Surface observation of Scanning Field Emission Microscope and Cu/Mo, Cu/S.S Clad-material Cell Development for High Gradient X-band Structure

XB-10 Workshop

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KEK

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Contributors

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Outline

- Scanning Field Emission Microscope
- Hard materials single cell SW structure

(no high temperature bonding or brazing)

- In-situ microscopic observation of metal surface

Motivation

- The fabrication technologies for X-band high gradient accelerating structures have been studied at KEK with SLAC, INFN and CERN. A scanning field emission microscope has been developed at KEK for the observation of the microscopic surface defects which may be related to the breakdown trigger.

- It is theoretically discussed and experimentally shown that the surface damages due to the pulse surface heating may cause the breakdowns. We propose accelerating structure cells which are composed of clad material with the hard copper in the high pulse surface heating area (to mitigate pulse heating damage) and the high melting point material (Mo, Stainless Steel) in the high electric field area (to mitigate breakdown damage) . Such cells are being prepared for the studies of fundamental breakdown phenomena.

- Material fatigue due to the pulse heating is of importance for high gradient structure design. We propose microscopic precise is-situ observation of the fatigue phenomena. These measurements are under preparation at SLAC/KEK.

High Gradient study

In-Situ Observation

1. Observation of surface deformation due to pulse heating using laser interferometer (ready)
2. Pulse heating temperature measurement by IR (ready)
3. High resolution microscopy (ready)
4. Particles observation busing laser scattering (under studying)

Materials

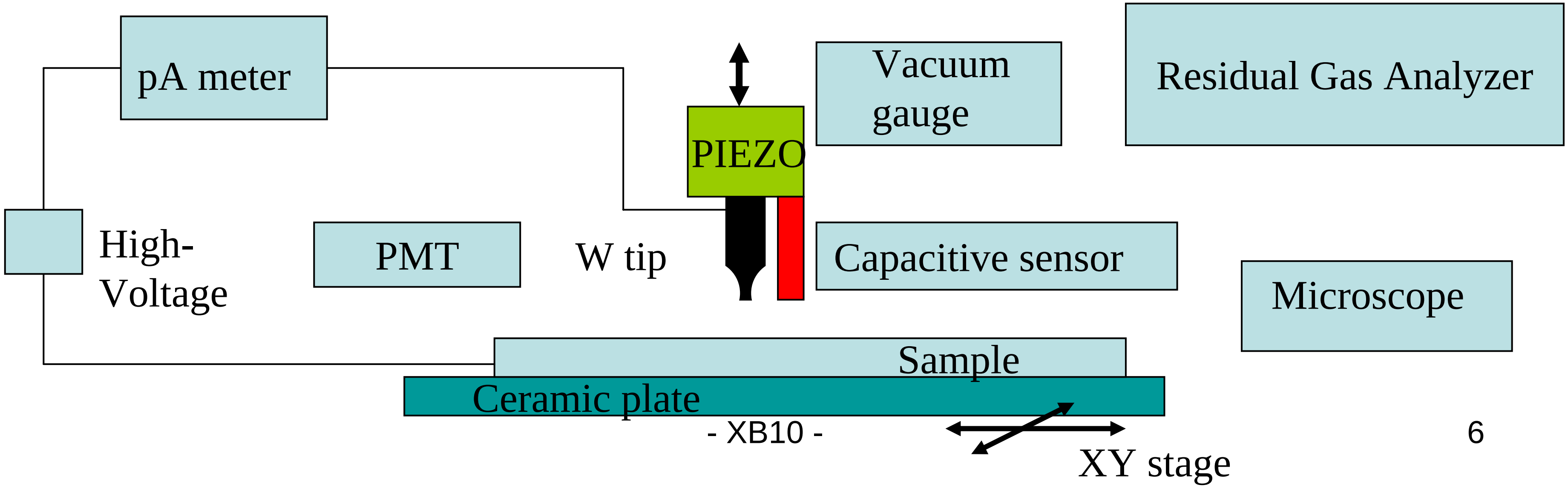
1. Cu/Mo, Cu/Stainless Steel Single Cell SW structure (almost ready)
2. 6N, Mo 4mm choke SW structure (fabrication)
3. Cu/Beryllium alloy

Surface Treatment

1. Chemical Polishing
2. Electro Polishing
3. Dust Free
4. High Temp. Vacuum Baking (control residual gas content)

Scanning Field Emission Microscope Configurations

- Tungsten tip: < 1micron radius
- Tip movement: linear stage+PIEZO mover
- Gap: 1 micron
- XY stage stroke +/- 6mm (rough 50mm)
- High voltage ~1 KV
- Pico-ammeter: ~pA resolution
- In-situ gap sensor: 0.1micron resolution
- Microscope
- Residual Gas Analyzer
- Vacuum gauge
- Vacuum level : 10^{-8} Pa
- Chamber size: 400 mm diameter and 300 mm height



Experiment Preparation

- Parallelize sample surface and stage movement

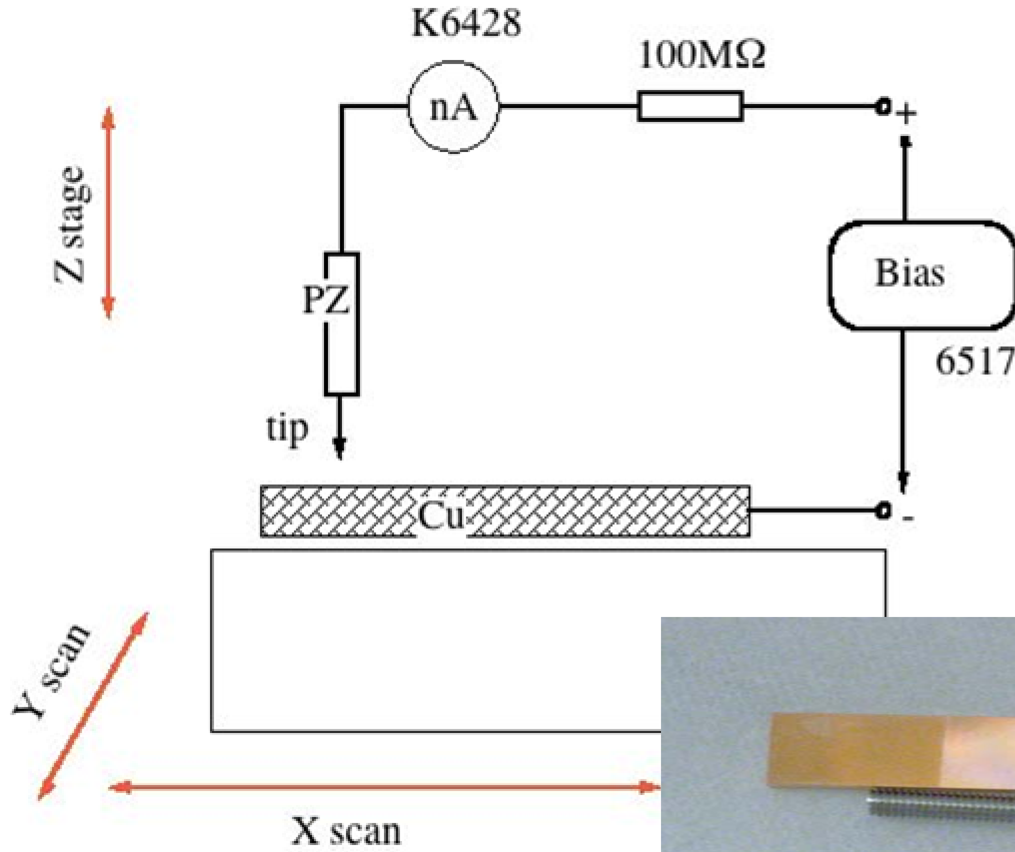
  <0.5μm/5mm stroke
- Vacuum chamber baking

