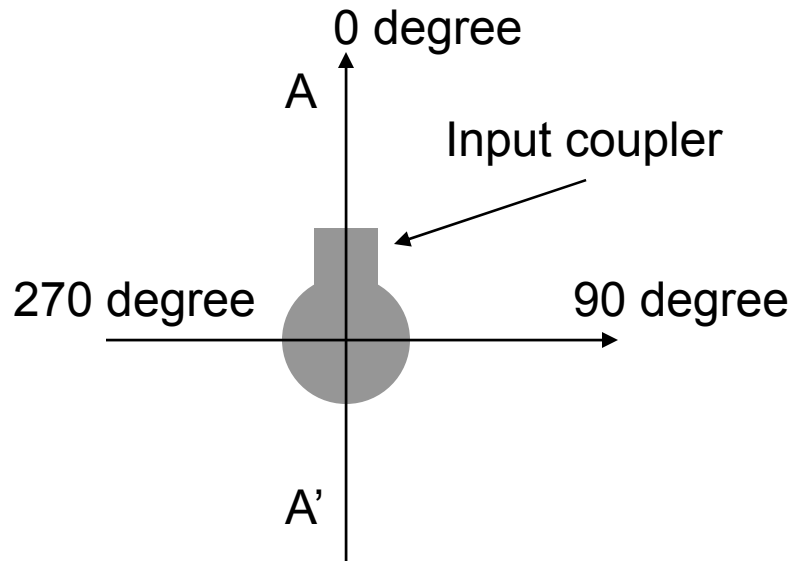
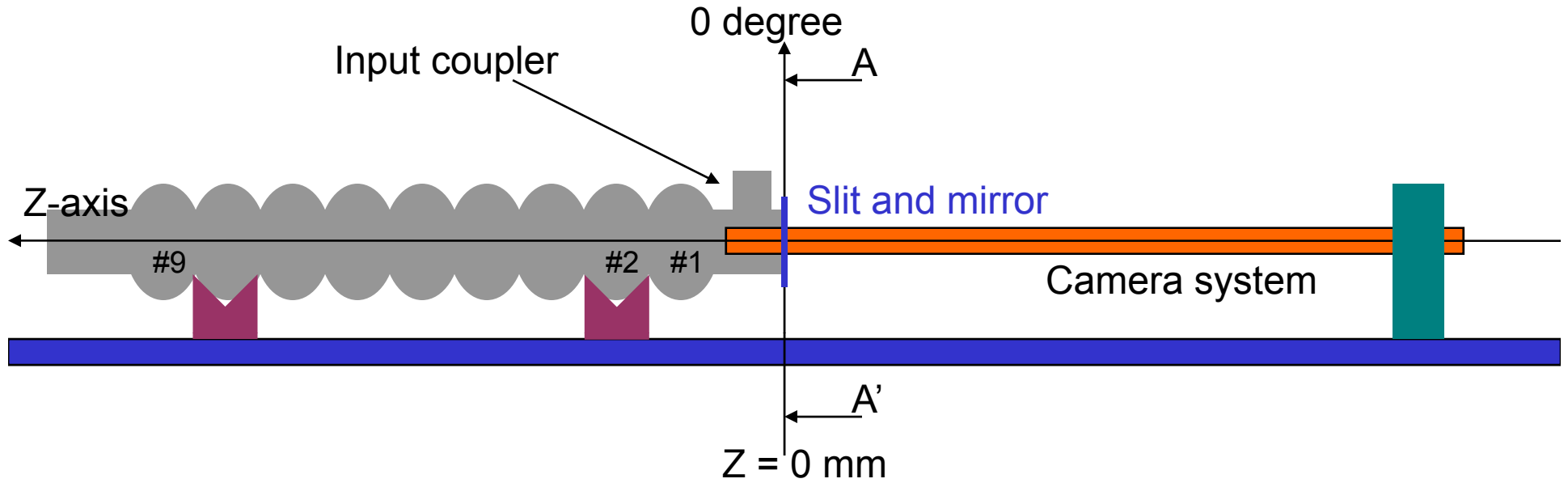


TESLA Z110、Z111
inner surface inspection by Kyoto/KEK camera

2008/5/16 Ken Watanabe (KEK)

Coordinate system



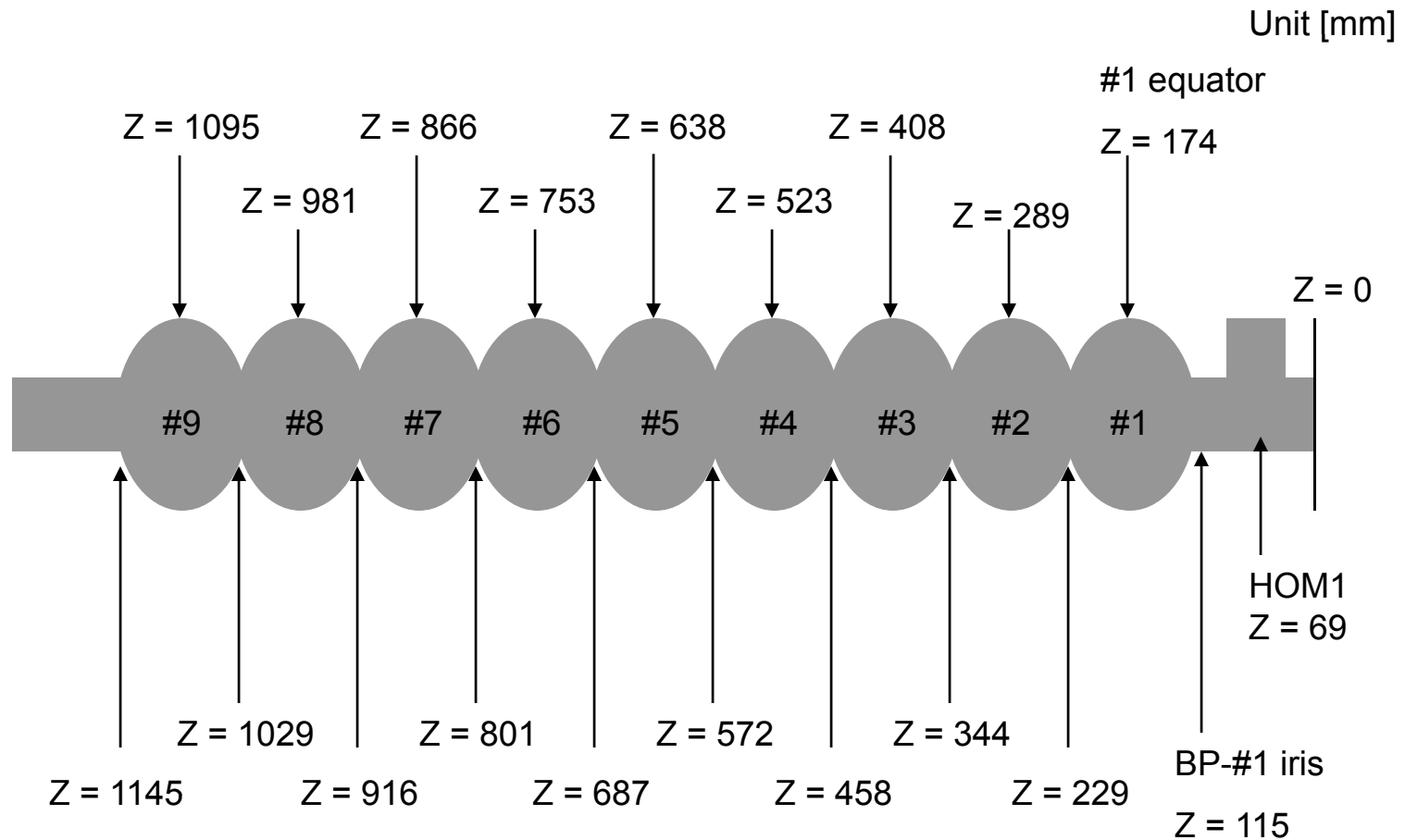
rotation angle :

Define 0 degree when the input coupler flange is in horizontal.

Z-axis :

Define 0mm(origin) at the input coupler side flange end surface. Cell number starts from the input coupler, #1, #2,..... #9.

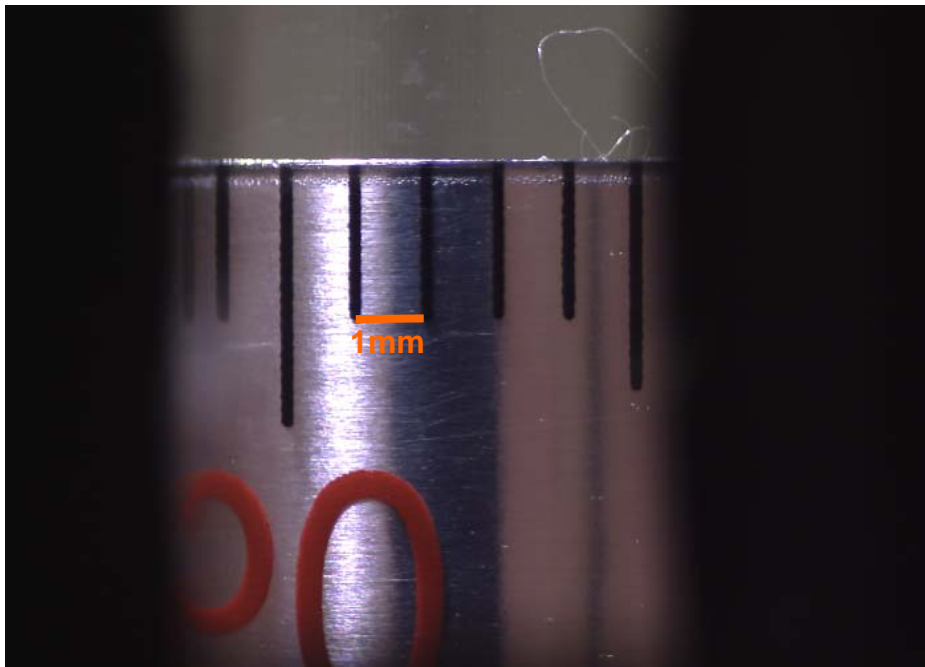
example of position for equator and iris



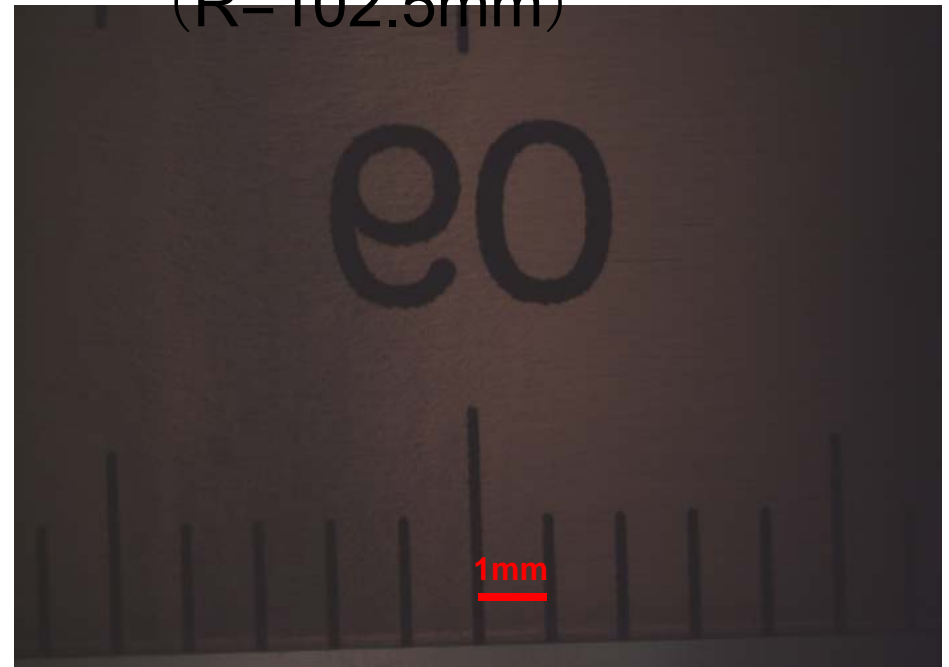
inspection : #1 ~ #9 equator → 9 positions
 : BP-#1i, #1-#2i ~ #8-#9i → 9
 positions
 : HOM1 antenna

scale reference

at iris ($R=35\text{mm}$)



at equator ($R=102.5\text{mm}$)



TESLA cavity Z110 history

Z110 (made by Zanon, Ingot : Tokyo Denkai at August 2001) , 2006/12/19 ~ 2007/8/29

•Vertical Test at 2 K : 3 times

1st test: Max Eacc= 13.8 MV/m, $Q_0= 1.3 \times 10^{10}$, No T-map data (800°C HT)

No Field emission, No Q-disease, 20 min processing : not effective

→all mode measurement : cells 2 or 8 →14.4 MV/m

cell 5 →20.0 MV/m quench limit

field

2nd test: Max Eacc= 14.7 MV/m, $Q_0= 1.3 \times 10^{10}$, T-map measured (800°C HT)

No Field emission, No Q-disease,

Quench was found by T-map in cell 8 (strong heating)

3rd test: Max Eacc= 14.2 MV/m, $Q_0= 1.5 \times 10^{10}$, T-map measured,

: 1350°C HT and BCP -> 110um removal

No Field emission, No Q-disease,

Quench was found by T-map in cell 8 (equator area)

3回の縦測定ともに水素病、field emission は無かった。2回目と3回目のテストでは#8セルが原因で加速電界が制限されていることがT-map から分かっている。1350°Cの処理を行った後、BCPを行っているが空洞性能の改善は無かった。

Z110 history from TTF database

Cavity Information				CW-Test Results					Power Rise Results												
Cavity	Production No.	Firm	Ingot No.	Removed Material [µm]	Cavity Status	Last HT [°C] before Test	Test Date	Test No.	Test Location	Max. Eacc [MV/m]	Qo @ Max. Eacc	Temperature [K]	Limitation	FE Onset		Eacc @ Qo=1E+10	Lowest meas. Qo	Qo @ Eacc=23.5 [MV/m]	Lowest meas. Eacc	Eacc @ (100W/9)*cell#	Lowest Loss> (100W/9)*cell#
														@ 4E-4 [mGy/min]	@ 1E-2 [mGy/min]						
Z110	4	Zanon	21	194.8	ep	800	19.Dec.06	1	v2	13.81	1.3E+10	2	bd			13.81	1.3E+10				
												13.78	1.3E+10	2	bd			13.78	1.3E+10		
				Aim: test of cavity first test					Result: not ok: Early quench at 13.8 MV/m, without FE				Remark: No Q disease. Only 13.8 MV/m, Q=1.3E+10, no FE, quench. Processing about 20 minutes not effective. MM : all modes quench limited, no FE seen, fields from 14.4 MV/m (cells 2&8) to 20.0 MV/m (cell 5). T mapping mounting and a new measurement is proposed now.								
				194.8	ep	800	07.Feb.07	2	v1	14.76	1.3E+10	2	bd			14.76	1.3E+10				
				Aim: test of cavity new test T-mapping added or fail					Result: ok				Remark: No Q disease. The same bad result like previously: 14.8 MV/m, Q=1.3E+10, no MP, no FE, no other modes. Quench was found by T mapping in cell 8, nearby equator but also strong heating was found especially in lower half of the cell. Similar to Z108 cavity.								
				302.3	bcp	1350	29.Aug.07	3	v2	14.18	1.5E+10	1.99	bd			14.18	1.5E+10				
				Aim: test of cavity new preparation low voltage quench (< 25 MV/m)					Result: not ok: Still quench at 14 MV/m				Remark: No Q disease., but still bad result: 14.2 MV/m, Q=1.5E+10, BD, no FE, no MP. MM : all BD, no FE and MP, fields 14 to 20 MV/m. After EP in tests 1 and 2 the same bad result, 14.8 MV/m, BD. In test 2 quench was found in cell 8 at and below equator by T map.								

195µm removal by EP,
then, 107µm removal by BCP,
total : 302µm removal.

