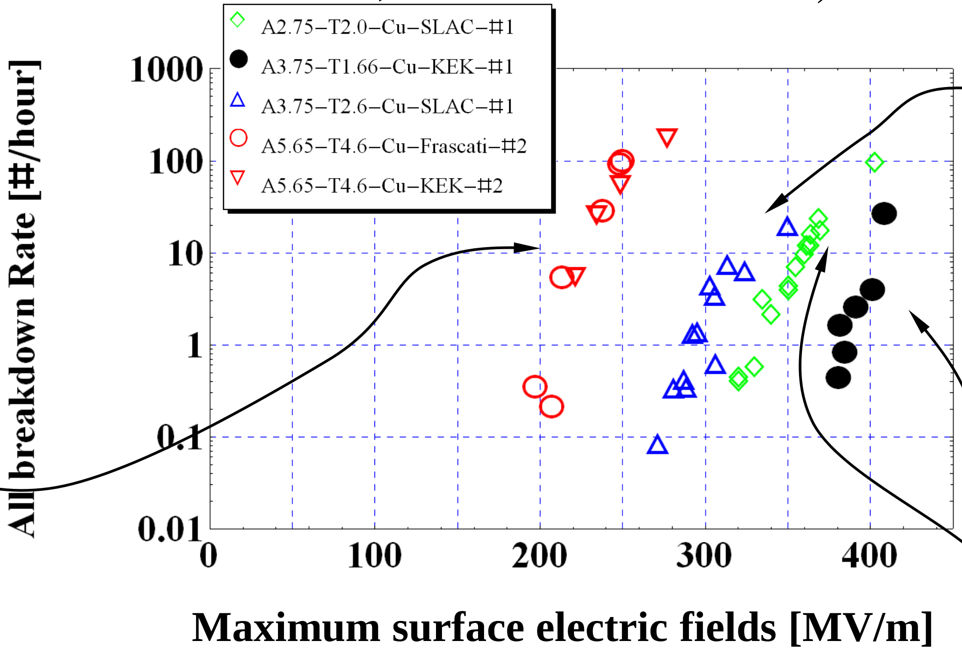
Comparison of high gradient test results

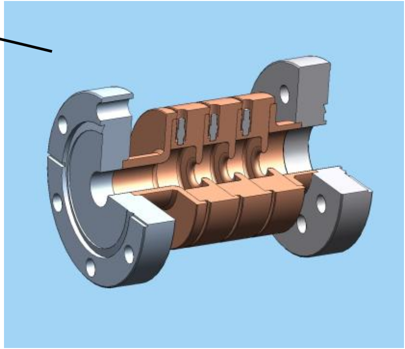
- Low shunt impedance, *a/lambda* = 0.215, *1C-SW-A5.65-T4.6-Cu*, 5 tested
- Low shunt impedance, TiN coated, *1C-SW-A5.65-T4.6-Cu-TiN*, 1 tested
- Three high gradient cells, low shunt impedance, *3C-SW-A5.65-T4.6-Cu*, 2 tested
- High shunt impedance, elliptical iris, *a/lambda* = 0.143, *1C-SW-A3.75-T2.6-Cu*, 1 tested
- High shunt impedance, round iris, *a/lambda* = 0.143, *1C-SW-A3.75-T1.66-Cu*, 1 tested
- Low shunt impedance, choke with 1mm gap, *1C-SW-A5.65-T4.6-Choke-Cu*, 2 tested
- Low shunt impedance, made of CuZr, *1C-SW-A5.65-T4.6-CuZr*, 1 tested
- Low shunt impedance, made of CuCr, *1C-SW-A5.65-T4.6-CuCr*, 1 tested
- Highest shunt impedance copper structure *1C-SW-A2.75-T2.0-Cu*, 1 tested
- Photonic-Band Gap, low shunt impedance, *1C-SW-A5.65-T4.6-PBG-Cu*, 1 tested
- Low shunt impedance, made of hard copper *1C-SW-A5.65-T4.6-Clamped*, 1 tested
- Low shunt impedance, made of molybdenum *1C-SW-A5.65-T4.6-Mo*, 1 tested
- Low shunt impedance, hard copper electroformed *1C-SW-A5.65-T4.6-Electroformed-Cu*, 1 tested
- High shunt impedance, choke with 4mm gap, *1C-SW-A3.75-T2.6-4mm-Ch-Cu*, 2 tested
- High shunt impedance, elliptical iris, *a/lambda* = 0.143, *1C-SW-A3.75-T2.6-6NCu*, 1 tested
- High shunt impedance, elliptical iris, *a/lambda* = 0.143, *1C-SW-A3.75-T2.6-6N-HIP-Cu*, 1 tested
- High shunt impedance, elliptical iris, *a/lambda* = 0.143, *1C-SW-A3.75-T2.6-7N-Cu*, 1 tested
- Low shunt impedance, made of CuAg, *1C-SW-A5.65-T4.6-CuAg-SLAC-#1*, 1 tested
- High shunt impedance hard CuAg structure *1C-SW-A3.75-T2.6-LowTempBrazed-CuAg*, 1 tested
- High shunt impedance soft CuAg, *1C-SW-A3.75-T2.6-CuAg*, 1 tested
- High shunt impedance hard CuZr, *1C-SW-A3.75-T2.6-Clamped-CuZr*, 1 tested
- High shunt impedance dual feed side coupled, *1C-SW-A3.75-T2.6-2WR90-Cu*, 1 tested

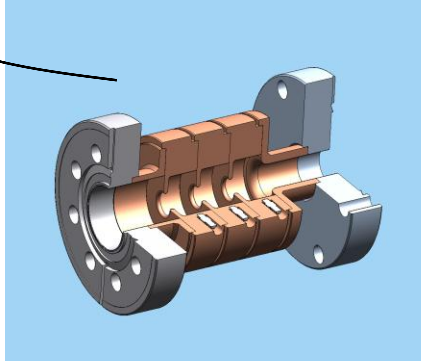
Surface fields for 5 different single cell structures, *shaped* pulse

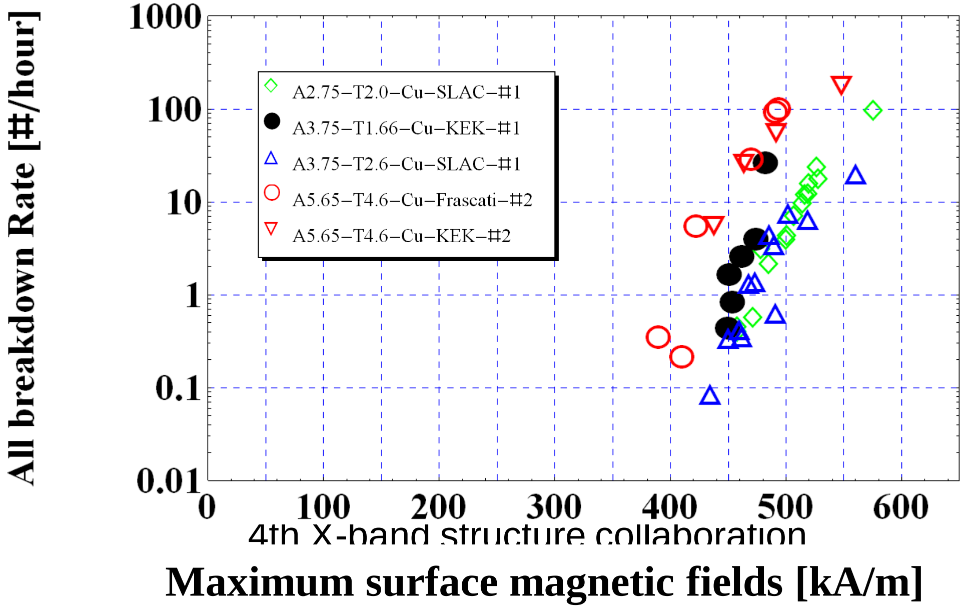
(*flat* part: A5.65-T4.6-KEK-#1- 150 ns, A5.65-T4.6-Frascati-#2- 150 ns, A3.75-T2.6-Cu-SLAC-#1: 150 ns, A3.75-T1.66-Cu-KEK-#1 200 ns, A2.75-T2.0-Cu-SLAC-#1 200 ns)