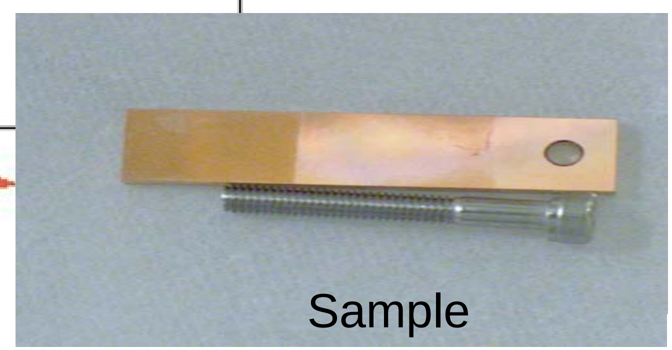
  150 deg.C for 10 hours
- W-tip aging

  200V@~1μm gap for 10 min period
- Absolute gap measurement

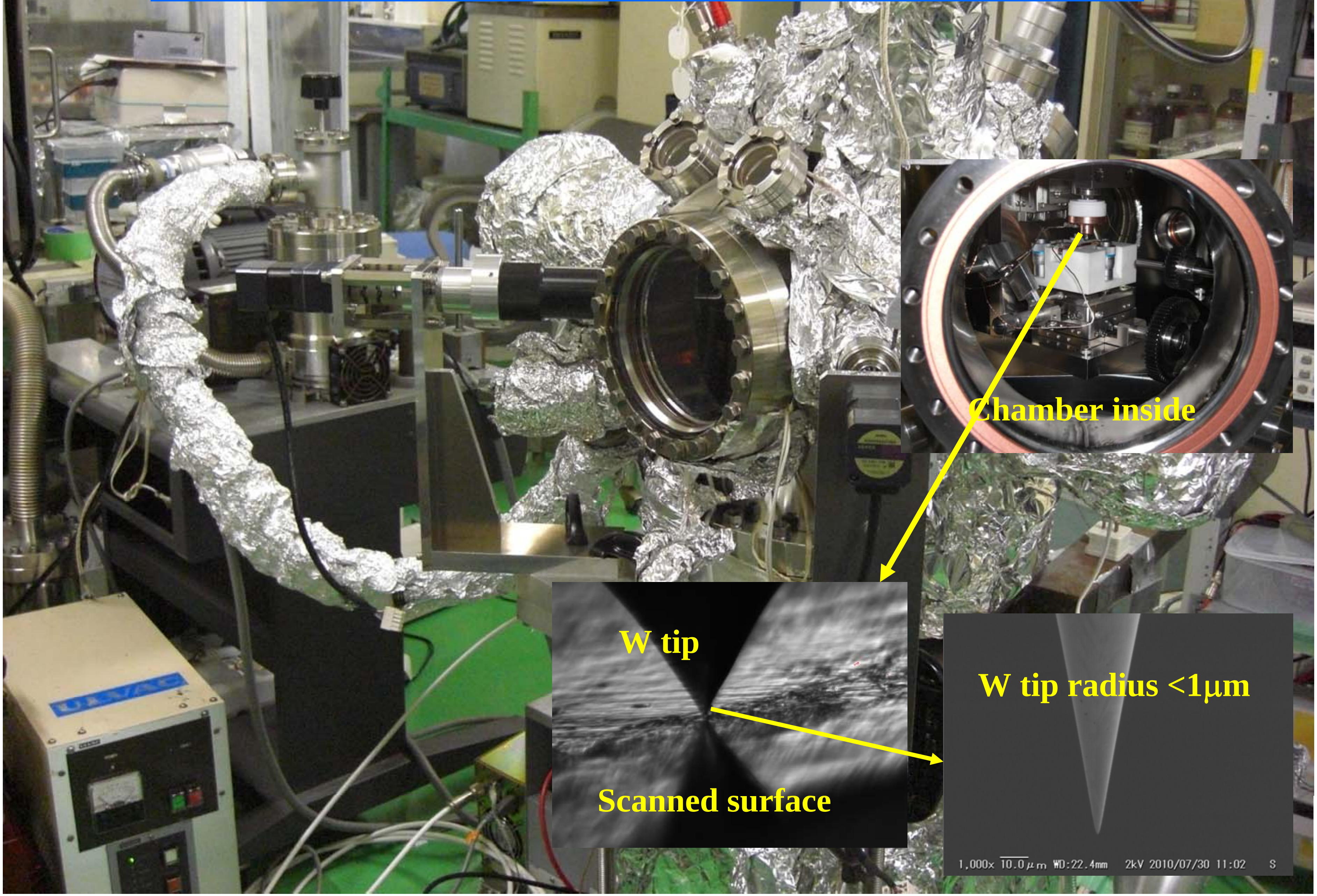
  Capacitance gauge, PIEZO actuator

Measurement circuit of Scanning Field Emission Microscope

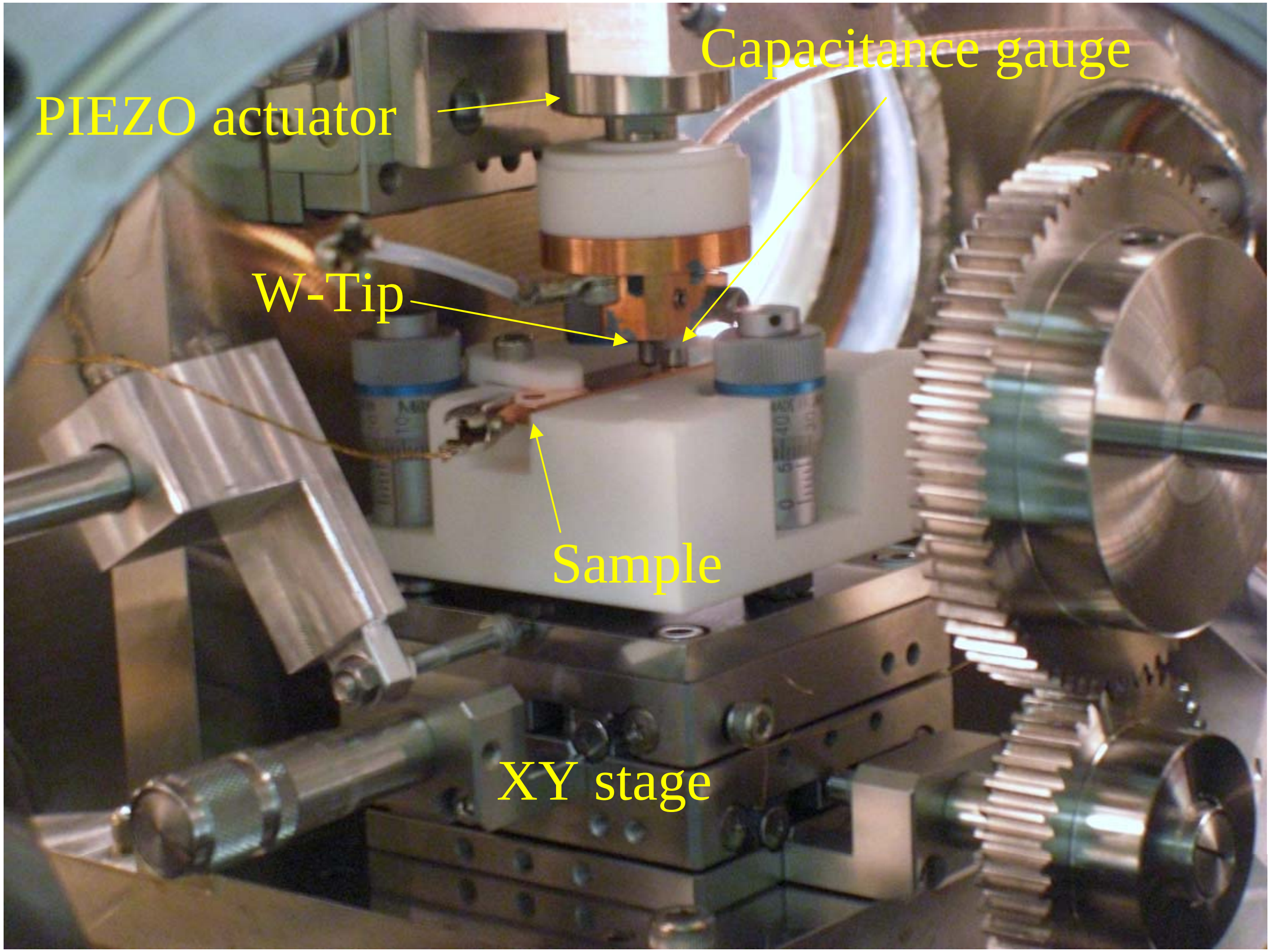




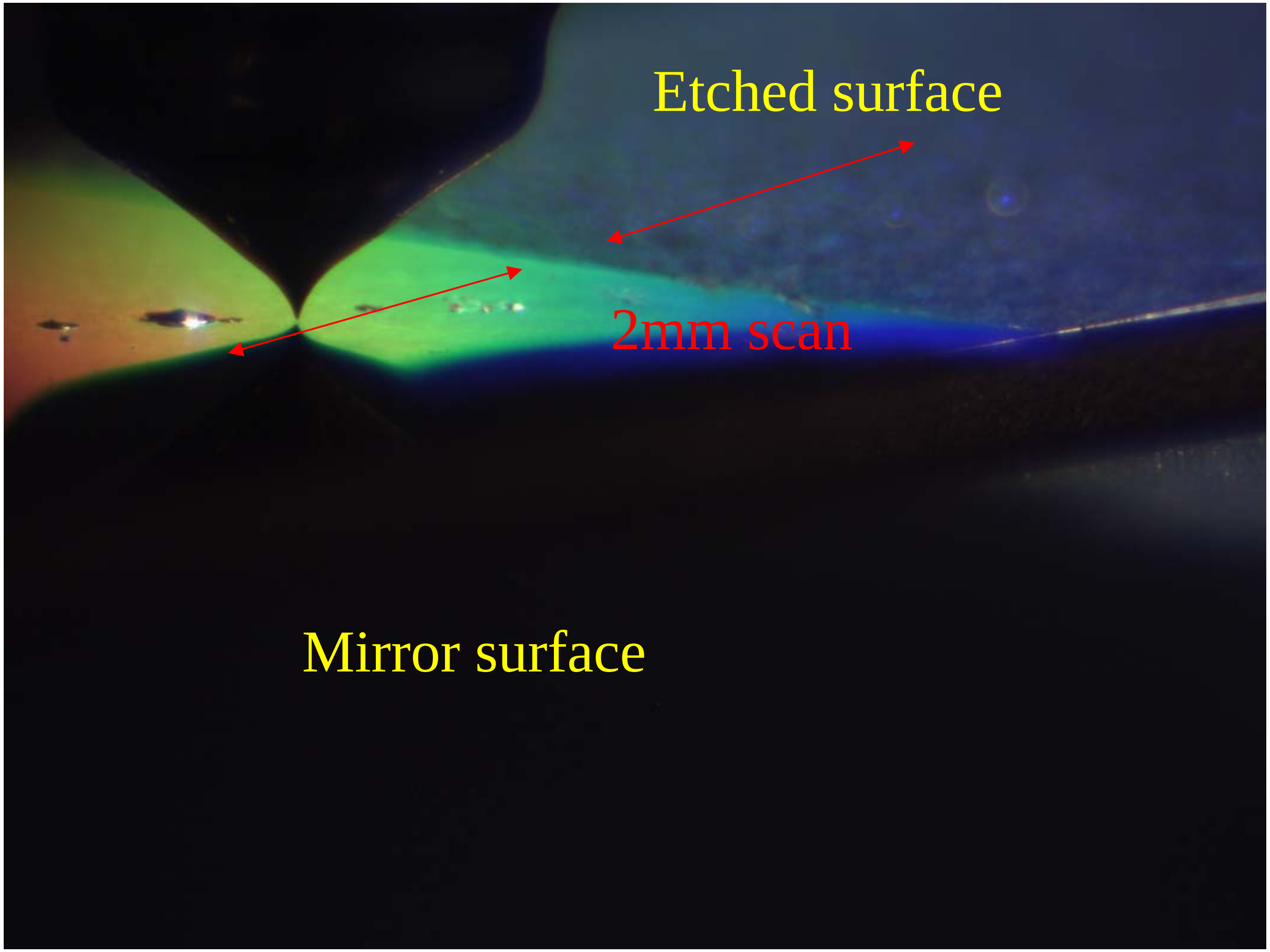
