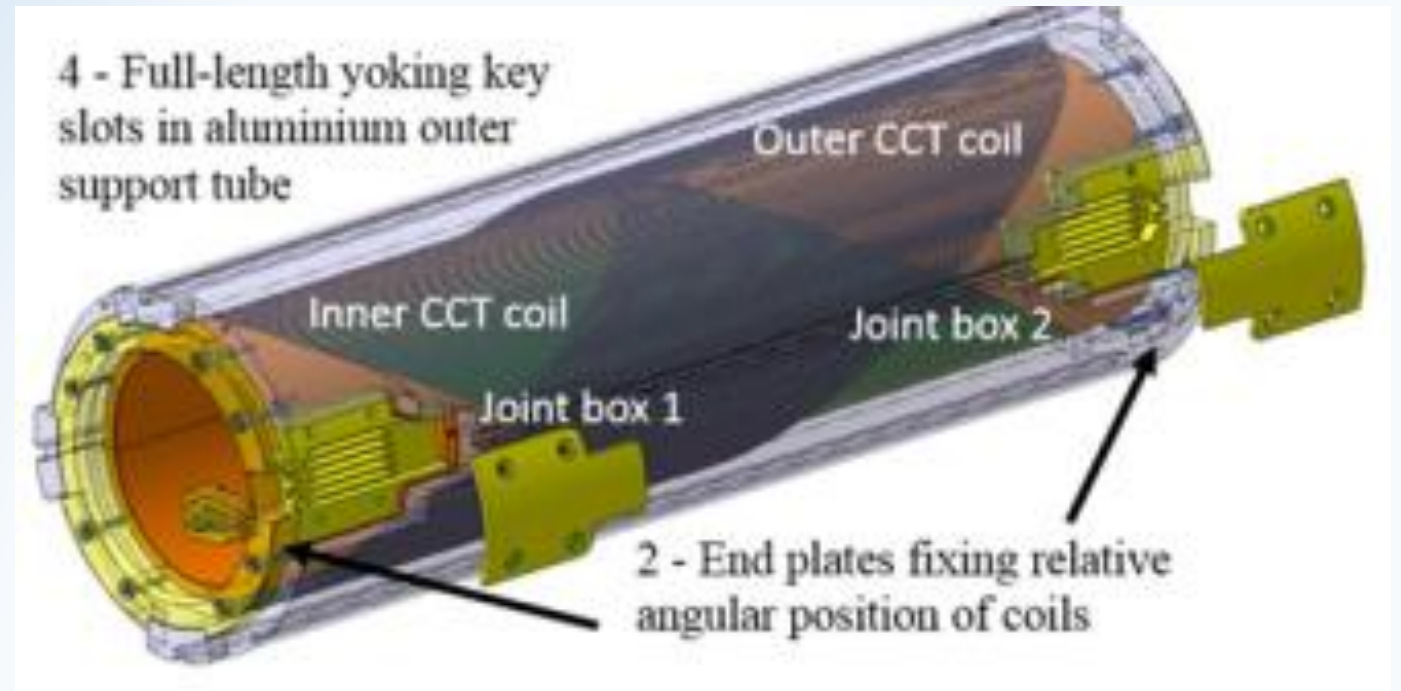


# Canted-Cosine-Theta (CCT) magnets

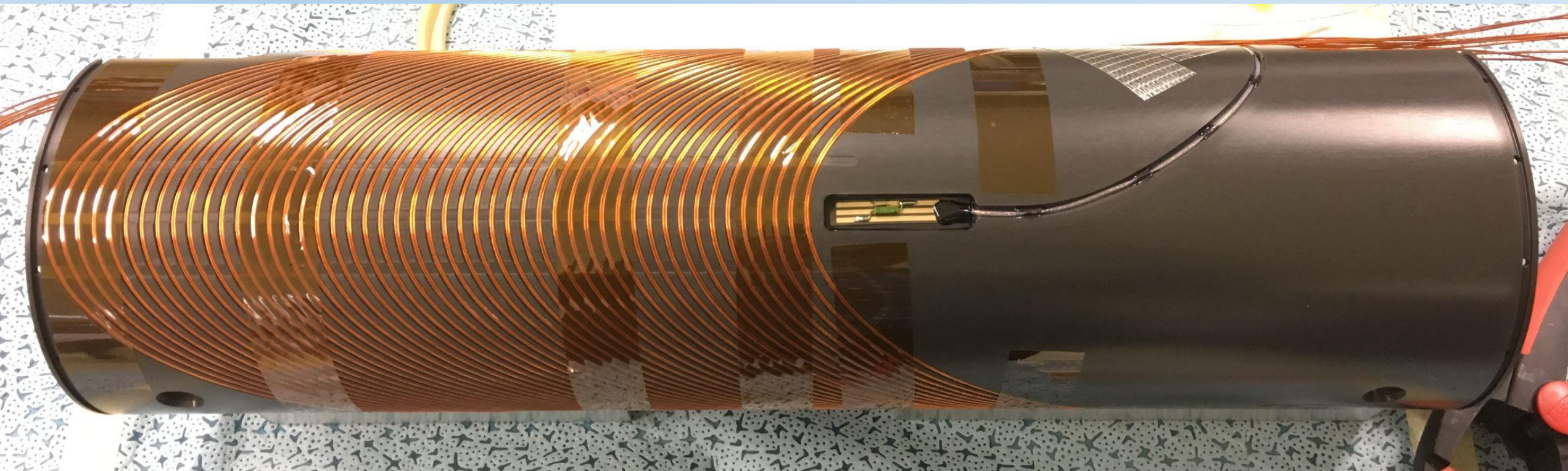
## Optical examination

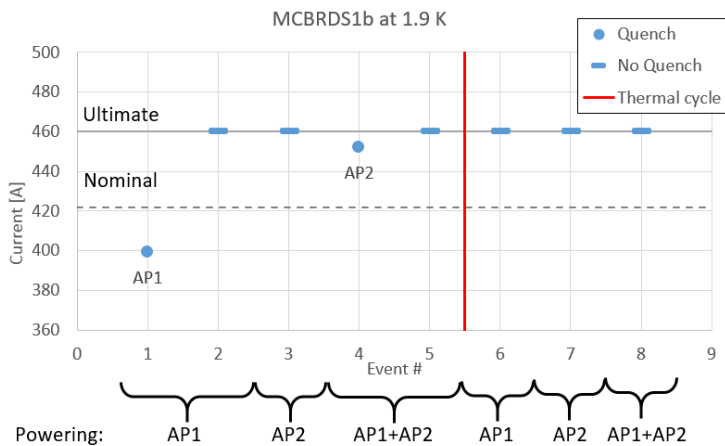
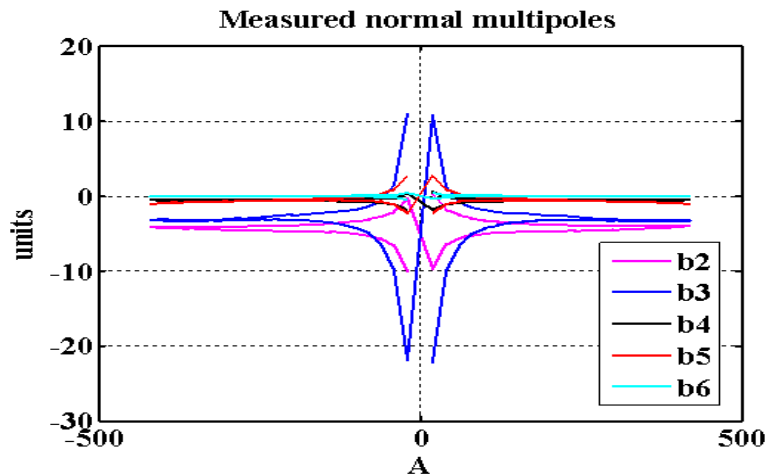


**Glyn Kirby** TE-MS-C-SMT & Mickaël MEYER - Mickaël CROUVIZIER EN-MME-MM

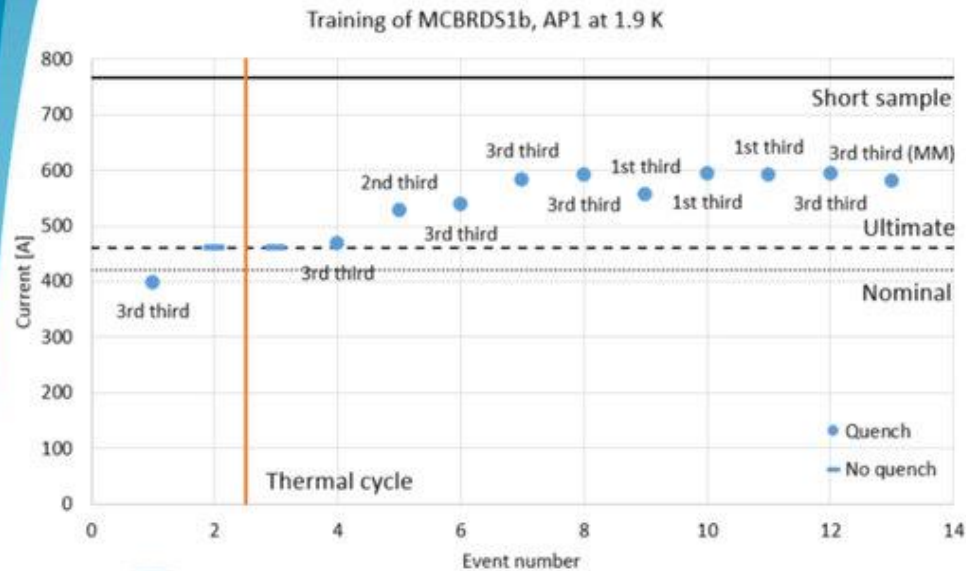








## Training beyond ultimate current: AP1



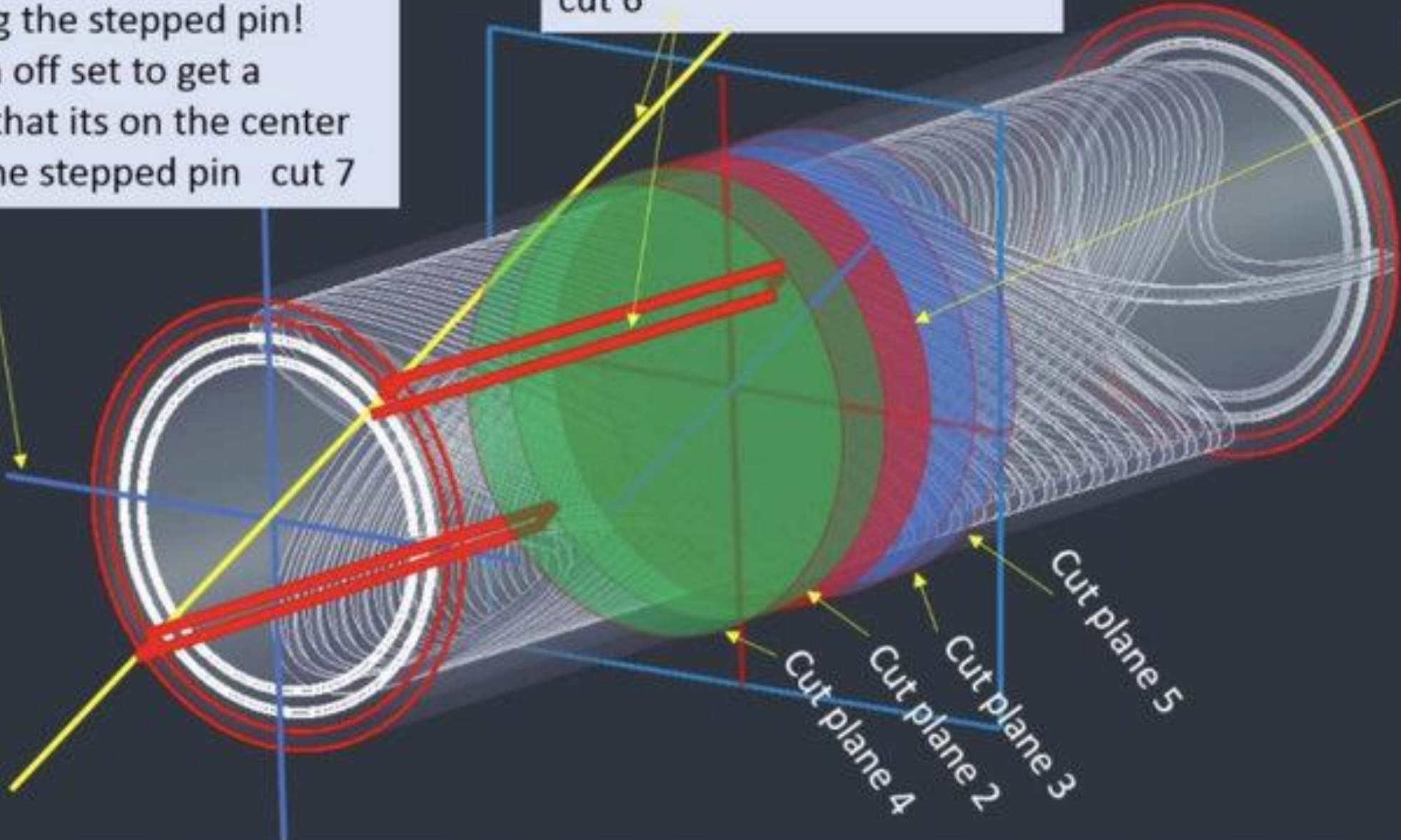
- Plateau at around 590 A (~80% ss)
- Last quench during MM at 580 A
- $QI < 11 \text{ kA}^2\text{s}$
- AP2: not yet