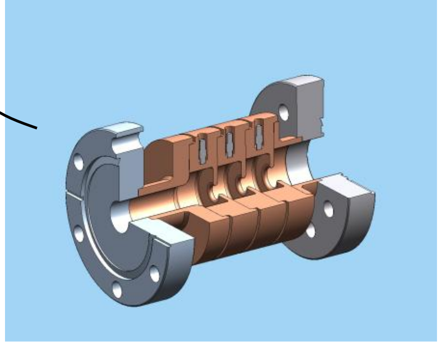








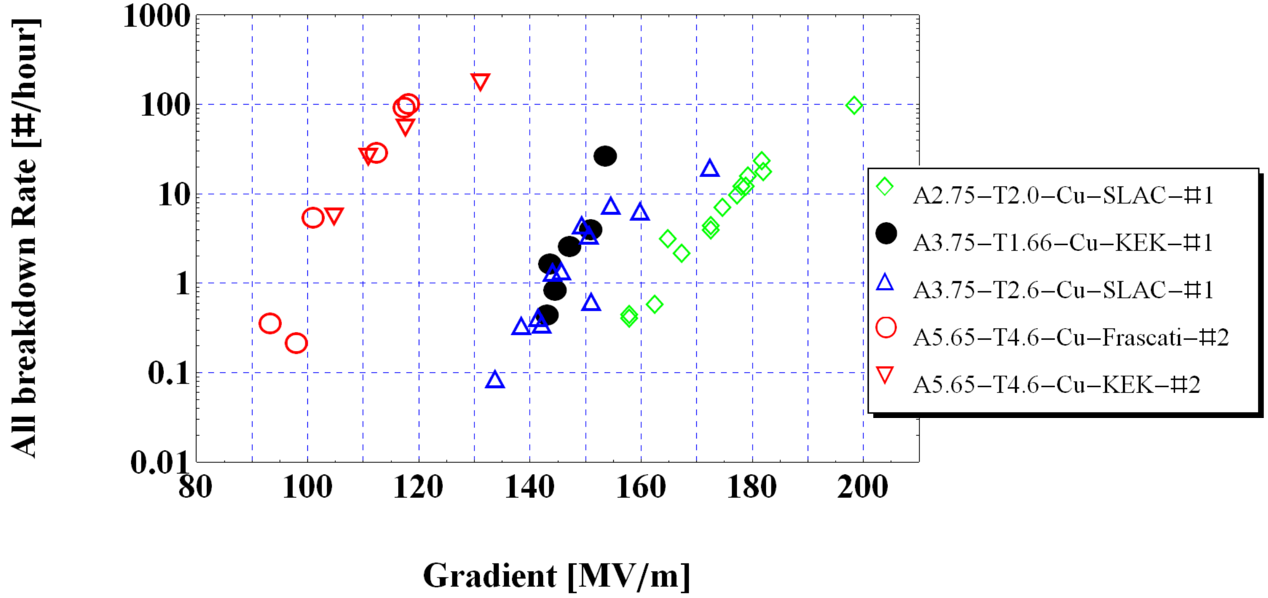


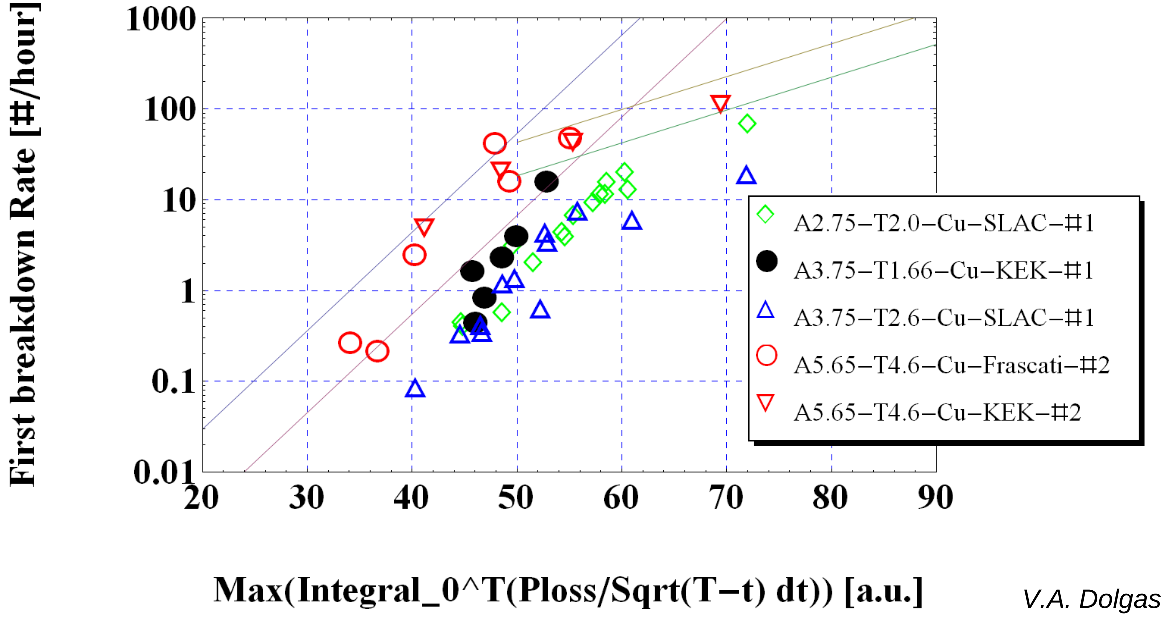


V.A. Dolgashev, 16 December 2008

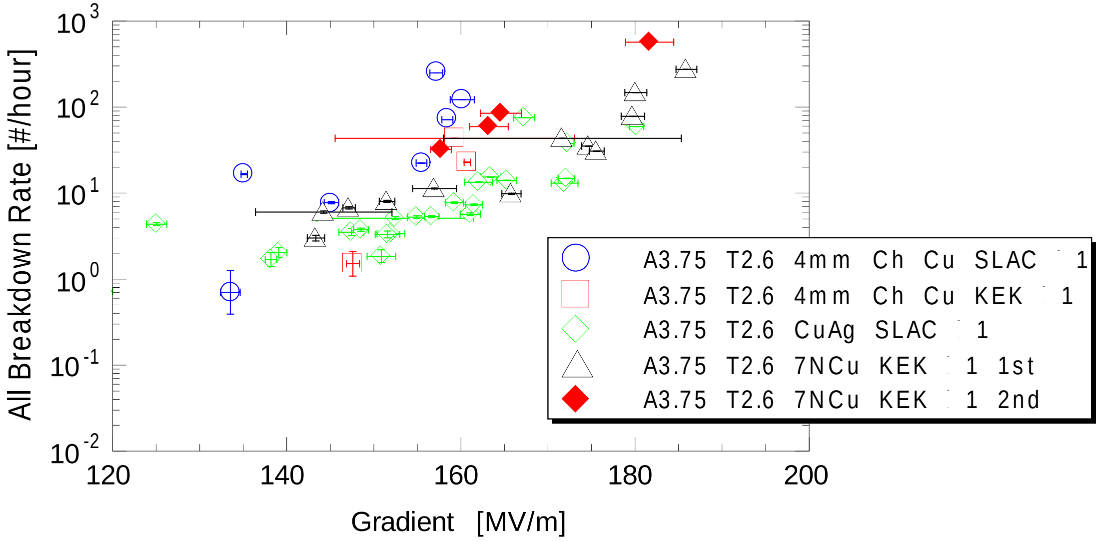
Gradient and pulse heating for 5 different single cell structures, *shaped* pulse

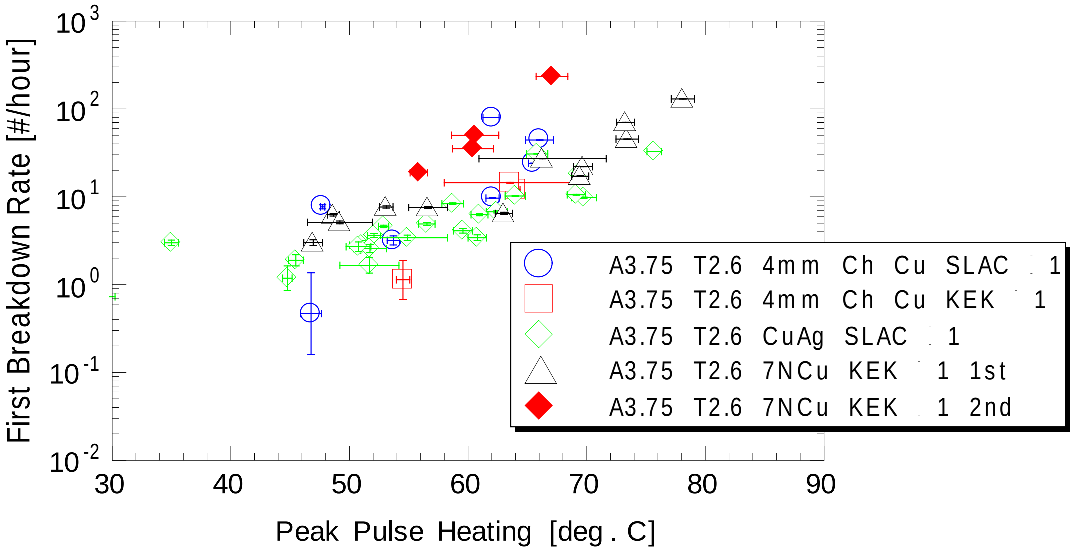
(*flat* part: A5.65-T4.6-KEK-#1- 150 ns, A5.65-T4.6-Frascati-#2- 150 ns, A3.75-T2.6-Cu-SLAC-#1: 150 ns, A3.75-T1.66-Cu-KEK-#1 200 ns, A2.75-T2.0-Cu-SLAC-#1 200 ns)





Breakdown rate *vs.* gradient and pulse heating for 4 A3.75-T2.6 structures, shaped pulse, 150 ns flat part. Two sets of data for 7N structure are shown, 1st taken 2/09/10-2/18/10, 2nd taken 3/11/2010





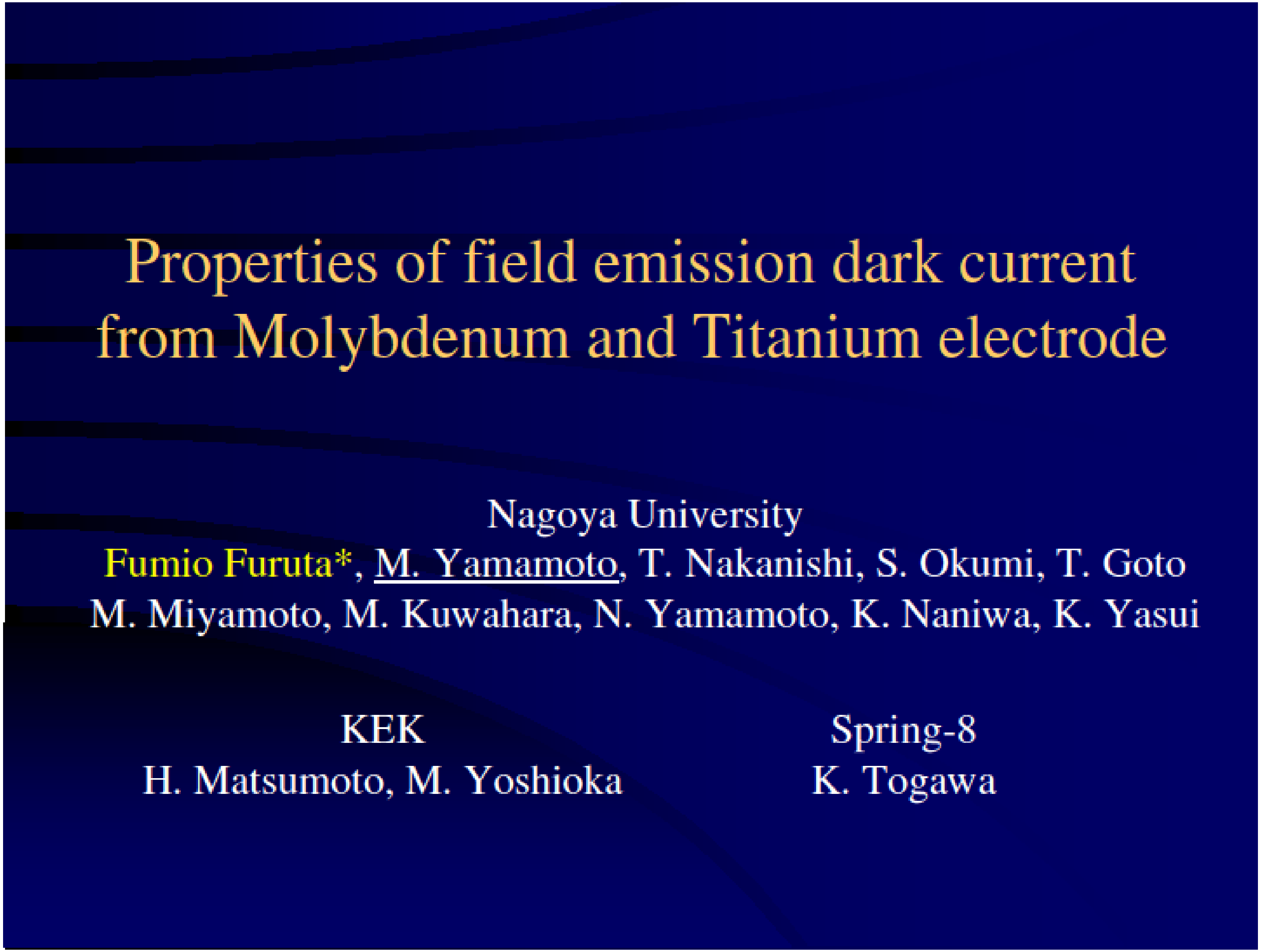
From valery E-mail

I attached file with most recent 150-200 ns data for 4 different types of structures. Again, looks like peak magnetic field has higher effect on breakdown rate then the peak electric field. Unfortunately, we still do not know why.

No surprise high gradient performance was found!!!!!

Improvement technologies for upgrading breakdown performance

- *Do we need extremely small roughness?*
- *Do we need extremely high vacuum?*
- *Do we need extremely dust free?*
- *Do we need deferent material in stead of Copper?*

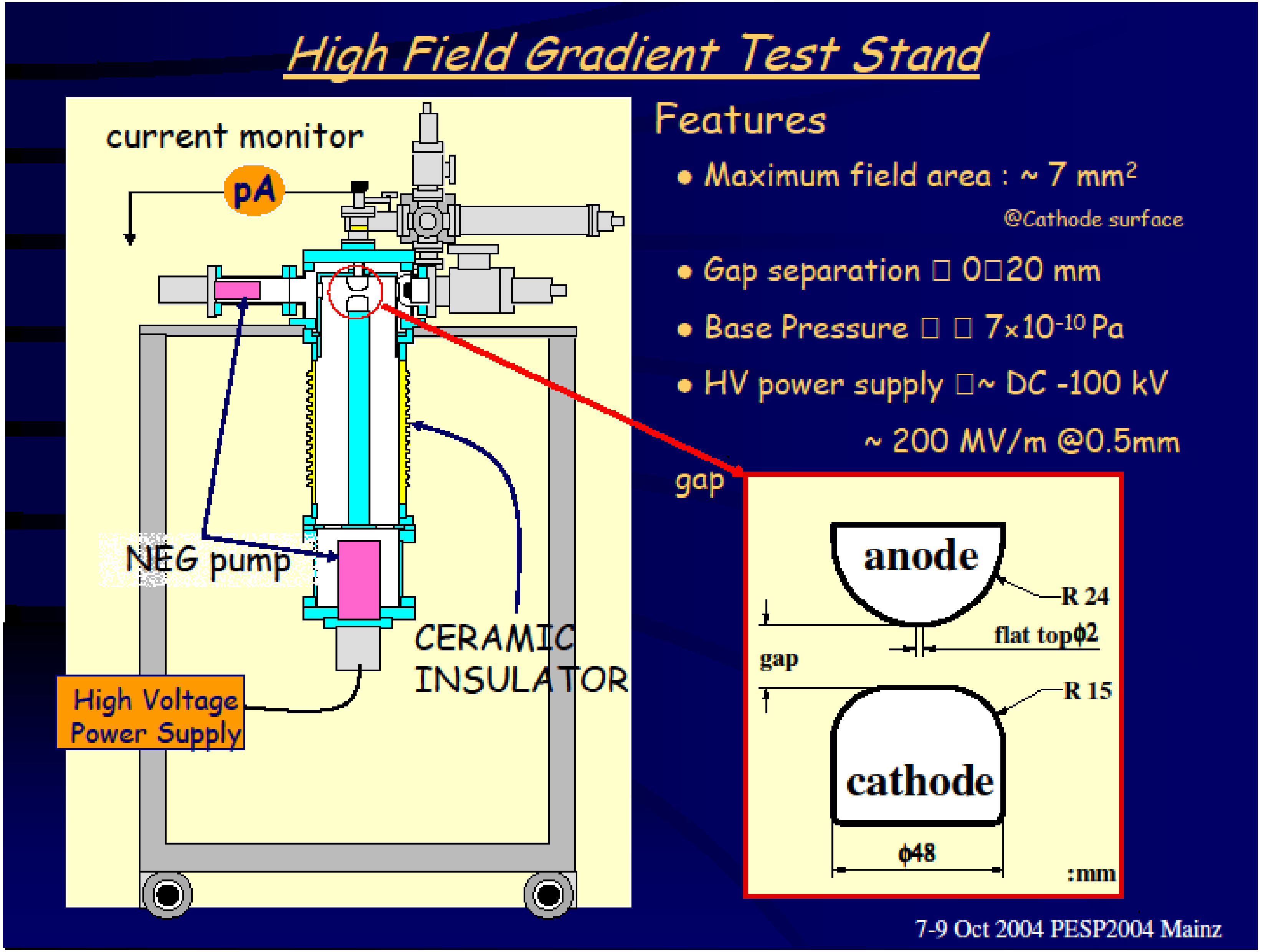


Properties of field emission dark current from Molybdenum and Titanium electrode

Nagoya University
Fumio Furuta*, M. Yamamoto, T. Nakanishi, S. Okumi, T. Goto
M. Miyamoto, M. Kuwahara, N. Yamamoto, K. Naniwa, K. Yasui