Scanning Field Emission Microscope



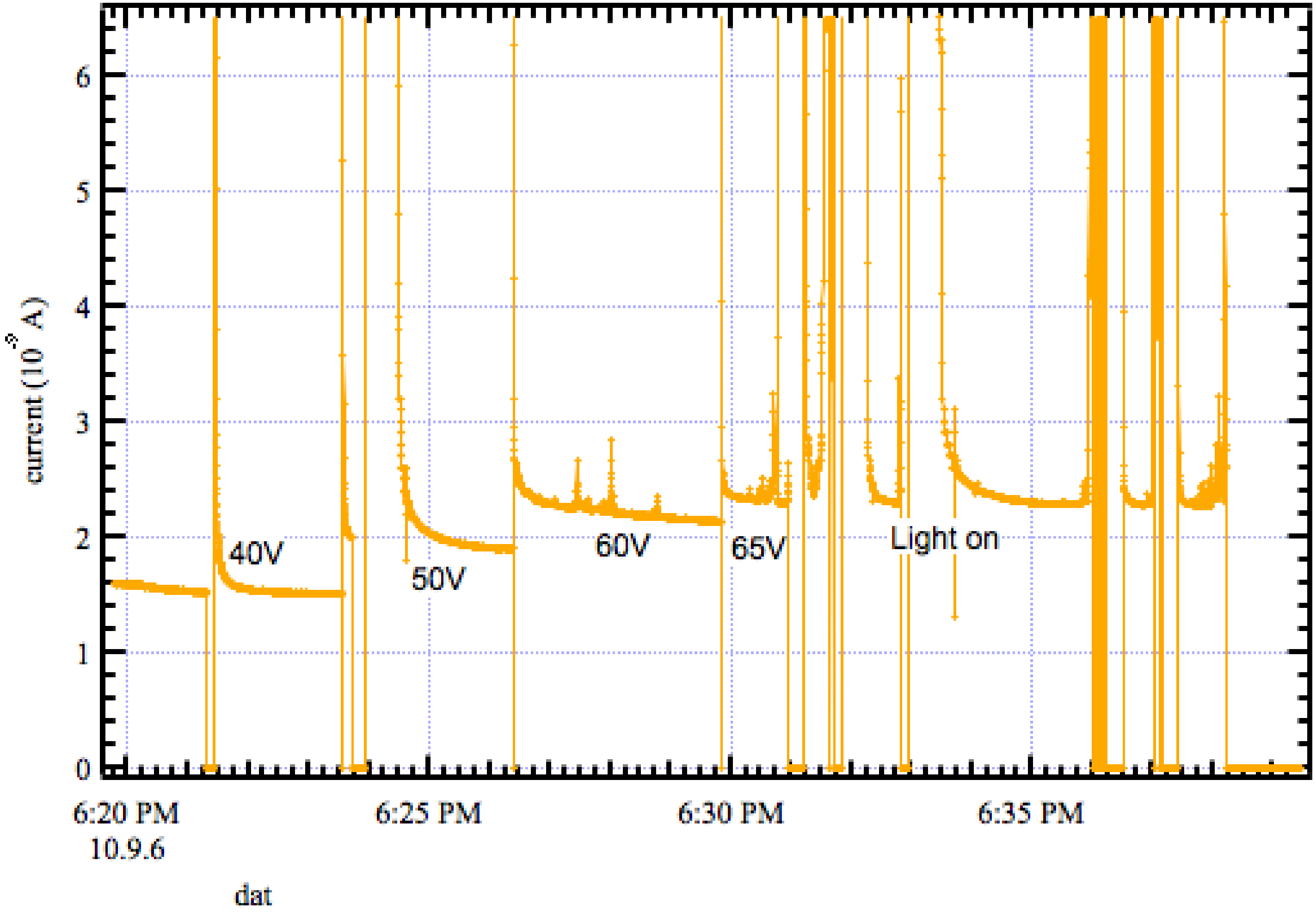
Sample and moving stages



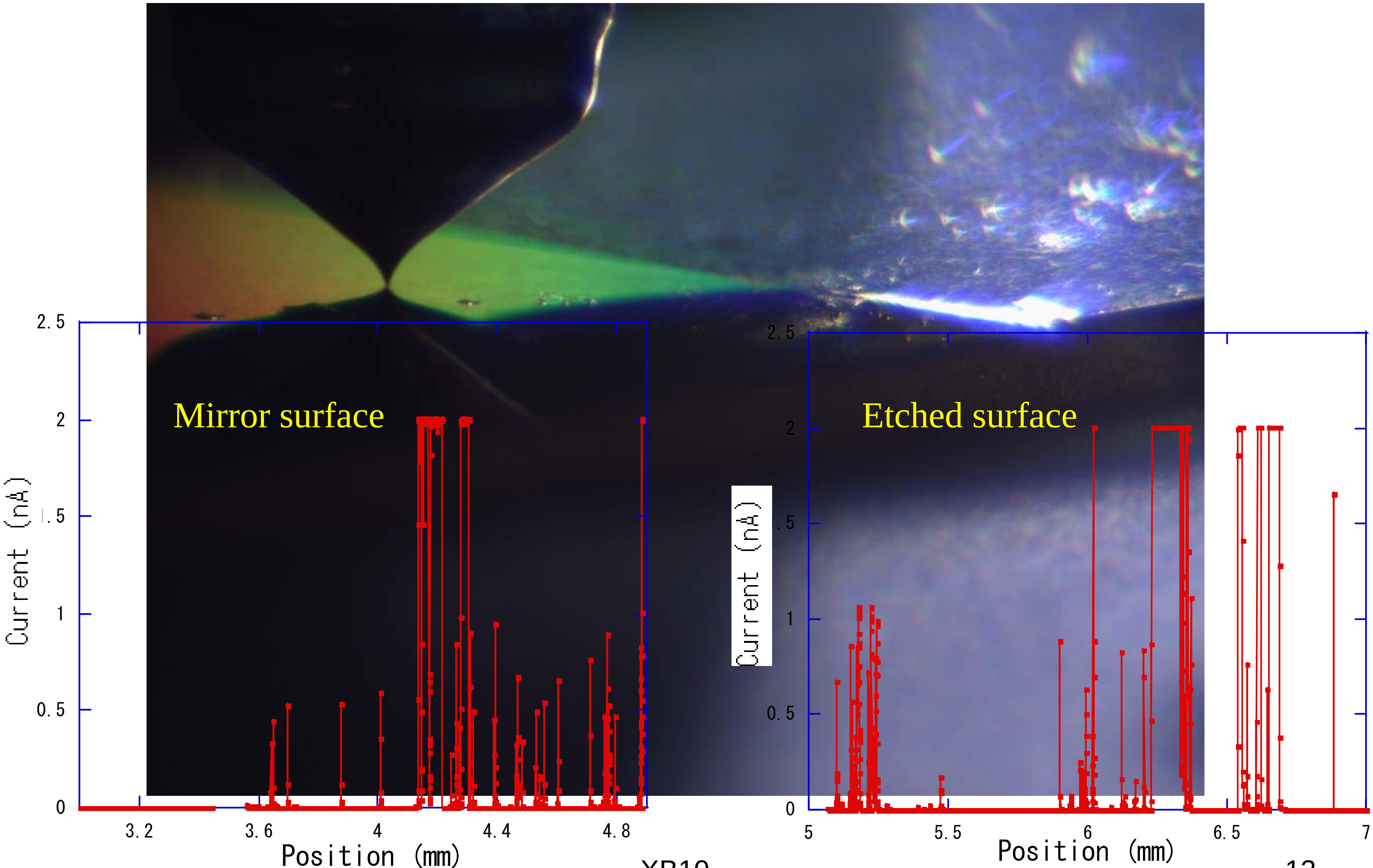
Surface Scan



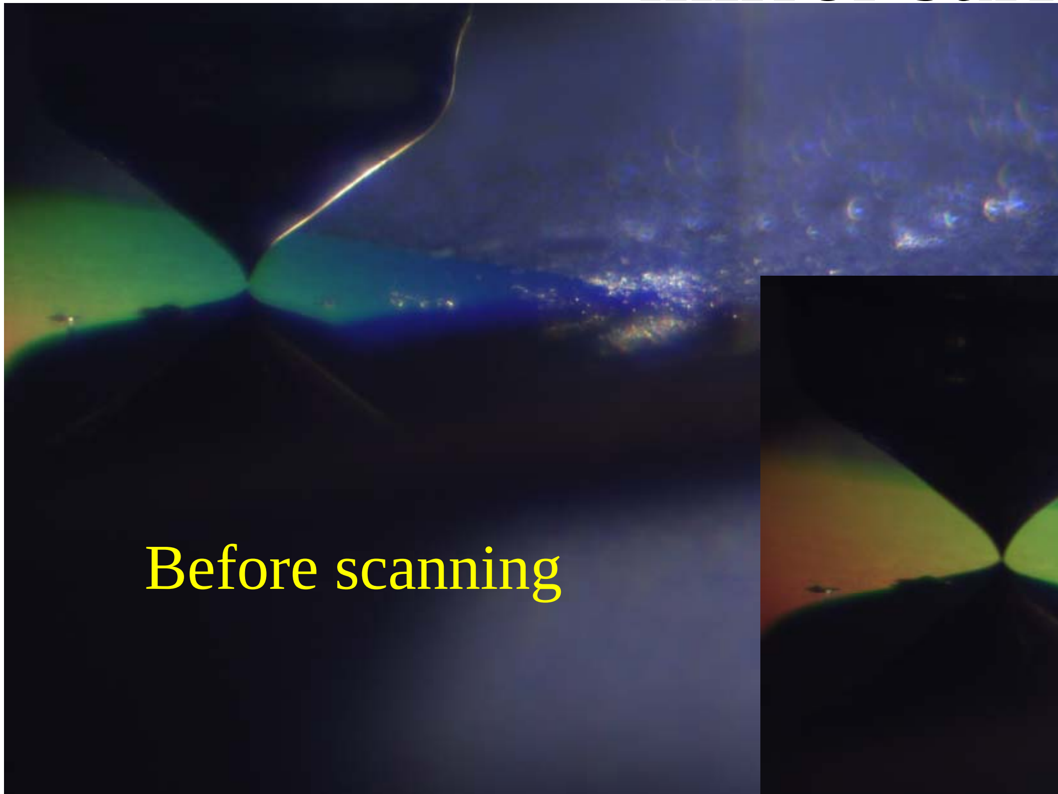
Current for Different Bias

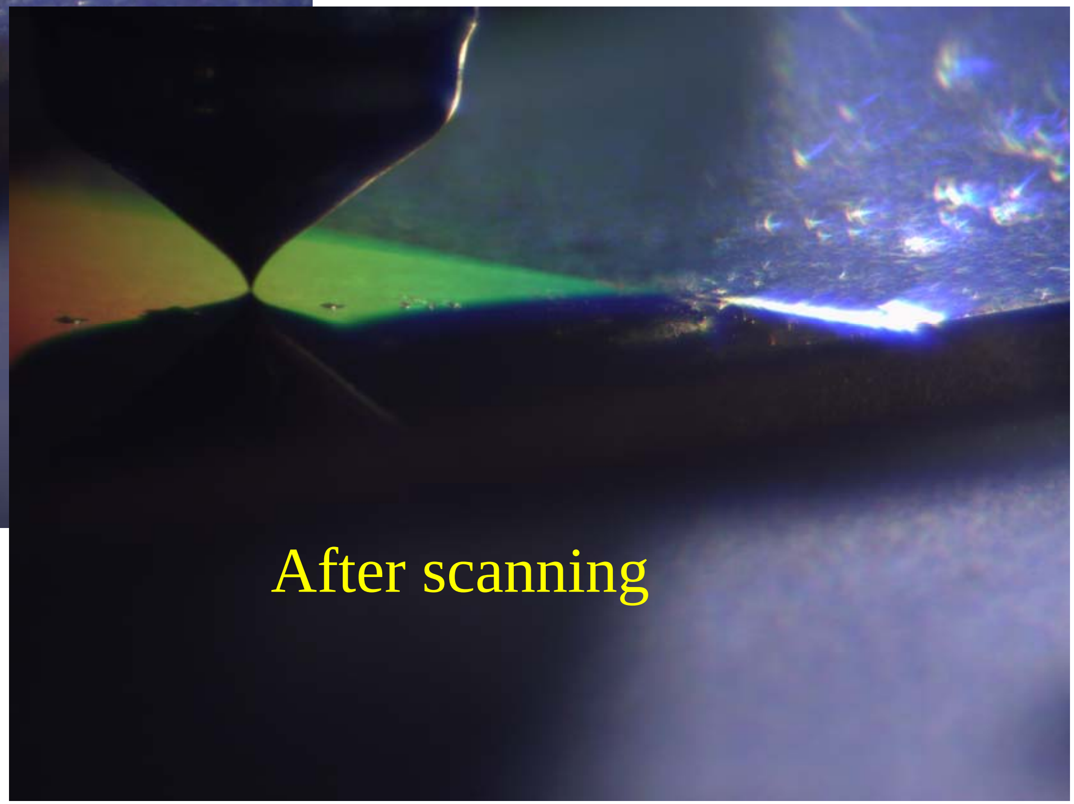


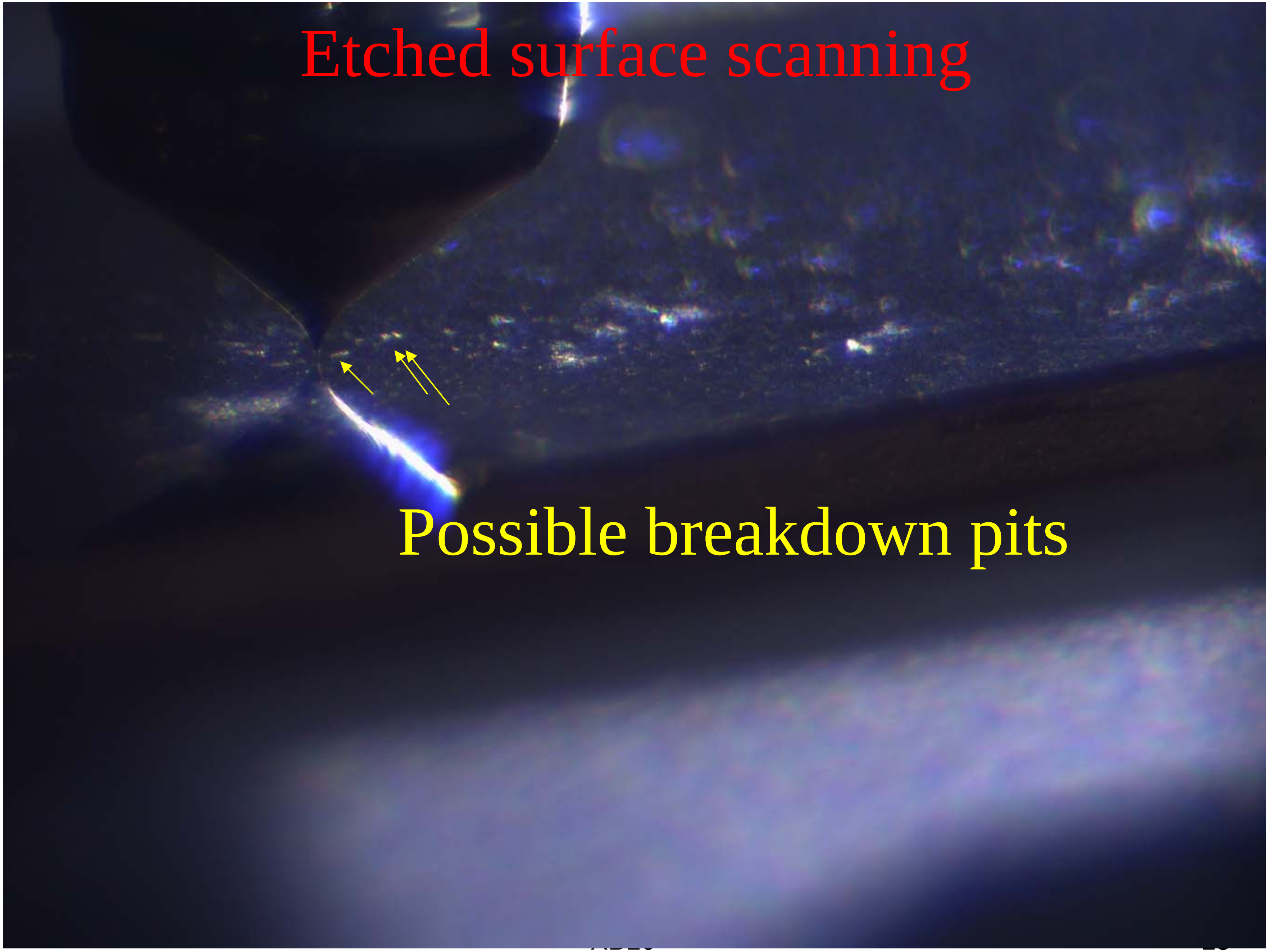
Measured field emission distributions