TESLA cavity Z111 history

Z111 (made by Zanon, Ingot : Tokyo Denkai at August 2001

and Teledyne Wah Chang November 2002) , 2006/11/24 ~ 2006/12/07

•Vertical Test at 2 K : 2 times

1st test: Max Eacc= 16.2 MV/m, $Q_0= 1.8 \times 10^{10}$, No T-map data (800°C HT)

No Field emission, No Q-disease, 90 min processing : not effective

→all mode measurement : cells 4 or 6 →16.2 MV/m

cell 1 or 9 →26.6 MV/m quench limit

field

Low X-ray seen in modes 8/9 and 3/9 pi.

2nd test: Max Eacc= 16.0 MV/m, $Q_0= 1.6 \times 10^{10}$, T-map measured (800°C HT)

No Field emission, No Q-disease,

Quench was found by T-map in cell 6 (equator area)

2回の縦測定ともに水素病、field emission は無かった。2回目のテストでは#6セルが原因で加速電界が制限されていることがT-map から分かっている。

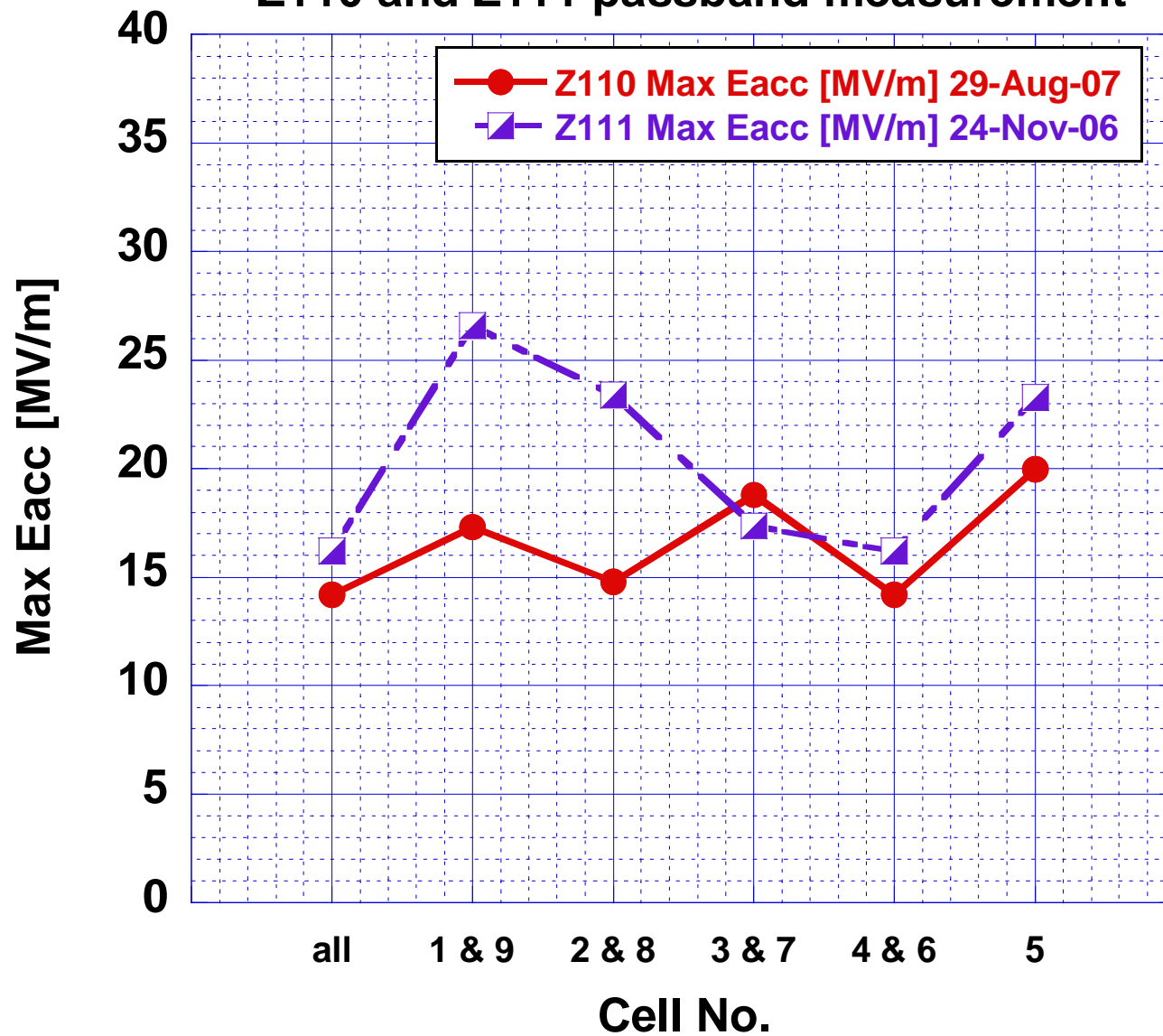
#1、#9セルは26.6 MV/mまで電界が出ている。

Z111 history from TTF database

Cavity Information				CW-Test Results						Power Rise Results											
Cavity	Production No.	Firm	Ingot No.	Removed Material [μm]	Cavity Status	Last HT [$^{\circ}\text{C}$] before Test	Test Date	Test No.	Test Location	Max. Eacc [MV/m]	Qo @ Max. Eacc	Temperature [K]	Limitation	FE Onset		Eacc @ Qo=1E+10	Lowest meas. Qo	Qo @ Eacc=23.5 [MV/m]	Lowest meas. Eacc	Eacc @ (100W/9)*cell#	Lowest Loss > (100W/9)*cell#
														@ 4E-4 [mGy/min]	@ 1E-2 [mGy/min]						
Z111	4	Zanon	21	154.8	ep+	800	24.Nov.06	1	v1	16.15	1.8E+10	2	bd			16.15	1.8E+10				
										16.19	1.8E+10	2	bd			16.19	1.8E+10				
Aim: test of cavity first test											Result: not ok: LOw gradient without FE				Remark: No Q disease. Only 16.2 MV/m, Q=1.8E+10, limited by quench, without FE. Processing for 1.5 hour not effective. MM: all cells limited by quench, fields 16.2 (cells 4&6) to 26.6 MV/m (cells 1&9). Low x rays seen in modes 8/9 and 3/9 pi.						
			154.8	ep+	800	07.Dec.06	2	v1		16.03	1.6E+10	2	bd			16.03	1.6E+10				
Aim: test of cavity new test Rotating T mapping mounted											Result: ok				Remark: Cavity is limited by quench at 16.0 MV/m, Q=1.7E+9, without x rays., like in previous test. T mapping done showed that quench is in cell 6 (like one could expect from previous modes measurement) at eqator area. New BCP or EP is proposed now for this cavity.						

155 μm removal by EP,
no more treatment,
total : 155 μm removal.

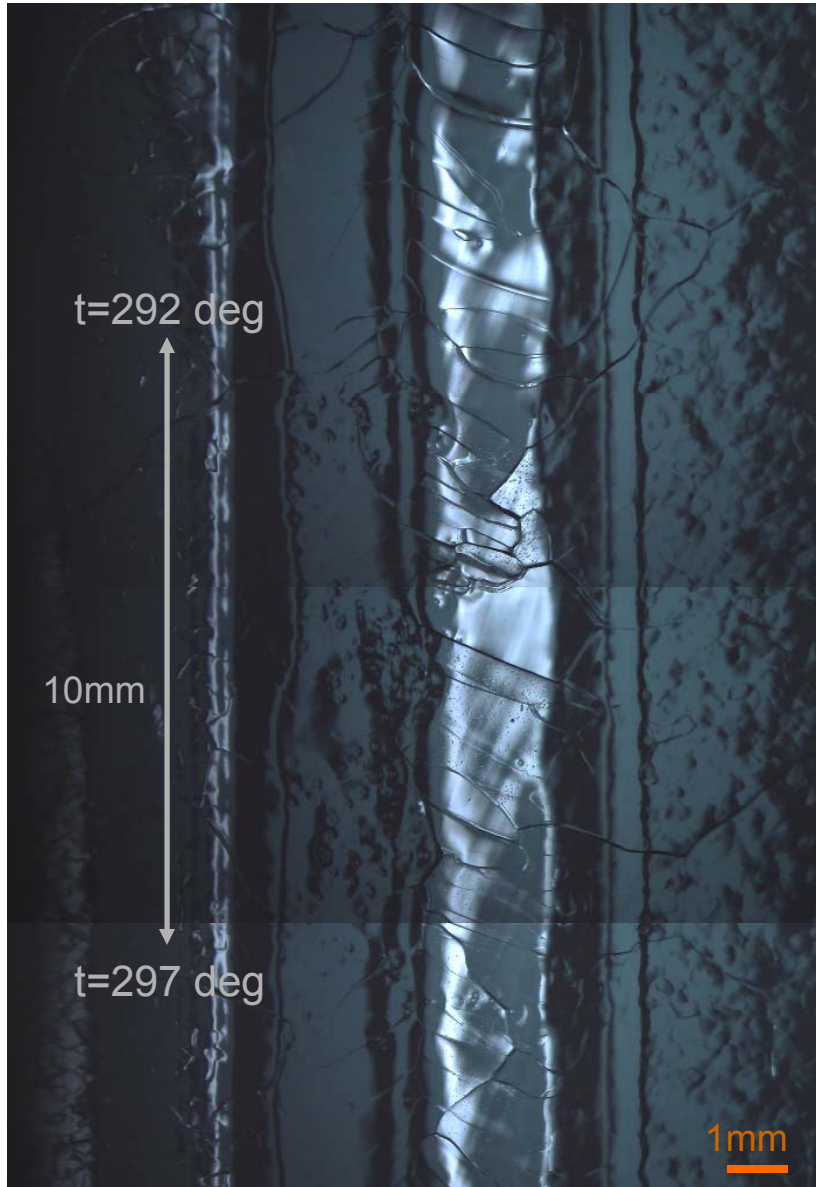
Z110 and Z111 passband measurement



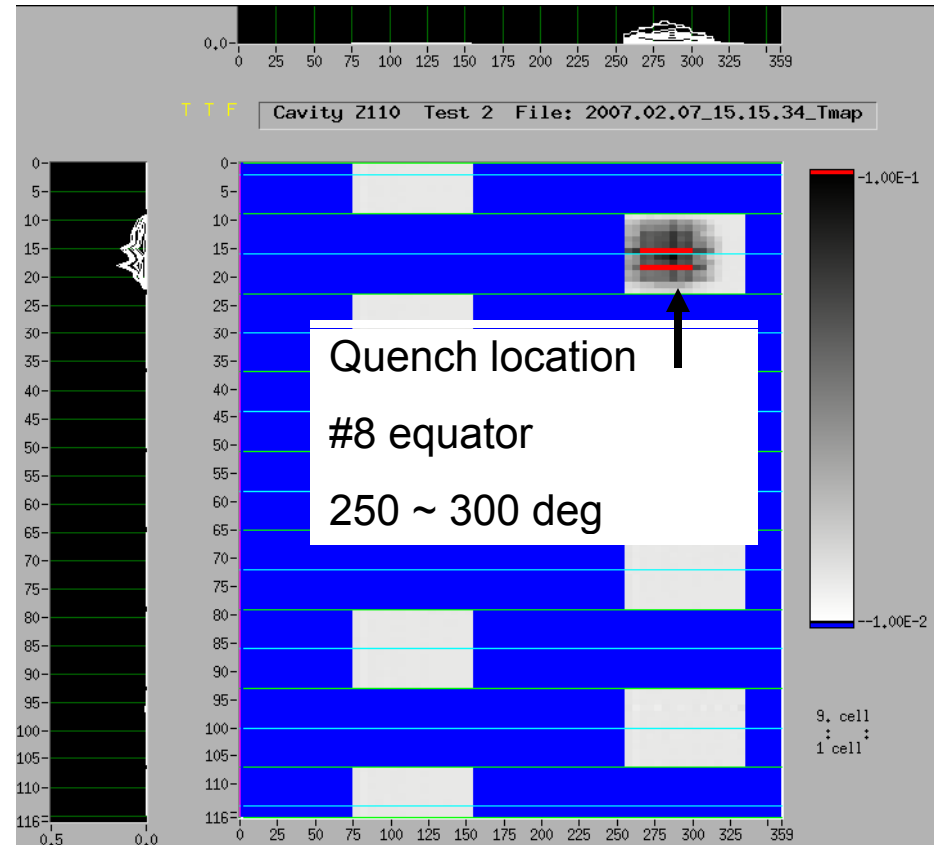
Z110 Equator

TESLA cavity Z110: #8 cell equator

#8 equator, $t=288 \sim 299$ deg



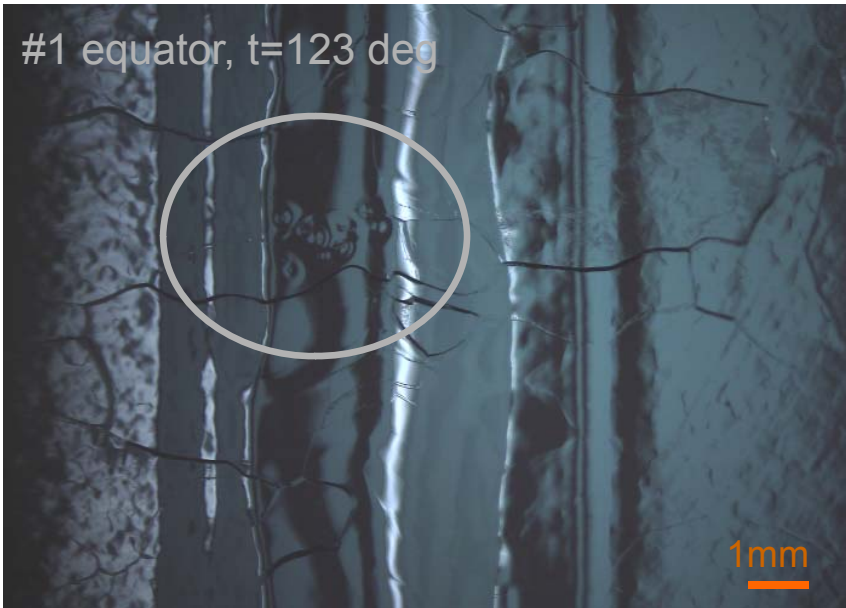
T-map data in test 2, 14.2 MV/m



group of beads(?) with 10mm wide were observed.

Similar beads group were also observed in several places. see following slides.