This is Ap1 powering it worked well

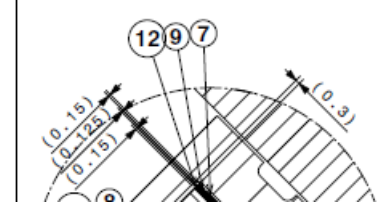
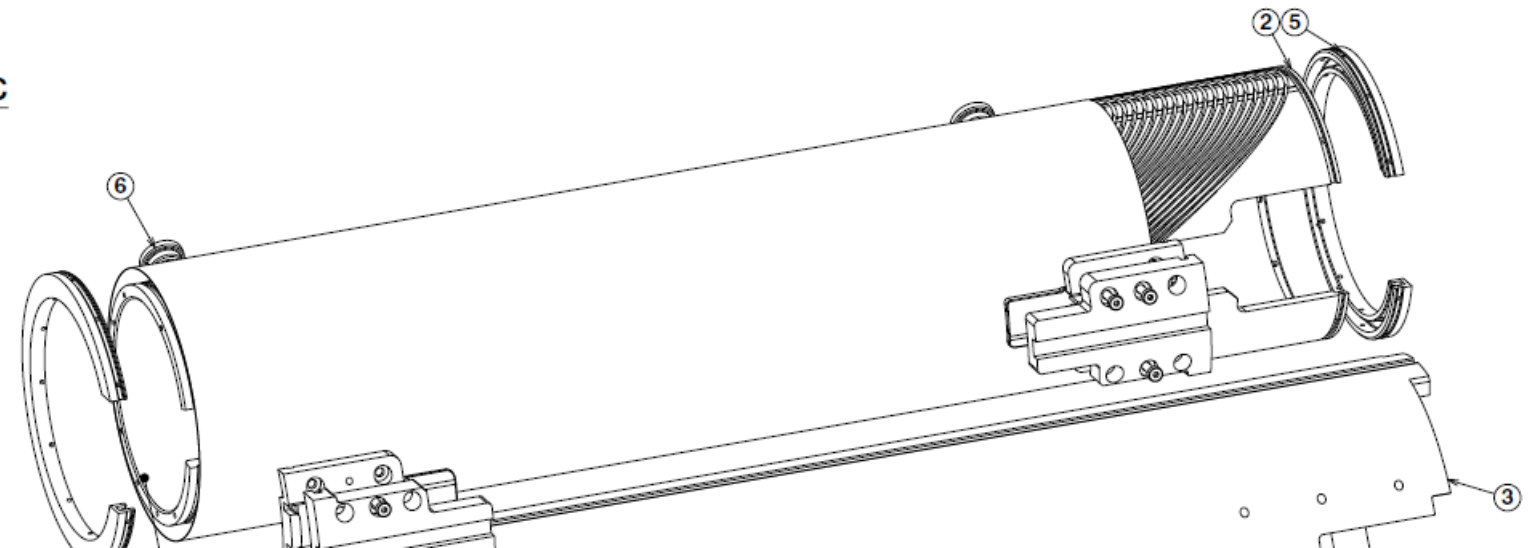
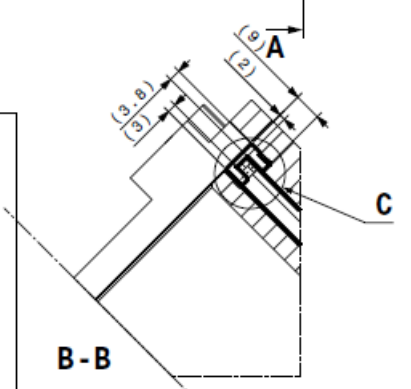
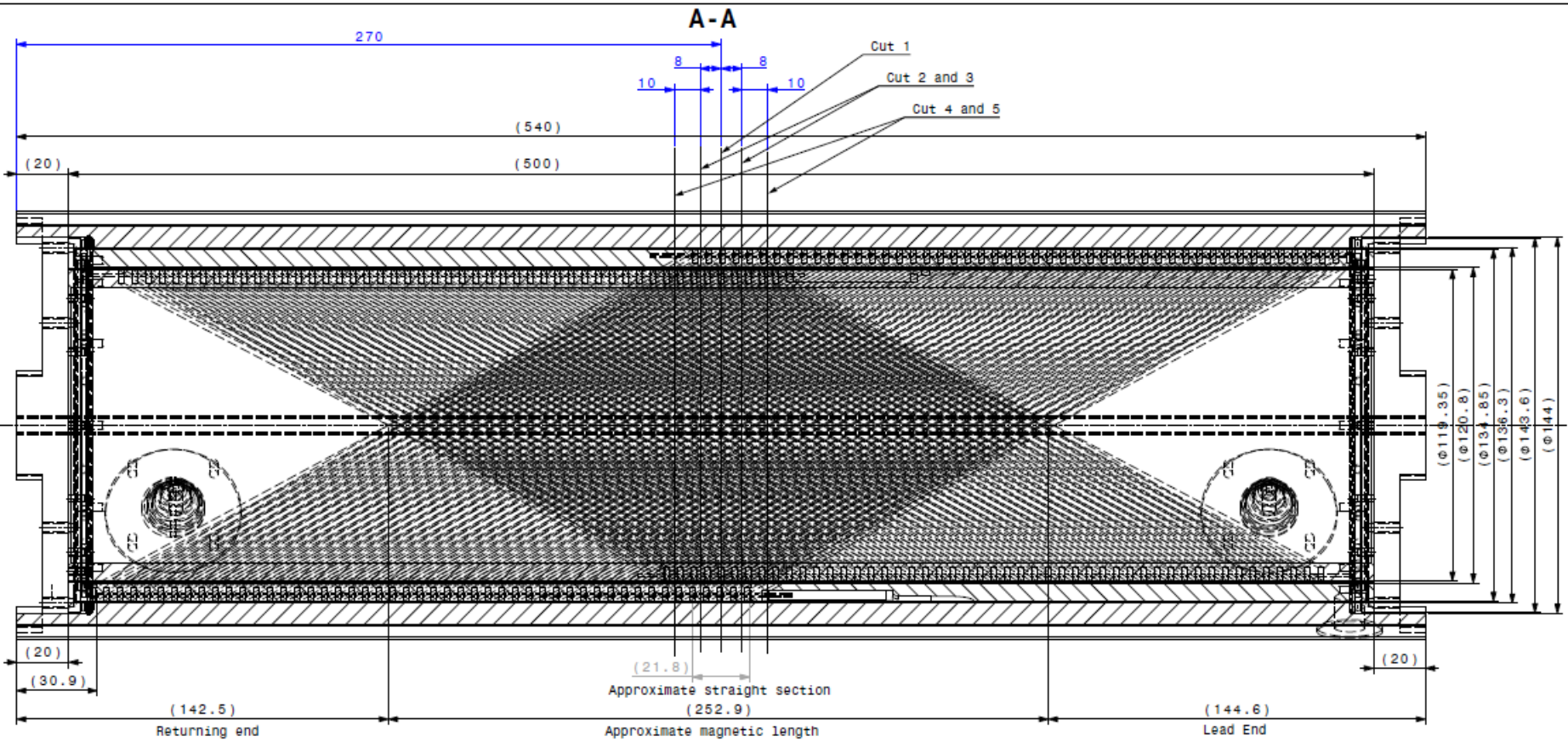
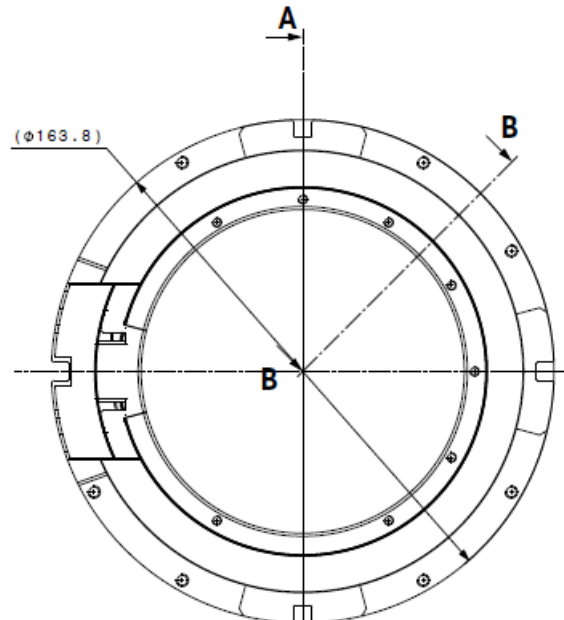
Cut through all layers of this end section. Including the stepped pin! with an off set to get a surface that its on the center line of the stepped pin cut 7

Cut through all layers at 45 deg to the horizontal axis cut 6

Center cut 1



the layers will fall apart so think how to support. Keep all parts. we plan to make a radiation test on part of the inner layer !



BILL OF MATERIALS					
PO#	QTY	DESCRIPTION	REFERENCE	MATERIAL	REV
01	1	MCRD Model Coil Assembly - Inner Coil	LHCMCRD00015 ST1012975	Alu EN #A-5882 (T4)	
02	1	MCRD Model Coil Assembly - Outer Coil	LHCMCRD00016 ST1012977	Alu EN #A-5882 (T4)	
03	1	MCRD Model Coil Assembly - External Support Tube	LHCMCRD00017 ST1012978	Alu EN #A-5885 (H116)	
04	2	MCRD Model Coil Assembly - Connection Box Assembly	LHCMCRD00018 ST1012980		
05	2	MCRD Model Coil Assembly - Insulation Ring	LHCMCRD00021 ST1012984	Epoxy GF # GC 38 (8-11)	
06	2	MCRD Model Coil Assembly - Stage Pin	LHCMCRD00022 ST1012985	Epoxy GF # GC 38 (8-11)	
07	1	MCRD Model Coil Assembly - Inner Sensor Temperature Trace	LHCMCRD00023 ST1012986	WPTM # (F1)	

# The two Mickael's from MME, took a lot of imagens see all in the EDMS report

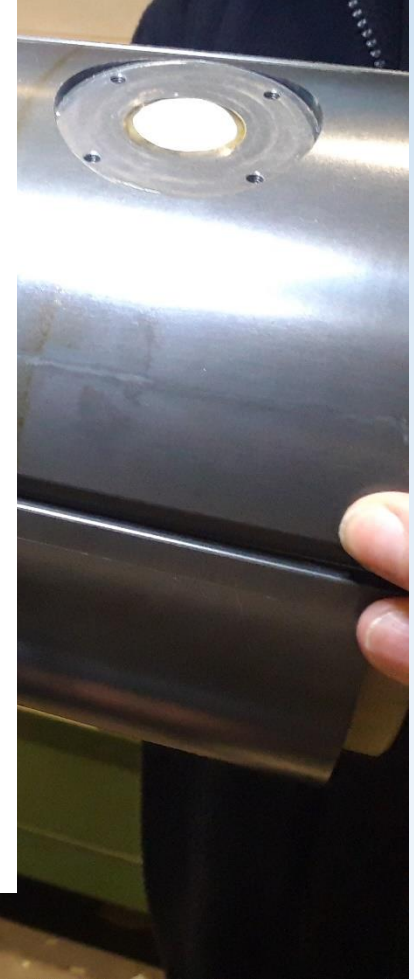




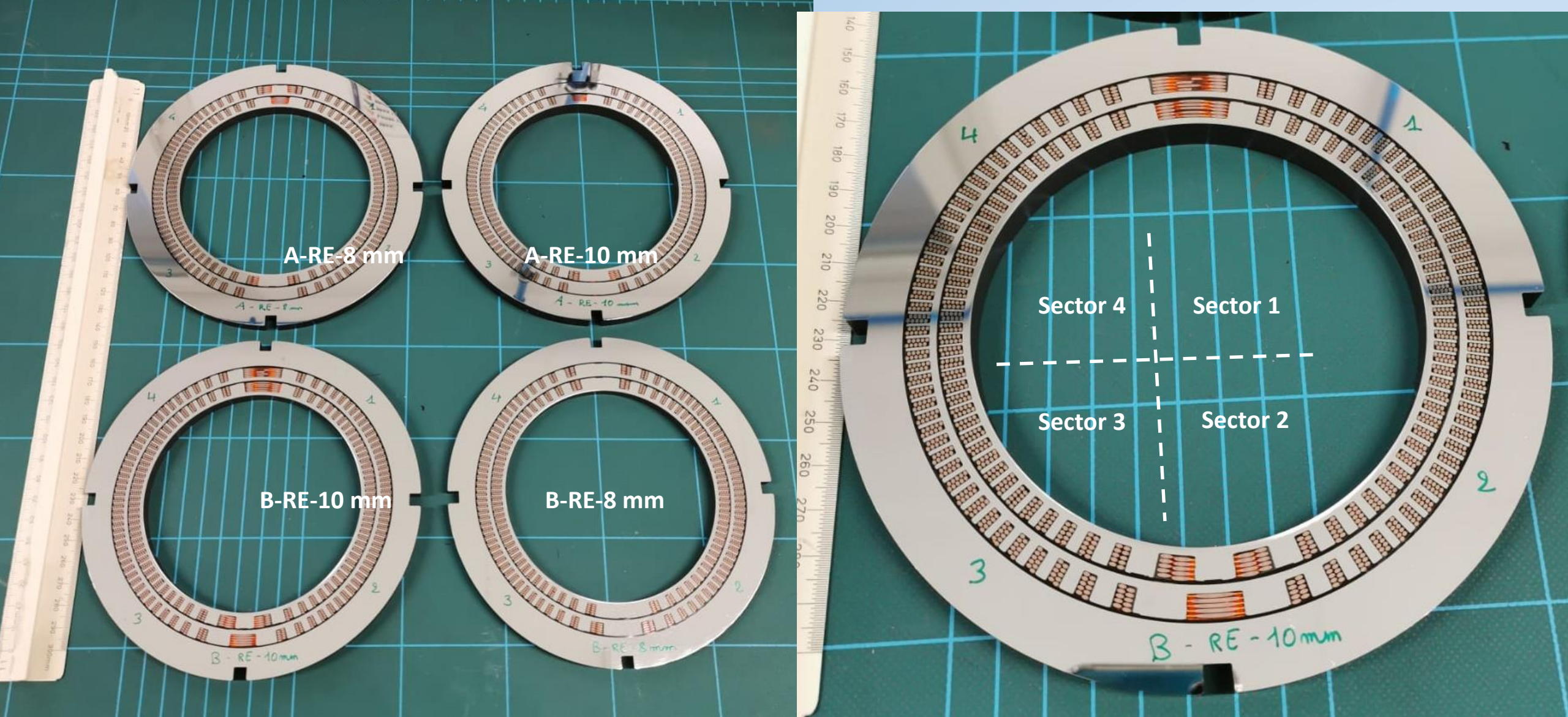
Thanks to Juan  
for arranging  
the cuts and  
polishing



Dimond wire to cut aperture



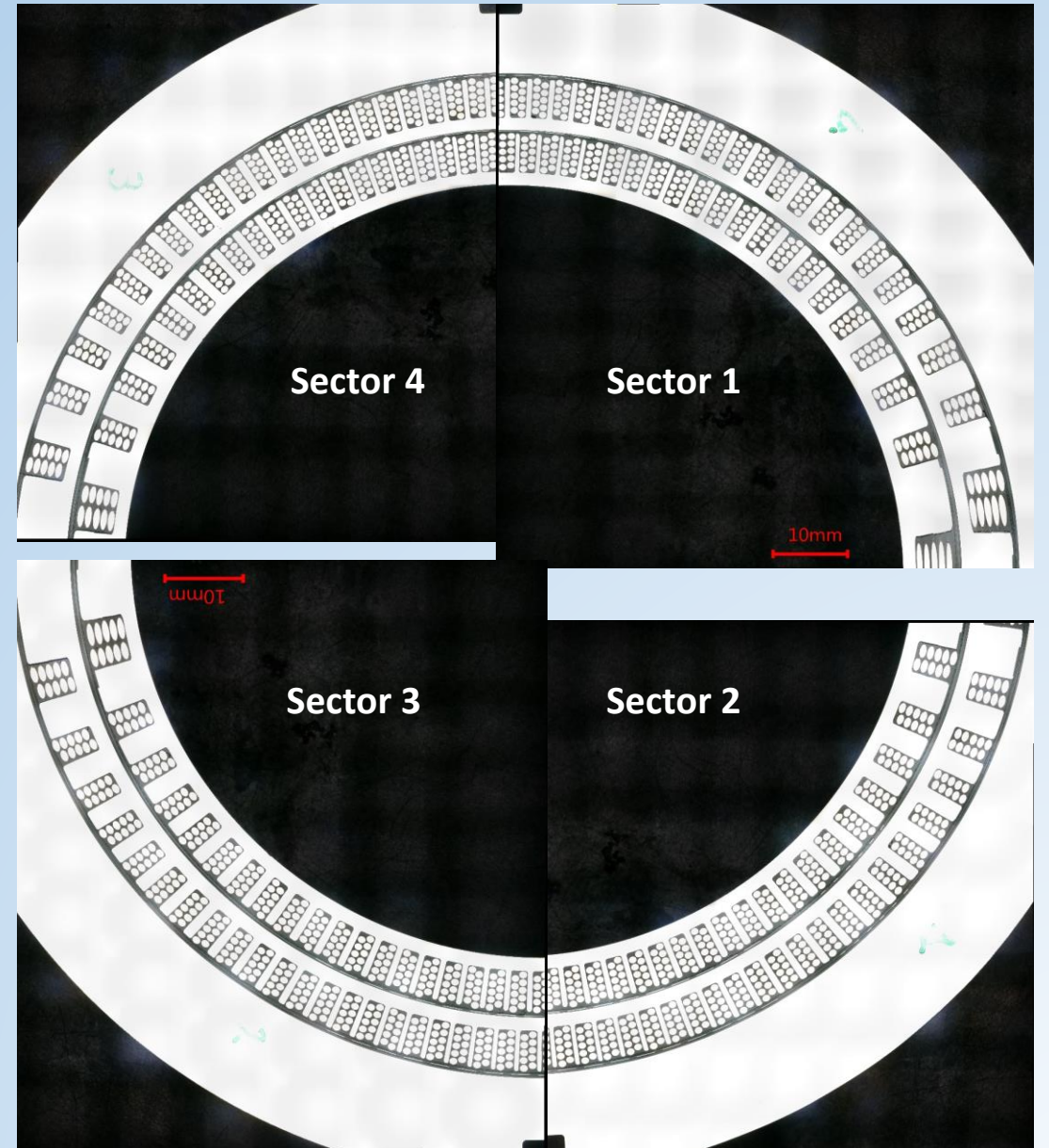
# Manual polishing of 4 slices from CCT magnet