KEK
H. Matsumoto, M. Yoshioka

Spring-8
K. Togawa



High Field Gradient Test Stand

Features

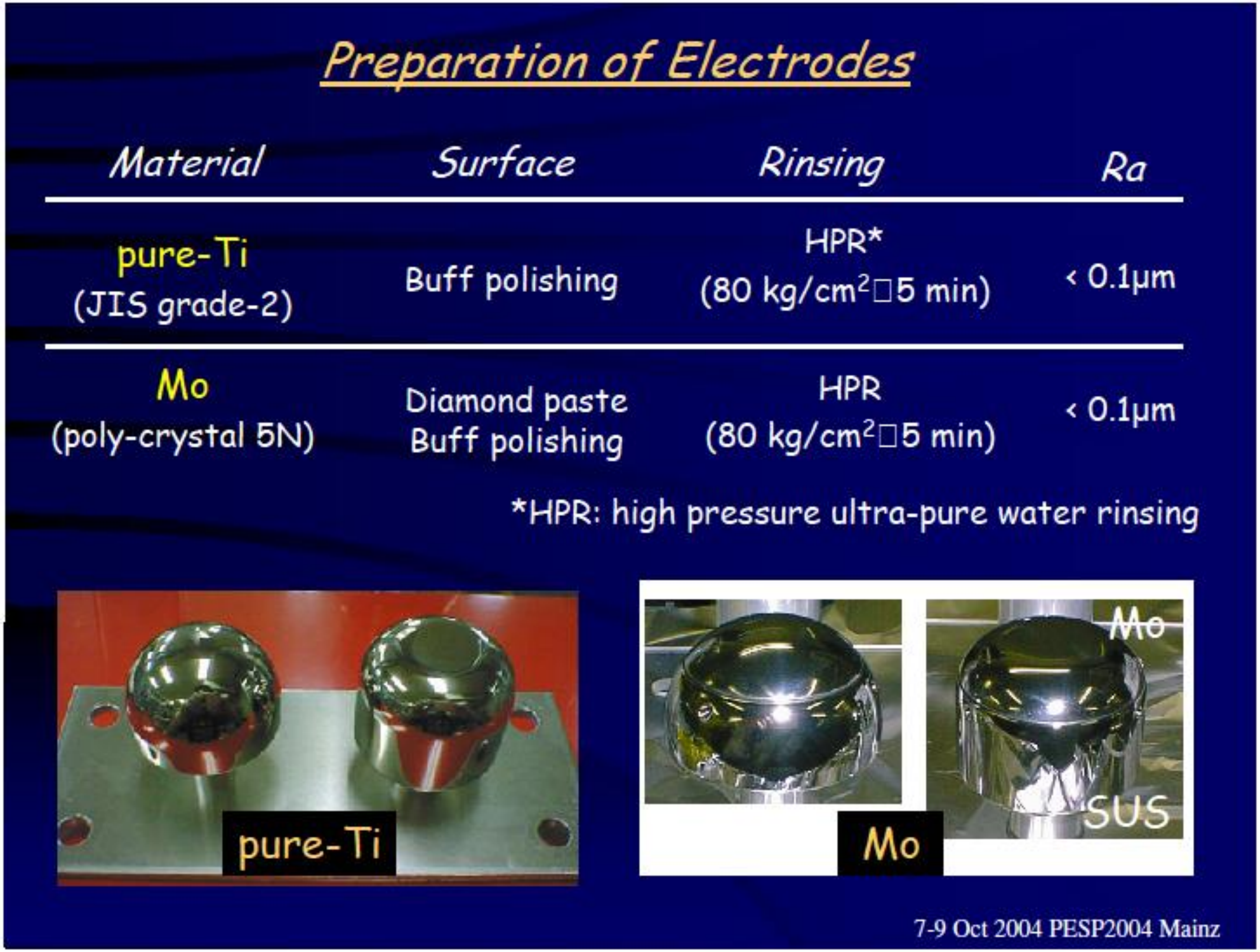
- Maximum field area : ~ 7 mm^2

  @Cathode surface
- Gap separation □ 0□20 mm
- Base Pressure □ □ 7×10^{-10} Pa
- HV power supply □~ DC -100 kV

  ~ 200 MV/m @0.5mm gap

7-9 Oct 2004 PESP2004 Mainz

meeting



Preparation of Electrodes

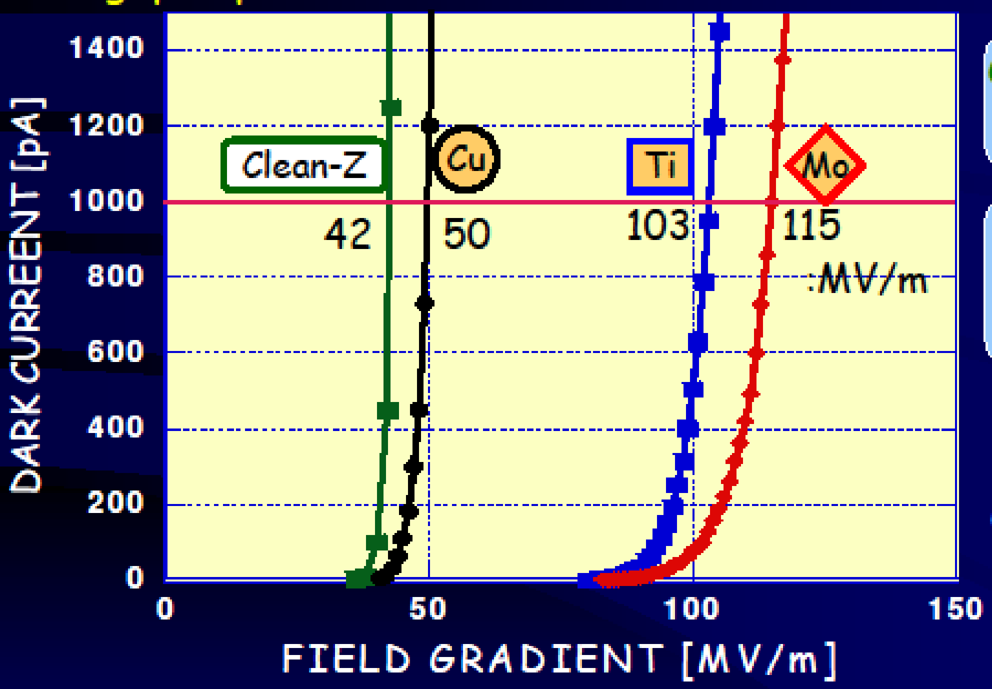
Material	*Surface*	*Rinsing*	*Ra*
pure-Ti (JIS grade-2)	Buff polishing	HPR* (80 kg/cm²□5 min)	‹ 0.1µm
Mo (poly-crystal 5N)	Diamond paste Buff polishing	HPR (80 kg/cm²□5 min)	‹ 0.1µm

*HPR: high pressure ultra-pure water rinsing

meeting

Dark Current Dependence (Electrodes Material)

gap separation=0.5mm Vac : ~1e-9 Pa



Researched materials

Clean-Z (Re-Melted SUS316L)
Electro-buff polishing

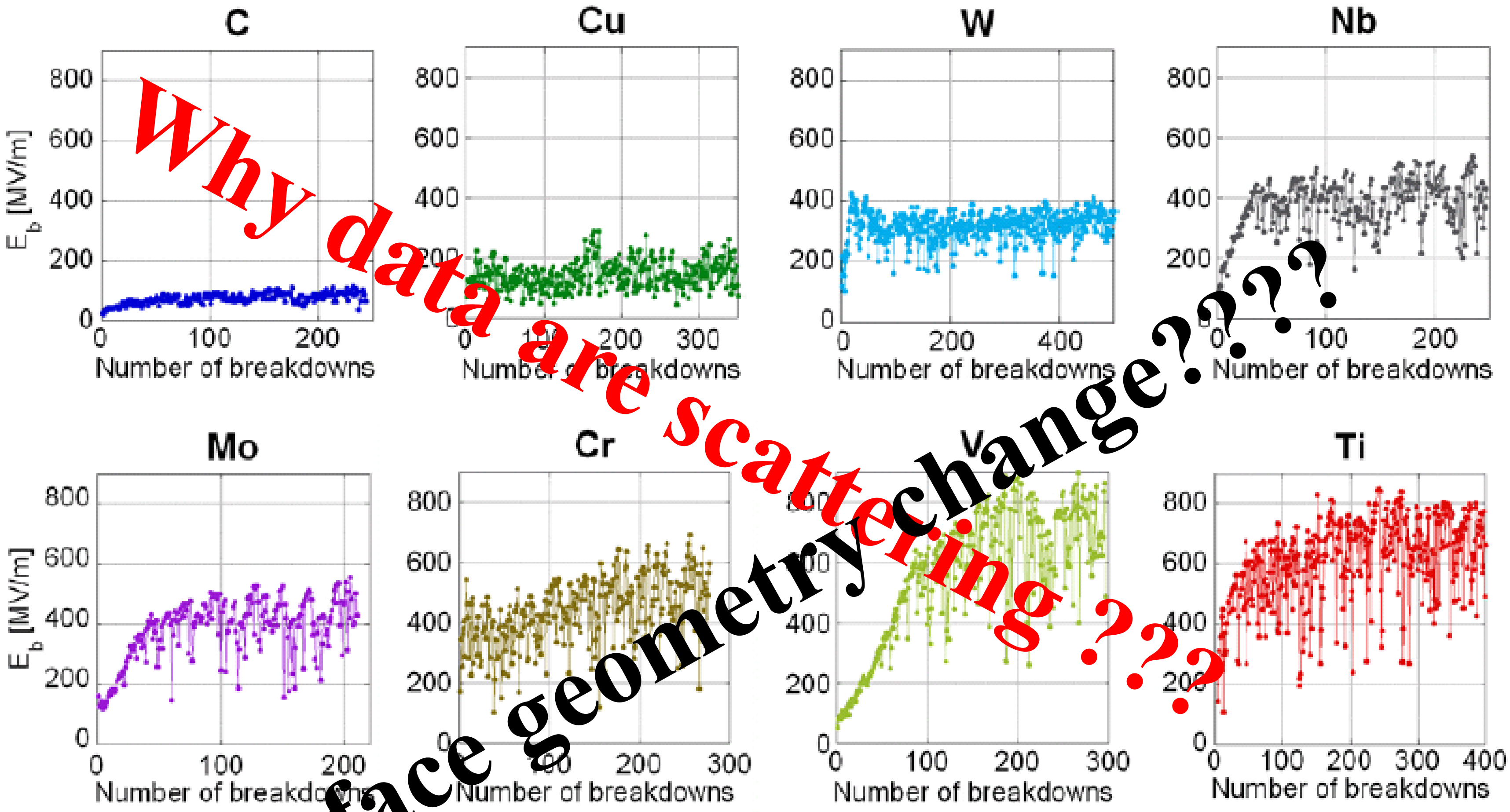
Copper (OFHC)
precision diamond machining
(no polishing)

Ti and Mo
Only (diamond) buff polishing

7-9 Oct 2004 PESP2004 Mainz

meeting

Conditioning curves of pure metals



Why data are scattering ???