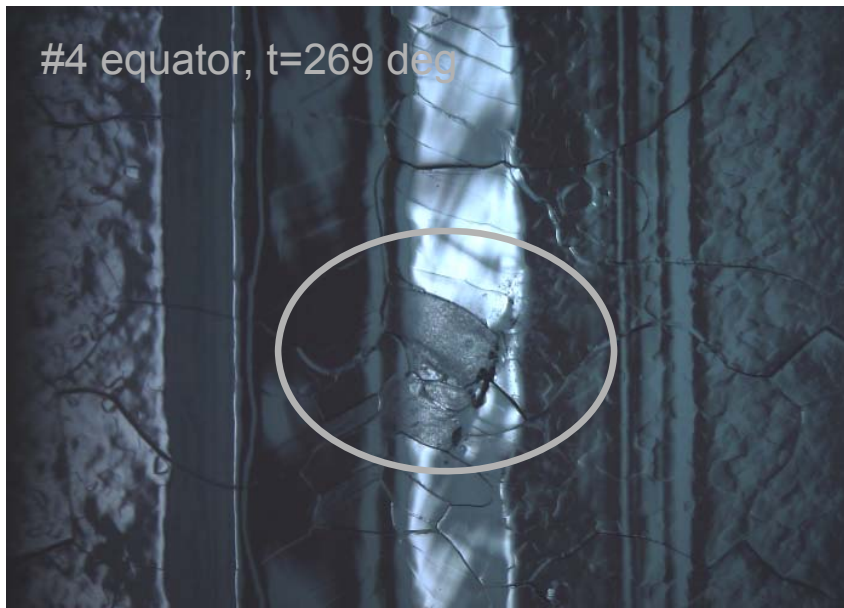
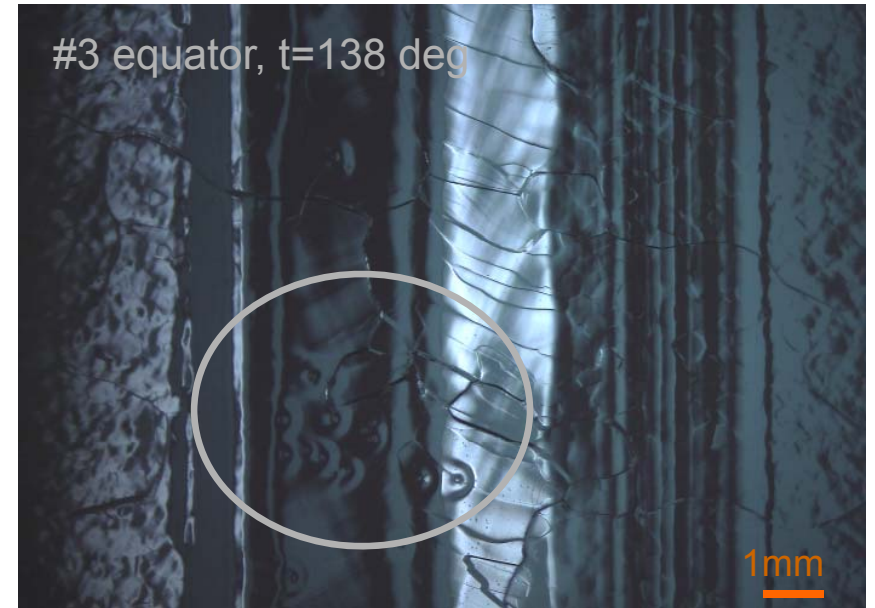
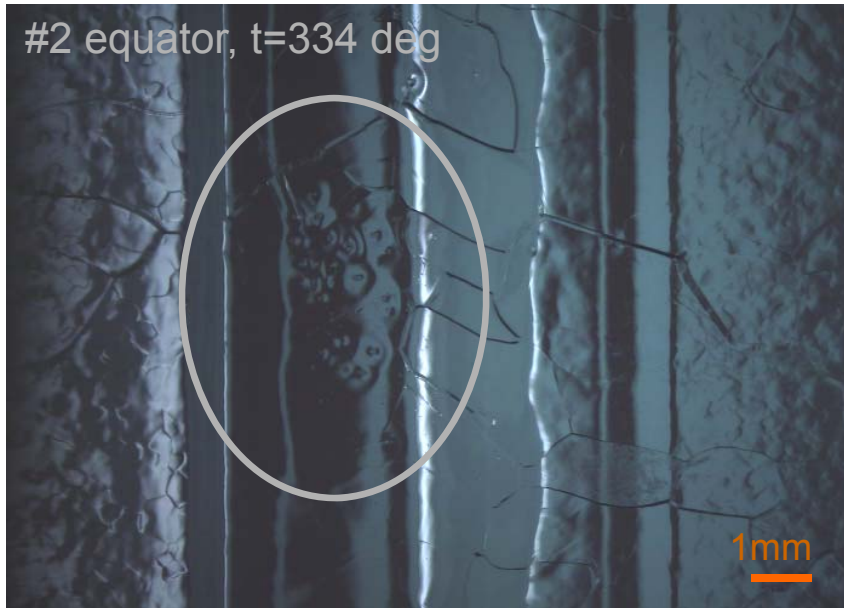
Z110: group of beads(?) (1)



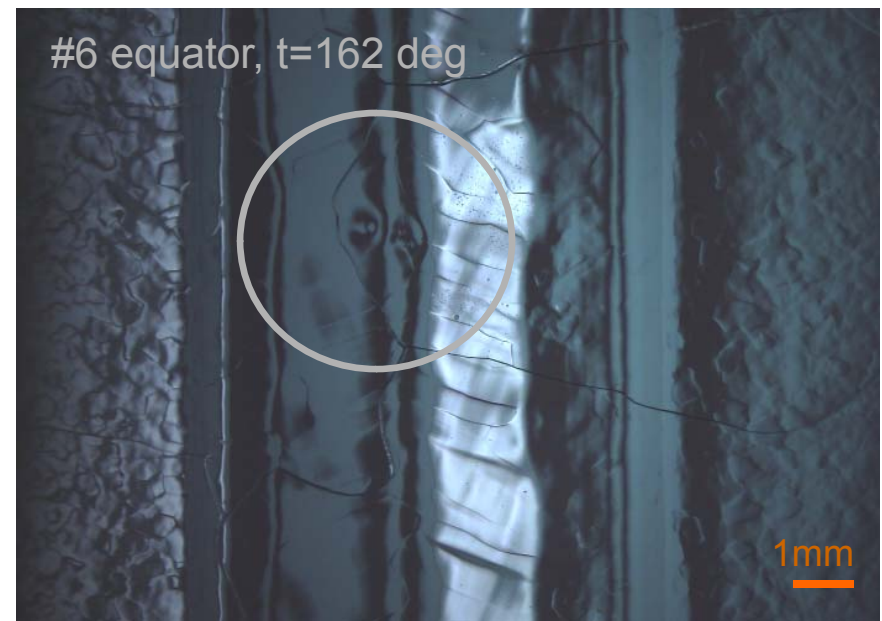
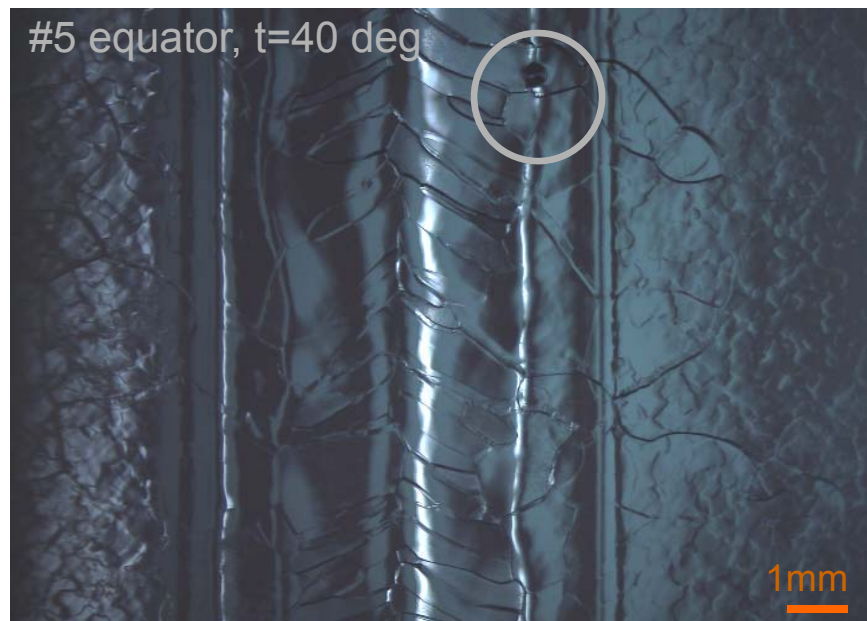
Z110: group of beads(?) (2)



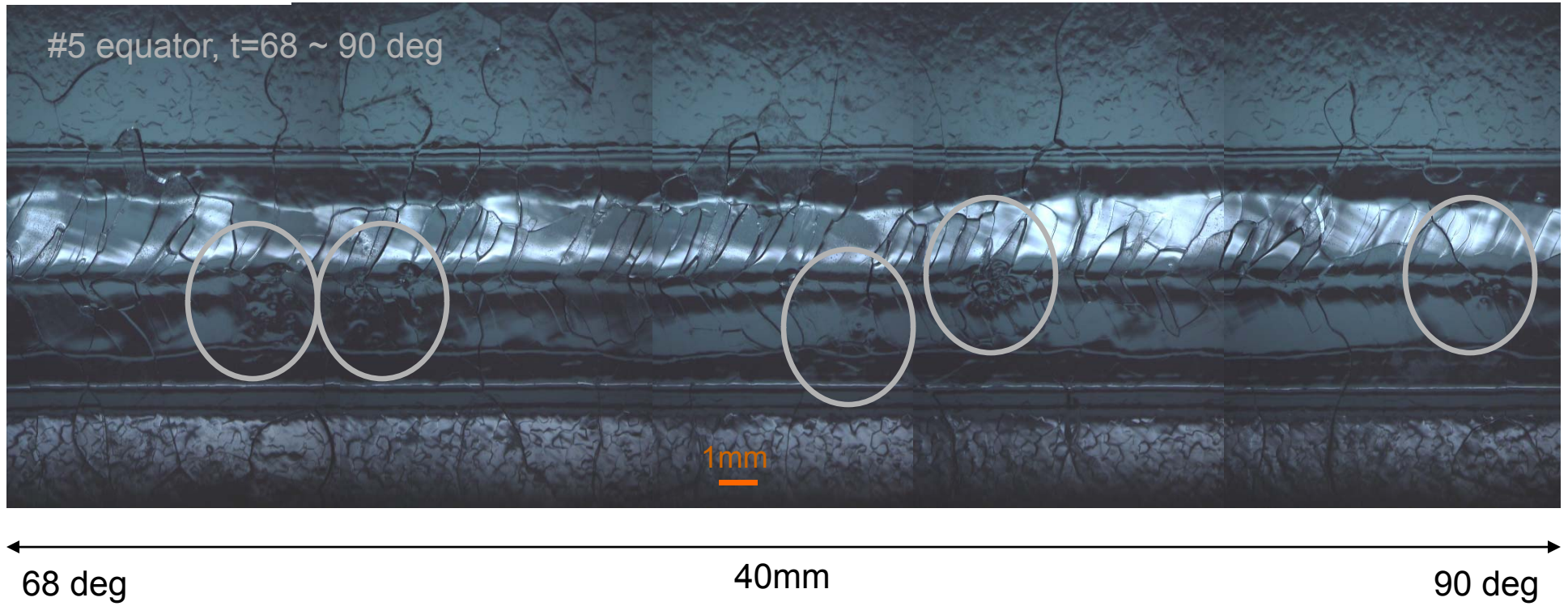
Z110: group of beads(?) (3)



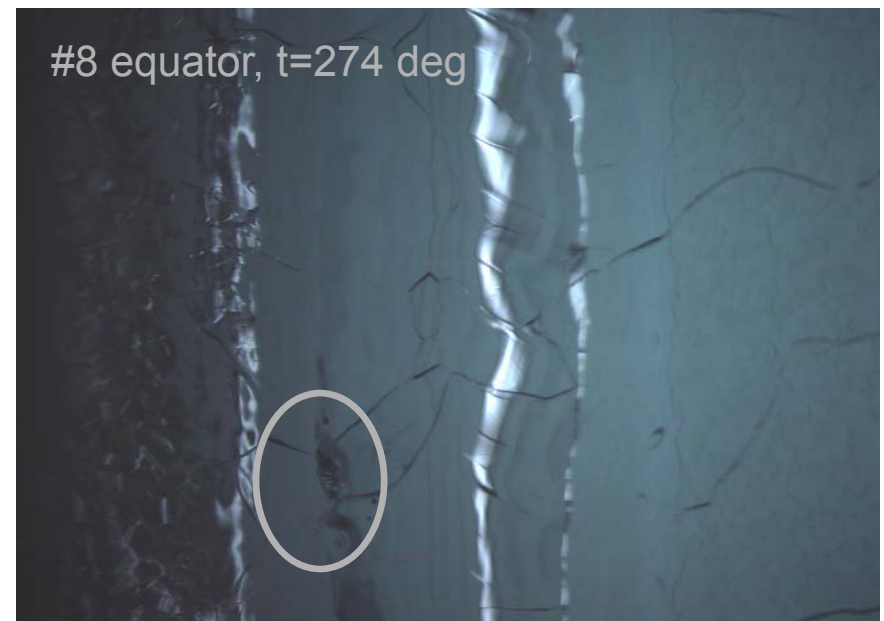
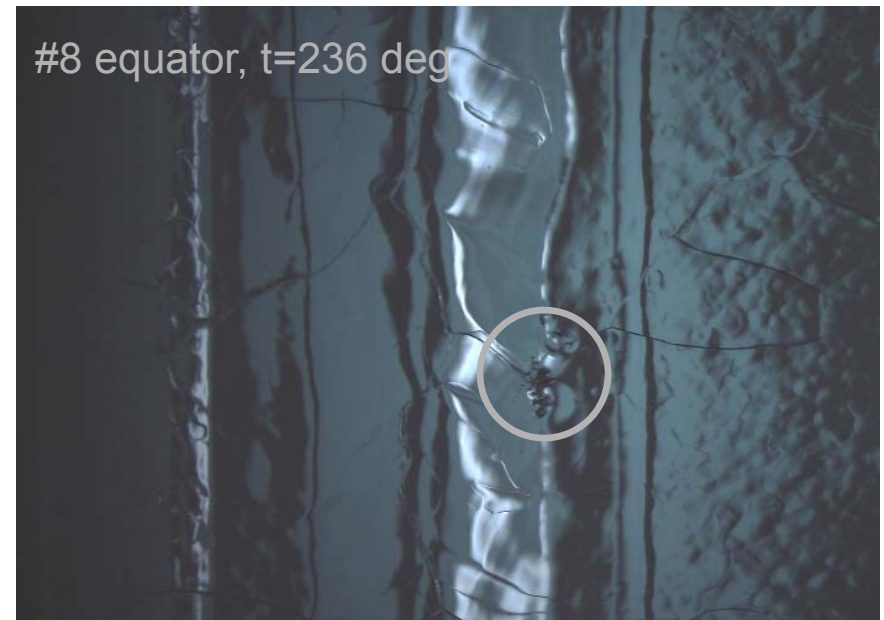
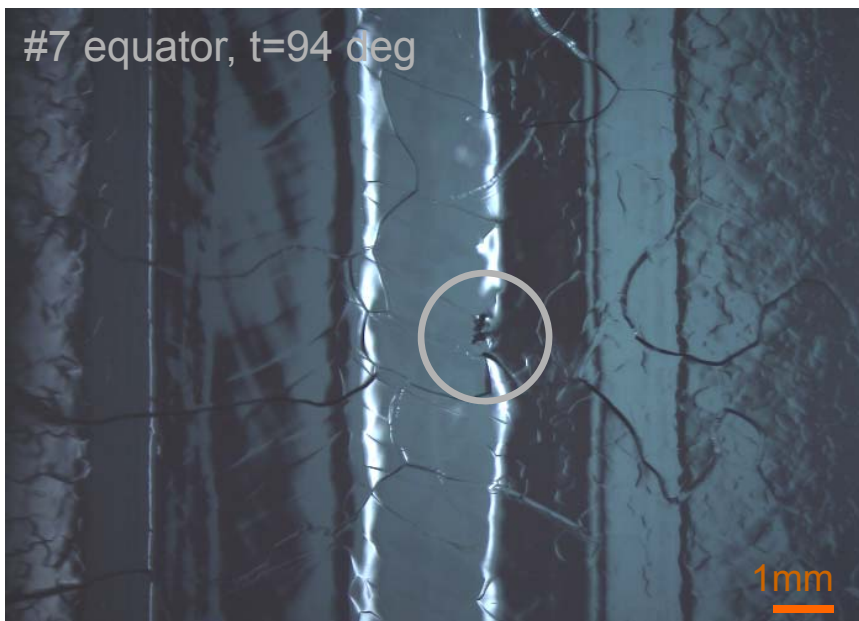
Z110: group of beads(?) (4)



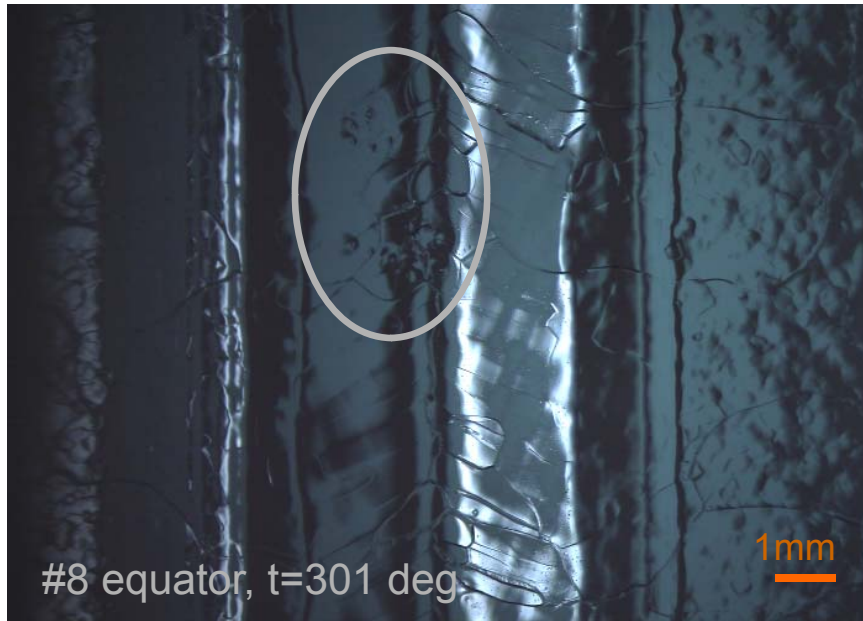
Z110: group of beads(?) (5)