# 1. Preparation

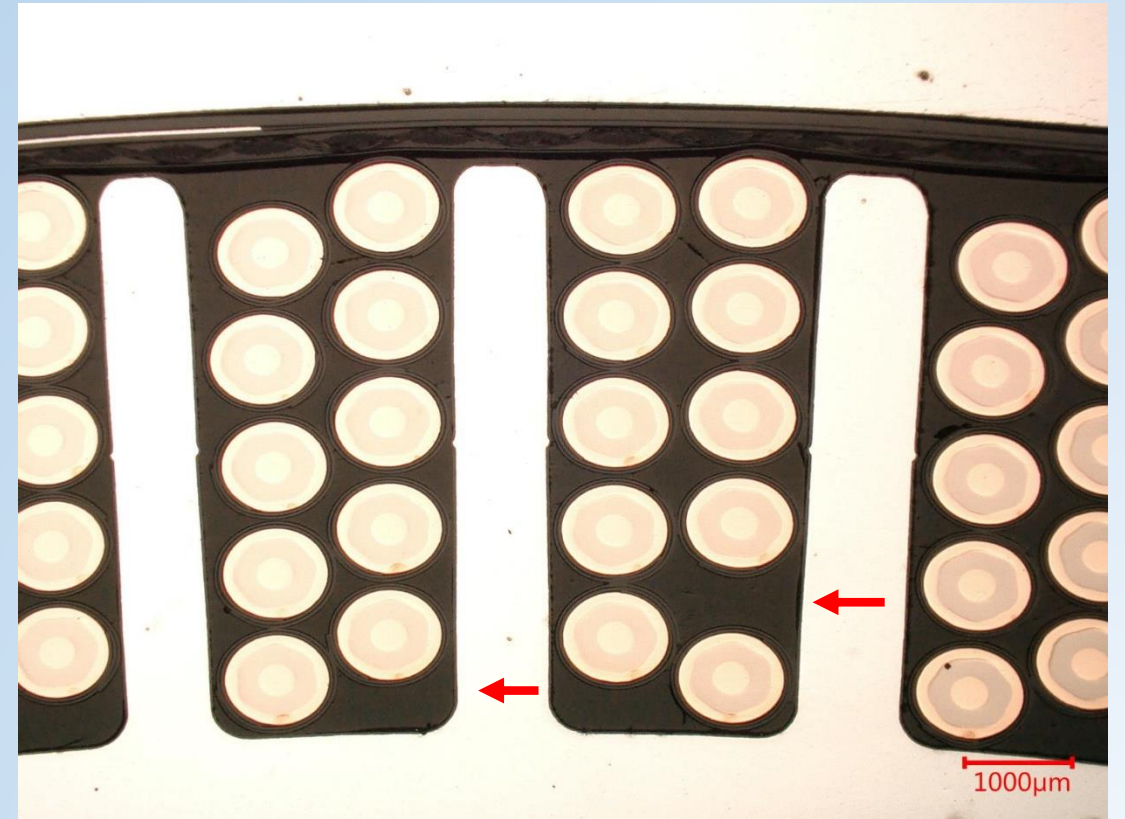
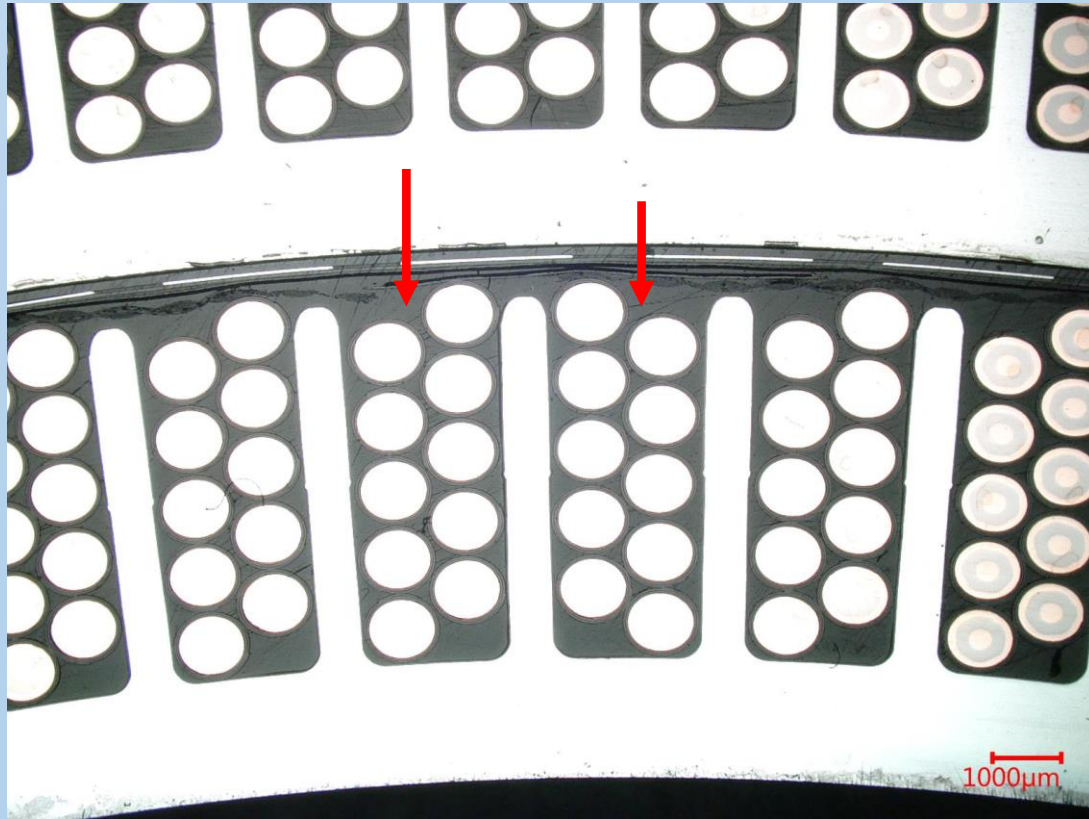
- Manual polishing of the 4 slices for optical observation with a digital microscope
- Full stitching of each sector and inspection of the different type of potential imperfections

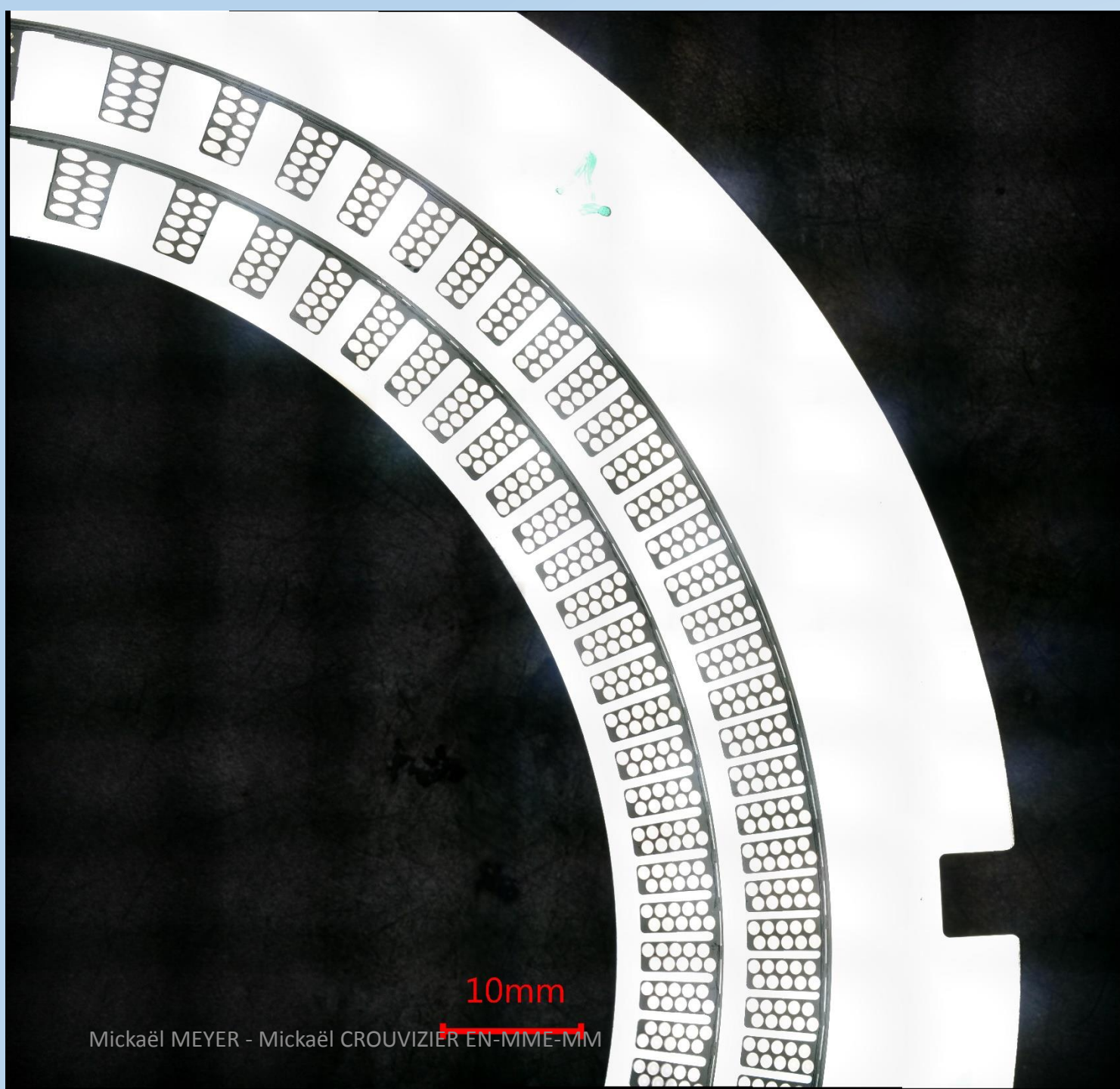
All original high definition pictures are set out in annexes in [EDMS 2453524](#)



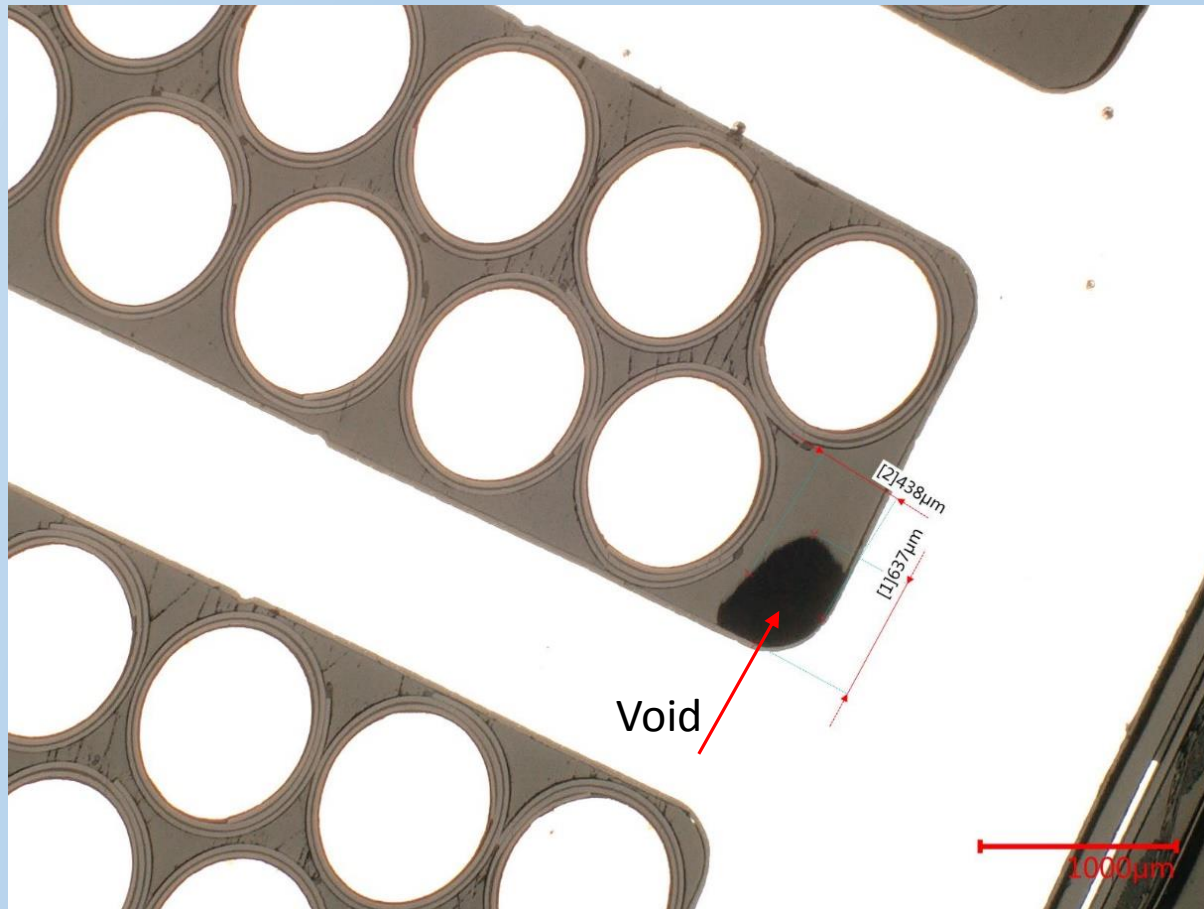
## 2. Type of potential imperfections

- Stacking positions of the superconductive wires

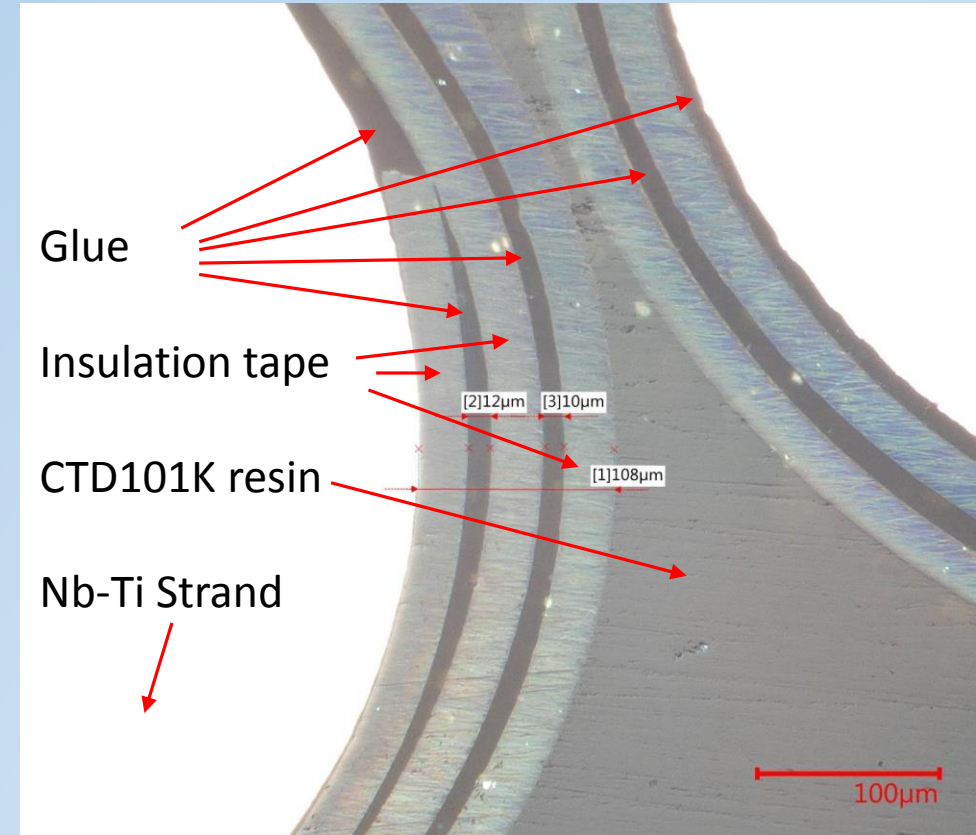
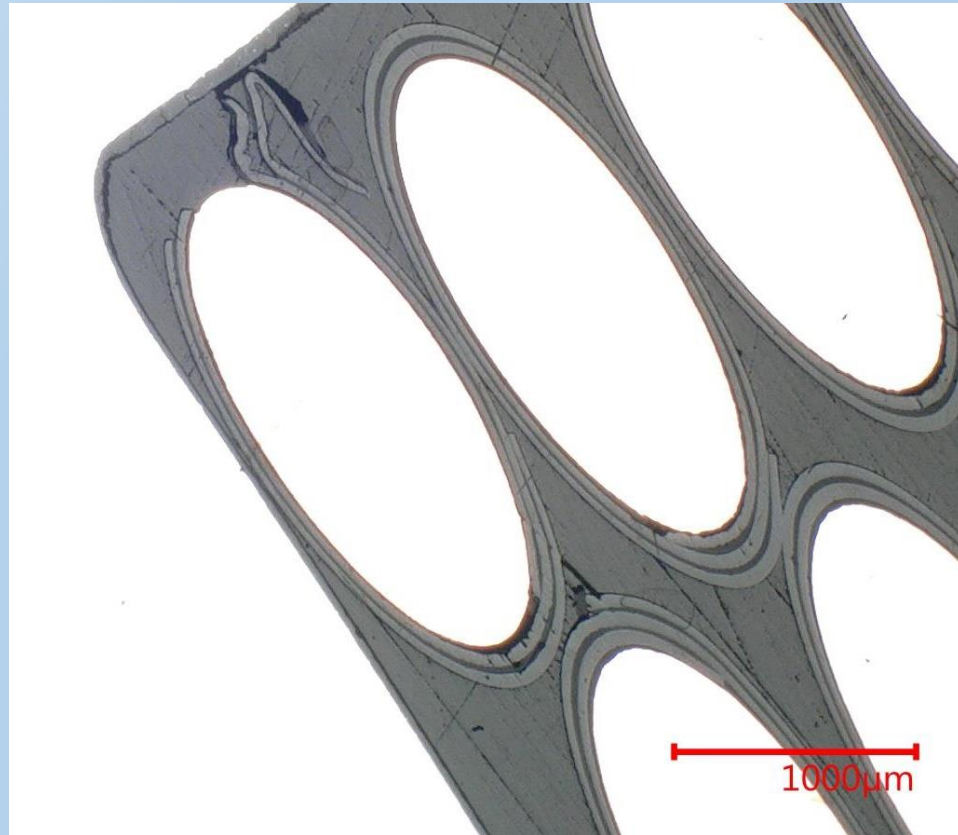