Surface geometry change????

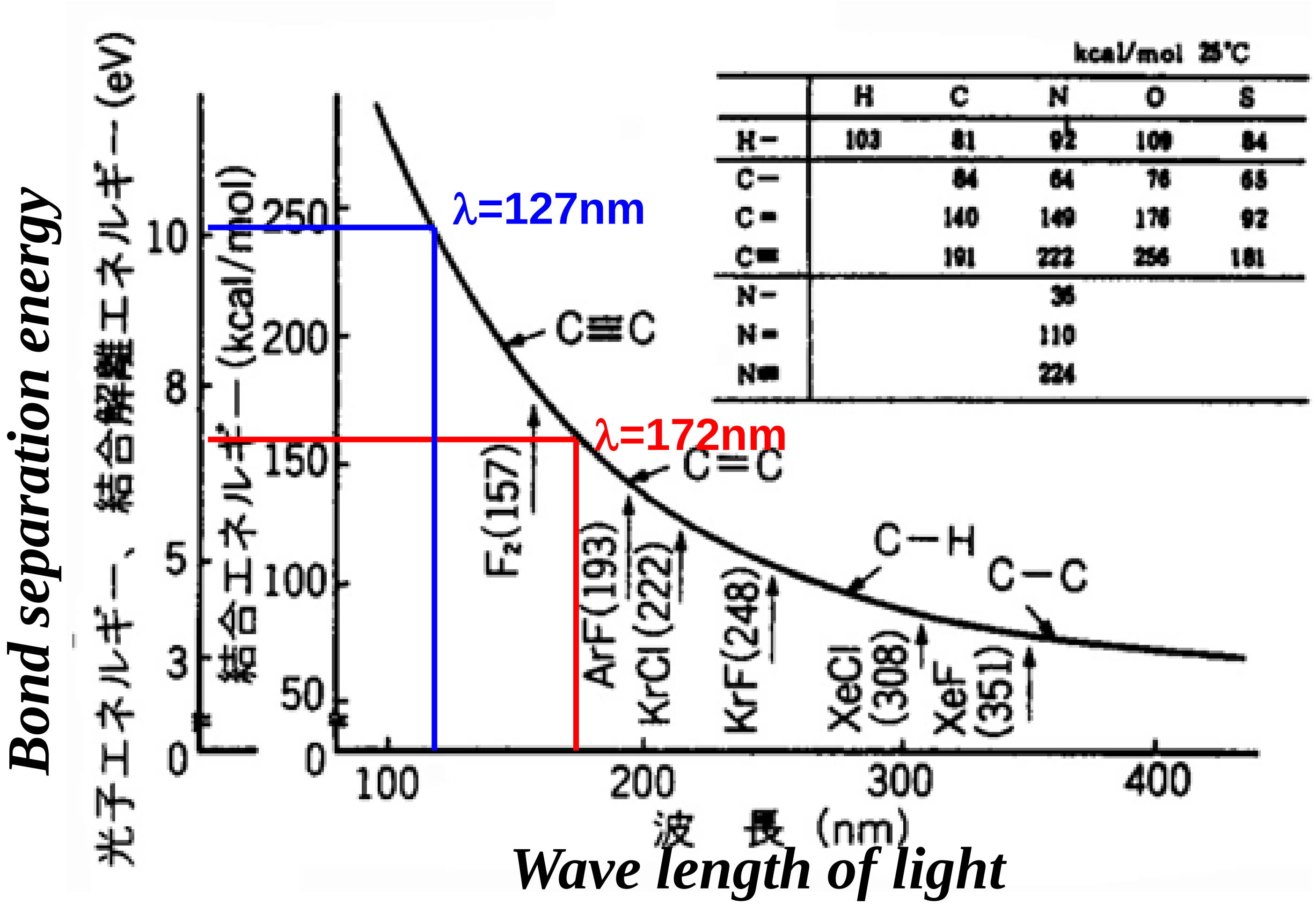
CLIC08 Workshop –CERN, 16th October 2008

My conclusion for CLIC structure needs

- *Extremely small roughness*
- *Extremely high vacuum*
- *Extremely dust free*
- *Out gas free*
- *Deferent material in stead of Copper*

Have to conform using Single Cell structure

UV Cleaning



kcal/mol 25°C

	H	C	N	O	S
H−	103	81	92	109	84
C−		84	64	76	65
C=		140	149	176	92
C≡		191	222	256	181
N−			36		
N=			110		
N≡			224		

Reflectivity of 172nm wavelength on Nb and Cu

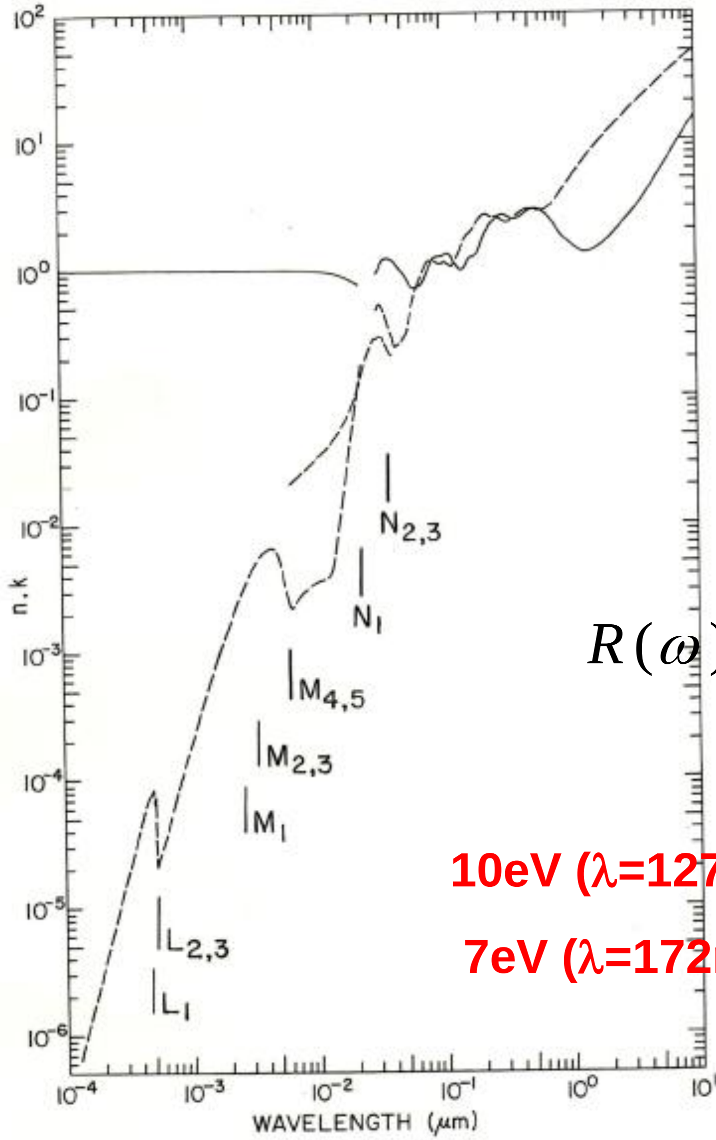


Fig. 1. Log–log plot of n (solid line) and k (dashed line) versus wavelength in microme for niobium.

$$R(\omega) = \frac{[n(\omega) - 1]^2 + [k(\omega)]^2}{[n(\omega) + 1]^2 + [k(\omega)]^2}$$

	Al	Nb	Cu (%)
10eV (λ=127nm)	92.8	19.38	13.88
7eV (λ=172nm)	92.6	44.18	27.03

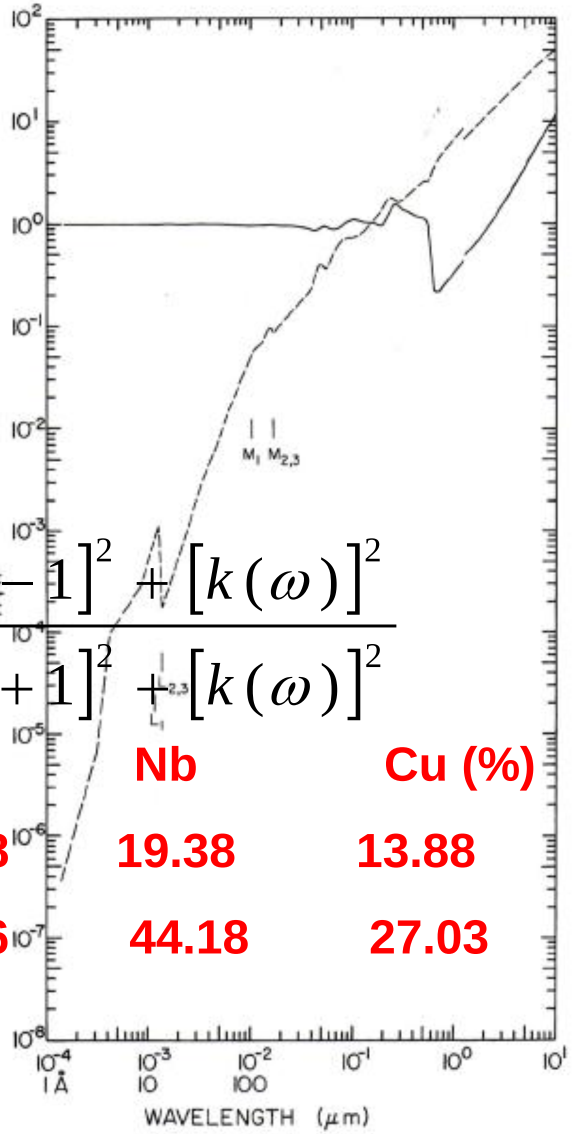
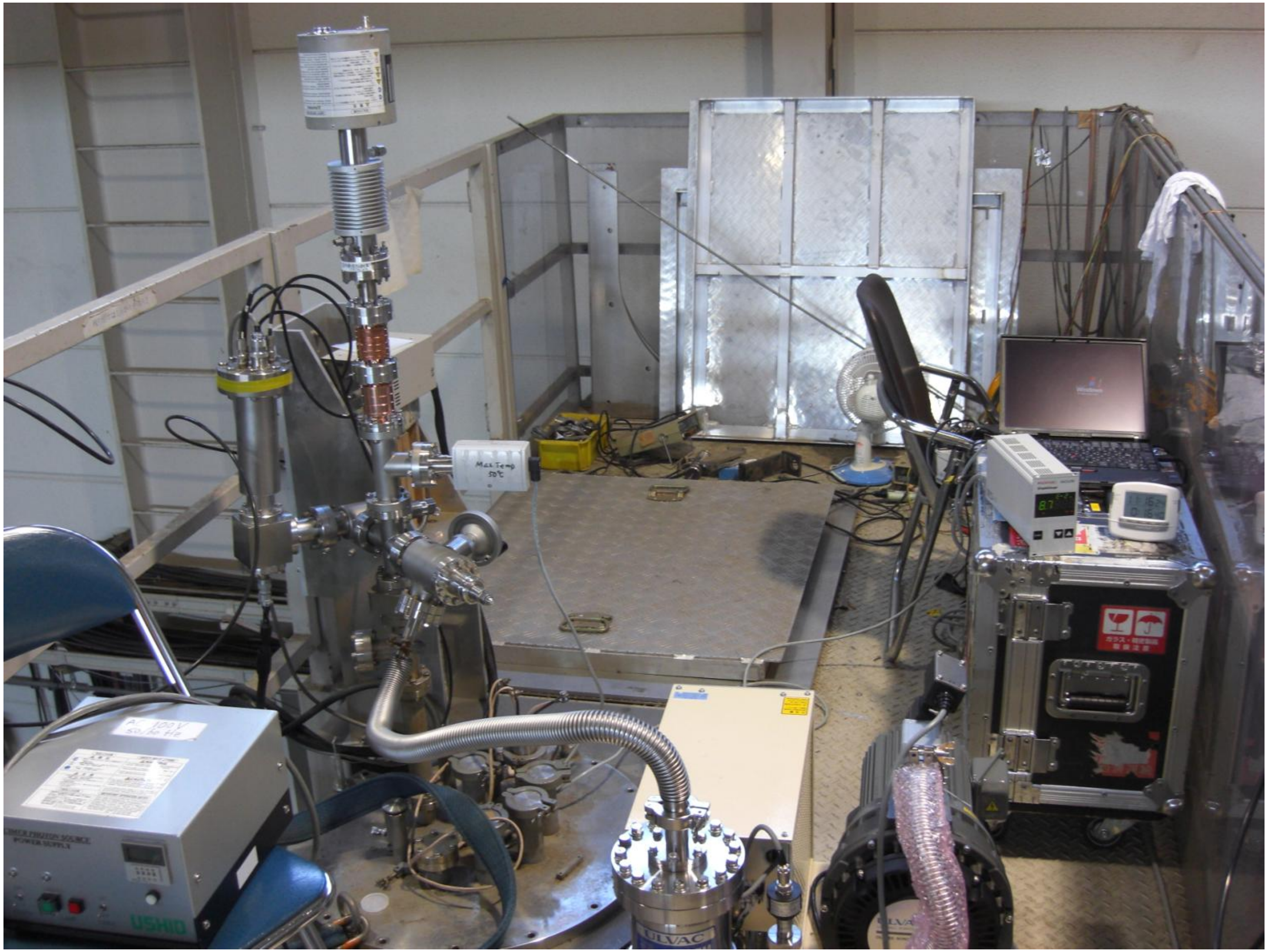