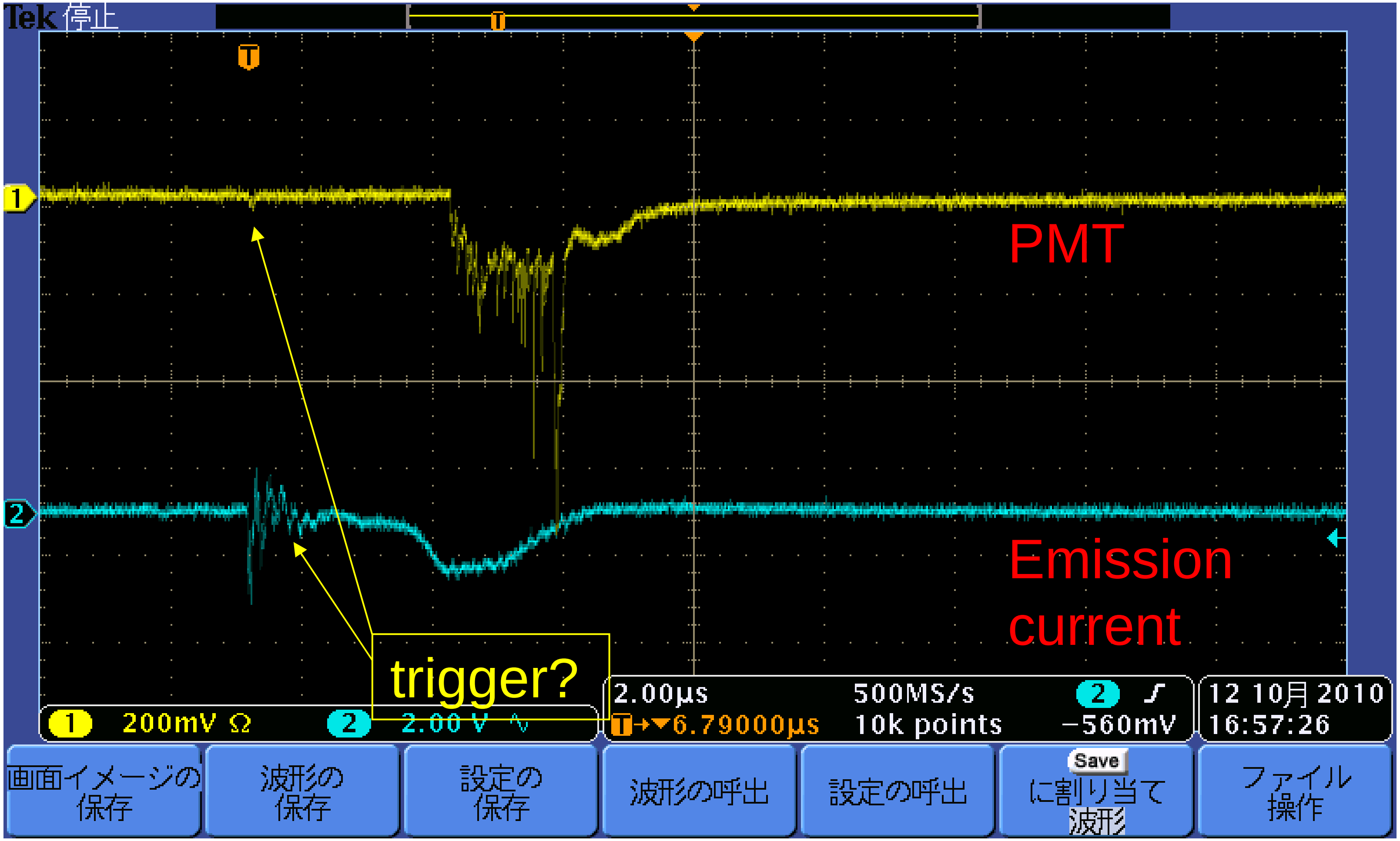
We found no surface damages after scanning on mirror surface



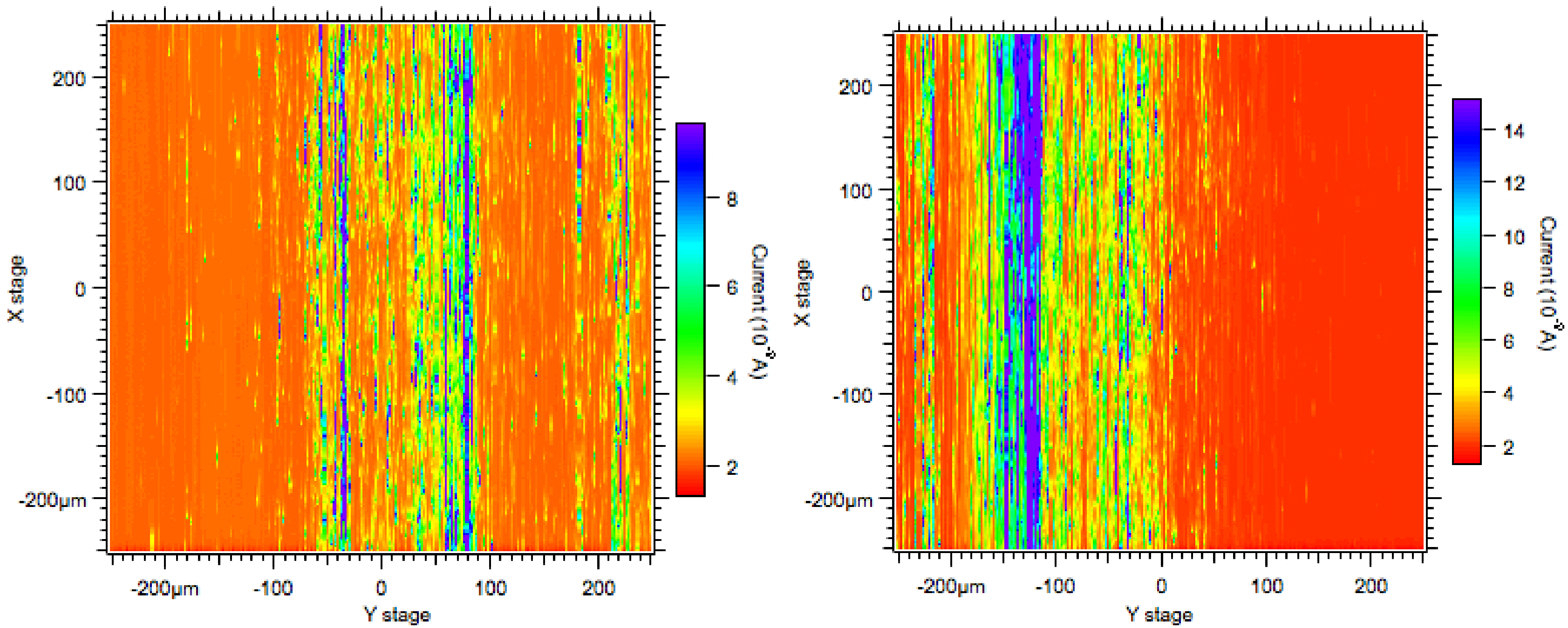



Etched surface scanning
Possible breakdown pits

PMT and Emission-current signals during breakdown event



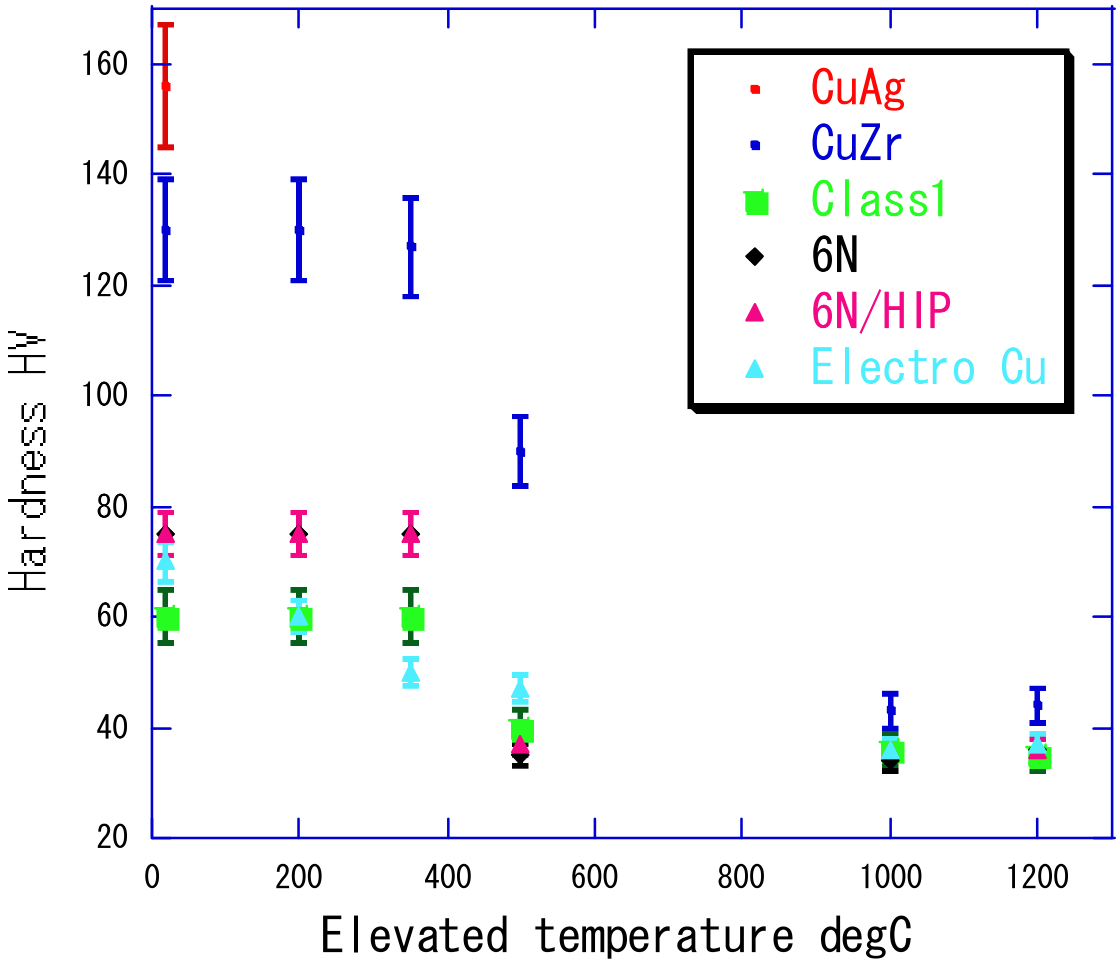
Example of XY scan, 2μm resolution, bias=200V 2010/10/15