- Void, shrinkage or crack at the resin



- Damaged wire insulation

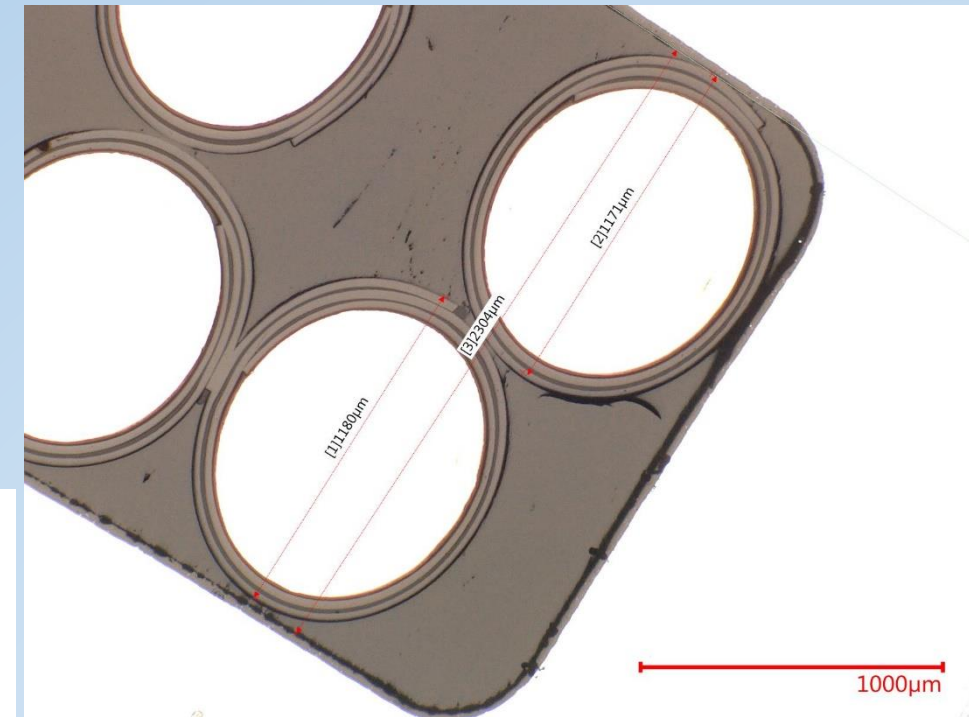
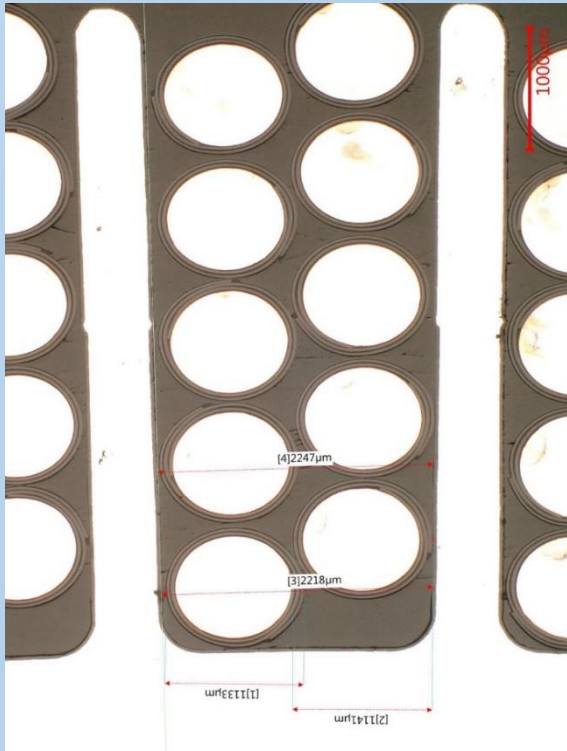


# 3. Observations

## ■ Measurement of throat width

- Throat width = 2218  $\mu\text{m}$
- Wire + insulation = 1133 + 1141 = 2274  $\mu\text{m}$

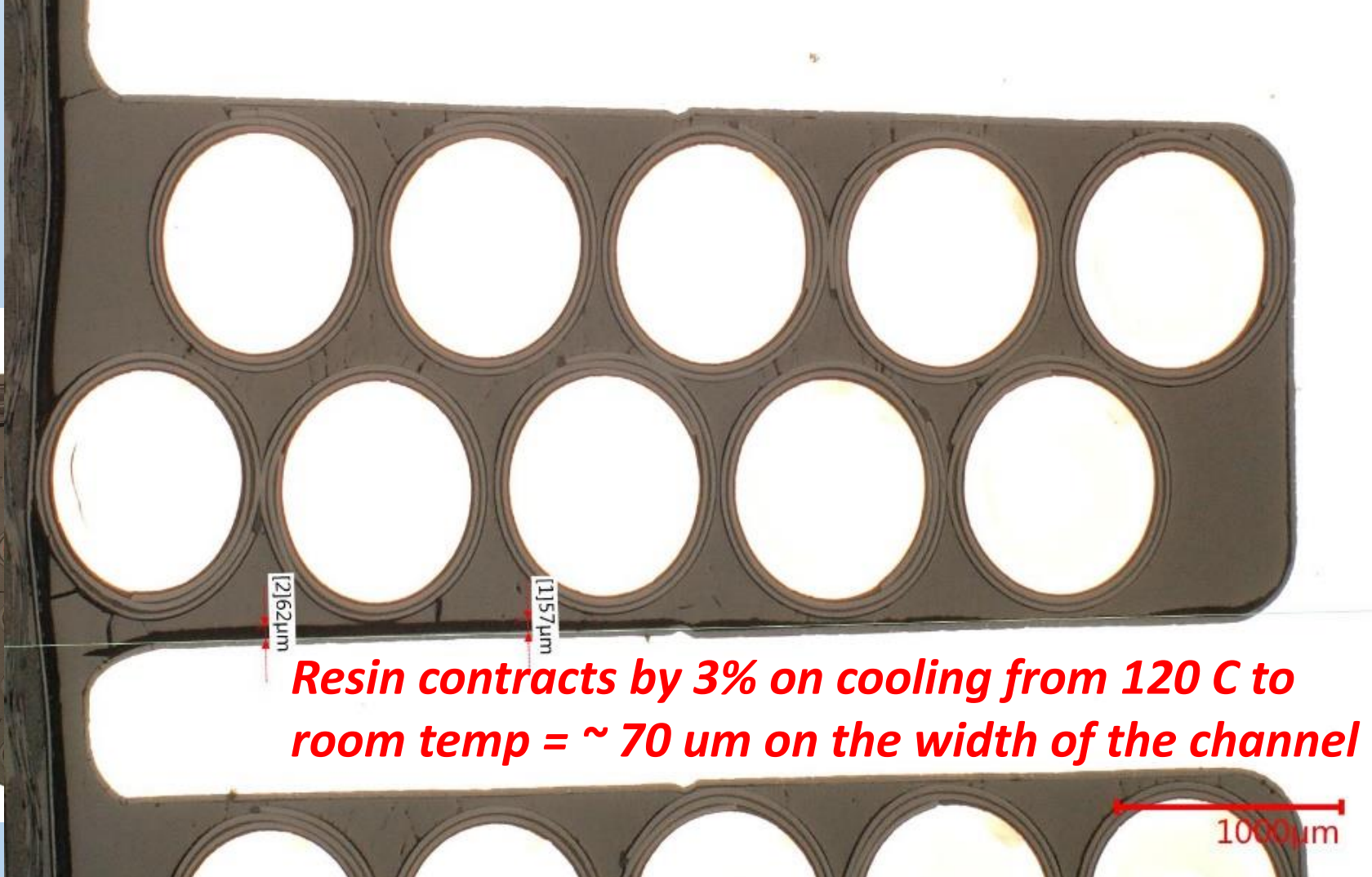
Designed stacking is not possible due to lack of space!



Systematic stacking position errors are observed at all examined slices. Only rare channels exhibit good alignment.

(see stitched pictures in annexes)





B 8mm sector 3

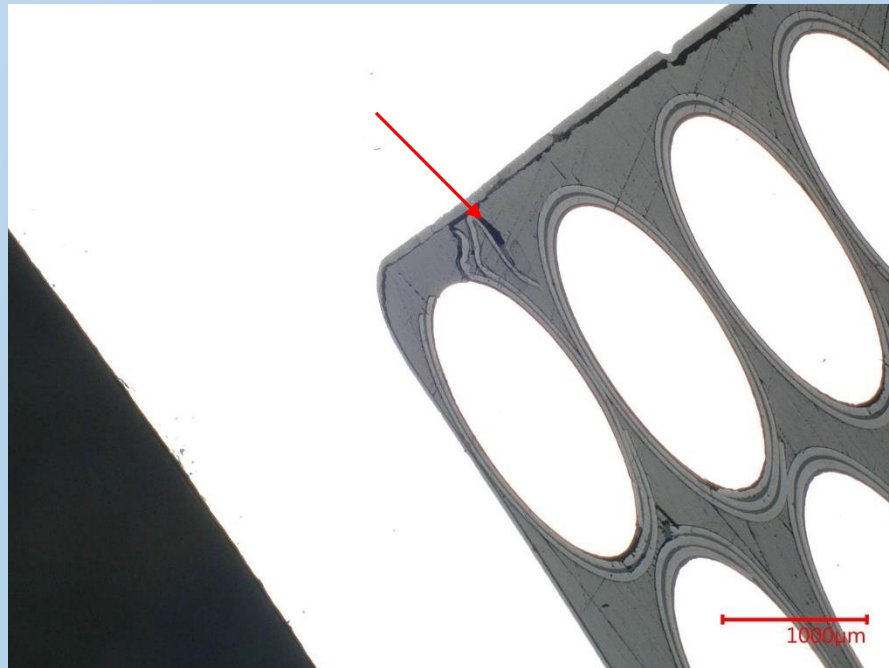
Shrinkage: up to approx. 0.5 mm

Lack: up to approx. 1.0 mm × 0.3 mm

Cracks: total length up to approx.  
0.5 mm

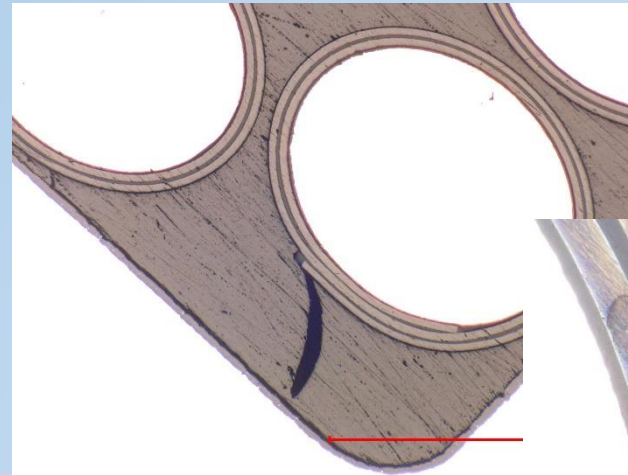
Only few examples of worst/largest resin imperfections are illustrated here. The latter are commonly observed at all prepared slices (see stitched pictures in annexes)