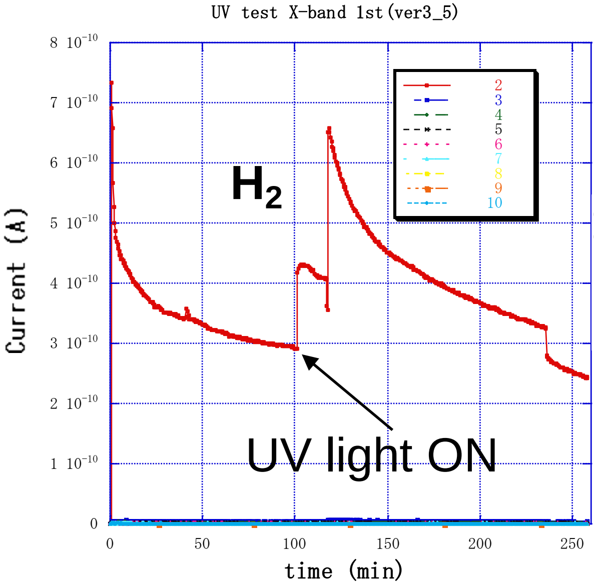
Fig. 1. Log–log plot of n (——) and k (––––) versus wavelength in micrometers for copper.

meeting

UV Cleaning Test Setup

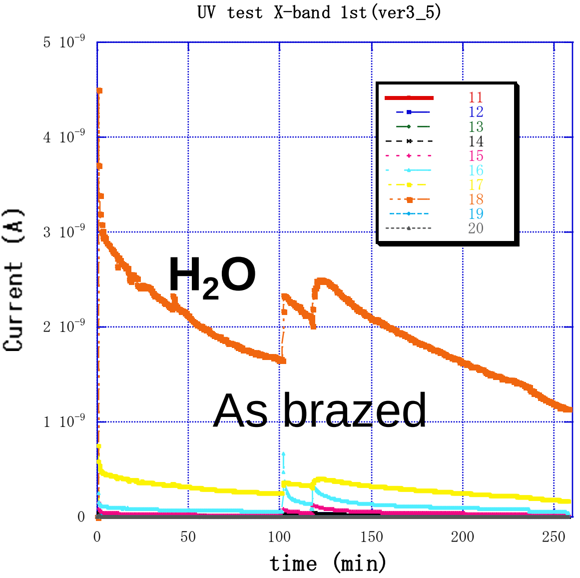


Results of UV cleaning on the cavity surface



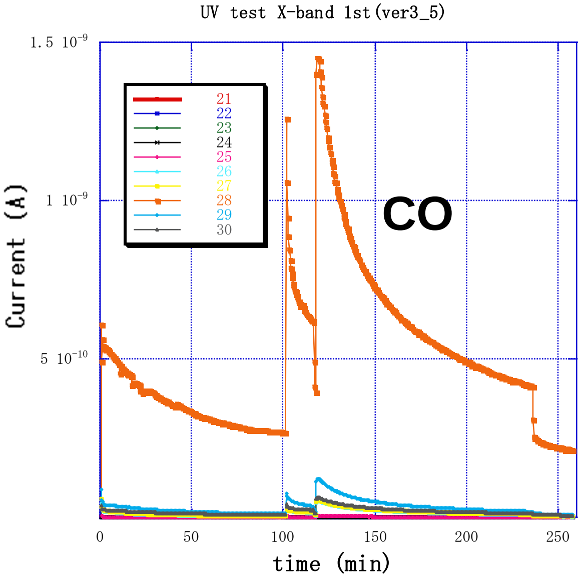
H_2

UV light ON

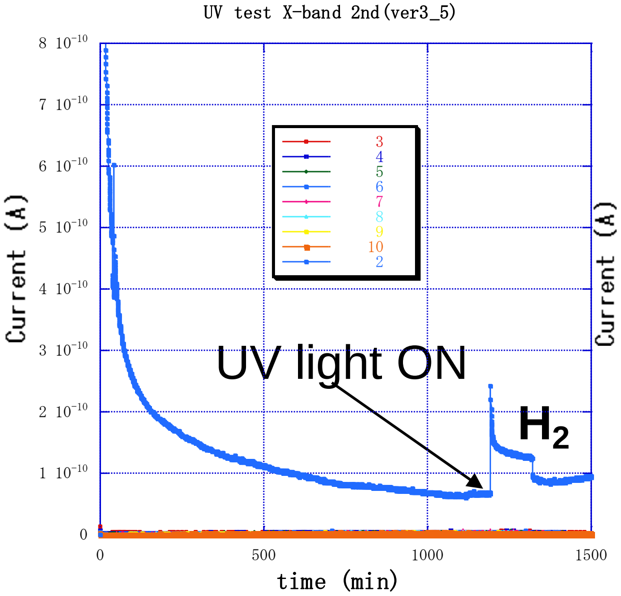


H_2O

As brazed

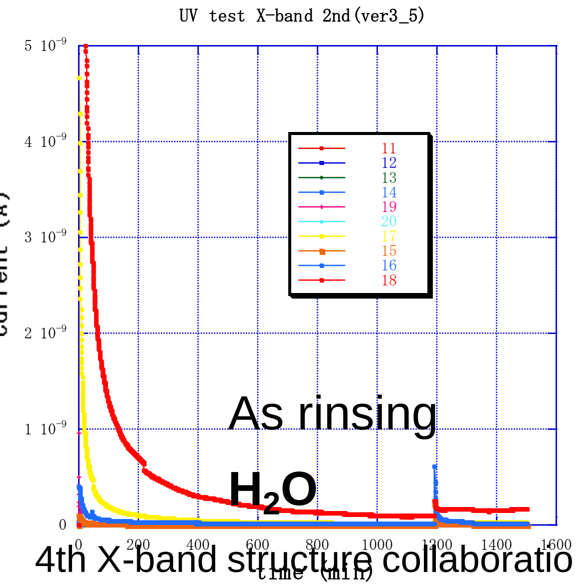


CO



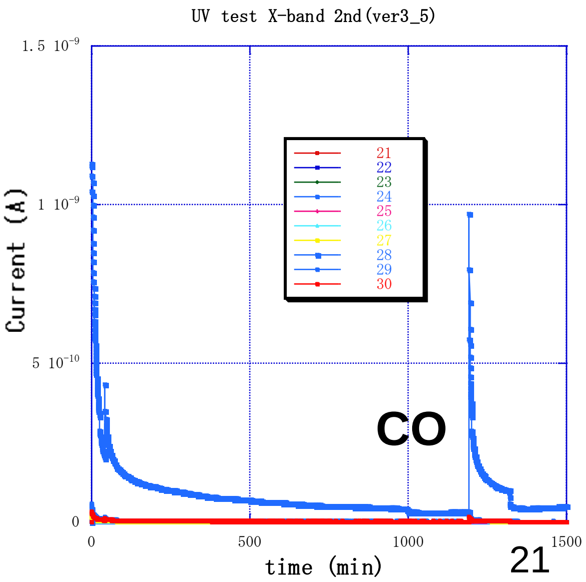
UV light ON

H_2

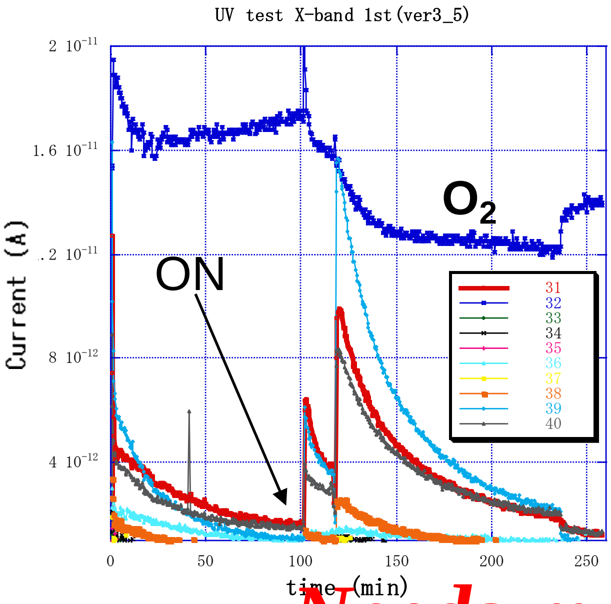


As rinsing

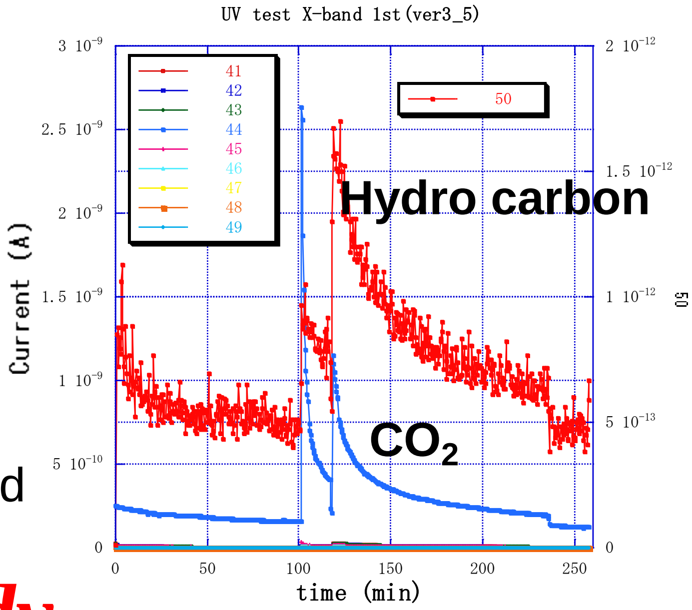
H_2O



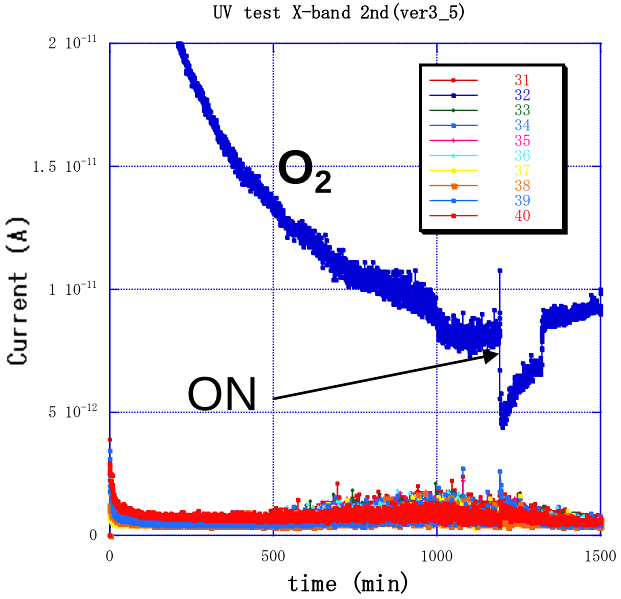