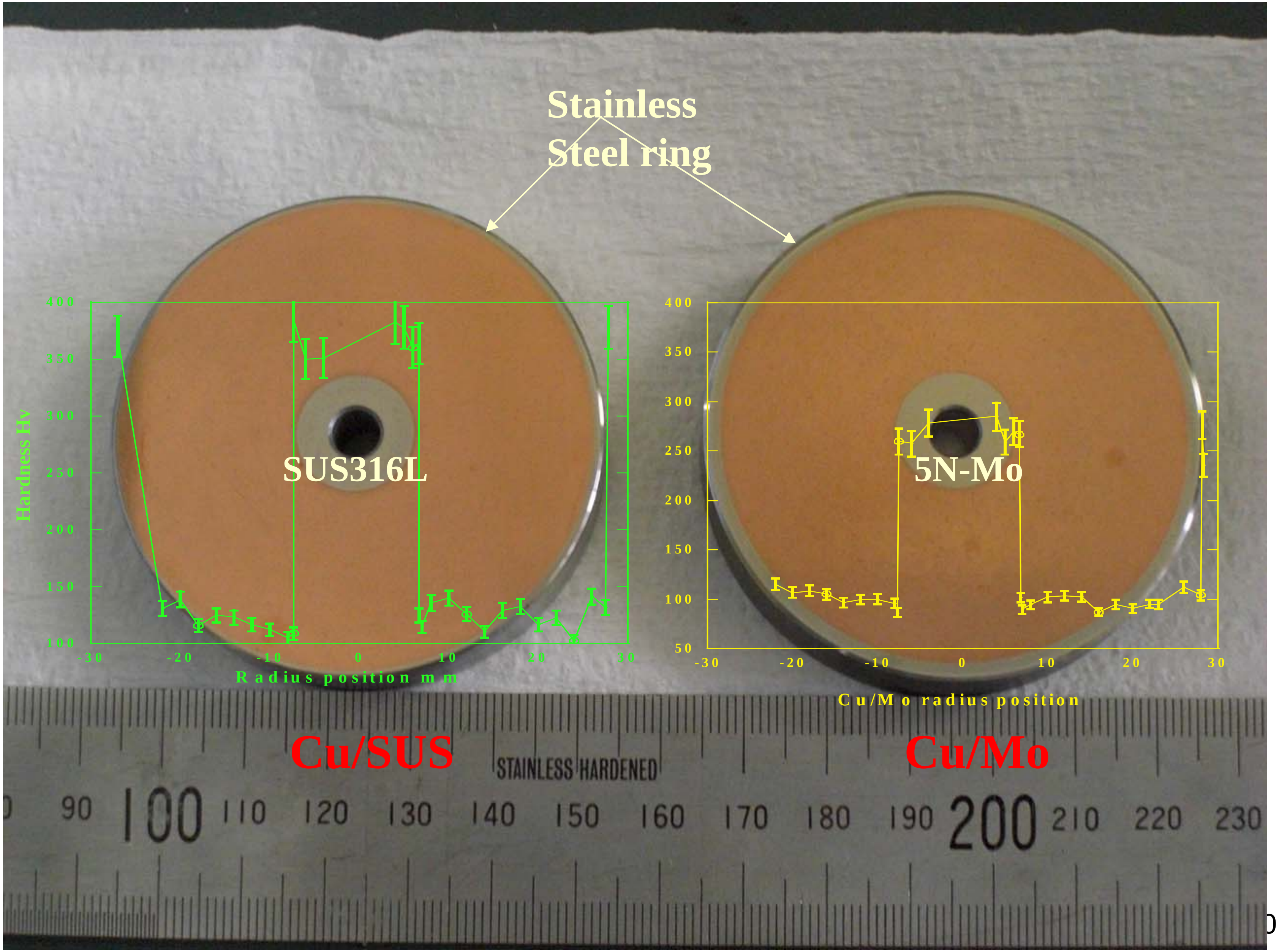
Hard material, Cu/Stainless Steel and Cu/Mo Single Cell SW structure development

It is theoretically discussed and experimentally shown that the surface damages due to the pulse surface heating may cause rf breakdowns. We propose accelerating structure cells which are composed of clad material with the hard copper in the high pulse surface heating area (to mitigate pulse heating damage) and the high melting point material (Mo, Stainless Steel) in the high electric field area (to mitigate breakdown damage) . Such cells are being prepared for the studies of fundamental breakdown phenomena.

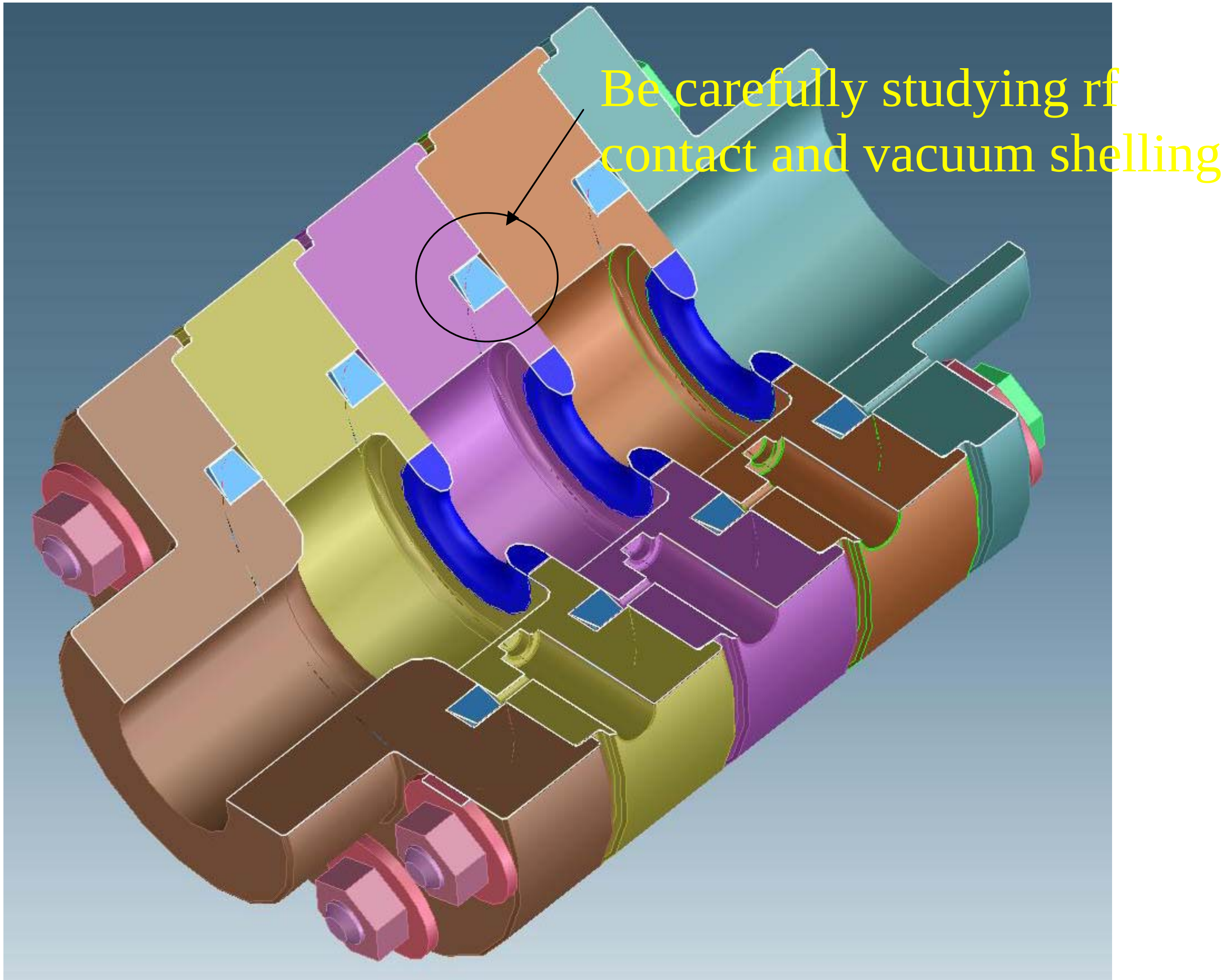
Hardness change due to annealing temperature for different copper and copper alloys



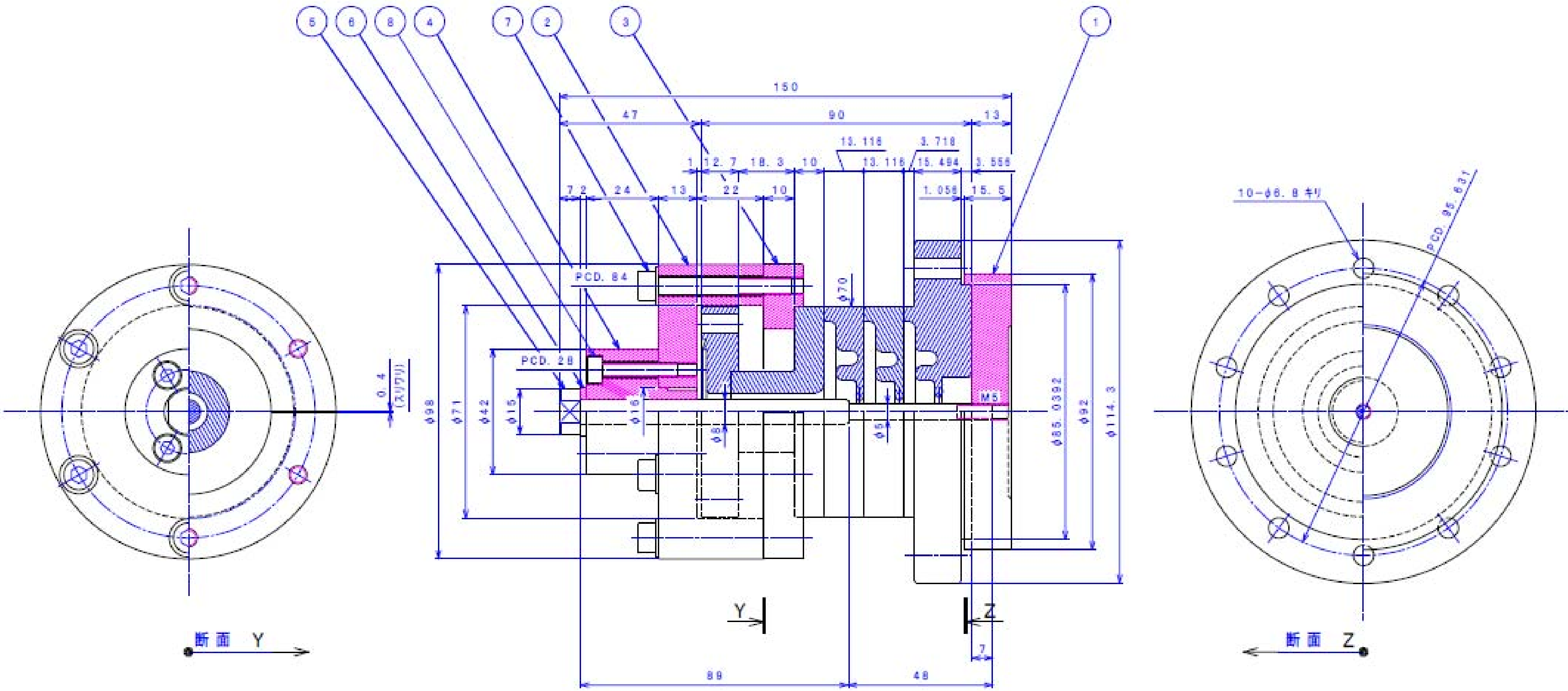
Hardness measurement results after HIP of Cu/SUS and Cu/Mo