- Damaged wire insulation / lack induced by insulation glue

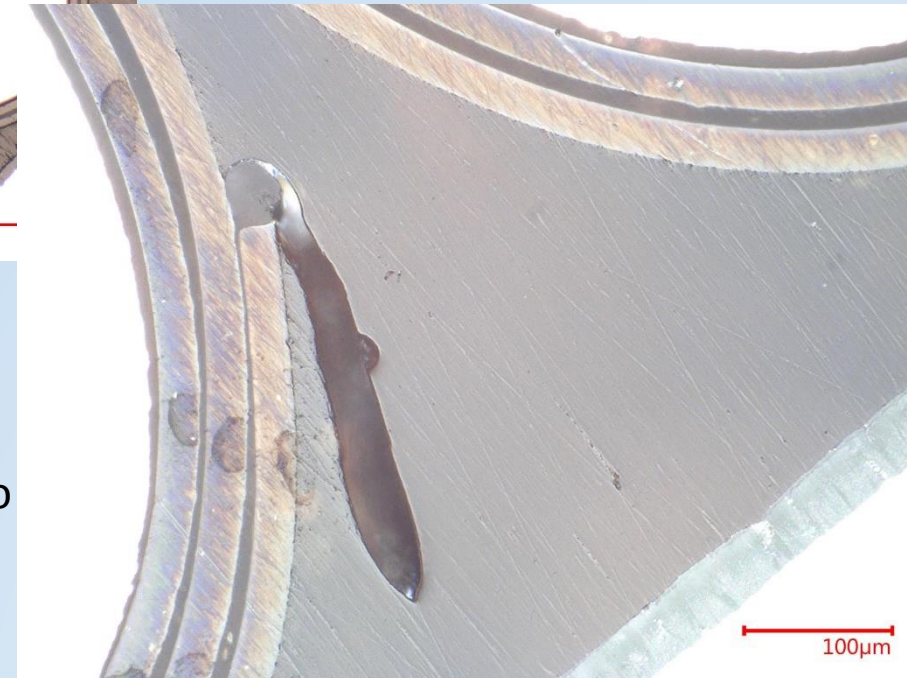


A 10mm sector 2

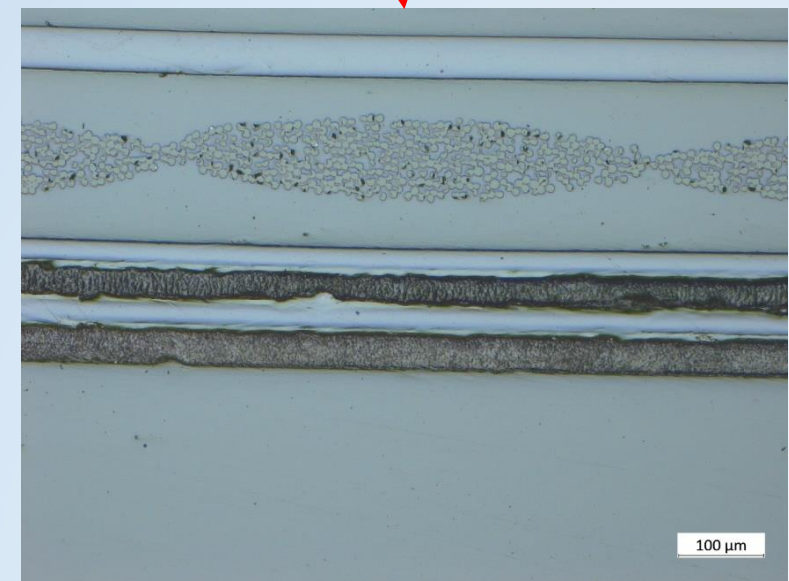
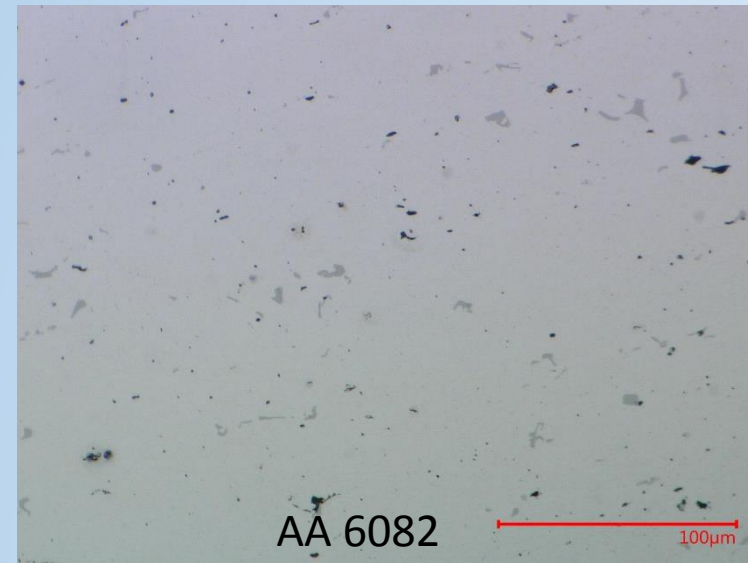
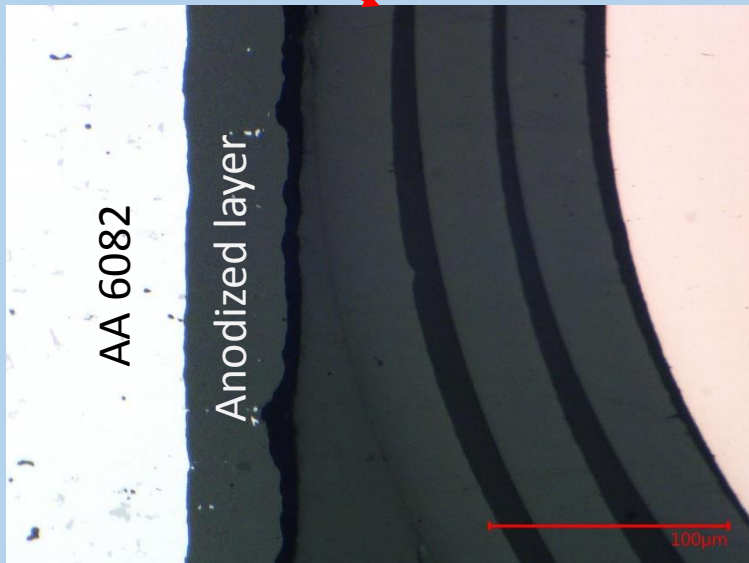
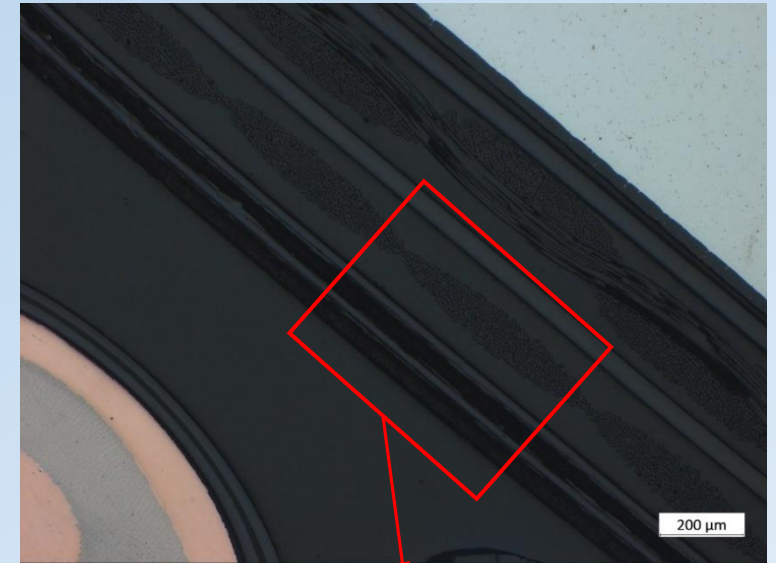
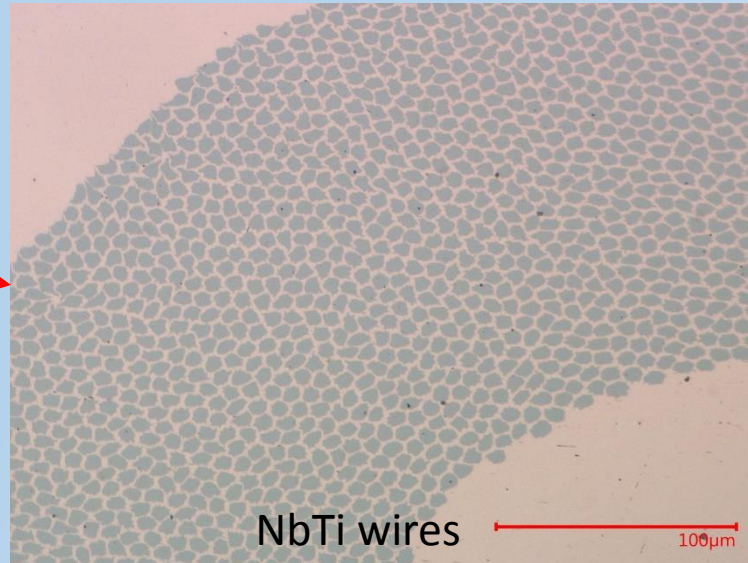
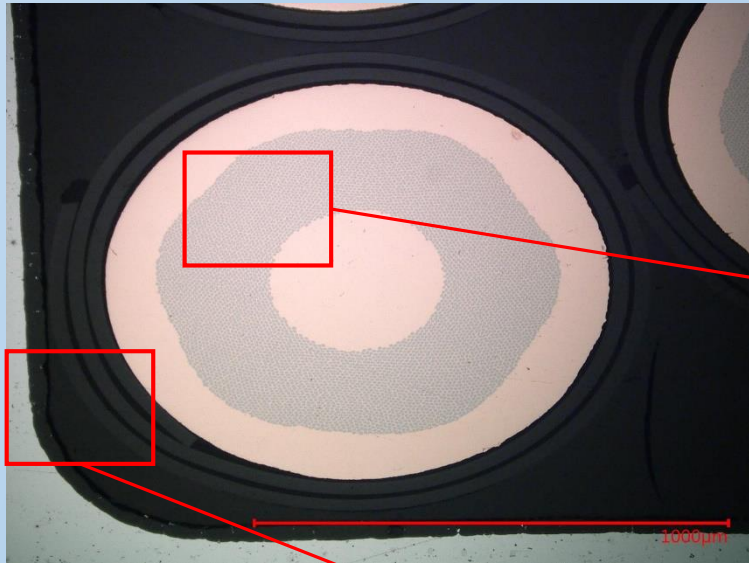
To the extent of present examinations, the only case that has been observed

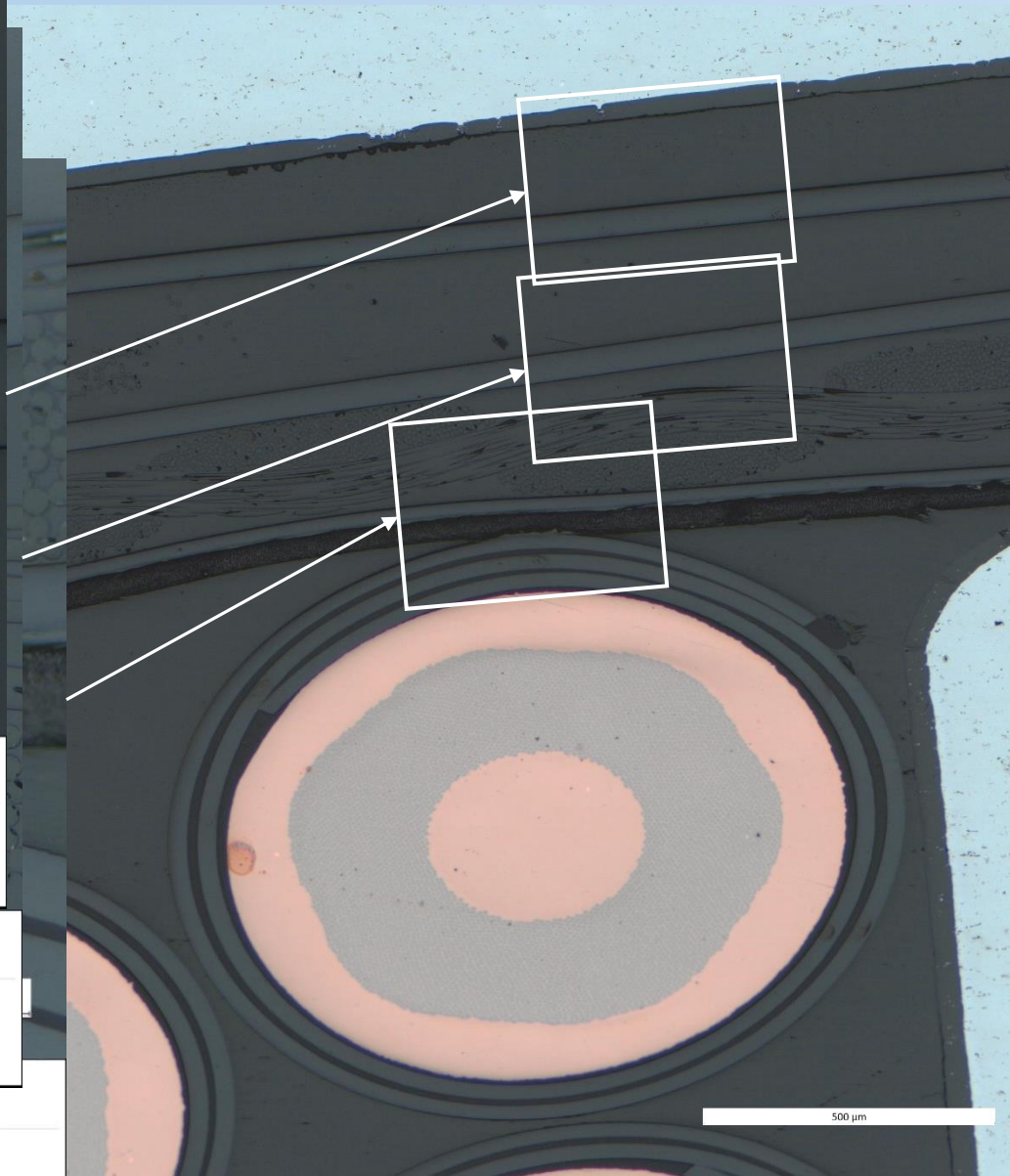
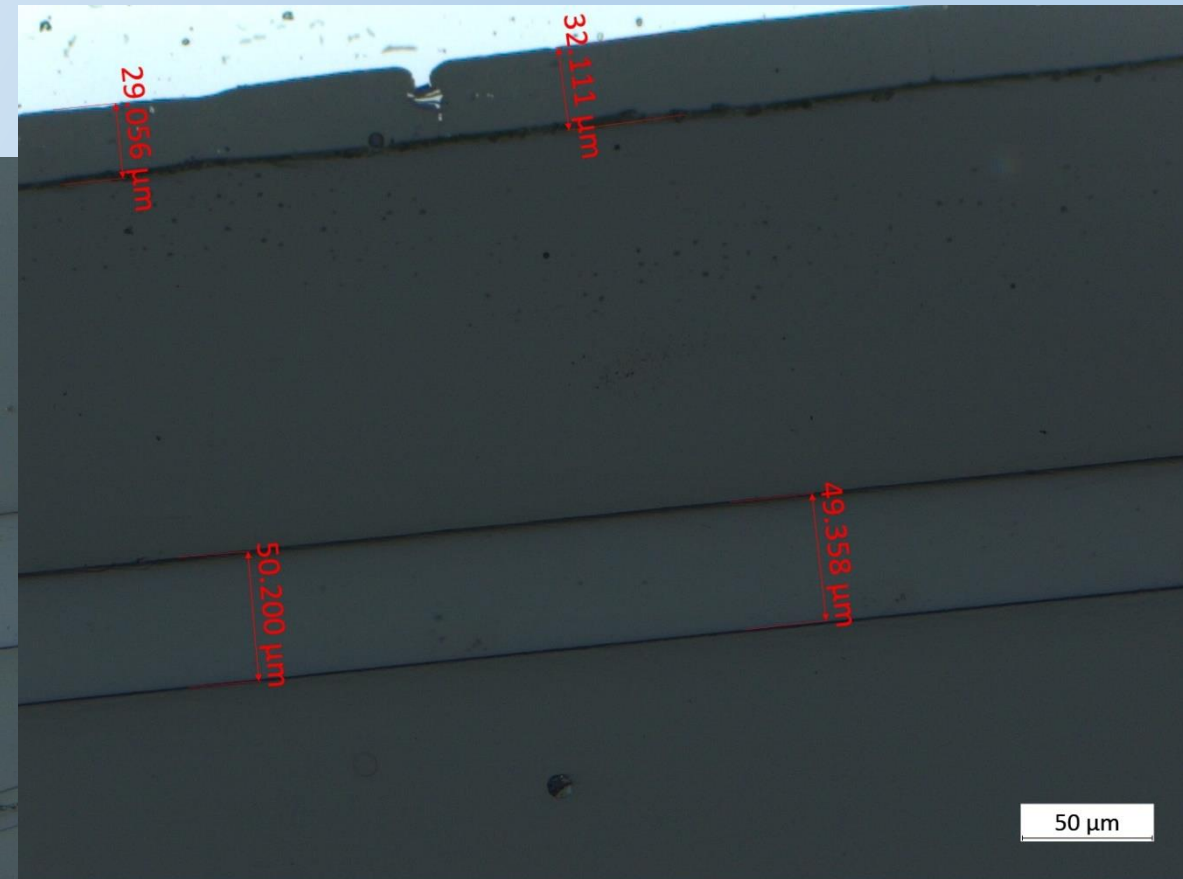


Systematic lack close to the wire insulation due to glue bleeding at insulation's end



# ■ Illustrations





Comment

20 μm

Modified date/time: 12/14/2020 11:16:32 AM	Company Name:
Microscope: Axio Imager.M2	Address:
Camera / Detector: AxioCam MR R3	File Name: Experiment-28
Objective: EC Epiplan-Neofluar 20x/0.5 HD DIC M27	Create date/time: 12/14/2020 11:16:31 AM

Comment

20 μm

Modified date/time: 12/14/2020 11:15:02 AM	Company Name:
Microscope: Axio Imager.M2	Address:
Camera / Detector: AxioCam MR R3	File Name: Experiment-27
Objective: EC Epiplan-Neofluar 20x/0.5 HD DIC M27	Create date/time: 12/14/2020 11:15:01 AM