Z110: group of beads(?) (6)

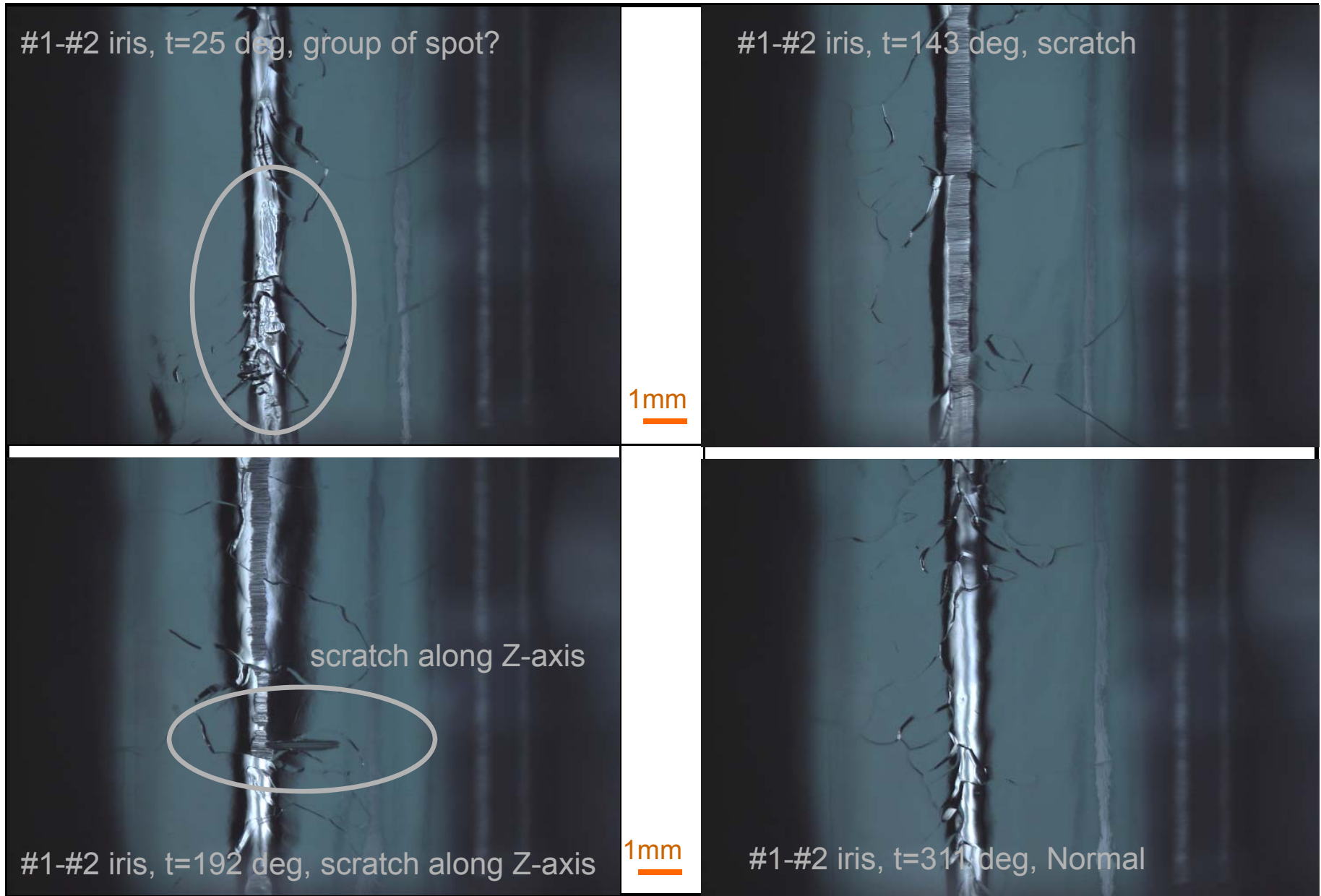


Z110: group of beads(?) (7)

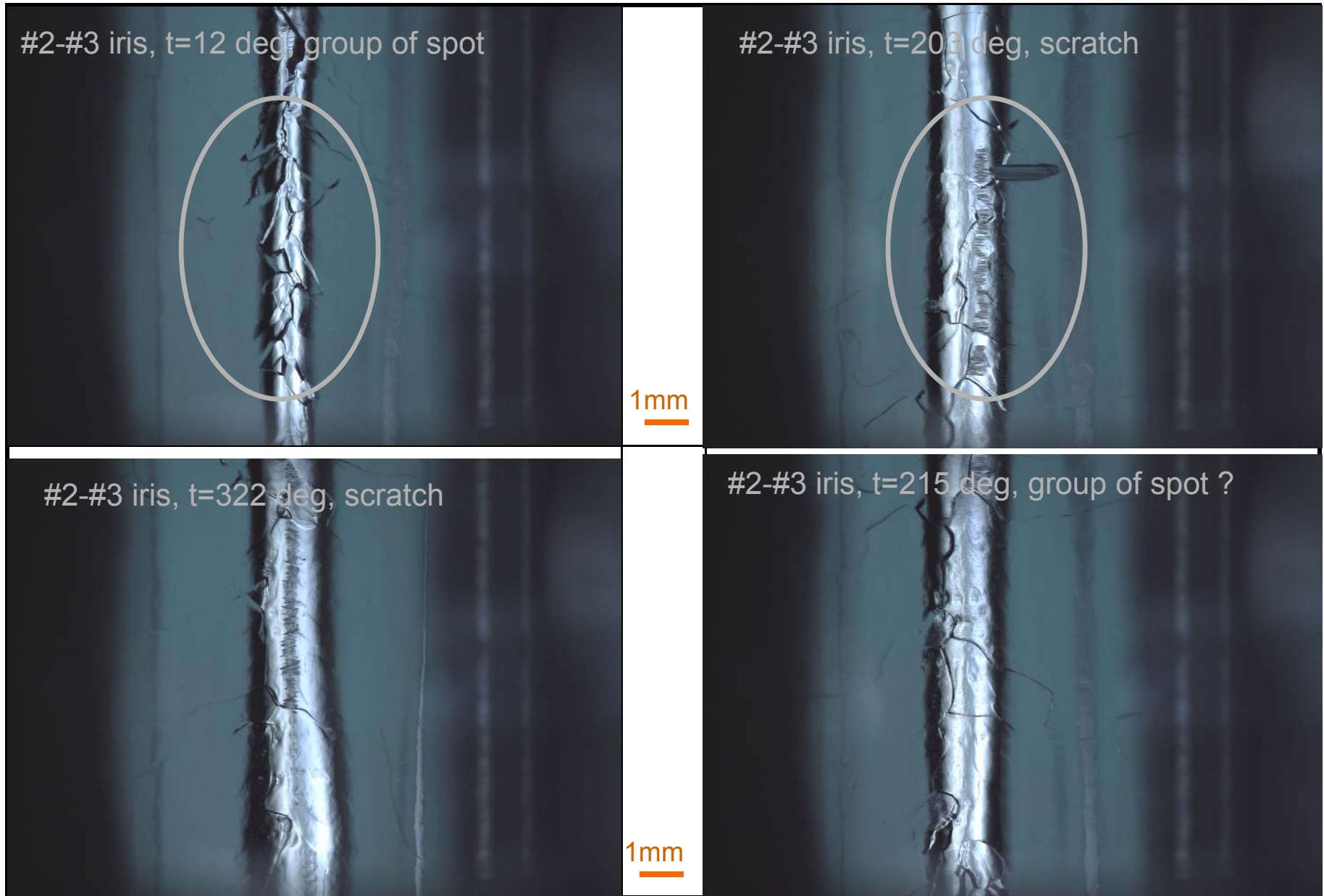


Z110 Iris

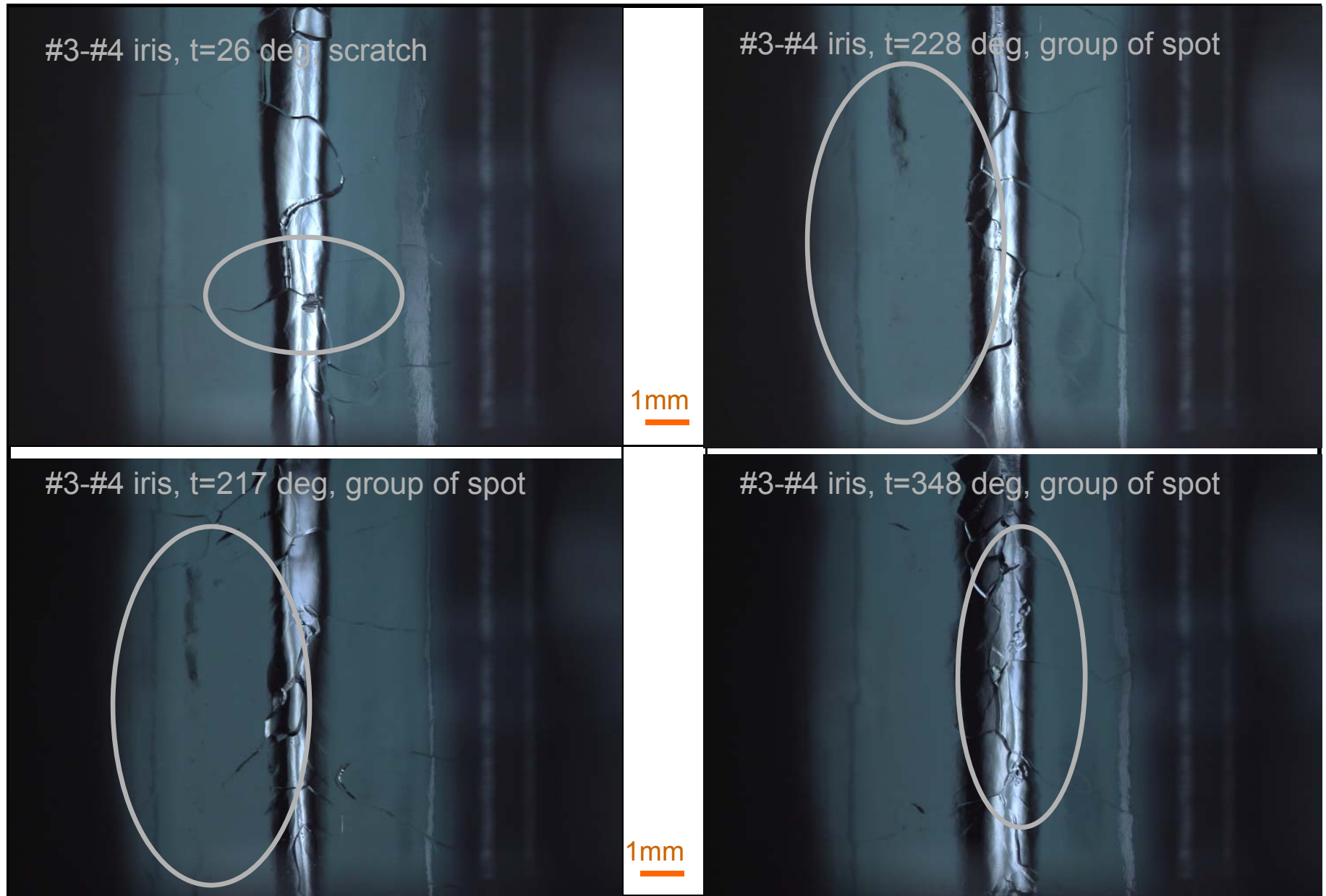
Z110: group of spot(?), scratch iris (1)



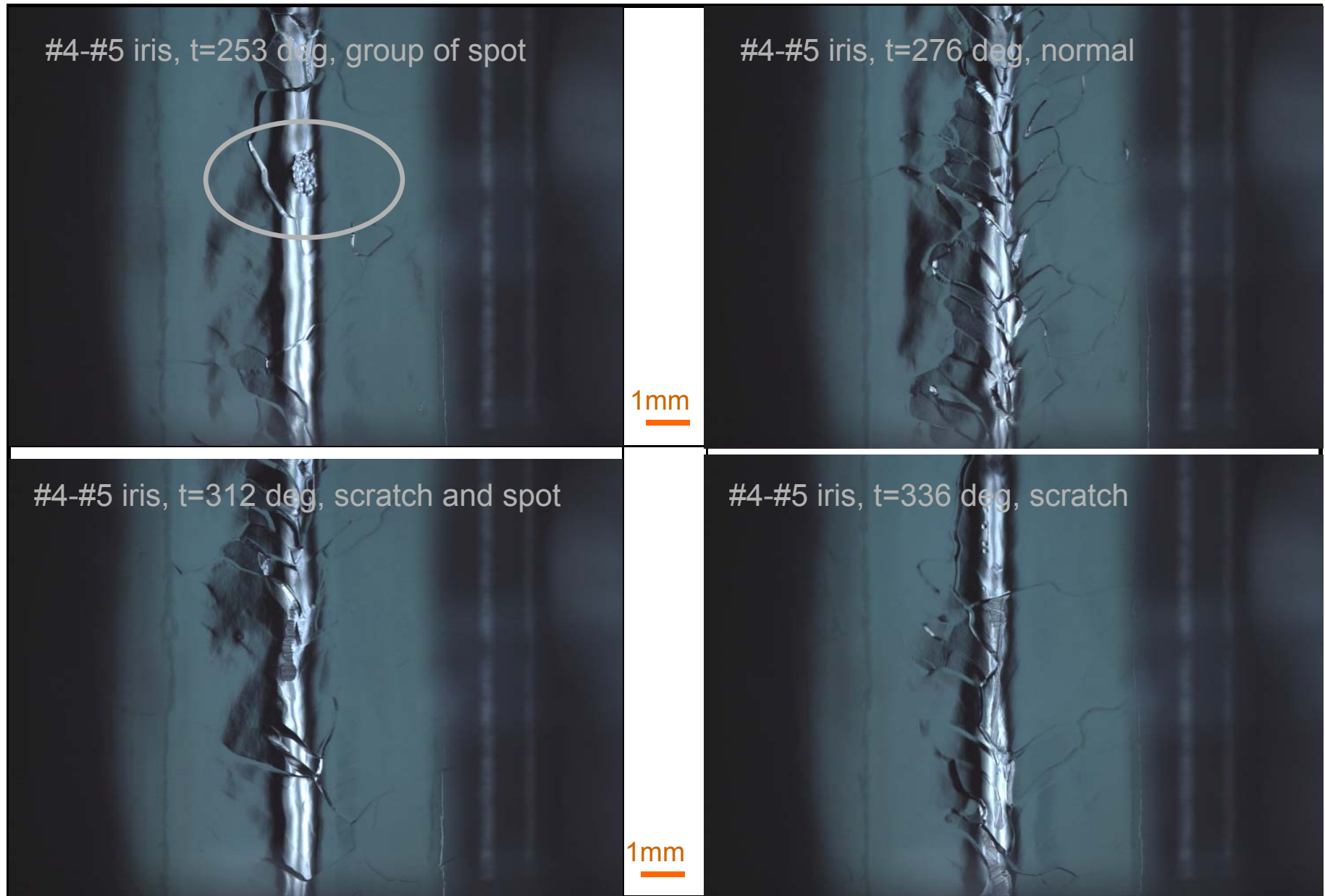
Z110: group of spot(?), scratch iris (2)