No high temperature bonding or brazing
Single cell SW structure



1C-SW-A3.75-T2.6-TripleCh-Mo

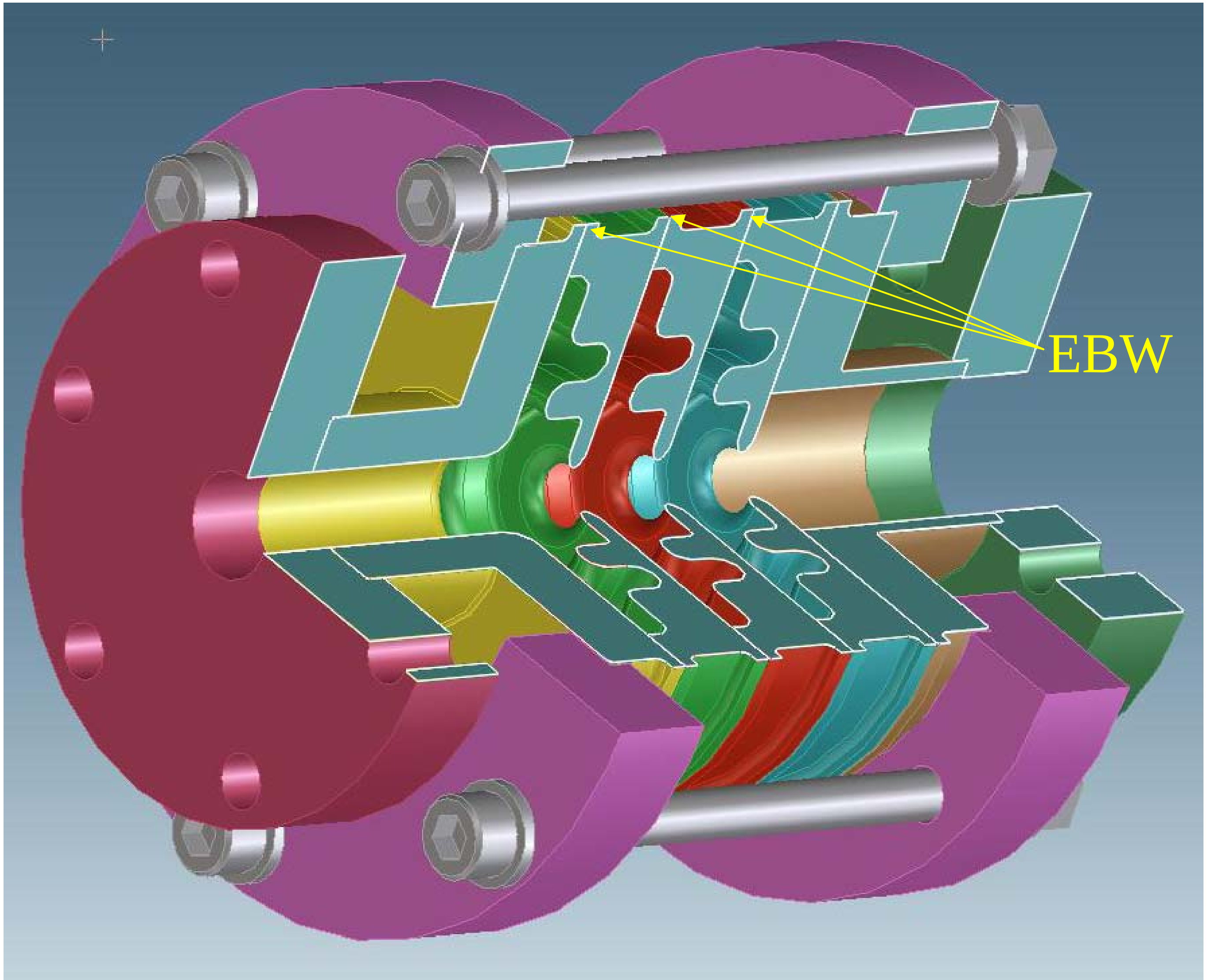


RFチョークフランジ変更（2−1）

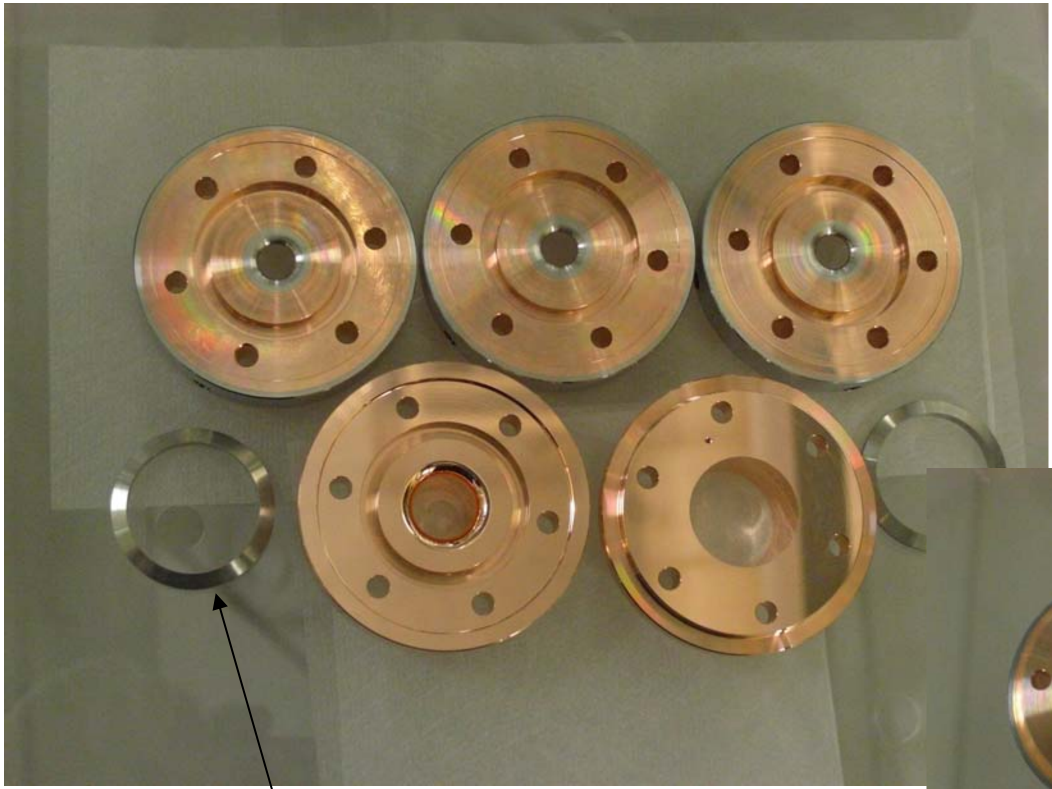
2010.05.17

8	六角穴付ボルト M5×25	SUS304	3		
7	六角穴付ボルト M6×45	SUS304	6		W 付き
6	ワッシャ WSSS16-8-2	SUS304	1		<ミスミ>
5	段付ボルト	SUS304	1		
4	ボルト挿入ガイド	SUS304	1		
3	半割りリング	SUS304	1組		
2	トップリング	SUS304	1		
1	ボトムリング	SUS304	1		

Triple choke structure

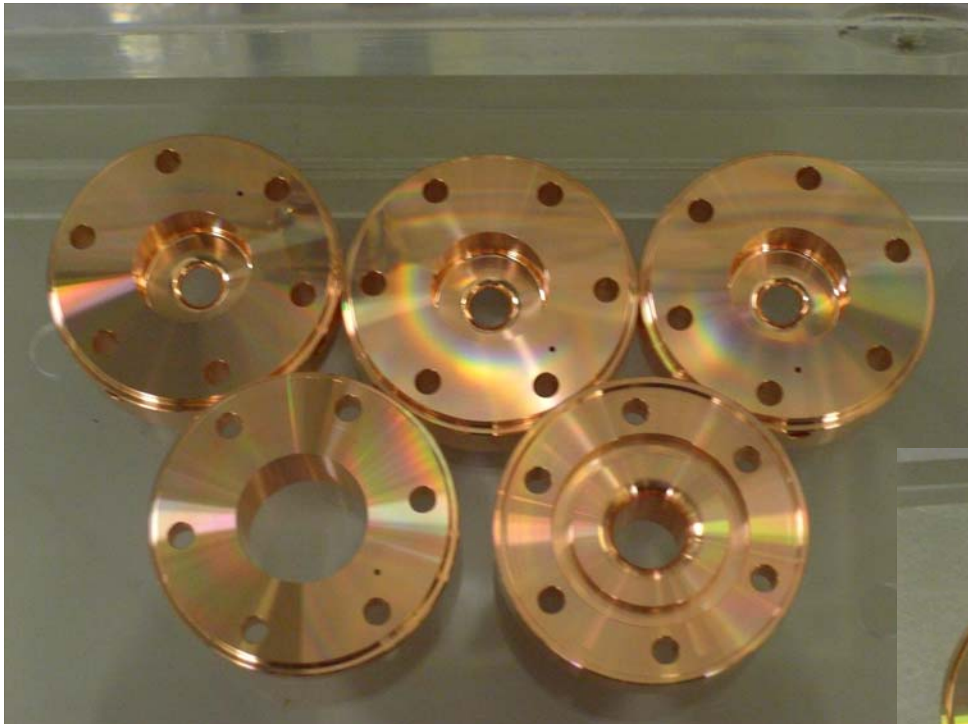


1C-SW-A3.75-T2.60-Cu/SUS-clamped



Ag coated SUS gaskets

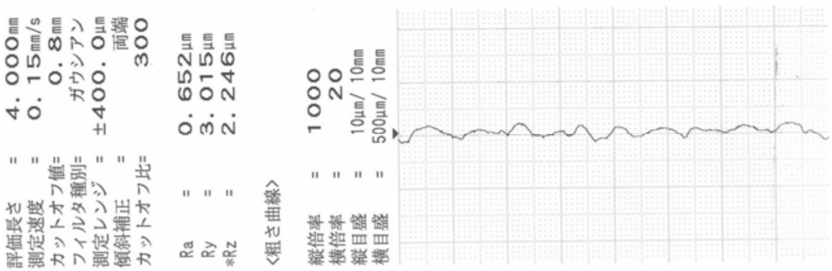
1C-SW-A3.75-T2.60-CuAg-clamped

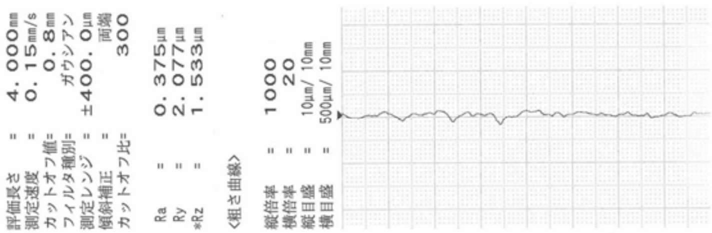


- X

Assembly test

Electro Polishing of Mo





Electro Polishing of Copper

In-situ observation of RF pulse heated surface

Material fatigue due to the pulse heating is of importance for high gradient structure design. We propose microscopic precise is-situ observation of the fatigue phenomena. These measurements are under preparation at SLAC/KEK.