CO



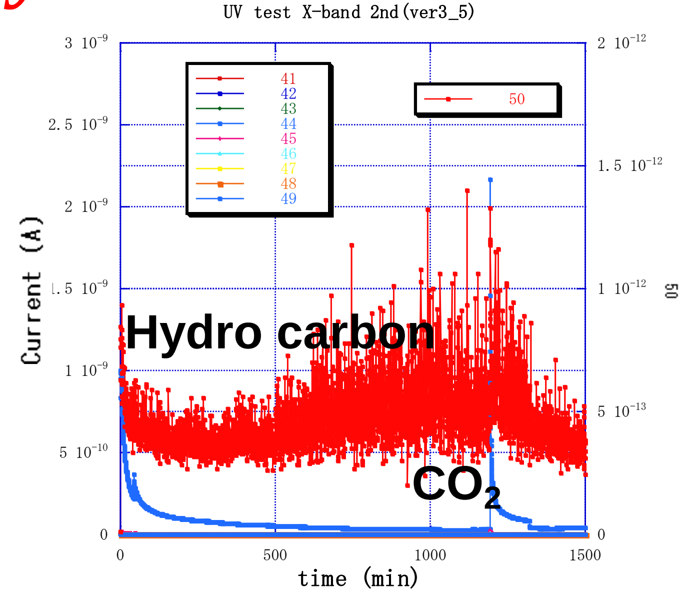
As brazed

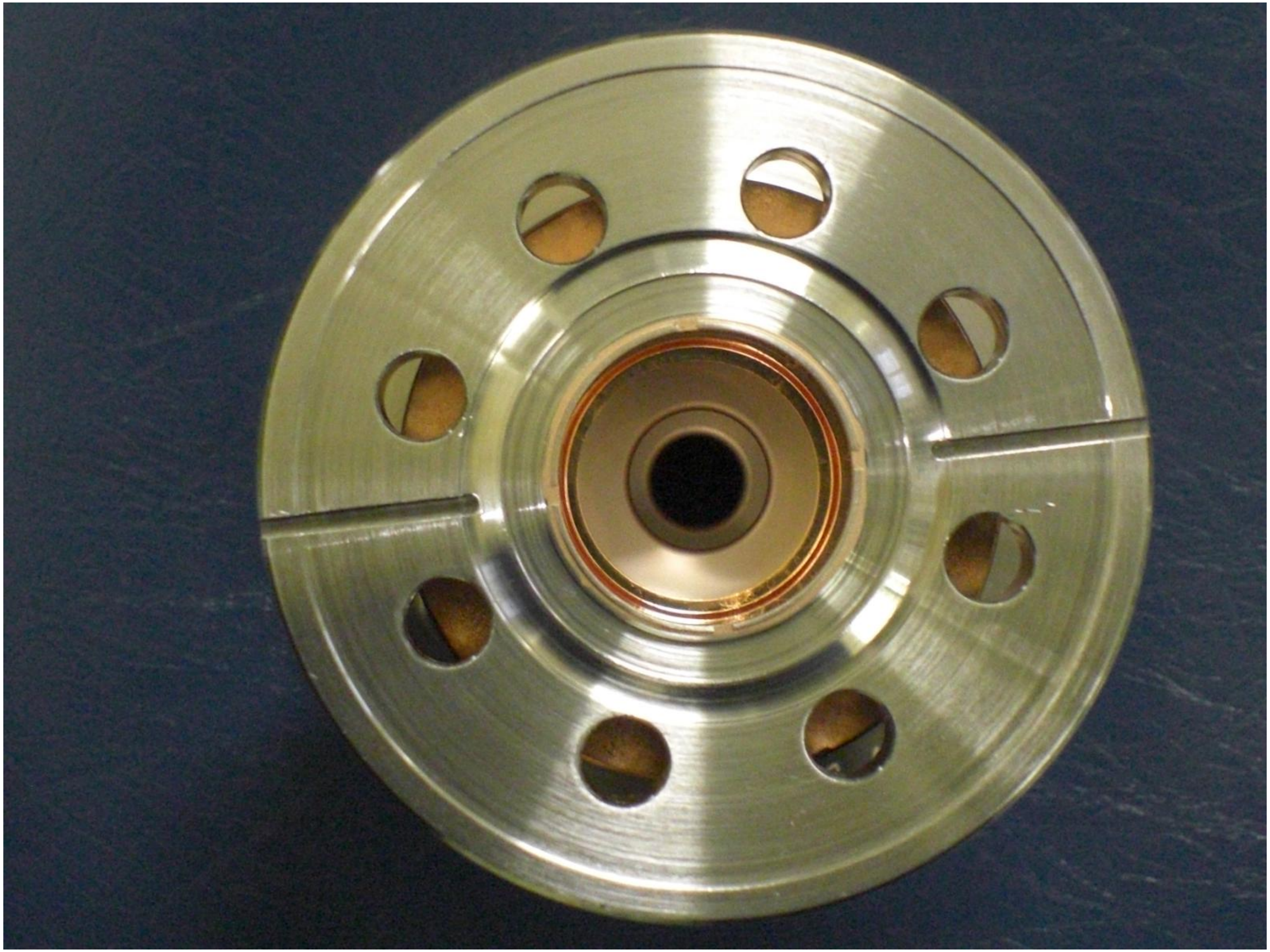


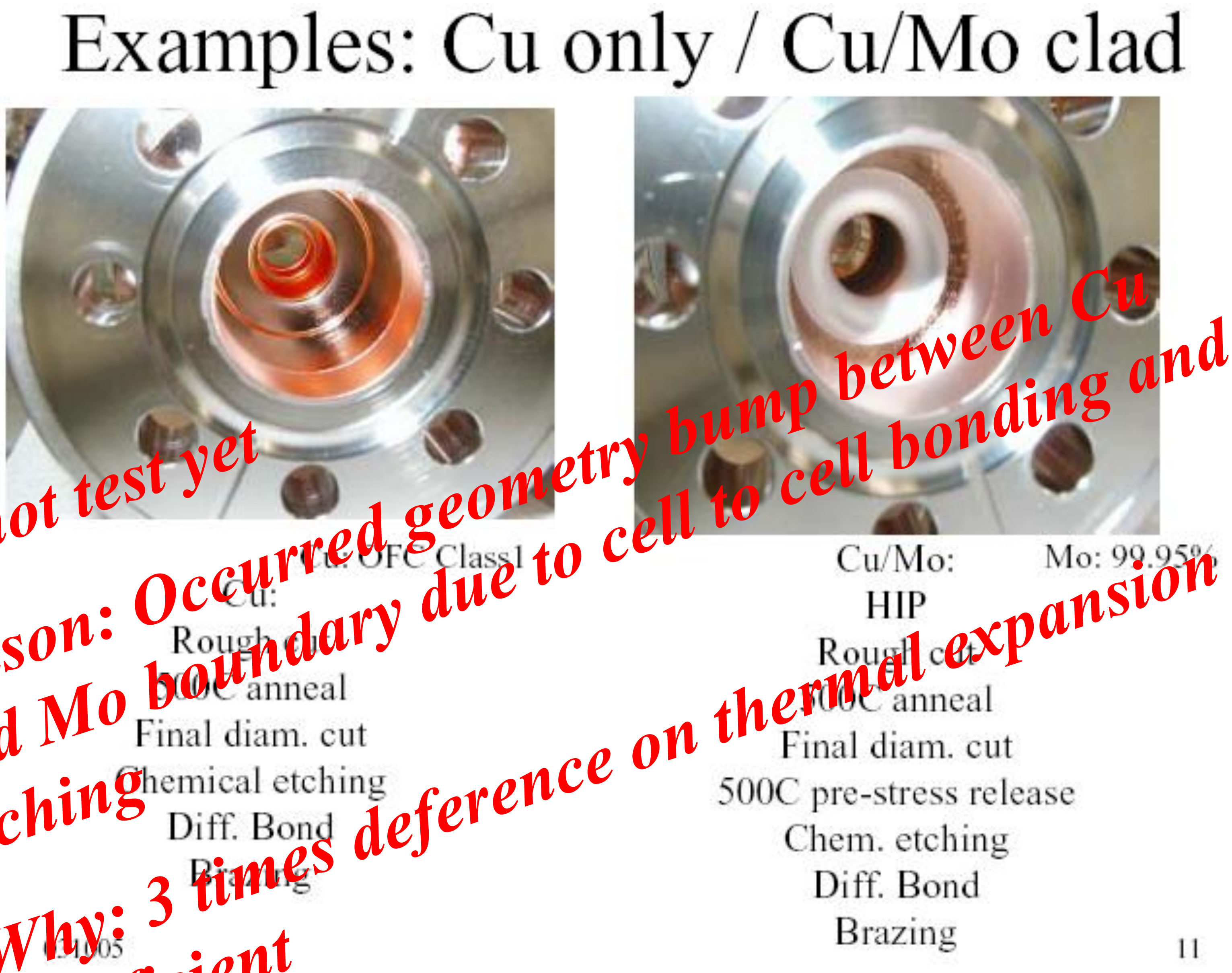
Needs more study



As rinsing







Examples: Cu only / Cu/Mo clad

Cu: OFC Class1
Cu:
Rough cut
500C anneal
Final diam. cut
Chemical etching
Diff. Bond
Brazing

Cu/Mo: Mo: 99.95%
HIP
Rough cut
500C anneal
Final diam. cut
500C pre-stress release
Chem. etching
Diff. Bond
Brazing

6/10/05

11

But not test yet

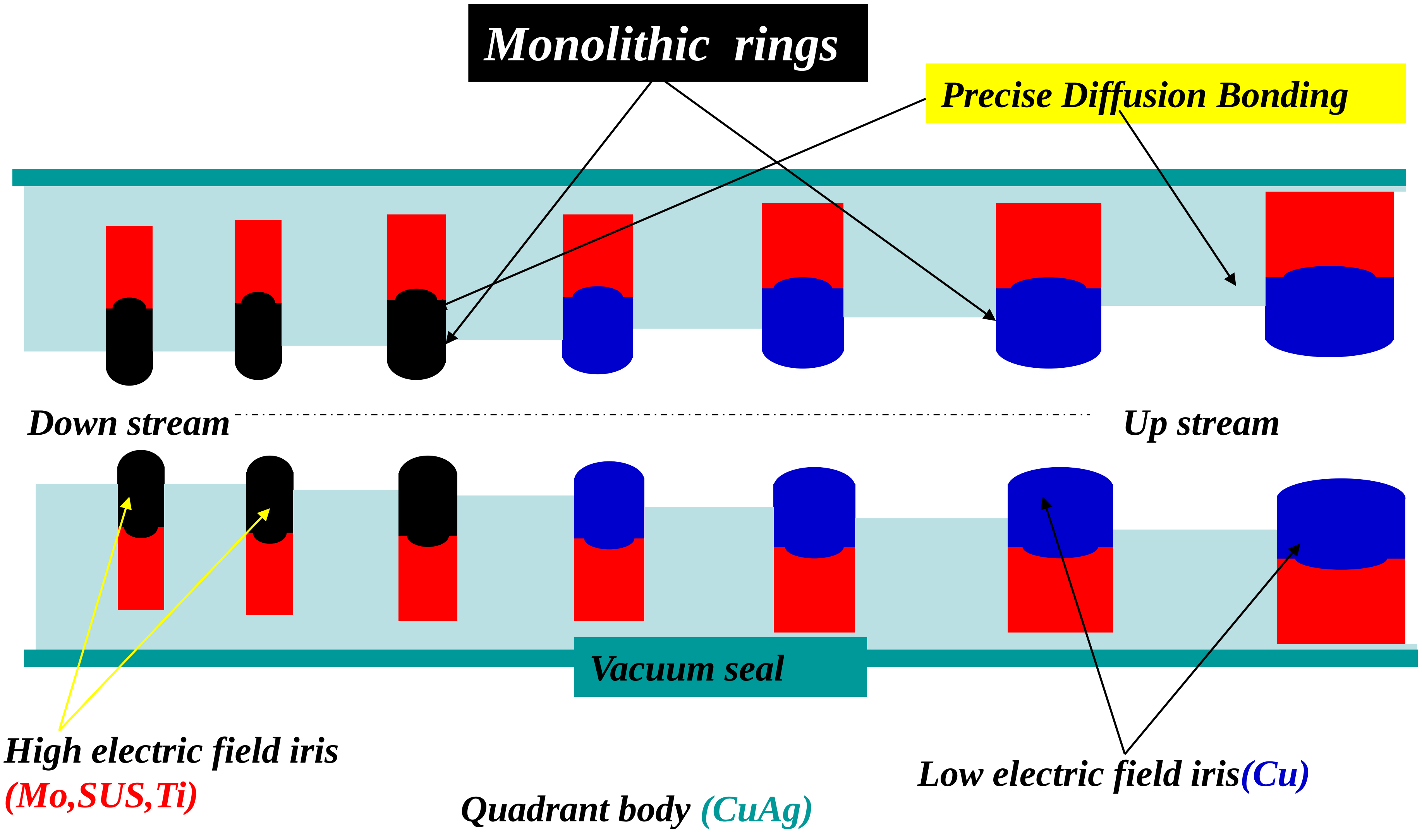
Reason: Occurred geometry bump between Cu and Mo boundary due to cell to cell bonding and etching