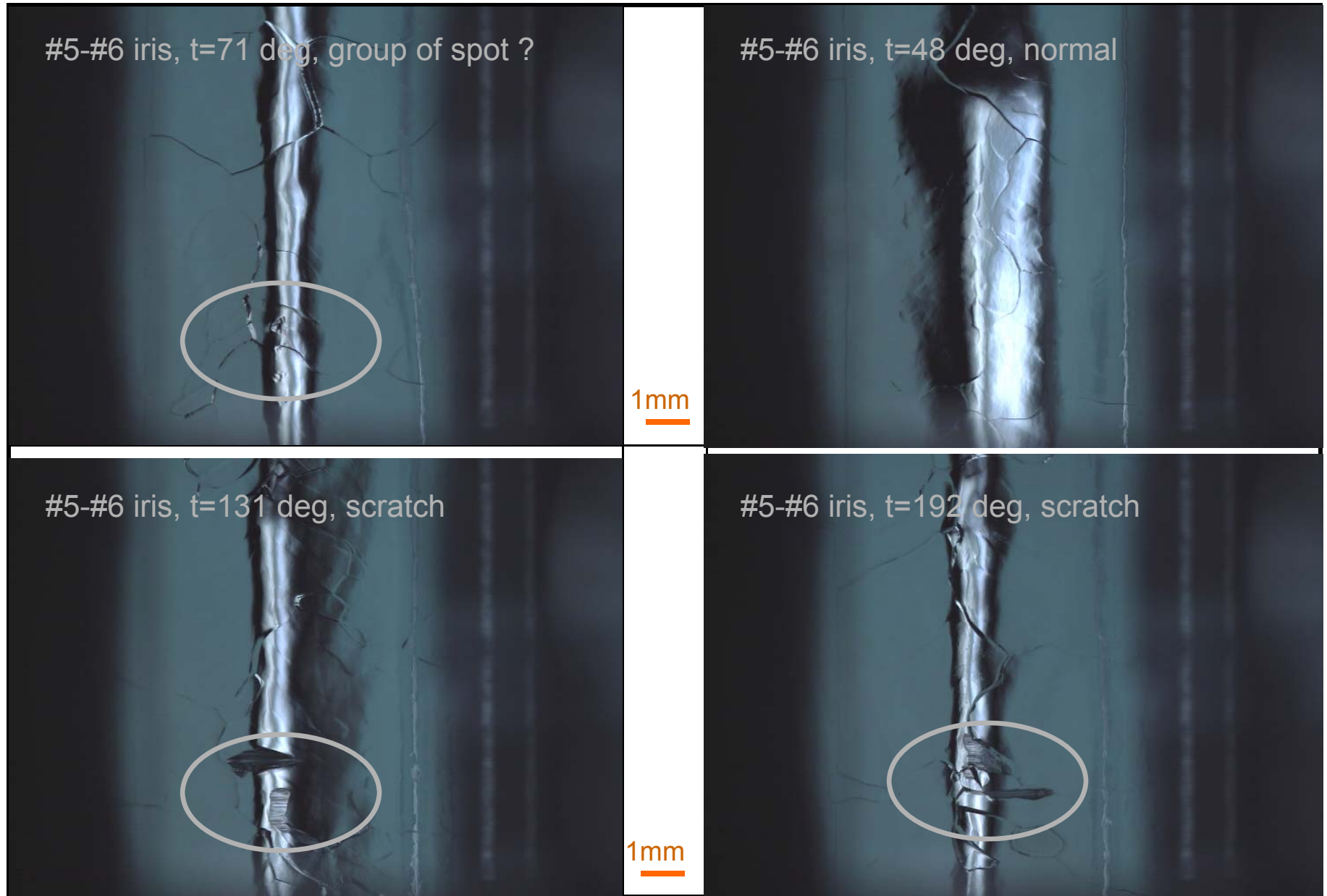
Z110: group of spot(?), scratch iris (3)



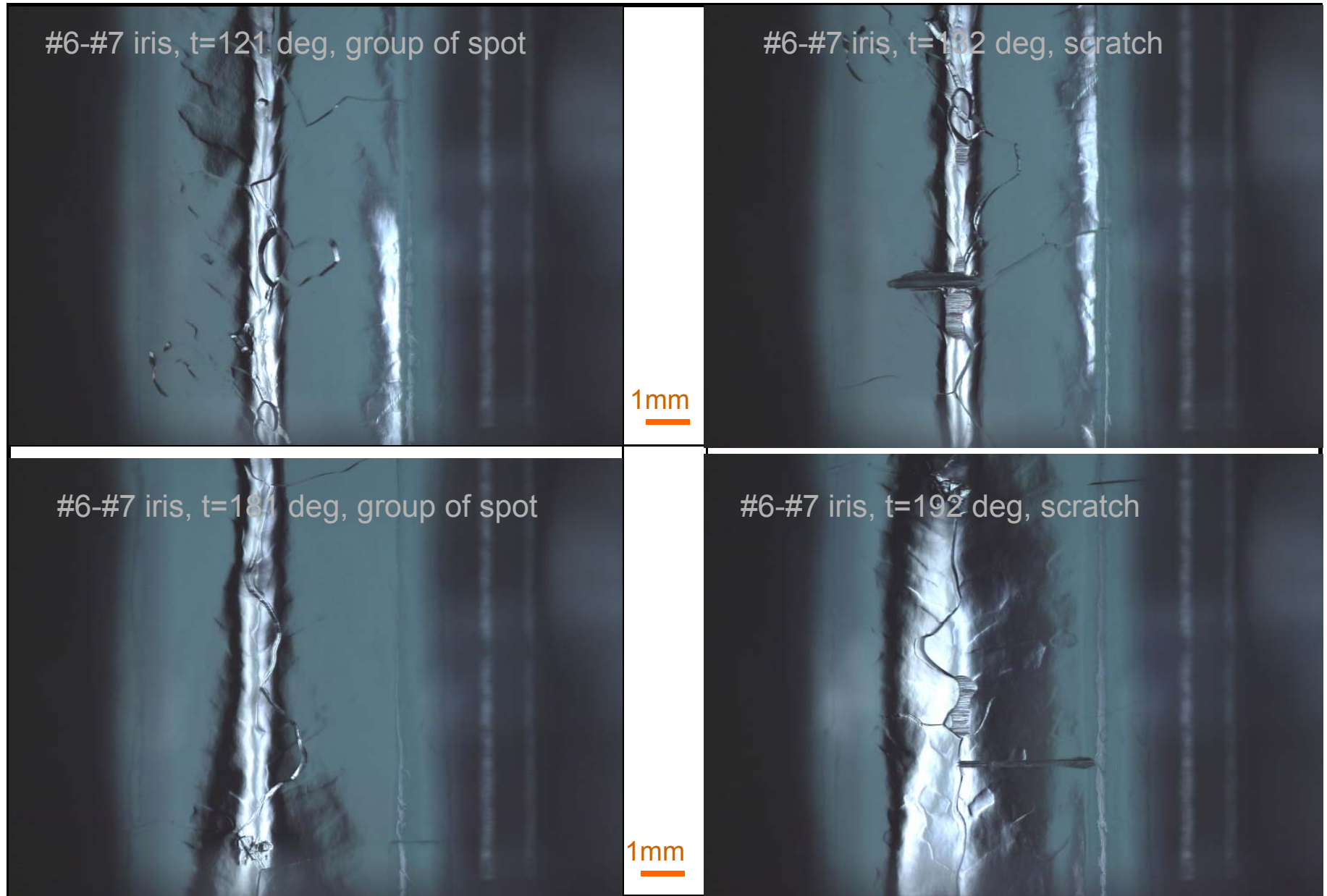
Z110: group of spot(?), scratch iris (4)



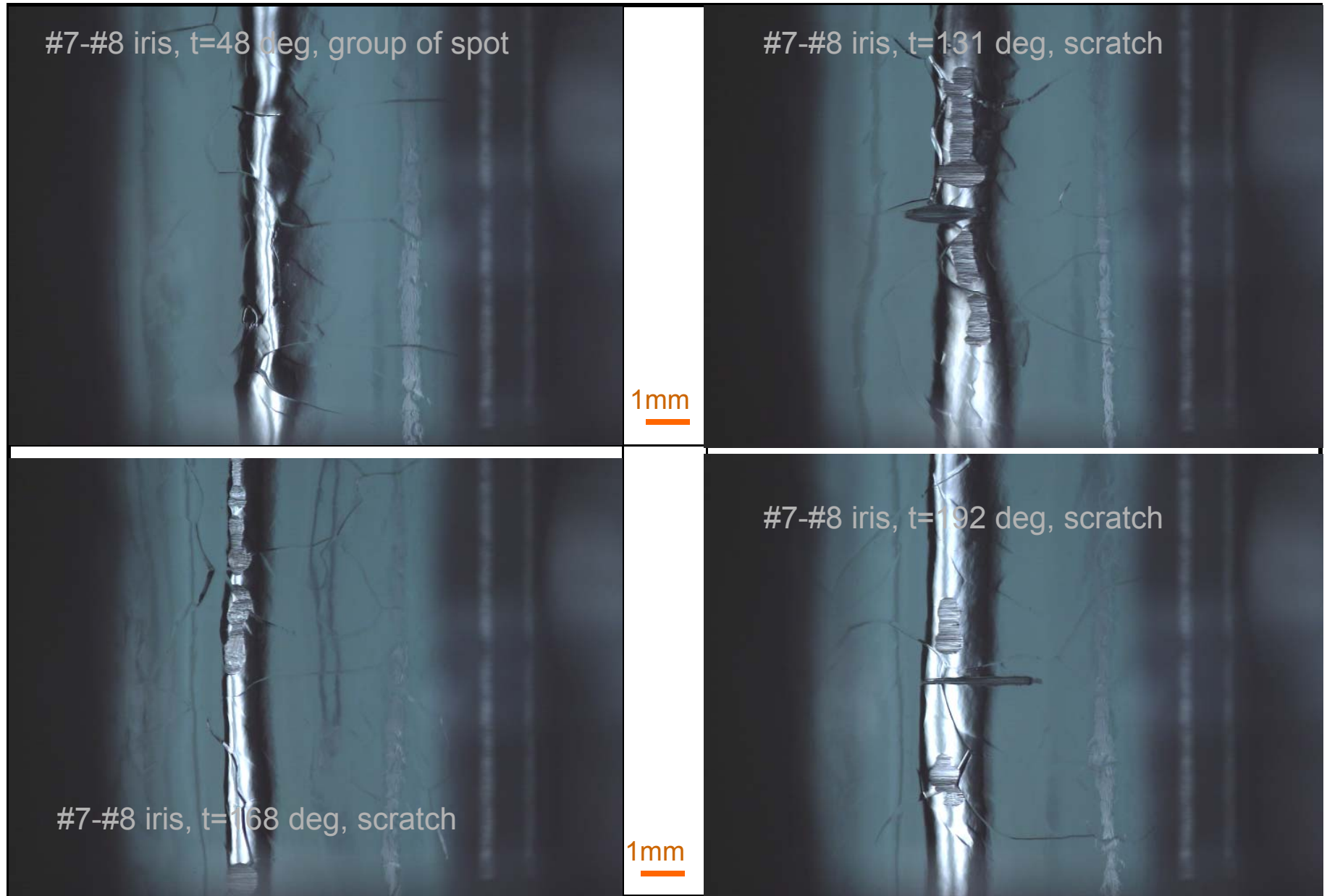
Z110: group of spot(?), scratch iris (5)



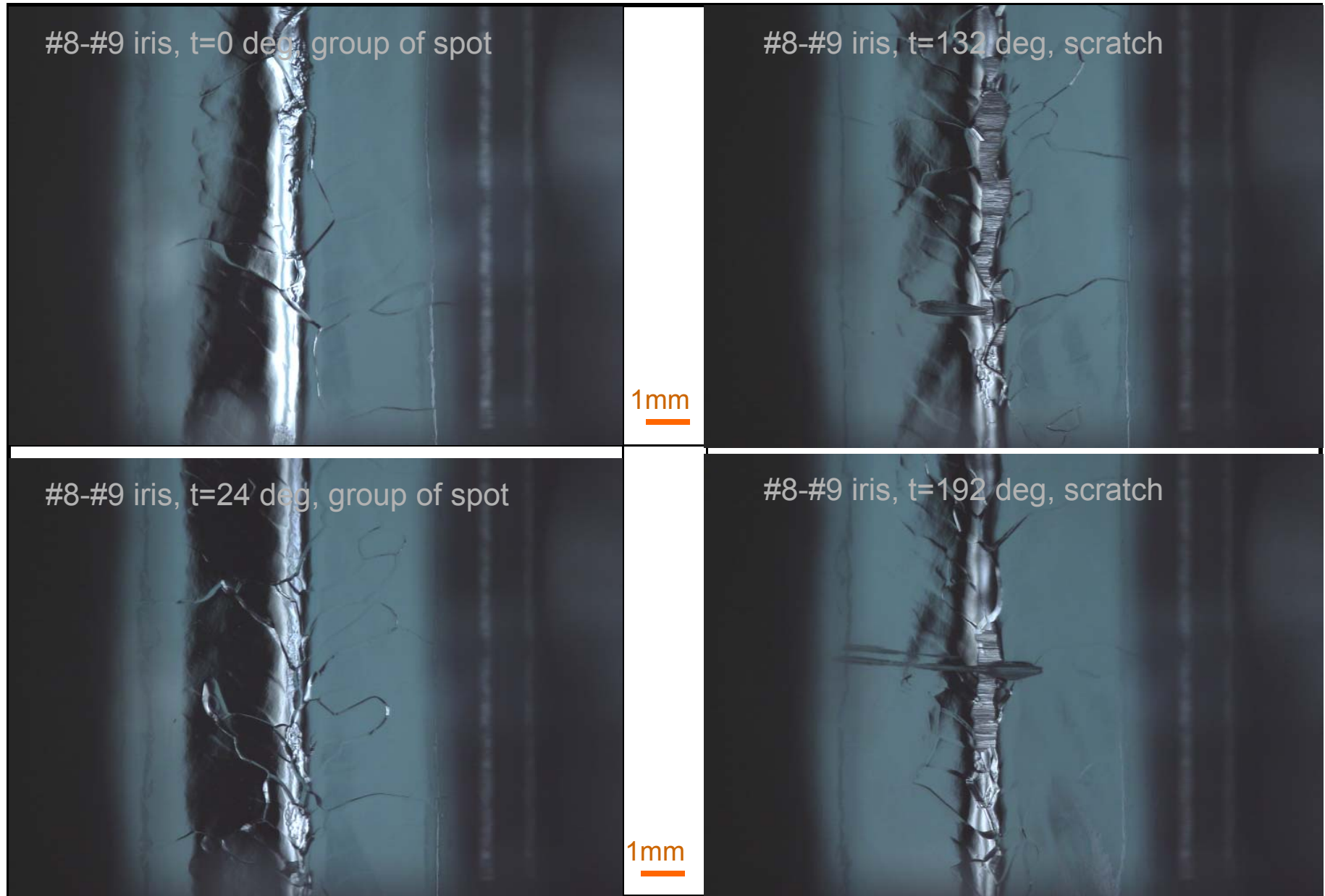
Z110: group of spot(?), scratch iris (6)



Z110: group of spot(?), scratch iris (7)



Z110: group of spot(?), scratch iris (8)



Z111 Equator

Two kind of spots in Z111

Type-1; clear bump spots or single spot.

ex) Z111 #4 equator, $t=296$ deg, group of spot



Type-2; faint bump spots or single spot.