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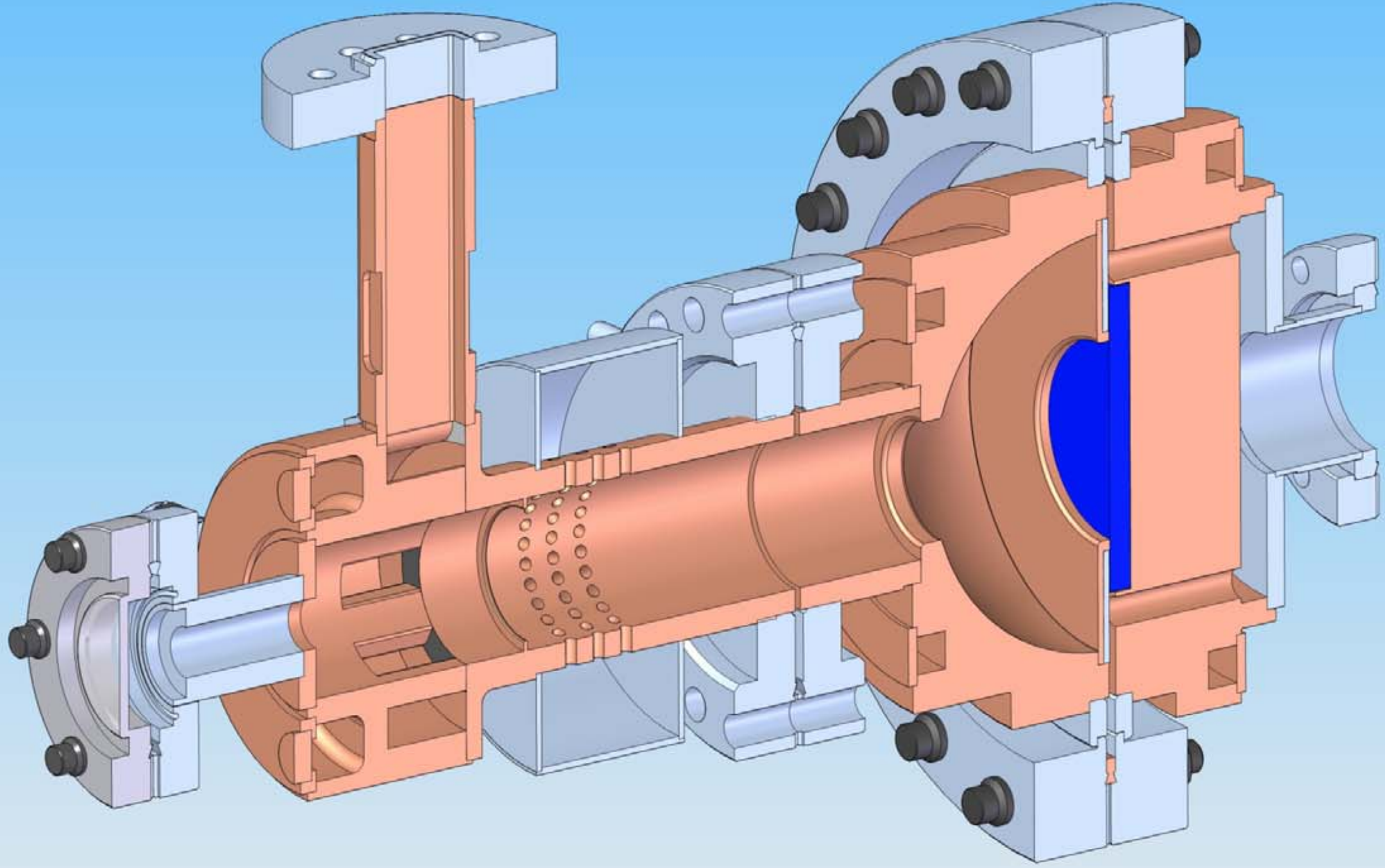
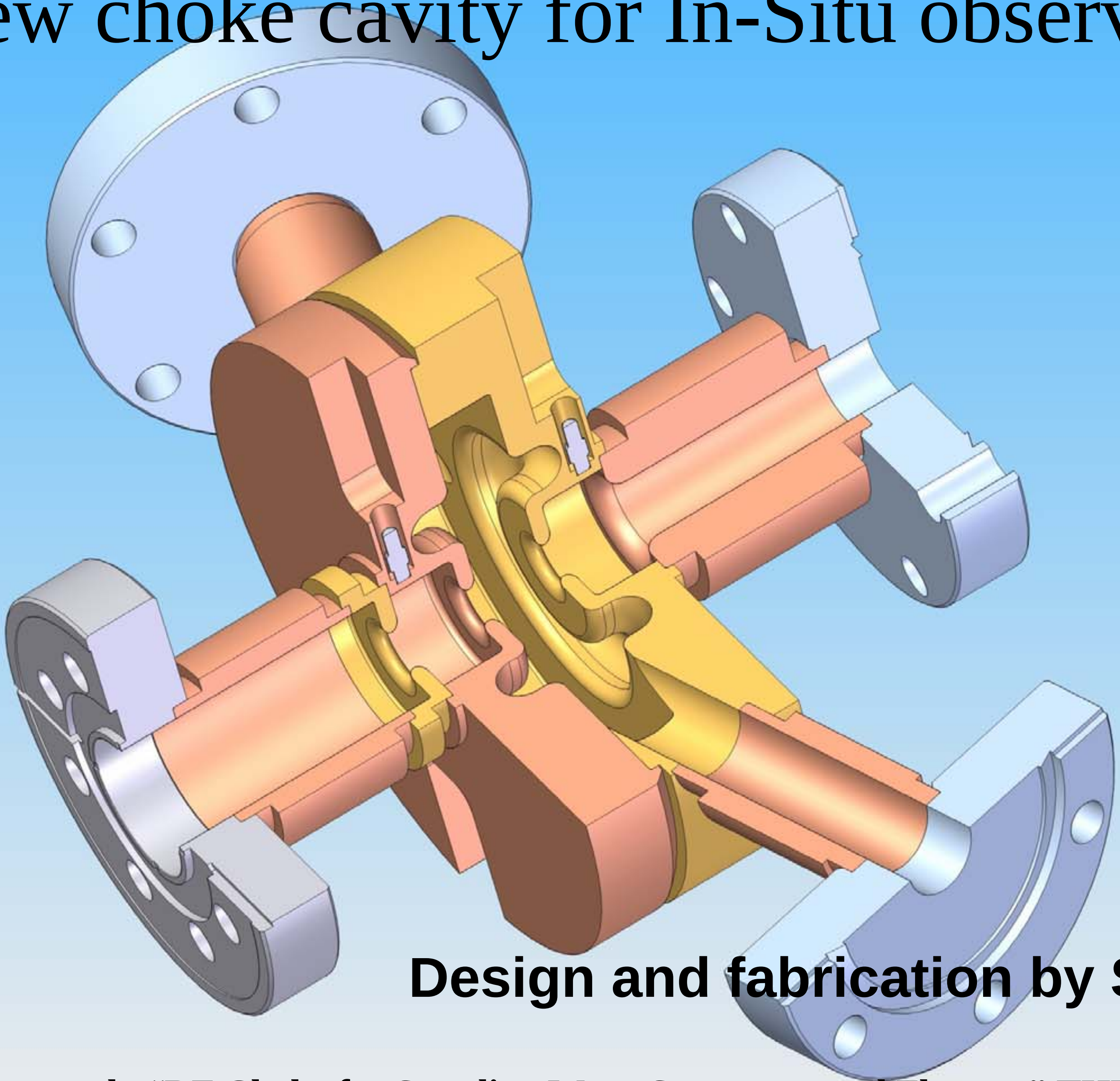
How to observe in the RF pulse

A new pulse heating cavity for In-situ observation



Design and fabrication by SLAC

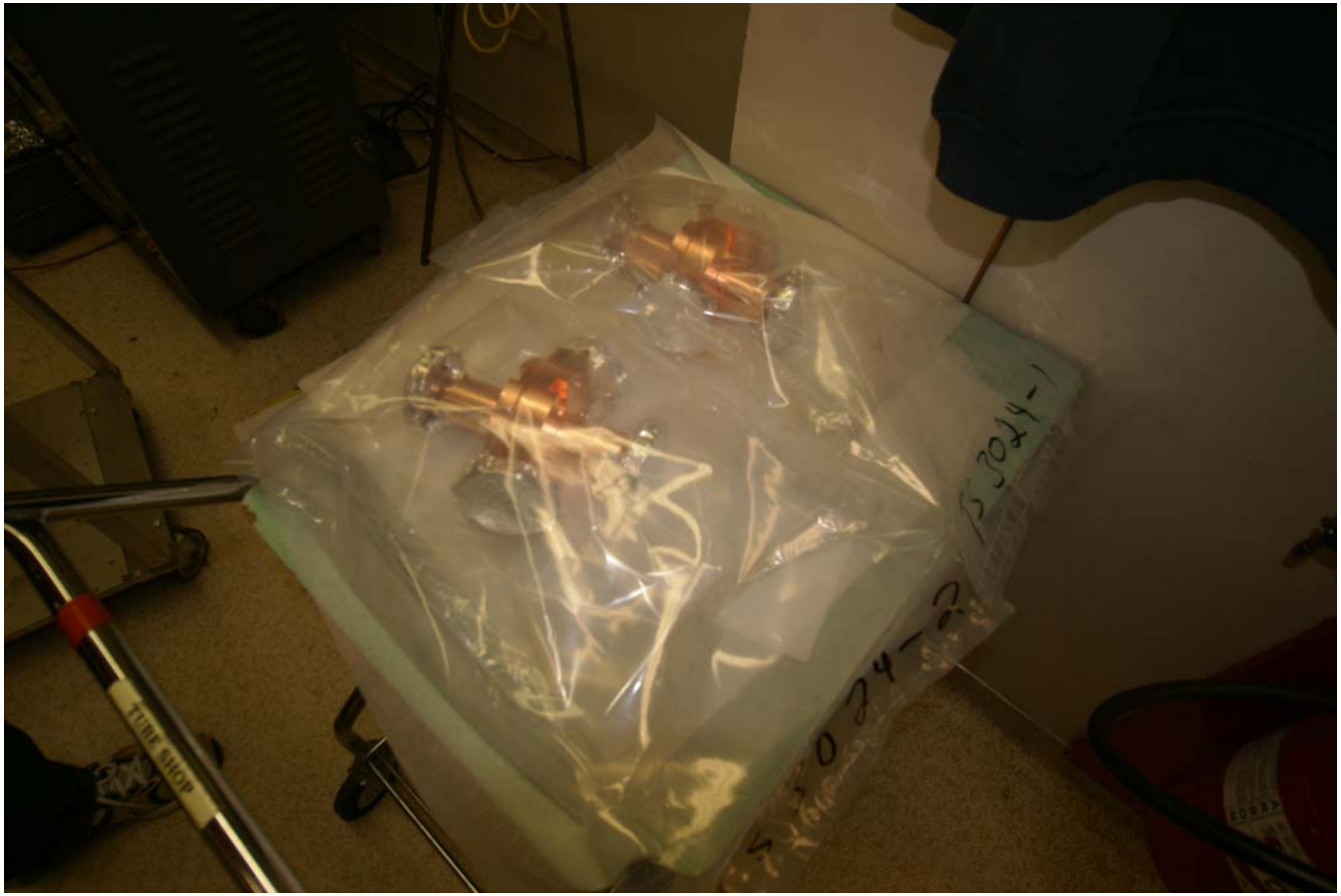
A new choke cavity for In-Situ observation