Why: 3 times deference on thermal expansion coefficient

New ideas on Quadrant

- ***No Vacuum tank***
- ***No Brazing***
- ***Easy machining***
- ***Easy Assembly***
- ***Easy Alignment***
- ***Cost Reduction***
- ***Utilizing EBW/Laser welding for vacuum seal***
- ***Mo, SUS, Ti for high electric field iris***

Cartoon for a new concept Quadrant



Monolithic rings

Precise Diffusion Bonding

Down stream

Up stream

Vacuum seal

High electric field iris (Mo,SUS,Ti)

Quadrant body (CuAg)

Low electric field iris(Cu)

Electric-Field Enhancements by Small Gaps and Bumps (T. Abe)

- *Have to keep dimensions error*

  Less than five micron

- *Smooth edge and keeping mirror surface*

  Electro-polishing

R/D Steps

- ***Single cell SW structure (Cu/Mo/Ti/SUS)***

- Aggressive high power conditioning test

- Compare to disk structure (A3.75, T2.6)

- Determines whether baking is necessary

- ***C10 Quadrant structure***

- Characterization test for high gradient performance

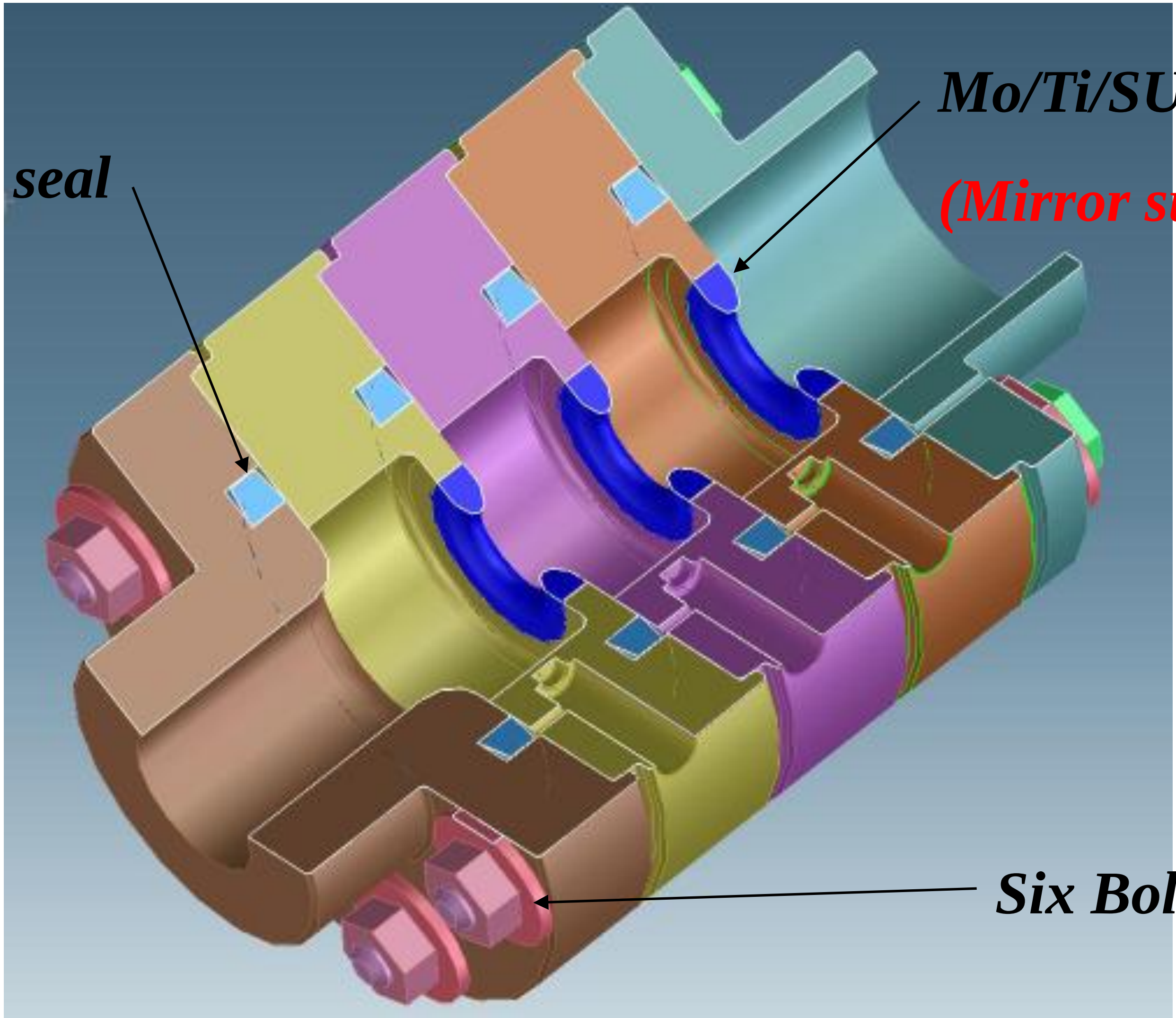
- ***TD24 Quadrant structure***

- Characterization for CLIC structure

R/D for Quadrant Fabrication

- ***Tool ware test on OFC, CuAg, CuZr, Mo,Ti, SUS***
  - They will tested by Kansai University
- ***Diamond wire cutting test for rough shaping***
  - Company
- ***Electro polishing for Mo, Ti, SUS***
  - KEK
- ***Wire discharge cutting test for rough shaping***
  - KEK
- ***Cu/Mo, Cu/SUS Diffusion tests***
  - KEK, Company
- ***EBW/Laser welding for vacuum seal***
  - KEK, Company

The First Step



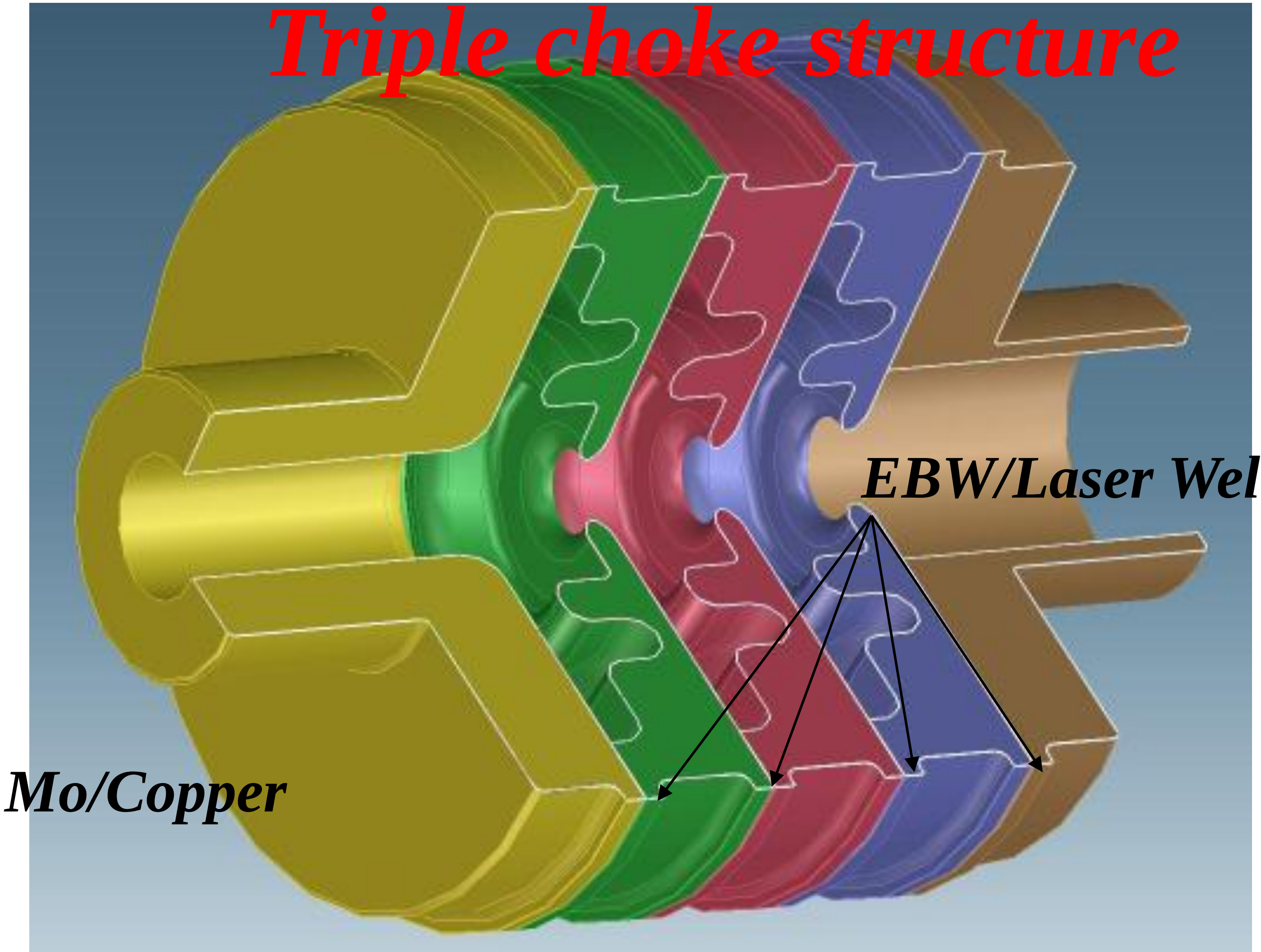
Vacuum seal

Mo/Ti/SUS Iris

(Mirror surface)