Comment

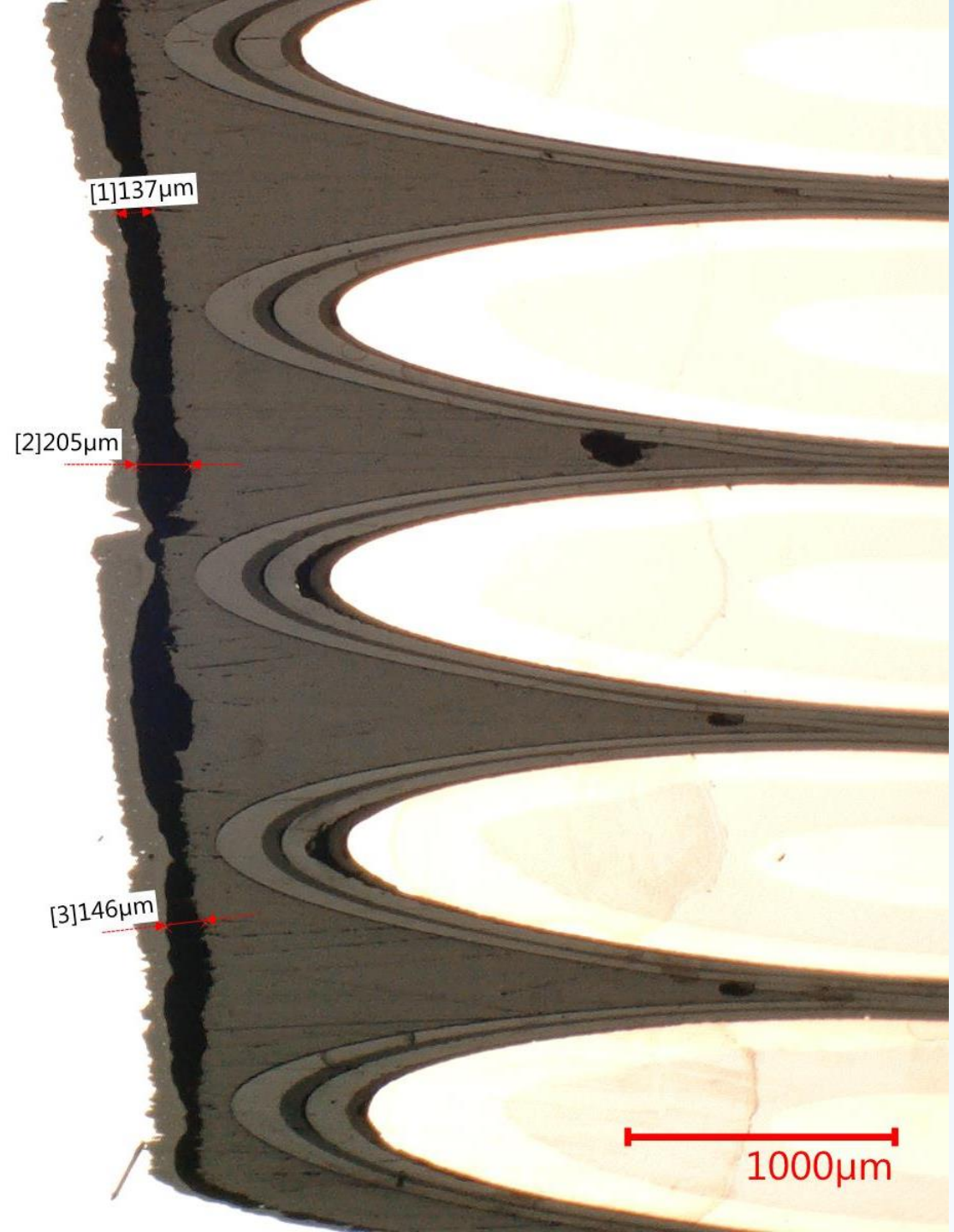
20 μm

Modified date/time: 12/14/2020 11:11:34 AM	Company Name:
Microscope: Axio Imager.M2	Address:
Camera / Detector: AxioCam MR R3	File Name: Experiment-26
Objective: EC Epiplan-Neofluar 20x/0.5 HD DIC M27	Create date/time: 12/14/2020 11:11:32 AM



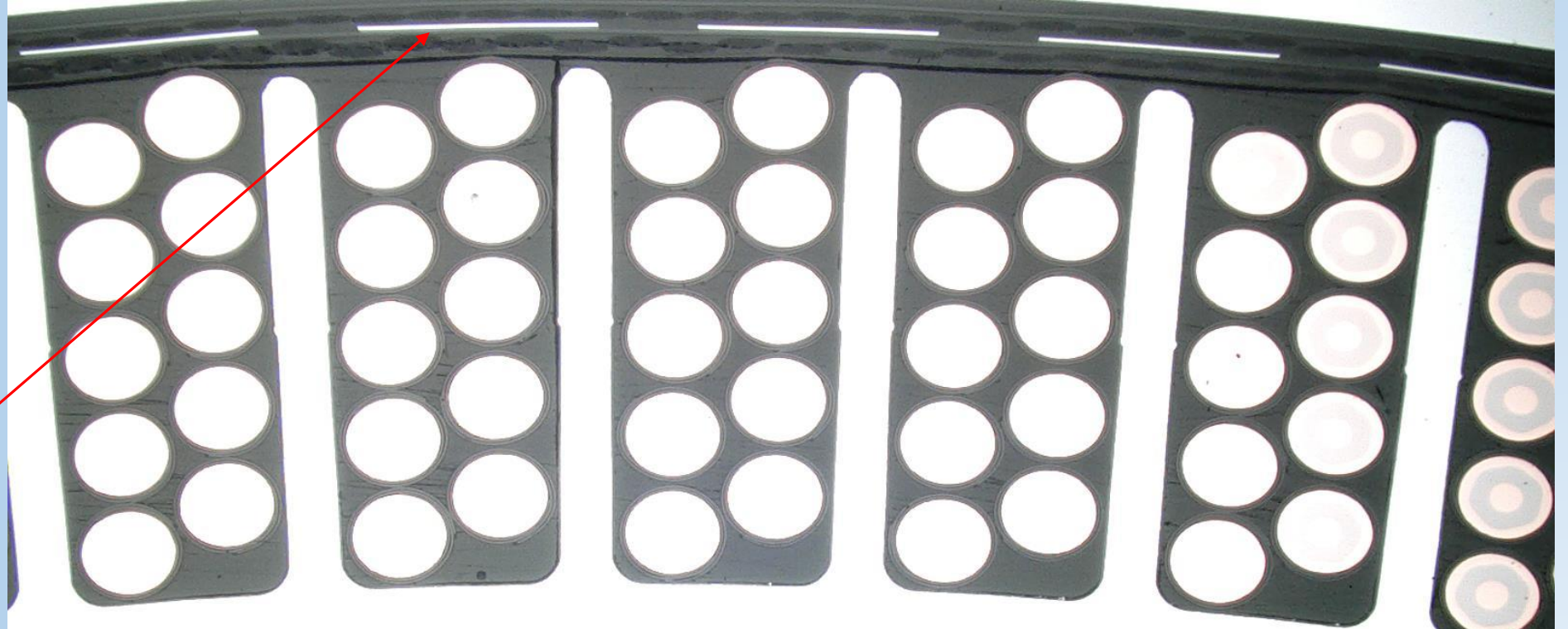
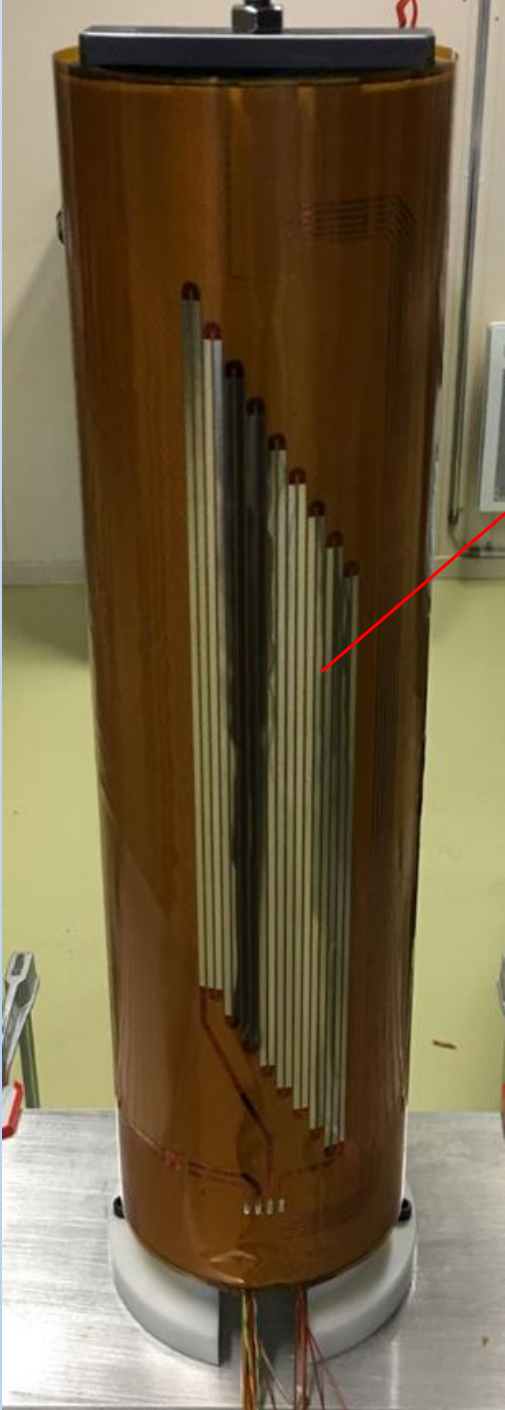
7-Dec-20

Mickaël MEYER - Mickaël CROUV

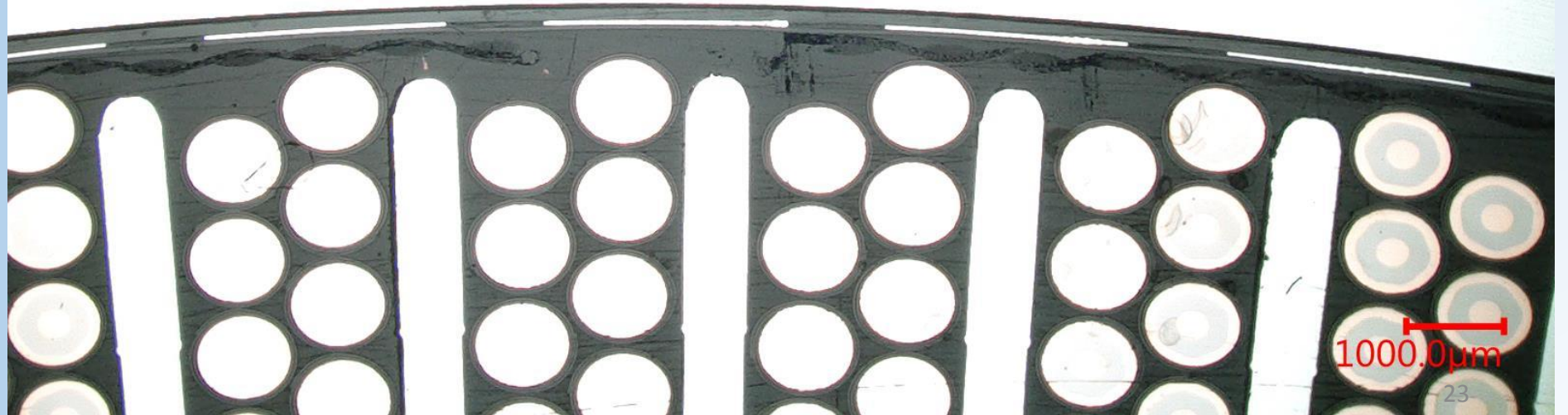


1000µm

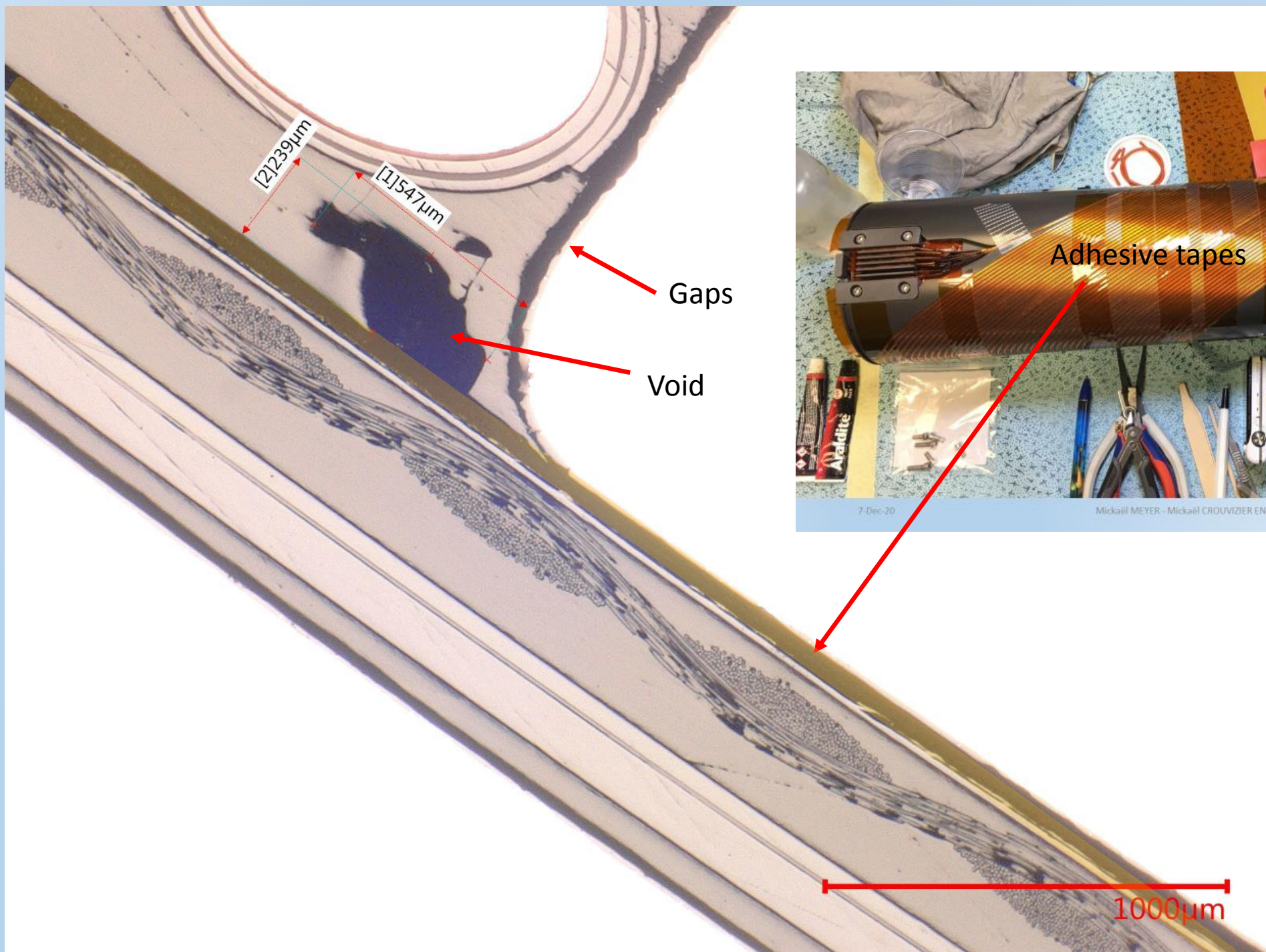




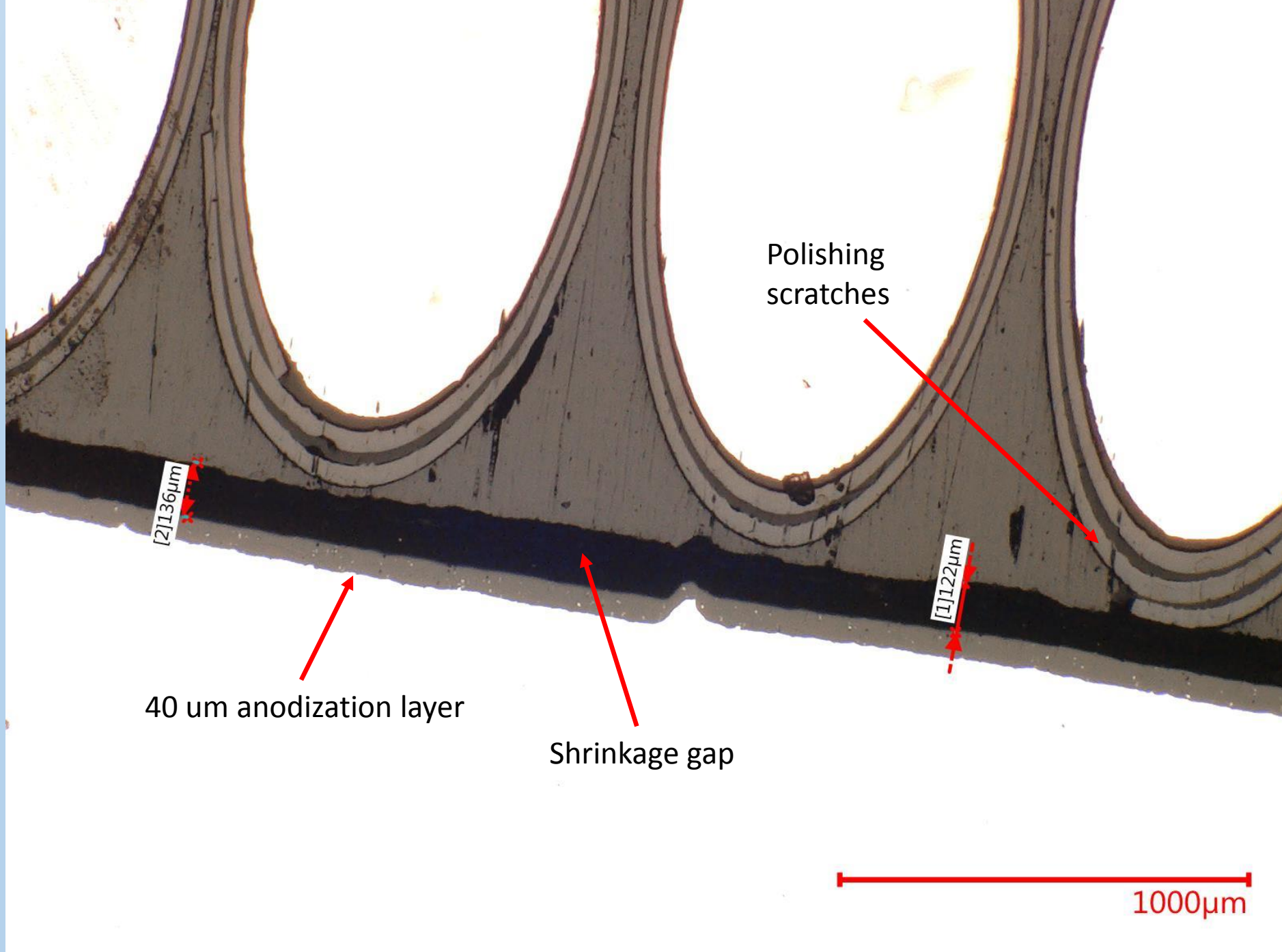
Beam simulation heaters, only in this model not in the full series magnets