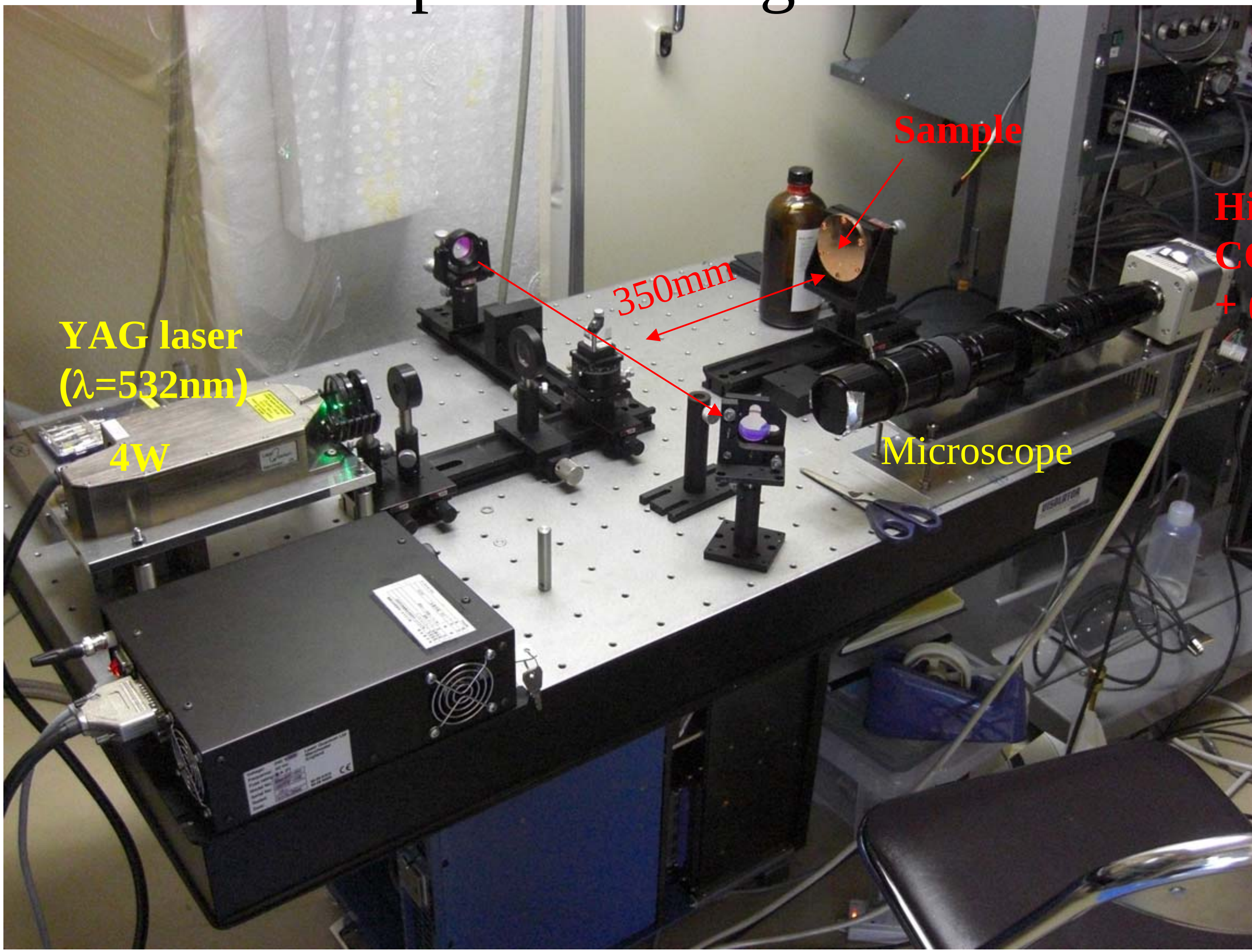
Design and fabrication by SLAC

A. D. Yeremian et al., "RF Choke for Standing Wave Structures and Flanges," THPEA065, IPAC 2010, Kyoto, May 2010.

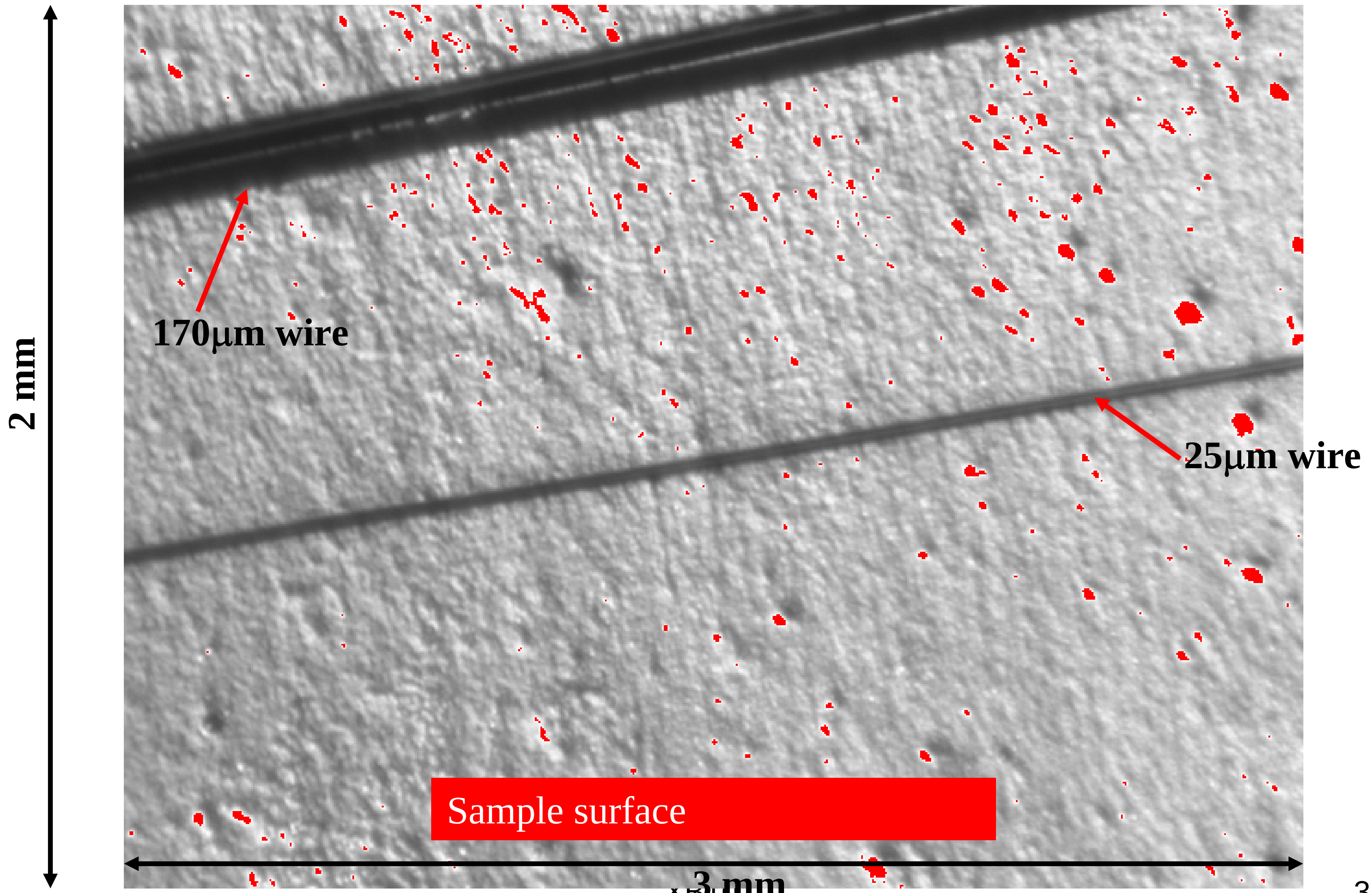
A new choke cavity fabrication November 24 at SLAC



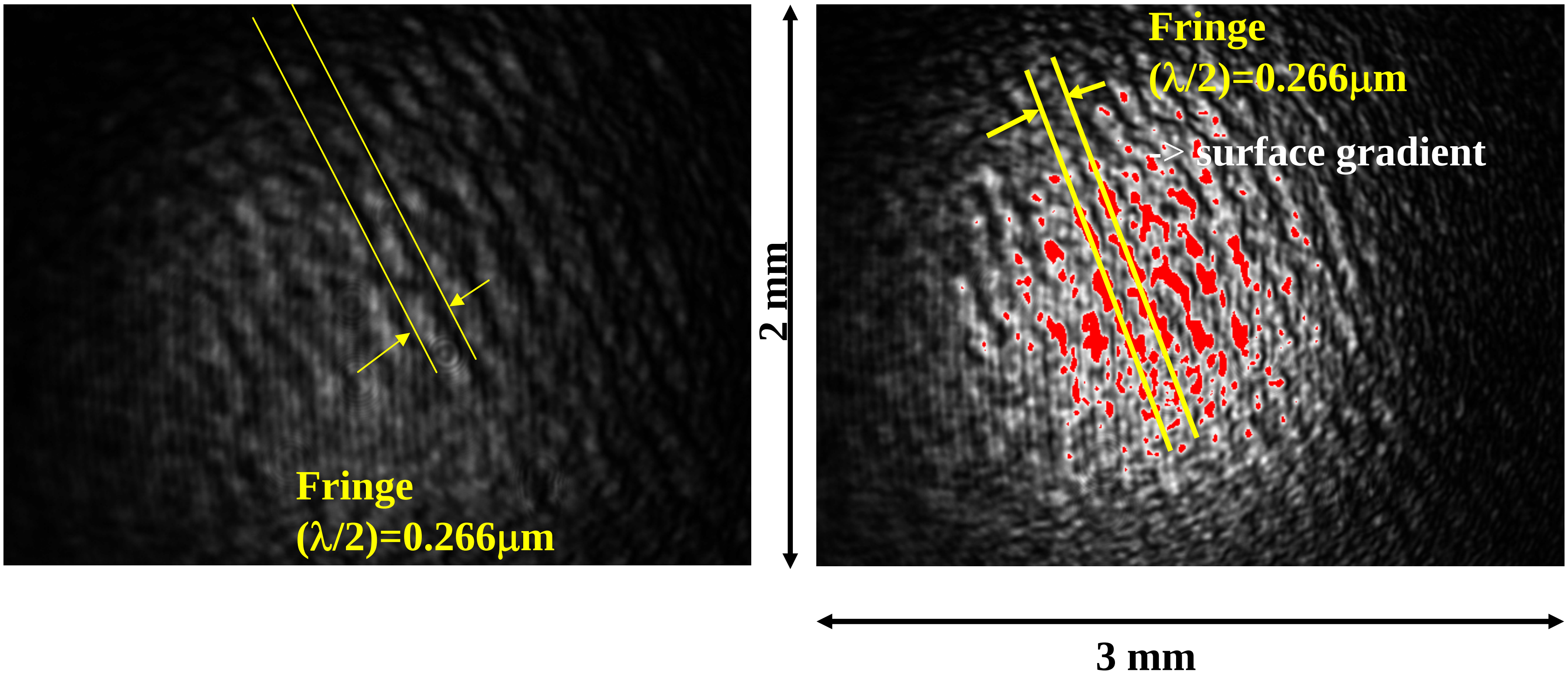
Laser interferometer for in-situ observation of pulse heating surface



Test of the microscope spatial resolution



Observation of fringe pattern



Main specifications of microscope and interferometer for in-situ observation rf pulse heating

- Microscope (350 mm distance)

  @ View area: 2x3 to 4x6 mm depend on zoom

  @ Spatial resolution: 7 μm max

- Laser interferometer

  @ View area: 2x3 to 4x6mm depend on zoom

  @ Spatial resolution: 5 μm max

  @ Surface gradient: 0.1μm/10μm

Thermo Vision CPA-T340 (Chino Co. Ltd.)

Specifications

Measured temp.: 0~350 degC

Resolution: 0.08 deg. C

Frame-rate: 60 Hz

Laser Pointer for target

Measured area: 30x30mm

Interface: USB

summary

- Scanning Field Emission Microscope

Test was started but sophisticate physics data of the surface defect is not yet observe.

- Hard materials single cell SW structure

(no high temperature bonding or brazing)

Cells fabrication completed. Surface treatment and rf contact with good vacuum shelling engineering is under studying. Needs more 1 month. They will be shipped to SLAC by end of next January

- In-situ microscopic observation of metal surface

Bench test will be started with existing cavity at KEK after this workshop.

Then will be shipped to SLAC by the end of this year