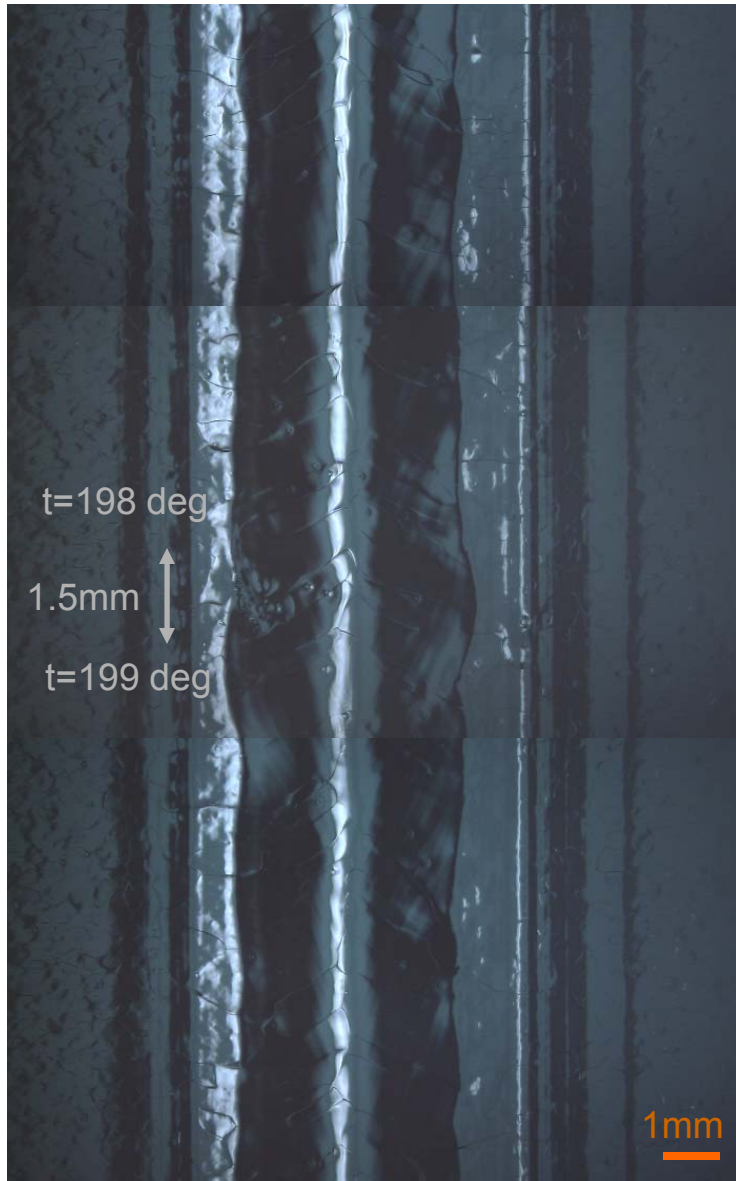
ex) Z111 #5 equator, $t=43$ deg, group of spot



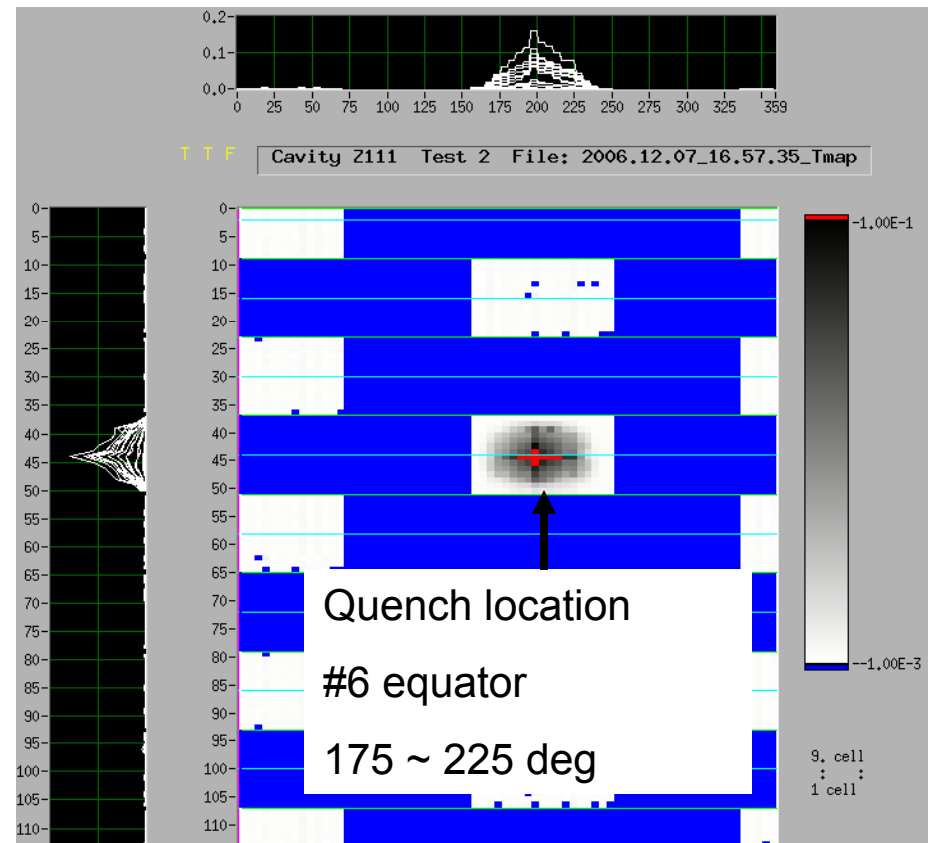
There was almost no type-2 spot in Z110.
Material removal difference?

TESLA cavity Z111: #6 cell equator

#6 equator, $t=193 \sim 204$ deg



T-map data in test 2, 16.0 MV/m



group of beads(?) with 1.5mm wide were observed.

Z111: group of spot (1)



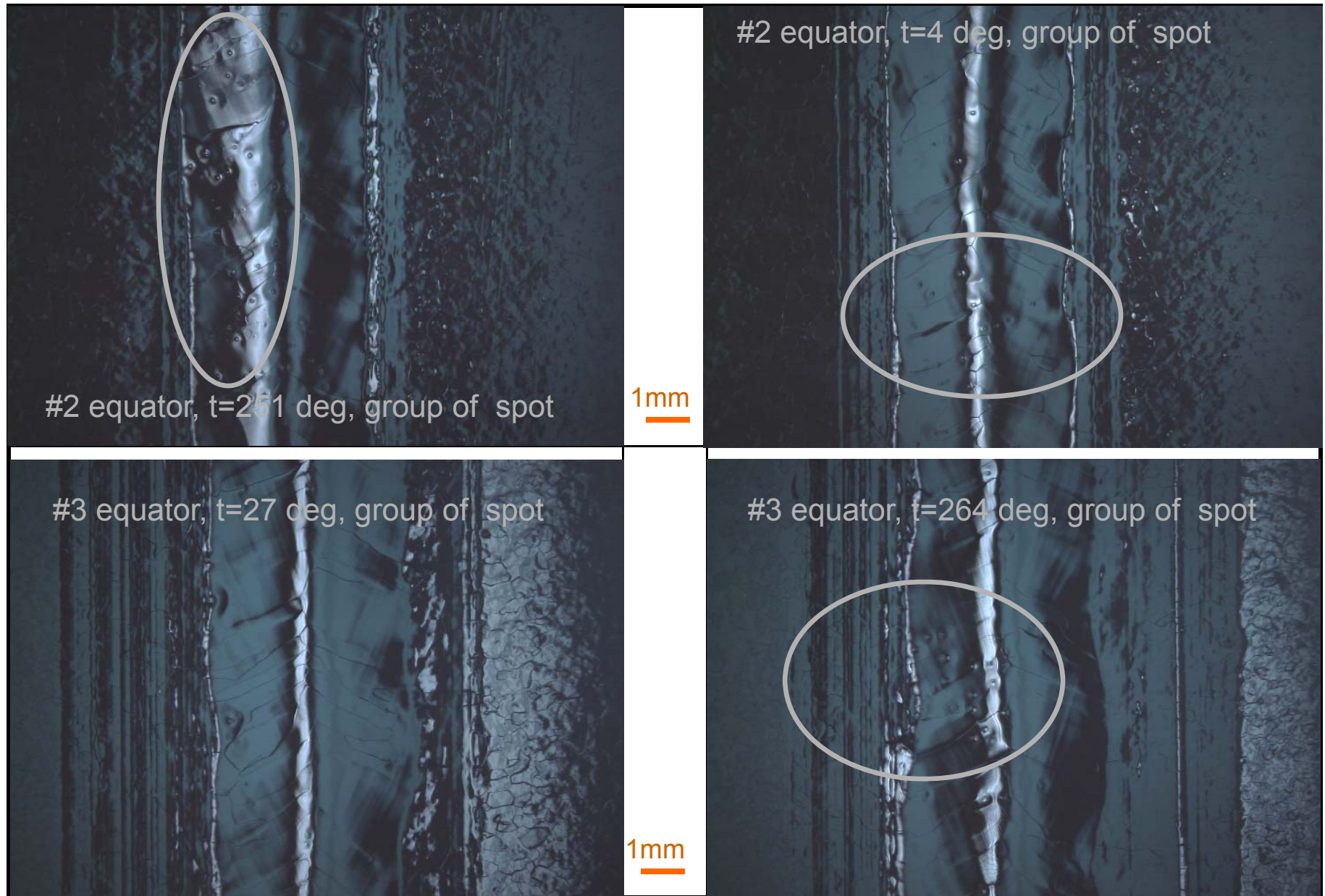
1mm



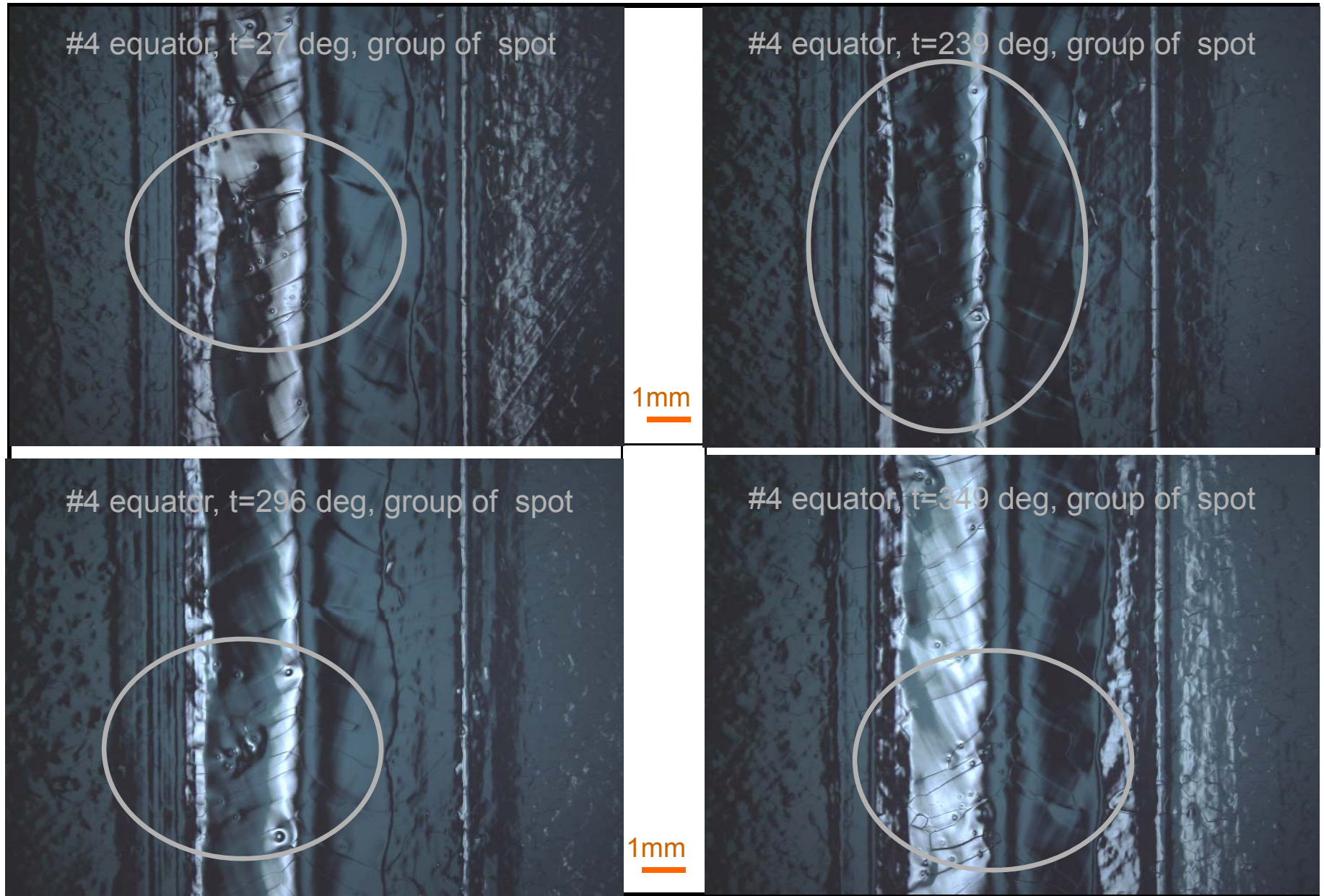
1mm



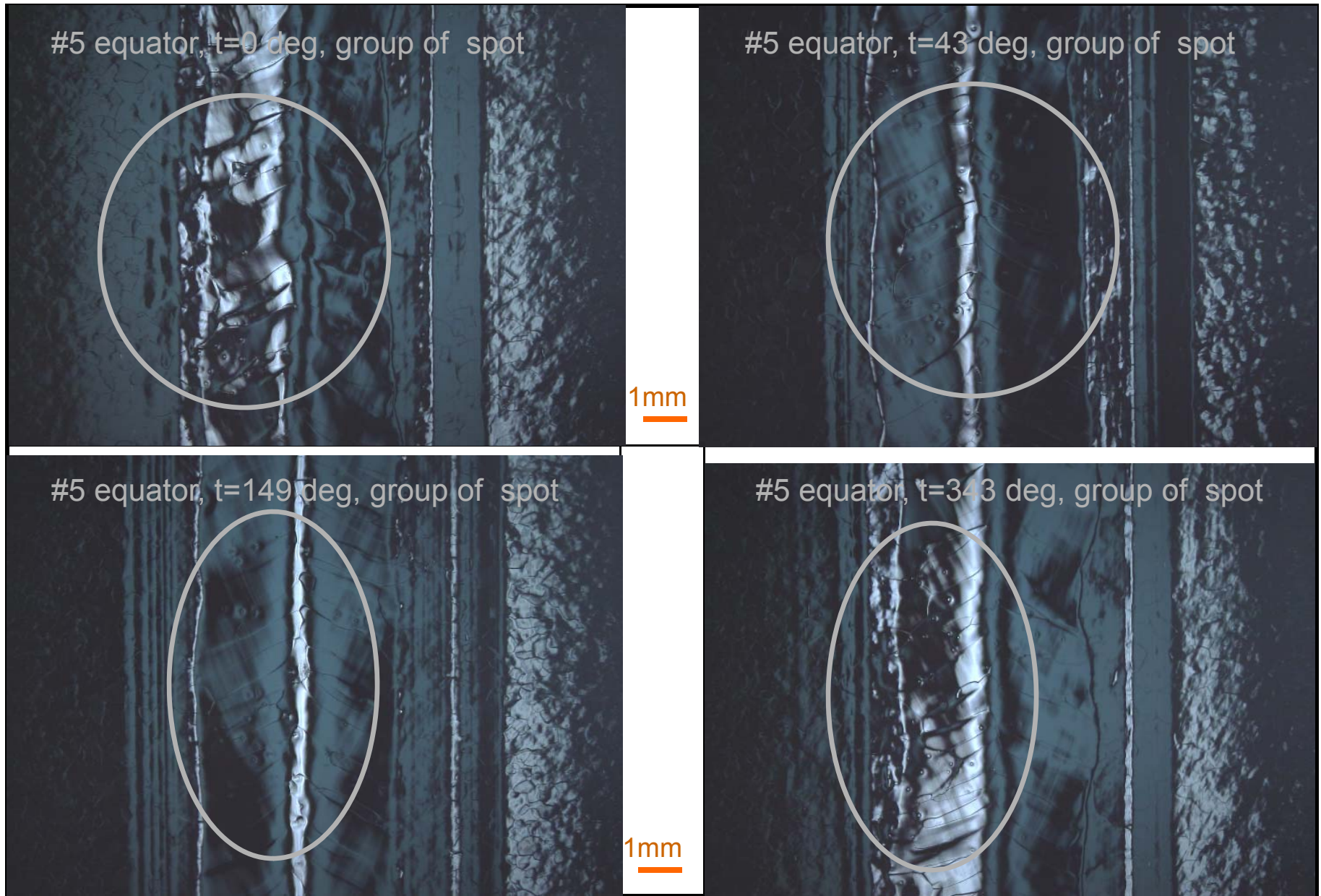
Z111: group of spot (2)