Six Bolts

The Second Step

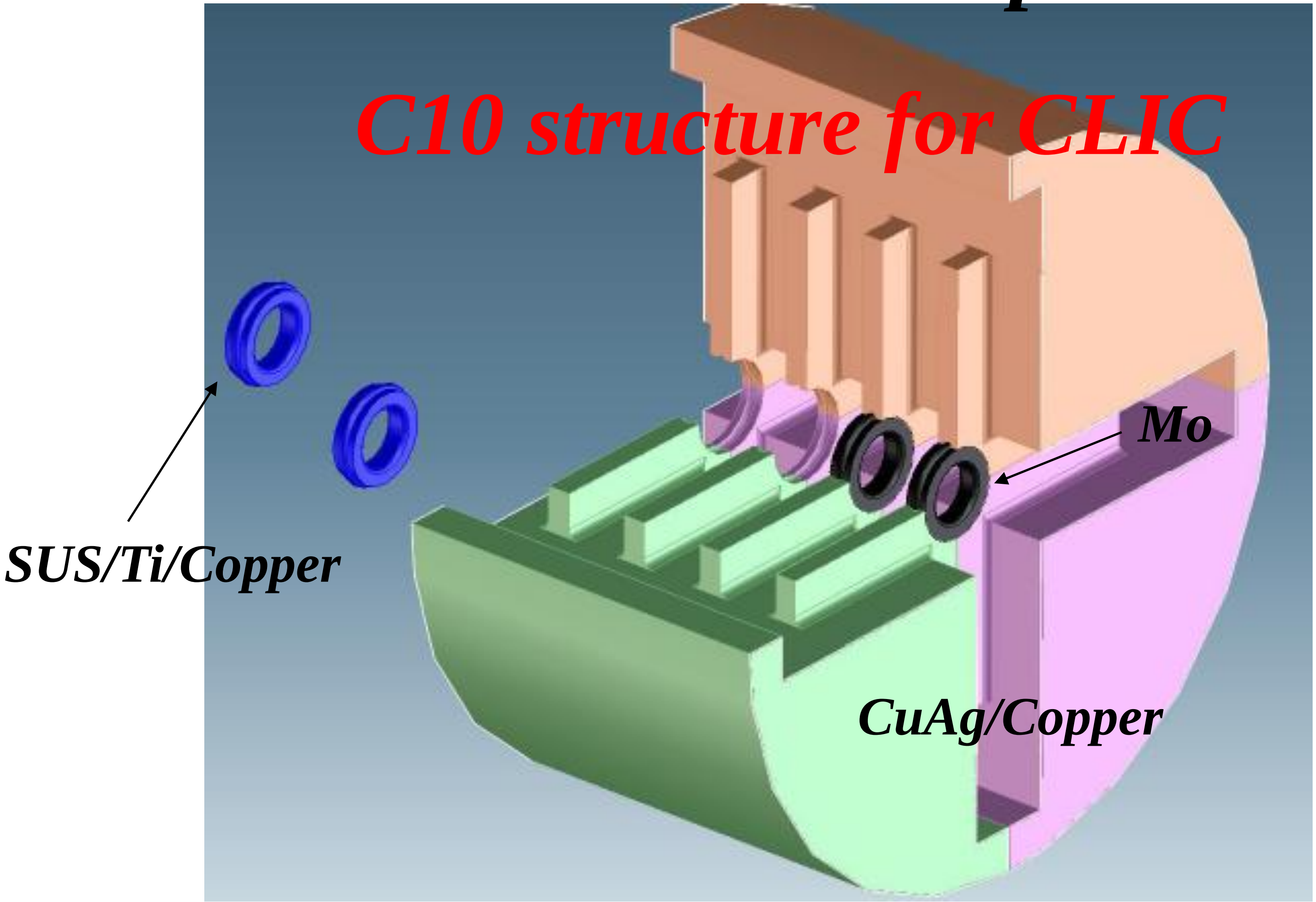


Triple choke structure

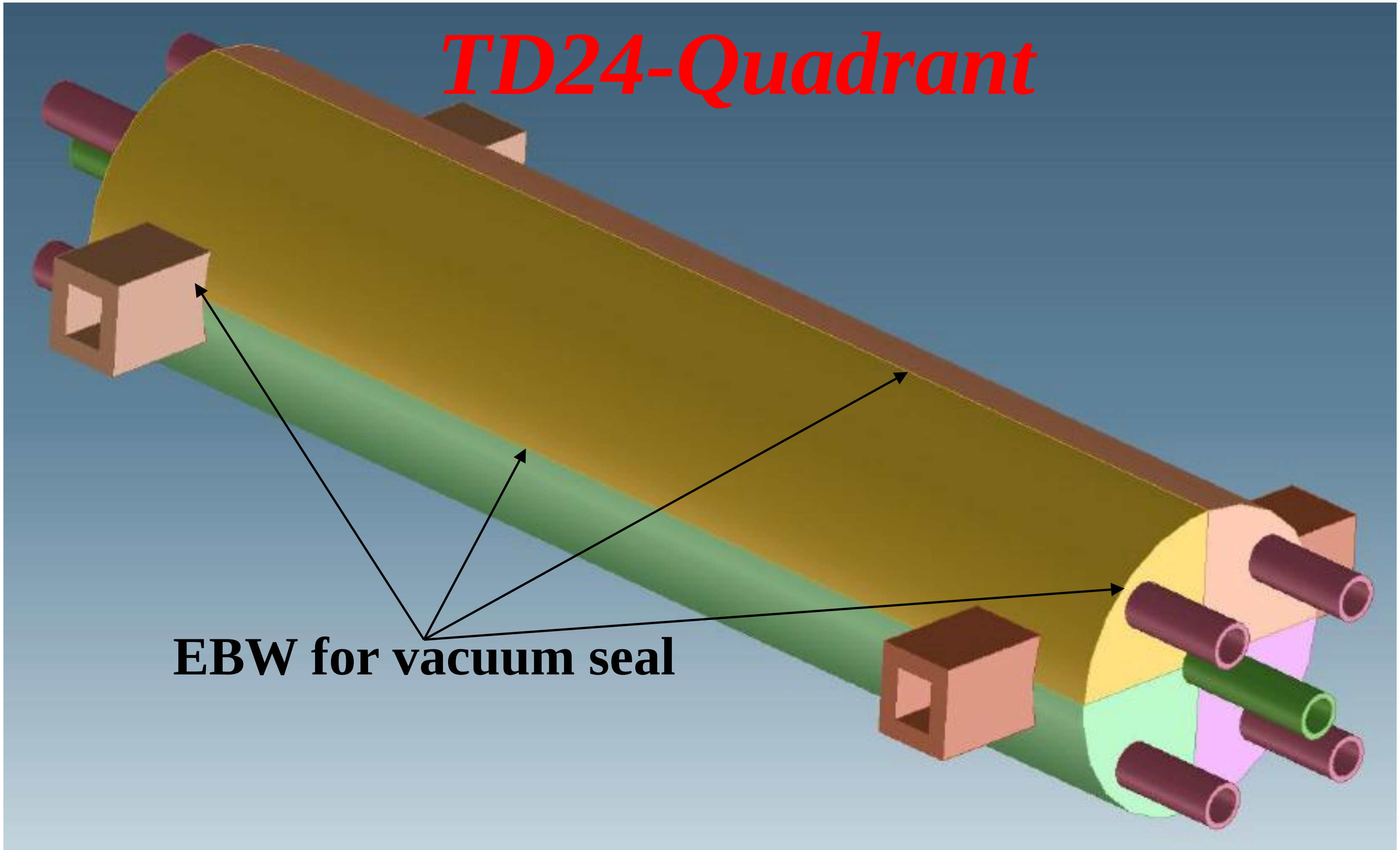
EBW/Laser Welding

Mo/Copper

The third Step

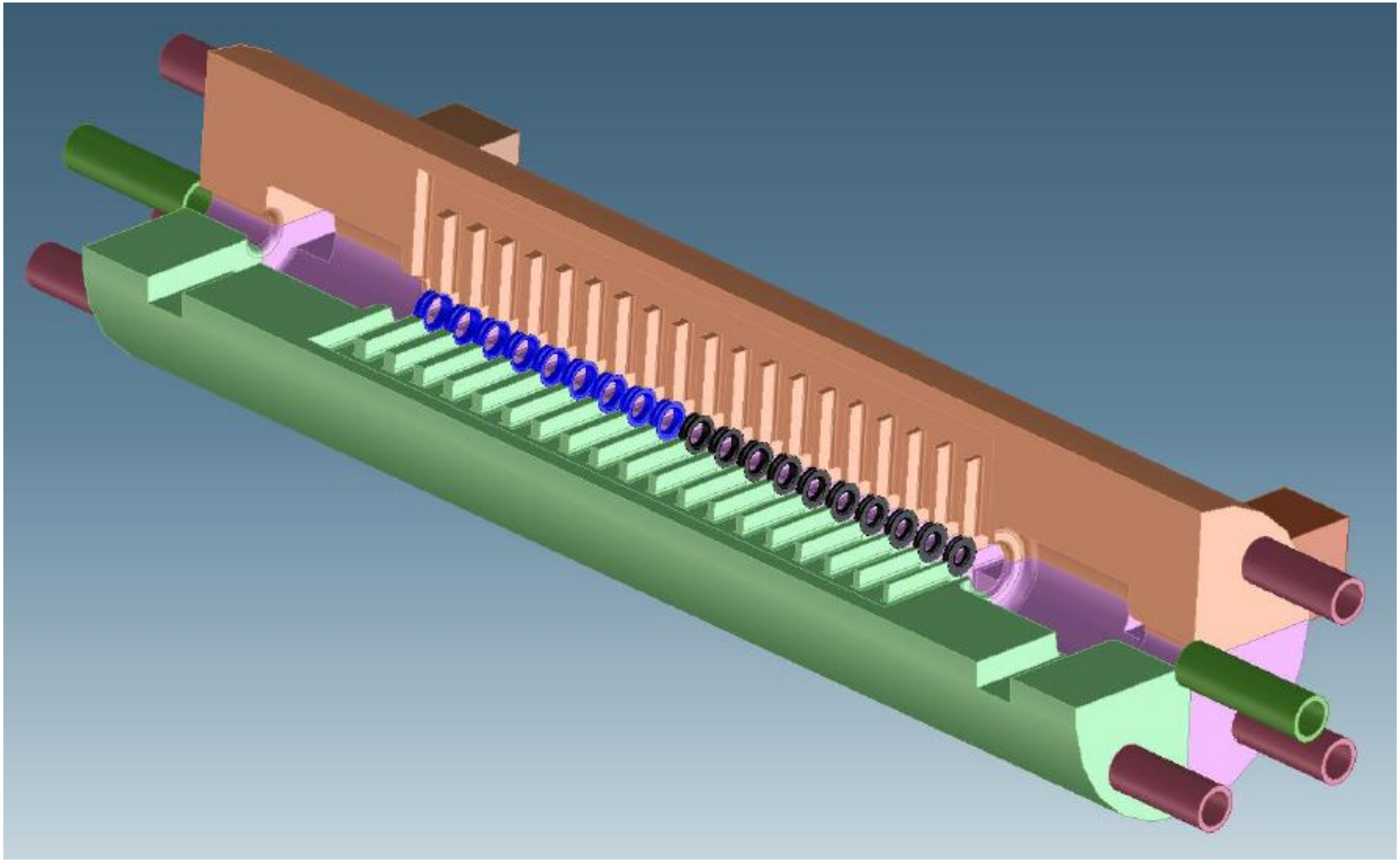


Final Step

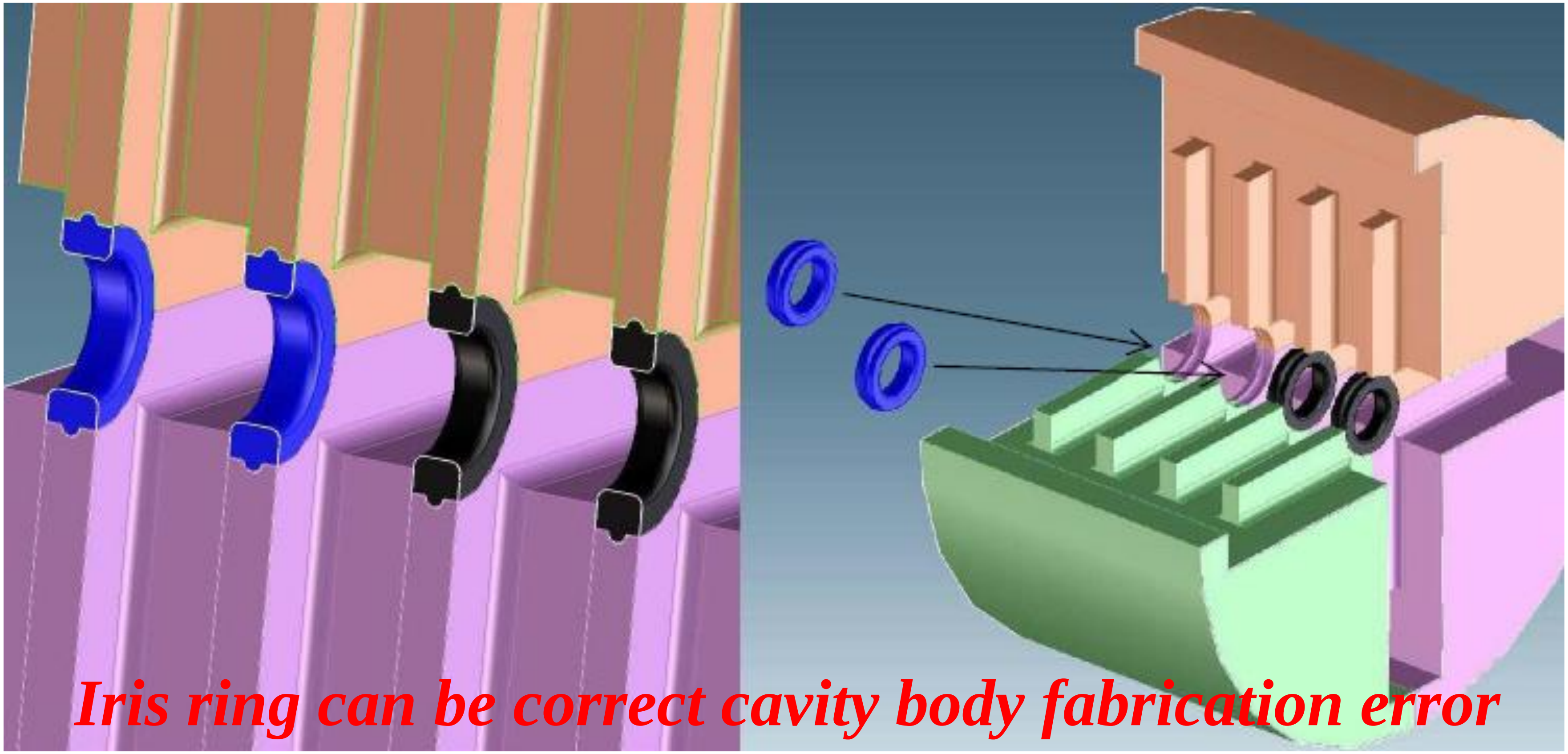


EBW for vacuum seal

Cavity Inside



Iris ring Configuration



Iris ring can be correct cavity body fabrication error

Plan for Future

- ***Continue to explorer gradient limit of copper material with SLAC***

- ***In-Situ observation of pulse heating damages and breakdown phenomena with SLAC***

- ***Performance test for new quadrant structure***