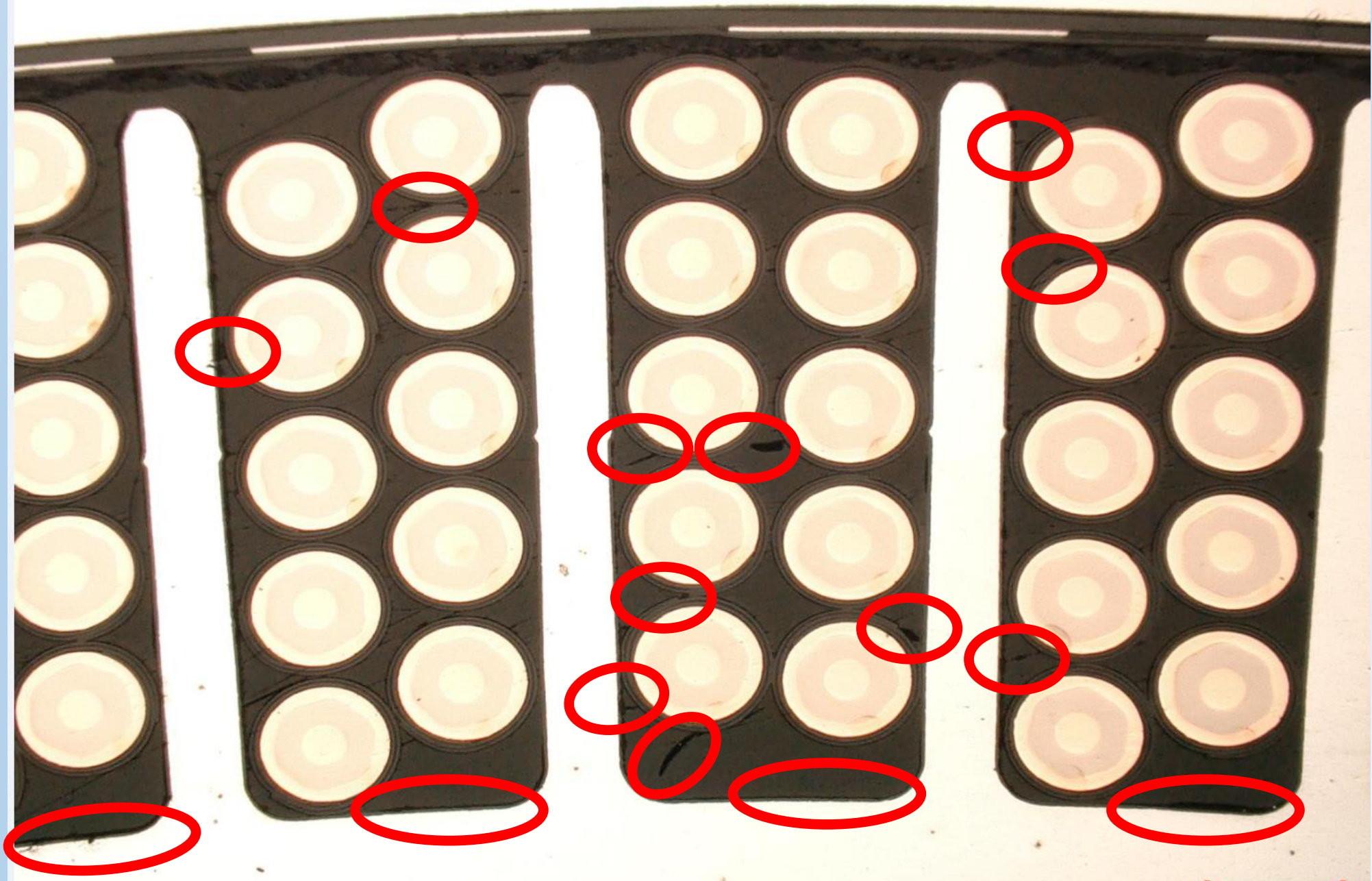


1000.0 μm



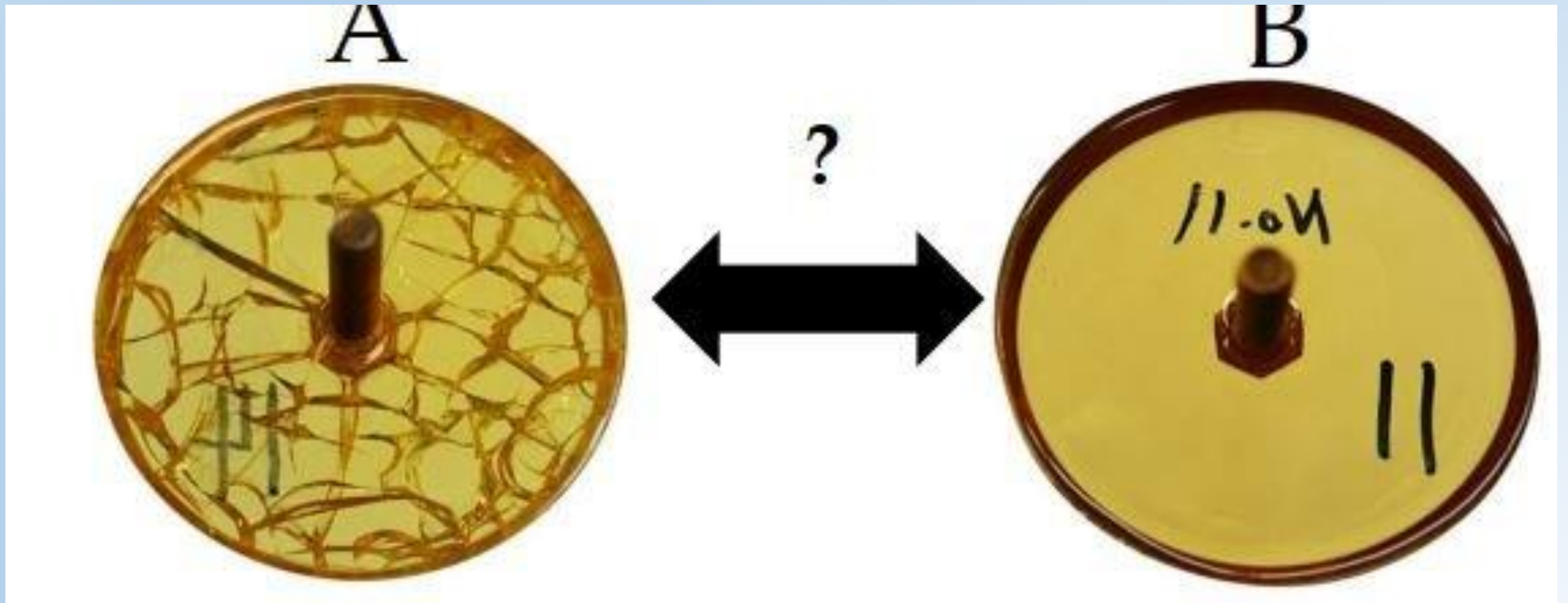


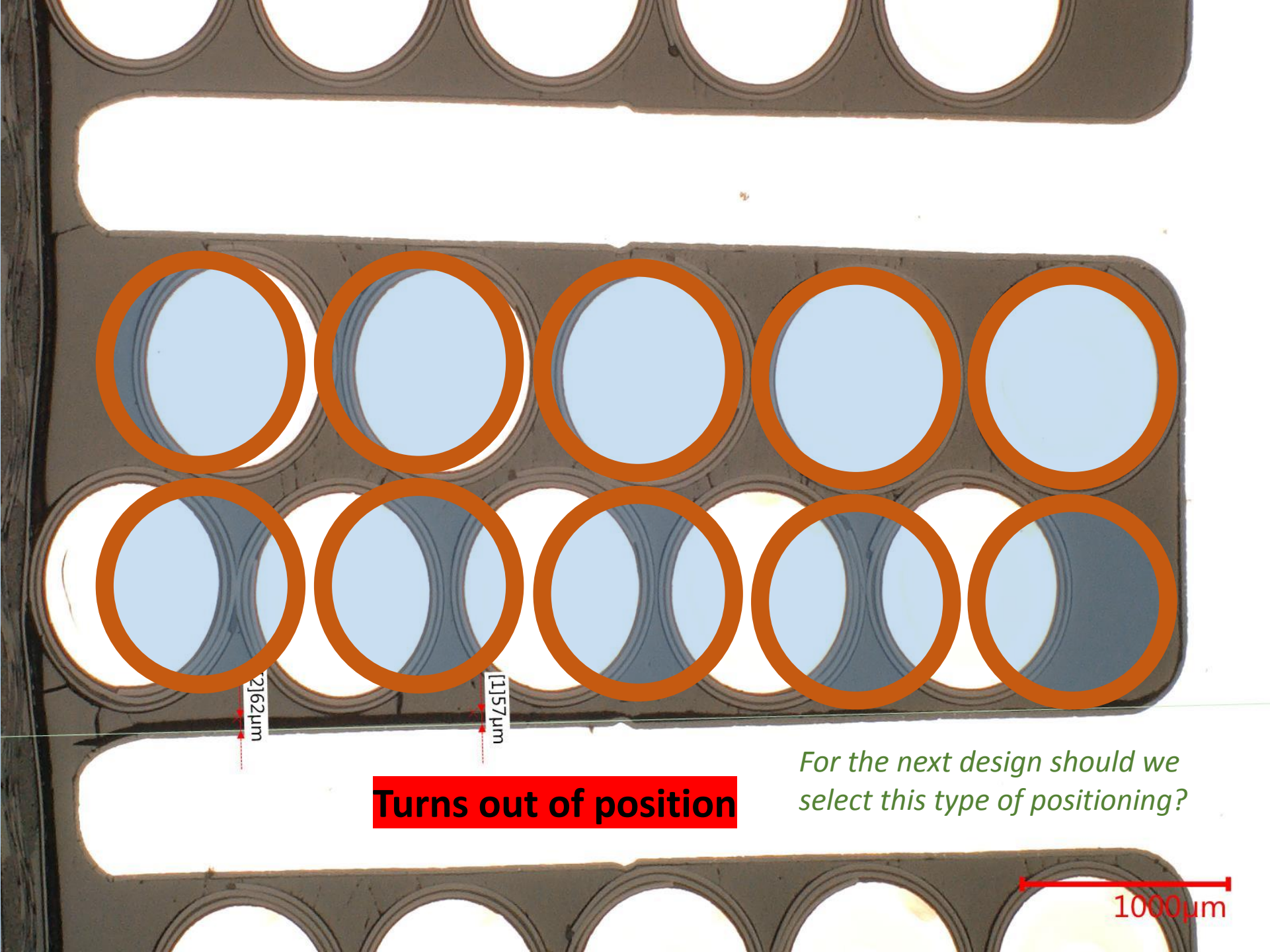




1000μm

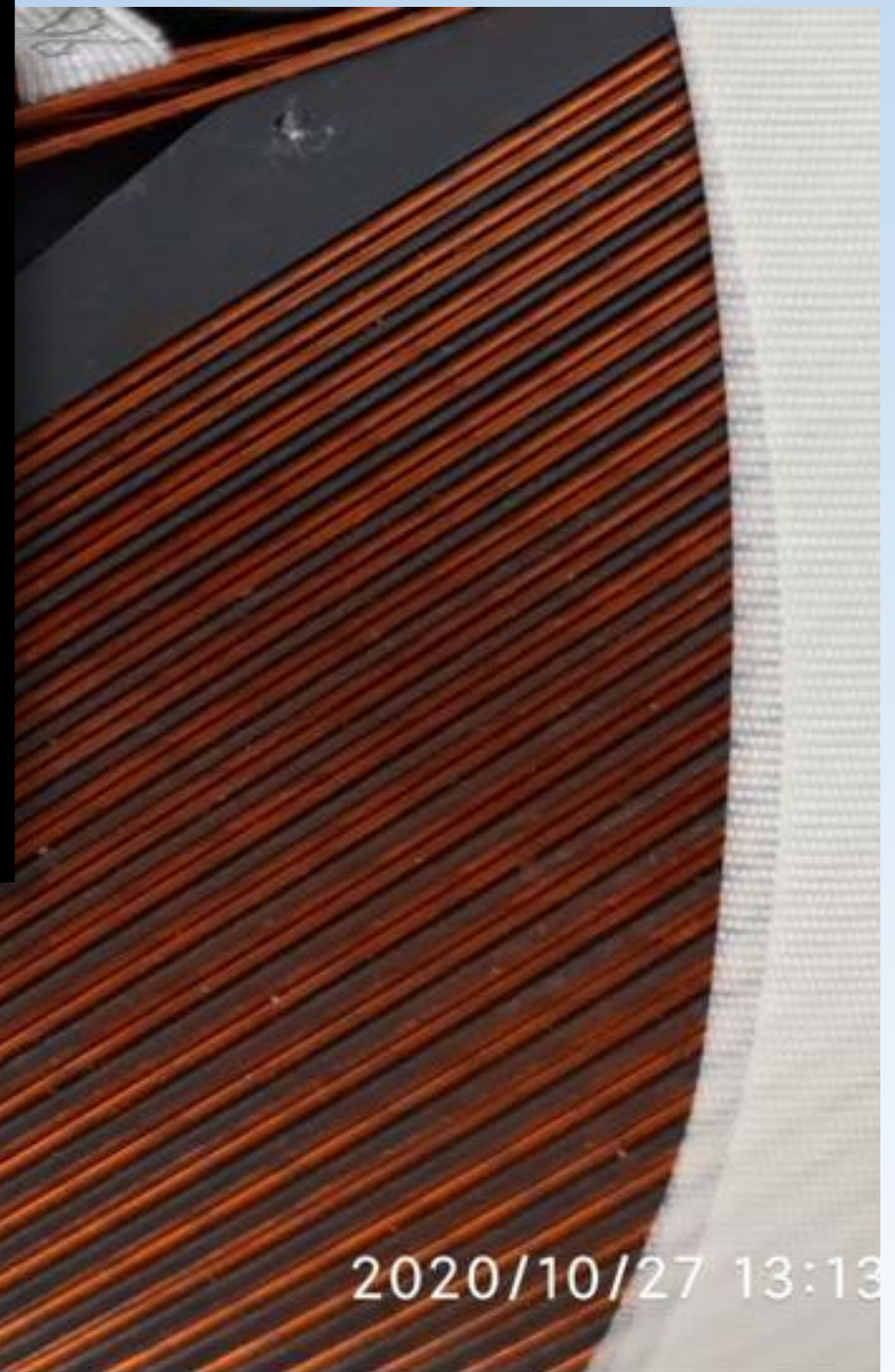
CTD v MY750 we should study the resins !