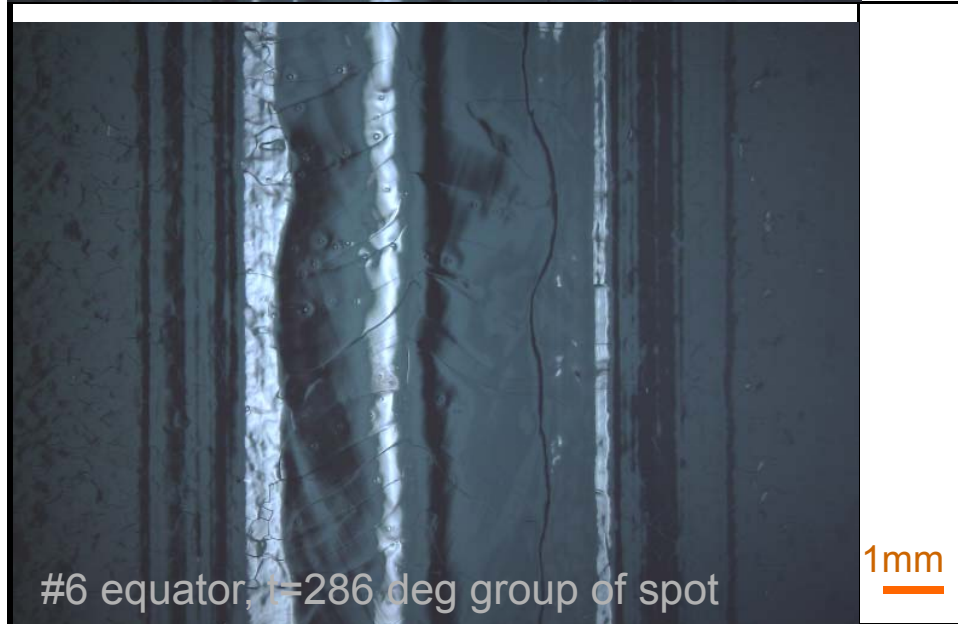
Z111: group of spot (3)



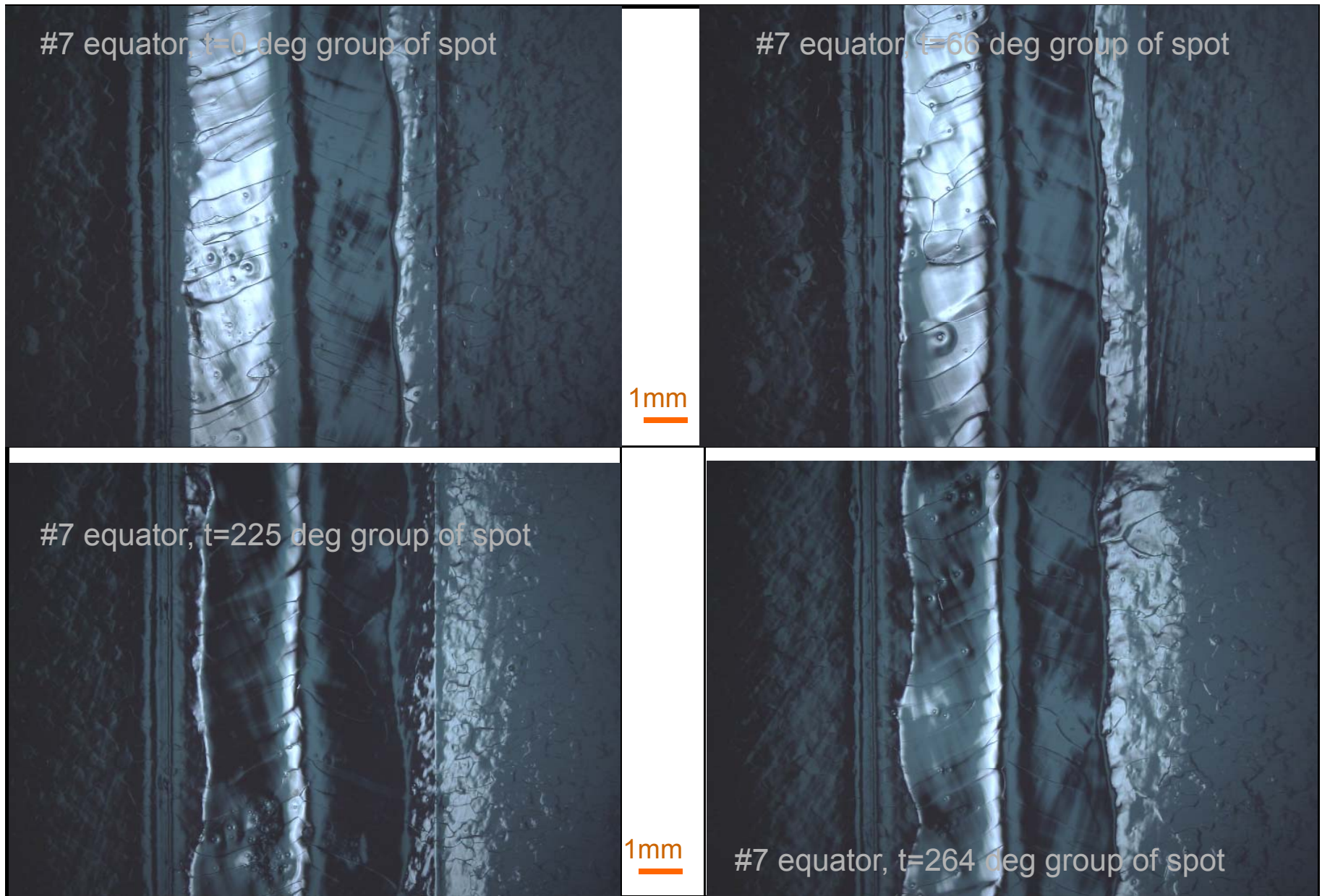
Z111: group of spot (4)



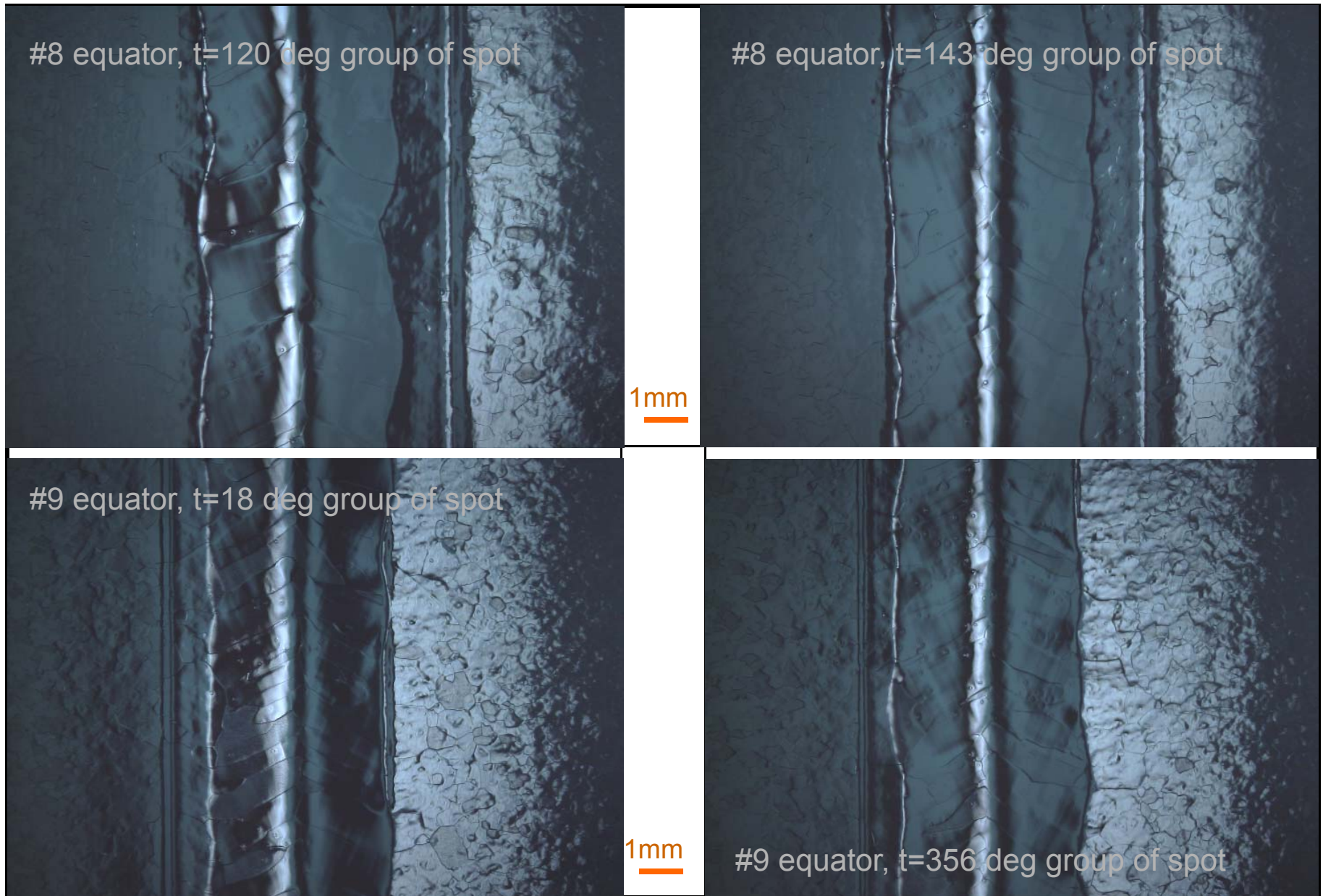
Z111: group of spot (5)



Z111: group of spot (6)



Z111: group of spot (7)



Summary: group of spot on equator

Z110 (total 31 points)

#1 equator : 123 deg.

#2 equator : 68, 121, 152, 178, 334, 356 deg.

#3 equator : 138, 264, 268 deg.

#4 equator : 269 deg.

#5 equator : 40, 48, 70, 74, 79, 84, 88, 128,
213, 276 deg.

#6 equator : 162, 185 deg.

#7 equator : 94 deg.

#8 equator : 236, 254, 274, 291, 294,
296, 301 deg.

(heat location by T-map : 250 ~ 300 deg.)

#9 equator : Nothing.

(There were single spots on along equator of every cell.)

#1,#9 = 17 MV/m, #2,#8 = 15 MV/m, #3,#7 = 19 MV/m

#4,#6 = 14 MV/m, #5 = 20 MV/m

fewer clear spot in the cell exceeding 20 MV/m.

Z111 (total 43 spots)

#1 equator : 0, 9, 13, 42, 154, 184, 192, 326, 339,
347 deg.

#2 equator : 4, 8, 17, 21, 39, 57, 168, 224, 229, 234,
251, 268, 272, 304 deg.

#3 equator : 18, 27, 40, 53, 71, 137, 189, 229, 234, 243,
252, 260, 264, 273, 281, 295, 300, 309,
322, 336 deg.

#4 equator : 0, 14, 18, 23, 27, 40, 54, 156, 160, 182,
208, 235, 239, 248, 256, 265, 273, 296,
340, 349 deg.

#5 equator : 0, 34, 39, 43, 83, 118, 149, 188, 214,
343 deg.

#6 equator : 0, 20, 34, 80, 172, 190, 198, 234, 286, 295,
304, 318, 322, 348 deg.

(heat location by T-map : 175 ~ 225 deg.)

#7 equator : 0, 6, 66, 87, 142, 185, 225, 243, 264, 277,
300 deg.

#8 equator : 19, 53, 120, 143, 173, 186, 265, 305,
340 deg.

#9 equator : 18, 35, 52, 101, 122, 140, 150, 176, 233,
322, 356 deg.

RED: group of faint spots

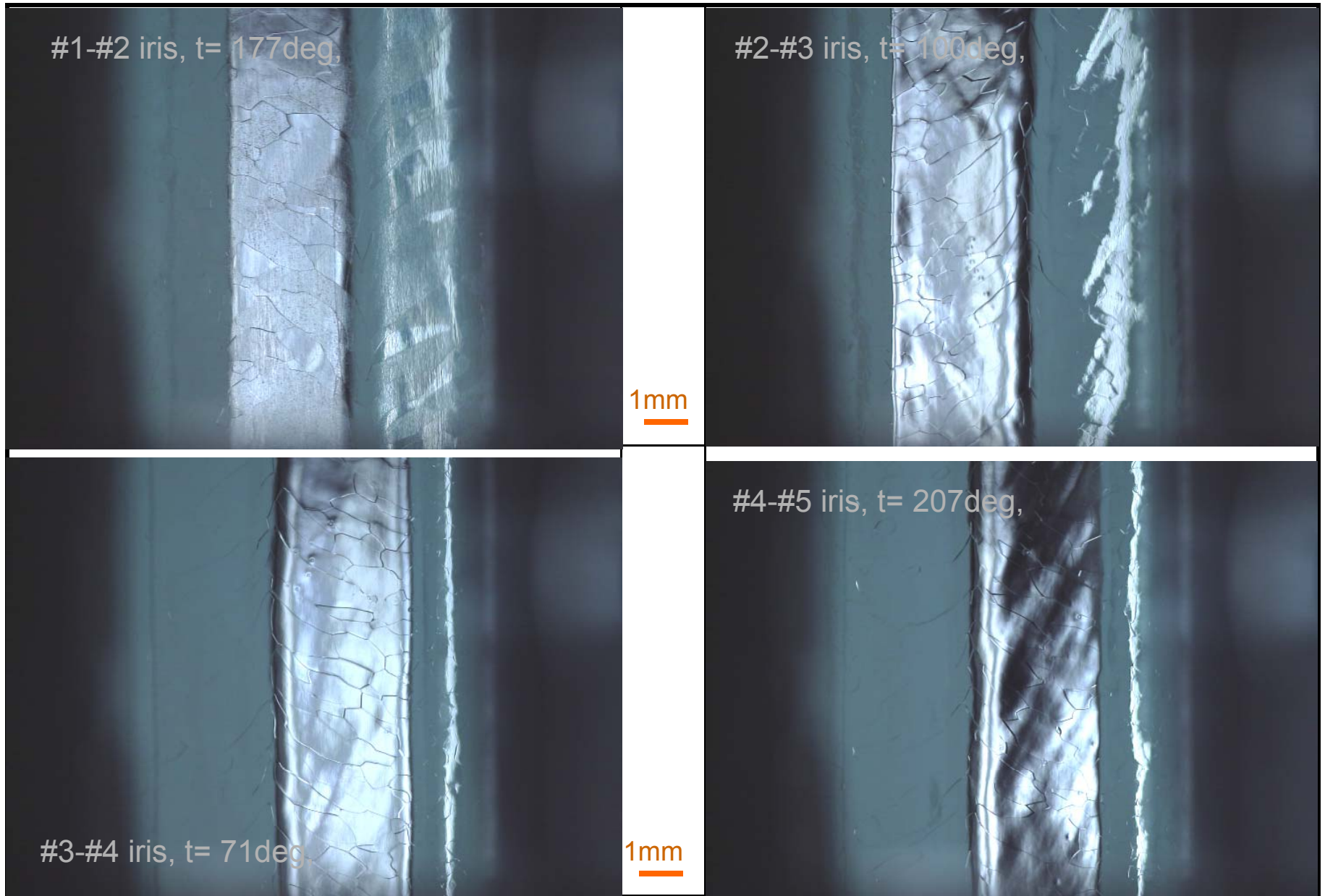
(There were single spots on along equator of every cell.)

#1,#9 = 26 MV/m, #2,#8 = 23 MV/m, #3,#7 = 17 MV/m

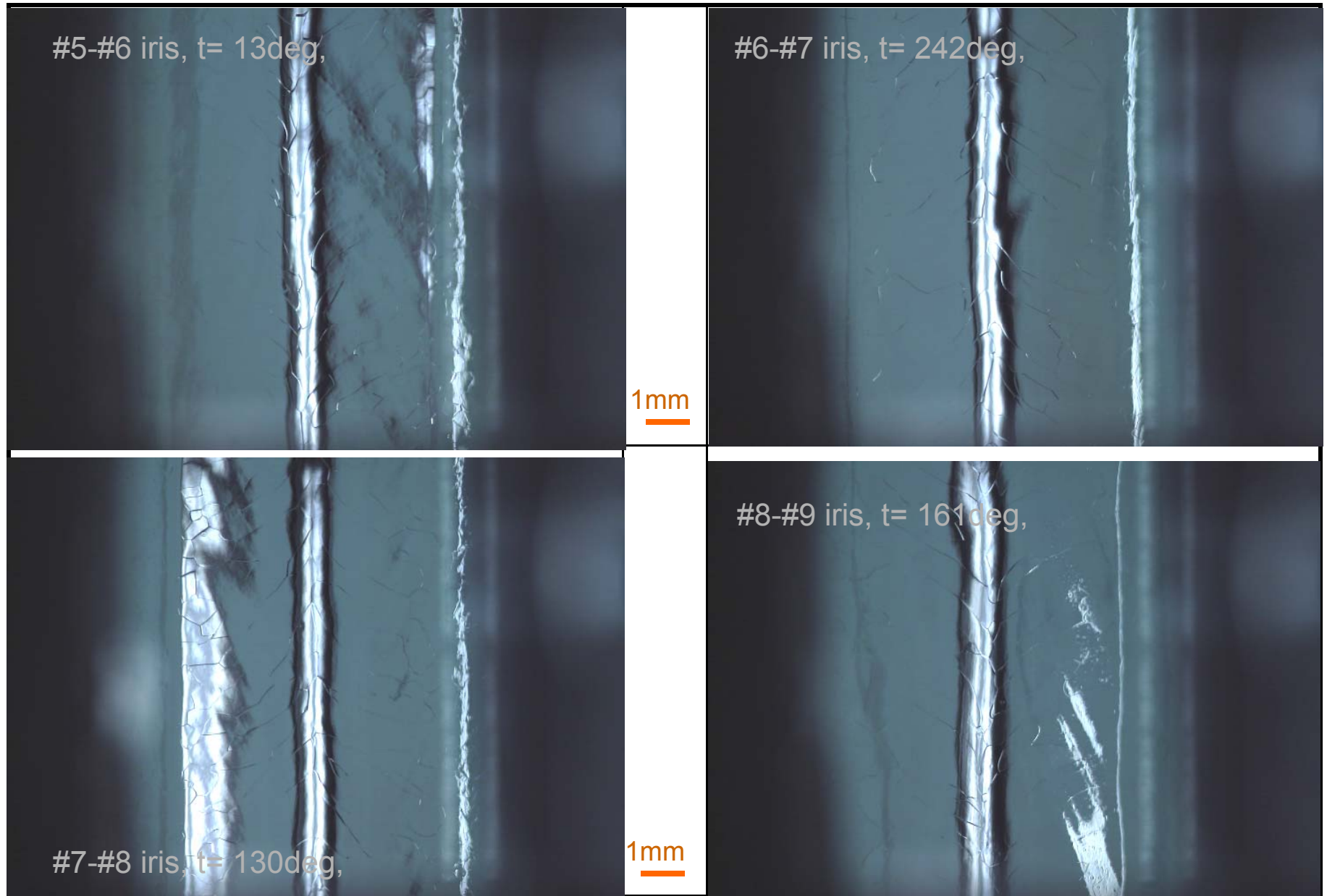
#4,#6 = 16 MV/m, #5 = 23 MV/m

Z111 Iris

Z111: typical pictures iris (1)



Z111: typical pictures iris (2)



Summary: group of spot on iris

Z110

#1-#2 iris : spot 25, 36, 47, 59, 119, 335 deg.

scratch 131, 143, 155, 168, 180, 192,

203, 239, 346 deg

#2-#3 iris : spot 12, 120, 143, 168, 192, 215,

227, 251, 274, 286, 298 deg.

scratch 35, 131, 180, 203, 298, 310,

322, 334, 346 deg

#3-#4 iris : spot 15, 170, 217, 228, 241, 348 deg.

scratch 0, 26, 337 deg.

#4-#5 iris : spot 25, 37, 217, 229, 253 deg.

scratch 25, 288, 312, 336, 348 deg.

#5-#6 iris : spot 71 deg.

scratch 25, 131, 180, 192 deg.

#6-#7 iris : spot 13, 121, 181 deg.

scratch 132, 144, 192 deg.

#7-#8 iris : spot 48, 335 deg.

scratch 131, 144, 156, 168, 180, 192,

204, 215, 228 deg.

#8-#9 iris : spot 0, 12, 24, 47, 59, 144, 227, 239,

263, 286, 311, 323 deg.

scratch 132, 144, 156, 169, 181,

192, 204, 215 deg.

(many scratches and spots on whole iris around.)

scratches on 132deg and 192deg seem to coincide on many of irises. Maybe, some long tool made them by putting/pulling into cavity?

Z111

#1-#2 iris : no big spot, no scratch.

#2-#3 iris : no big spot, no scratch.

#3-#4 iris : no big spot, no scratch.

#4-#5 iris : no big spot, no scratch.

#5-#6 iris : no big spot, no scratch.

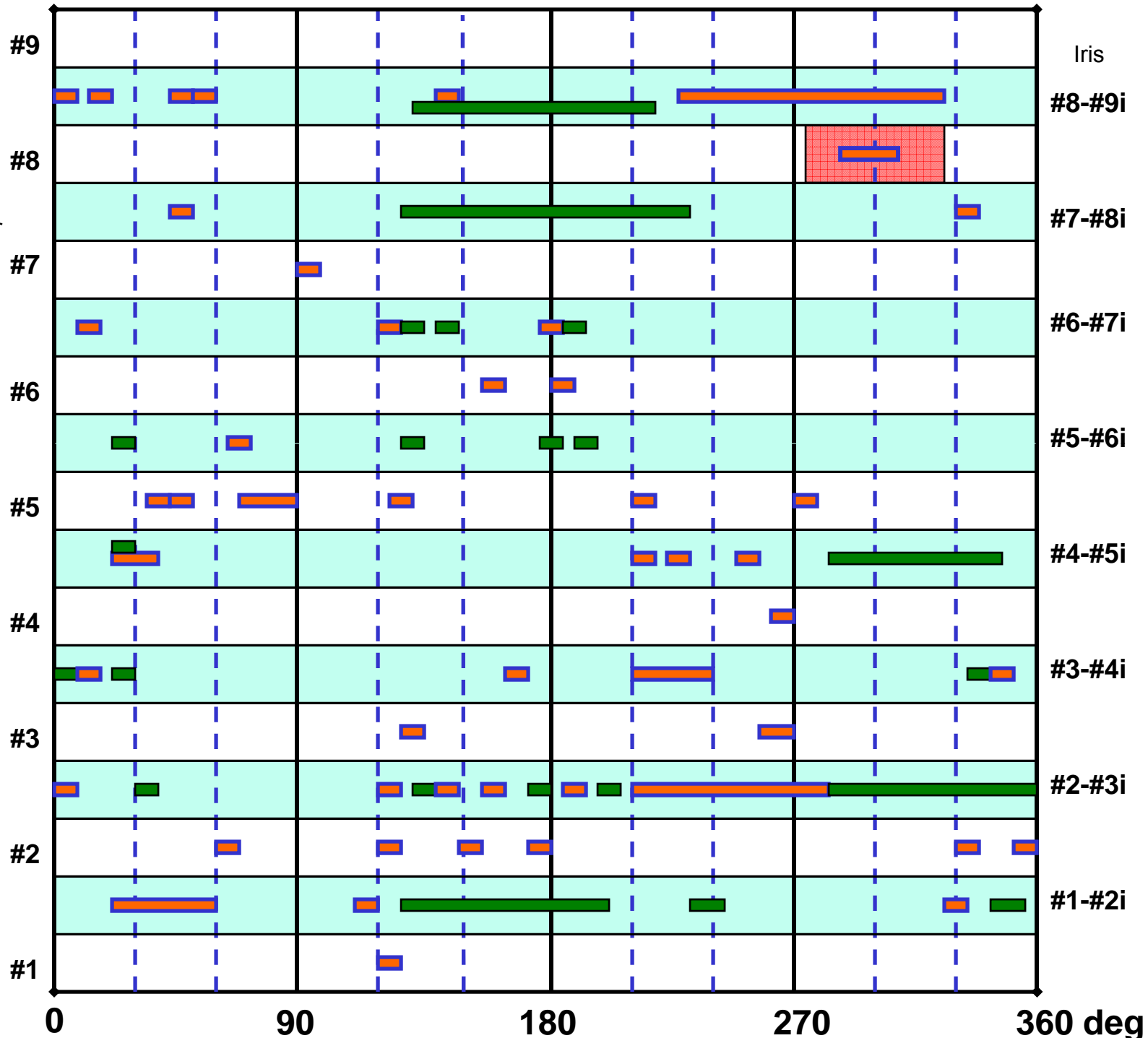
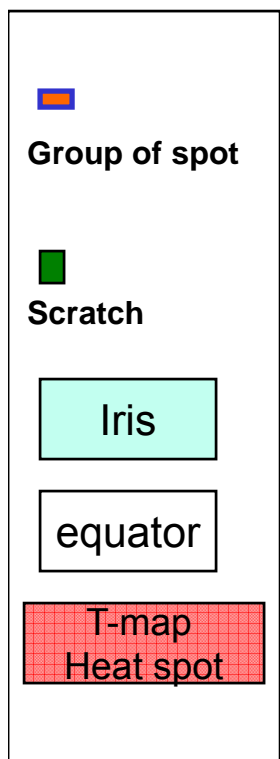
#6-#7 iris : no big spot, no scratch.

#7-#8 iris : no big spot, no scratch.

#8-#9 iris : no big spot, no scratch.

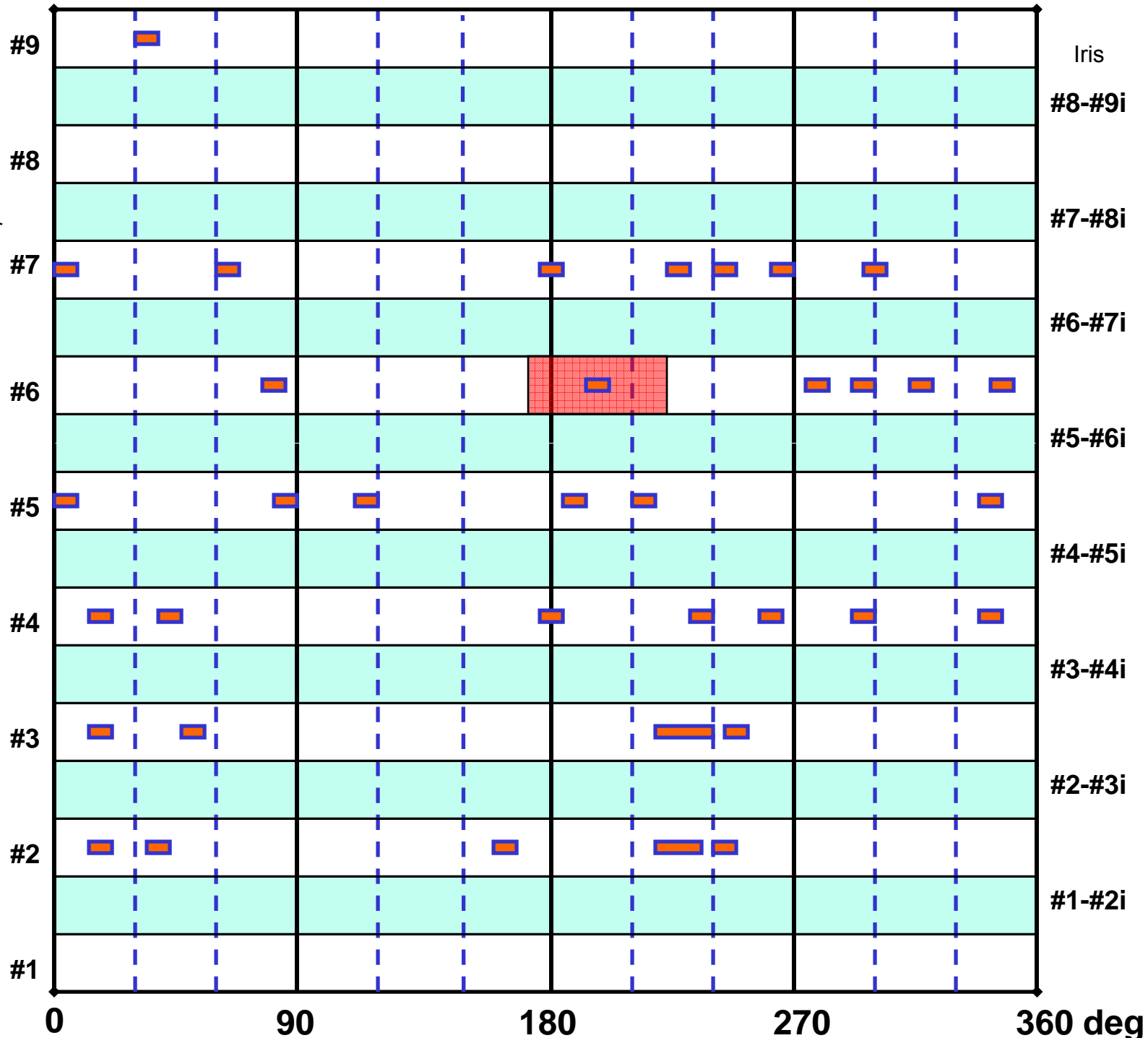
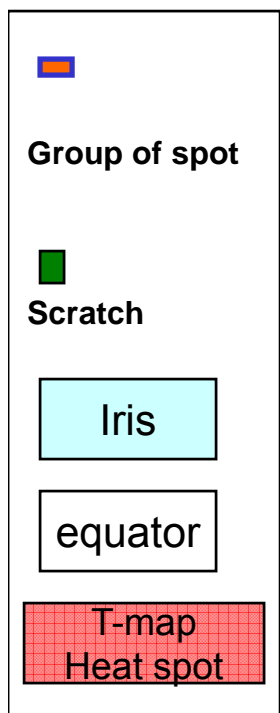
Z110
summary
08/05/12

cell equator



Z111
summary
08/05/15

cell equator



Inspection Summary

1. Surface inspection was done on T-map heat spot location and whole of EBW location (whole of equator and iris).
2. Group of spots (bead or pit will be analyzed later) were found in coincident with T-map heat location.
3. There were two type of spots on Z111, clear bump spots and faint bump spots.
4. Clear bump spots are seen on $< 23\text{MV/m}$ cell field.
5. Faint bump spots dominant cell has $>26\text{MV/m}$ cell field.
(Z111 #1 #9 cell)
6. Z111 #1, #9 cell were relatively smooth surface.
7. Spots are relatively bumpy in lower cell field.

Next: re-inspection of AC71,74,80 (it was done by Y. Tajima (Kyoto) with in hurry), and compare with Z110,Z111 in detail.

まとめ

TESLA Z110,Z111の発熱位置および溶接ビード全面の内面観察を行った。

DESYでの縦測定で観測された発熱位置の内面にはスポットの集合体があった。

スポットを大雑把に分類すると、凹凸の大きい集合体と凹凸の小さい集合体がある。

(このスポットの分類が最大電界とどのような関係があるのか?、ないのか?)

Z110とZ111の内面観察より見られた傾向は、加速電界が23MV/m以下のセルでは凹凸の大きいスポットの集合体があった。

加速電界が26MV/m出ているセル (Z111 : #1,9セル) では、凹凸の小さいスポットが支配的であった。

: 加速電界が出ているセル (Z111 : #1、#9など) はスポットの集合体が観測されはしたが、表面自身は滑らかで、起伏が小さかった (Z110では見られなかった。Z110は302 μ m研磨している。Z111は155 μ m研磨している。研磨量の違いによるものか。) 。

加速電界が出ていないセルのスポットの集合体は起伏が激しいものであった。

今後の予定

AC71 7 1 80 の3穴眼の内面観察を行い、Z110とZ111との比較を行う