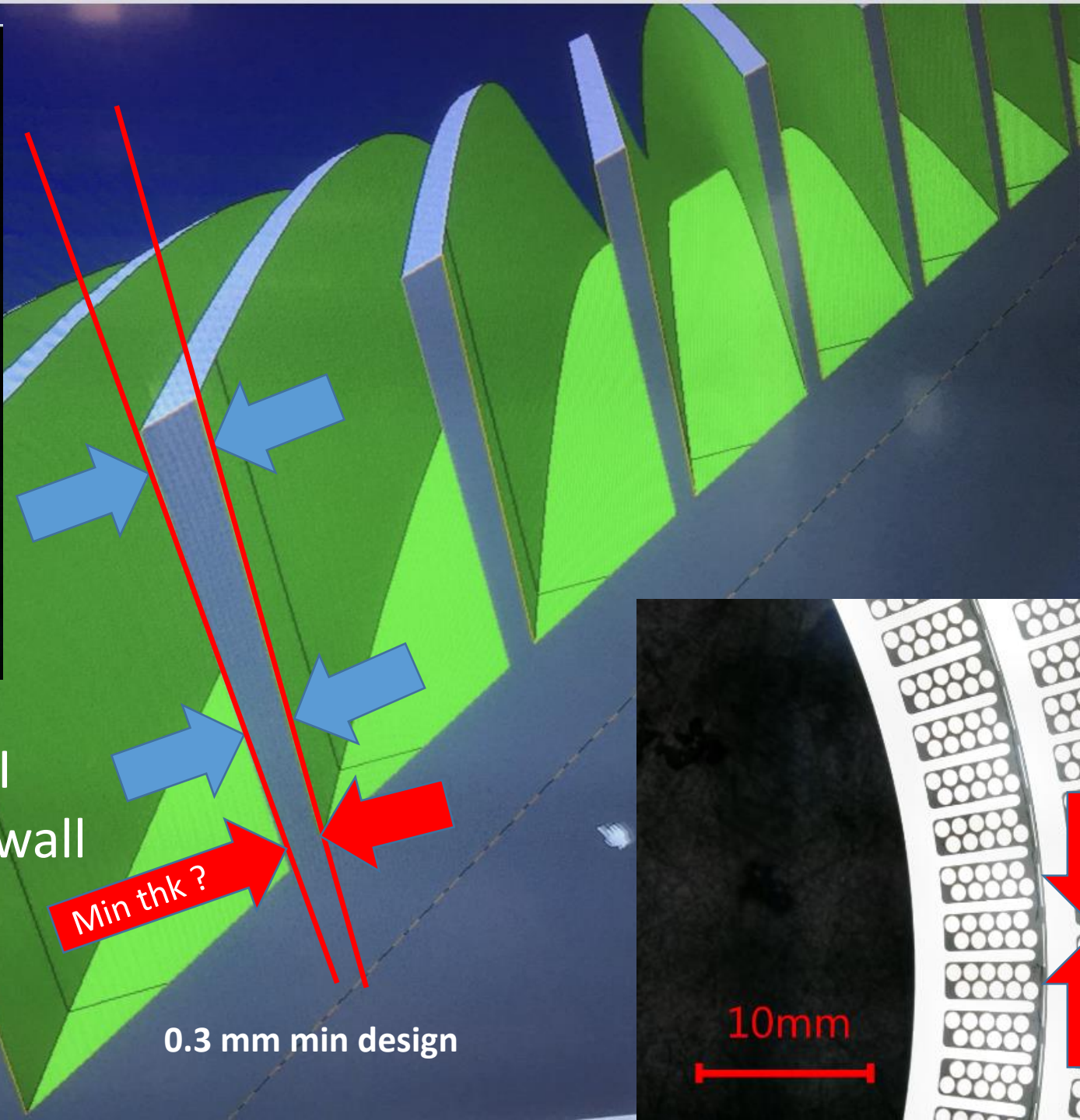
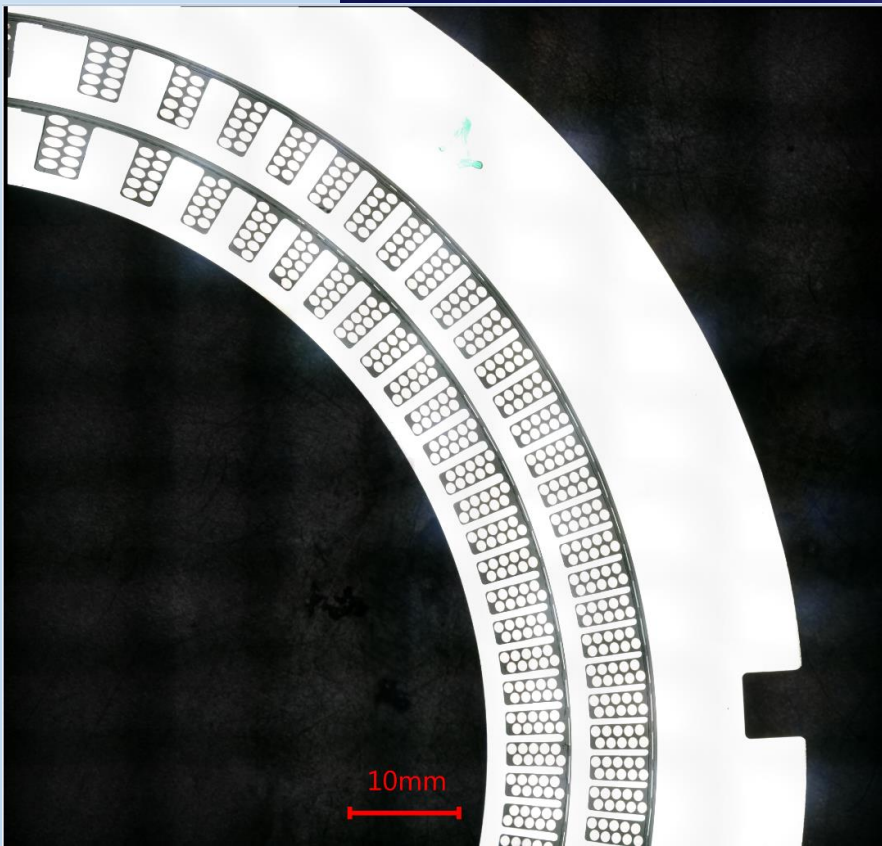


**Turns out of position**

*For the next design should we select this type of positioning?*



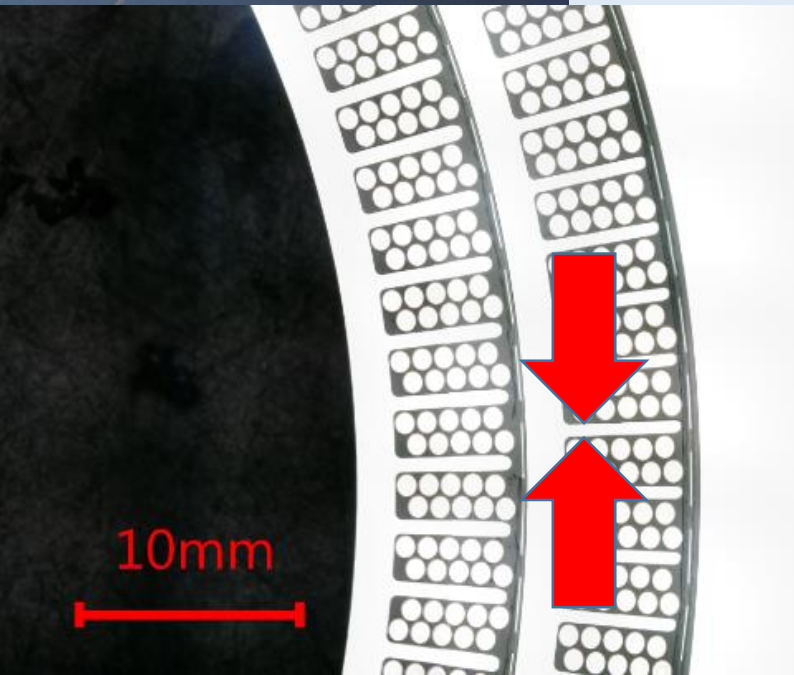
2020/10/27 13:13

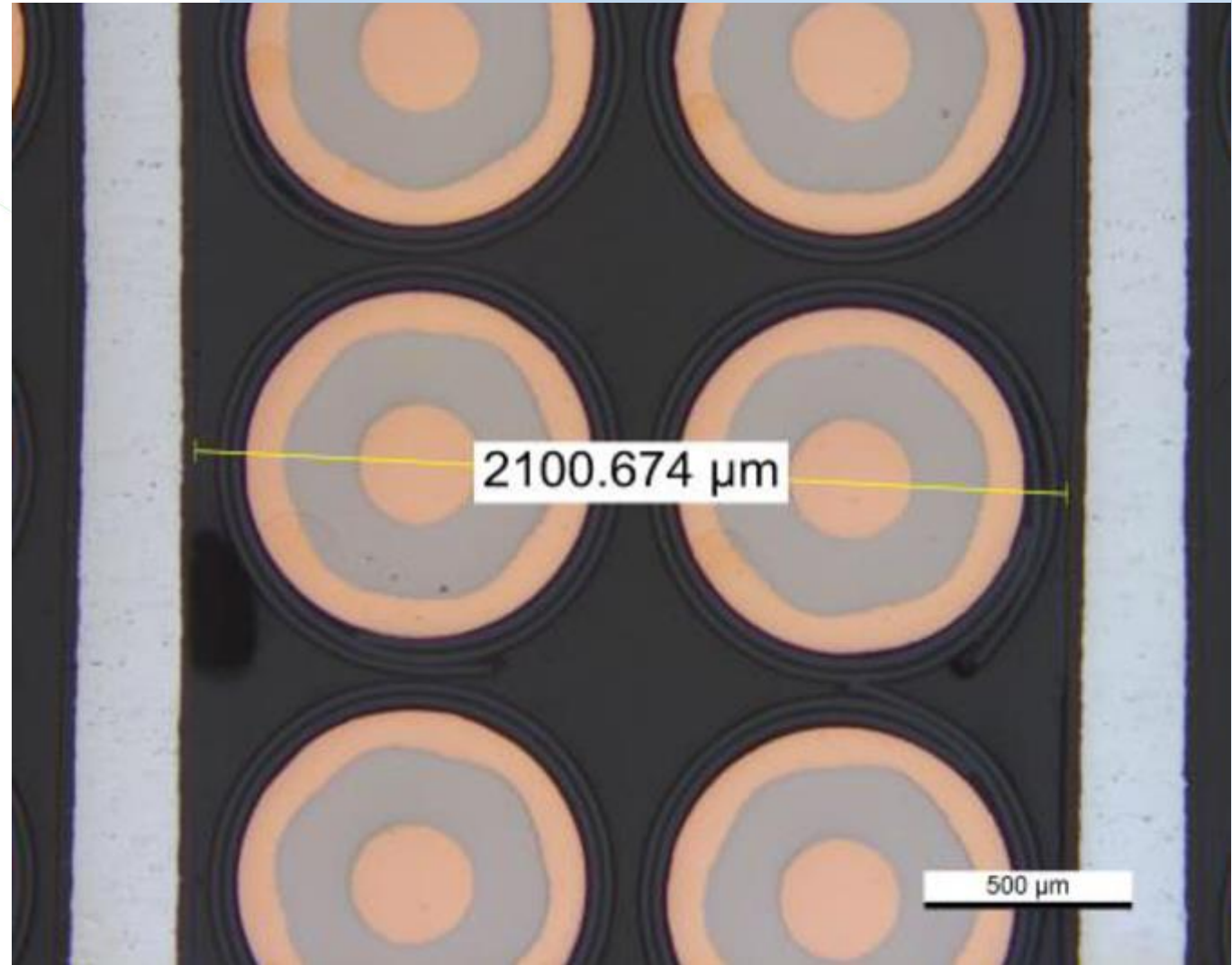
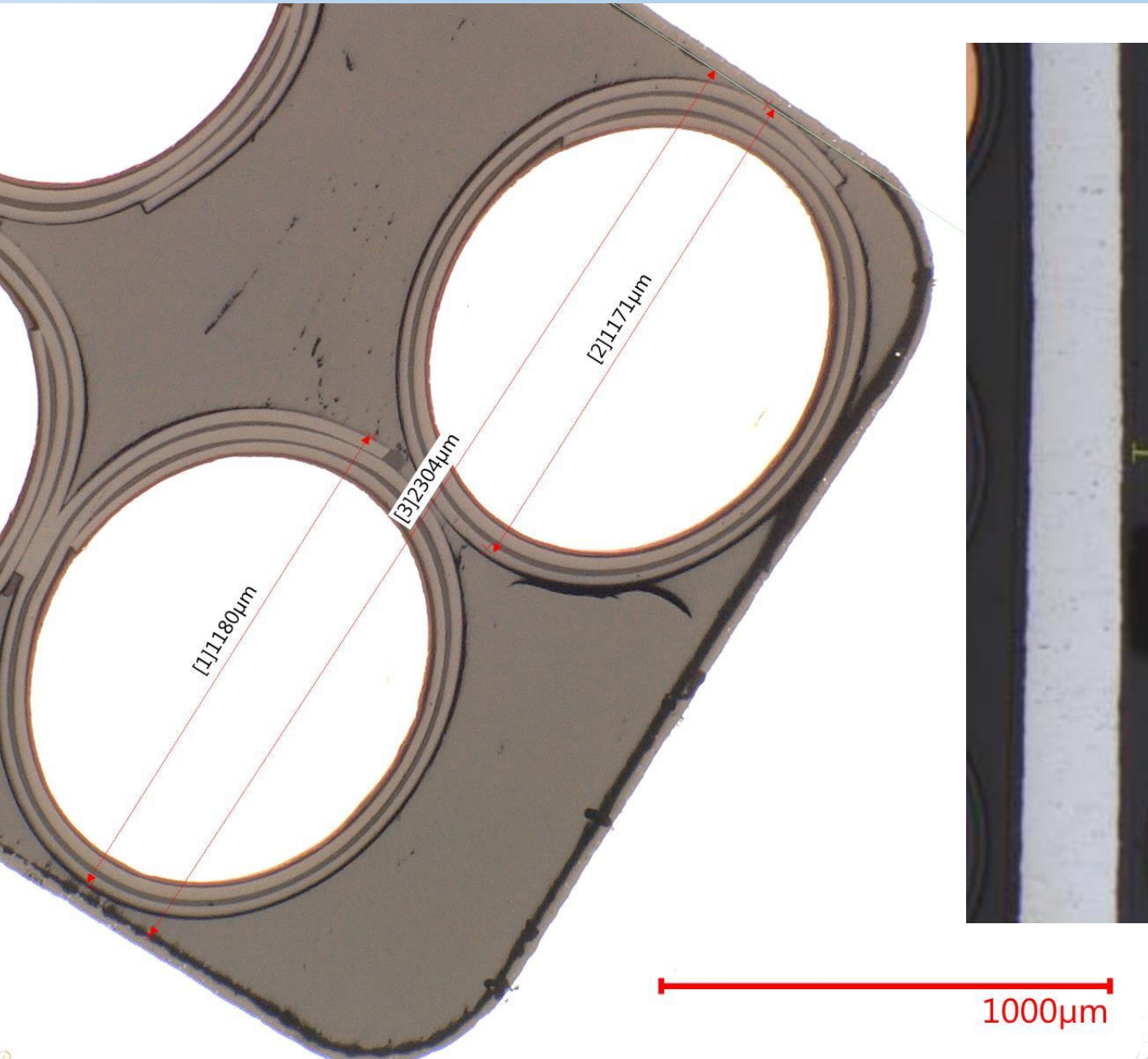


We are at what I consider is min wall thickness

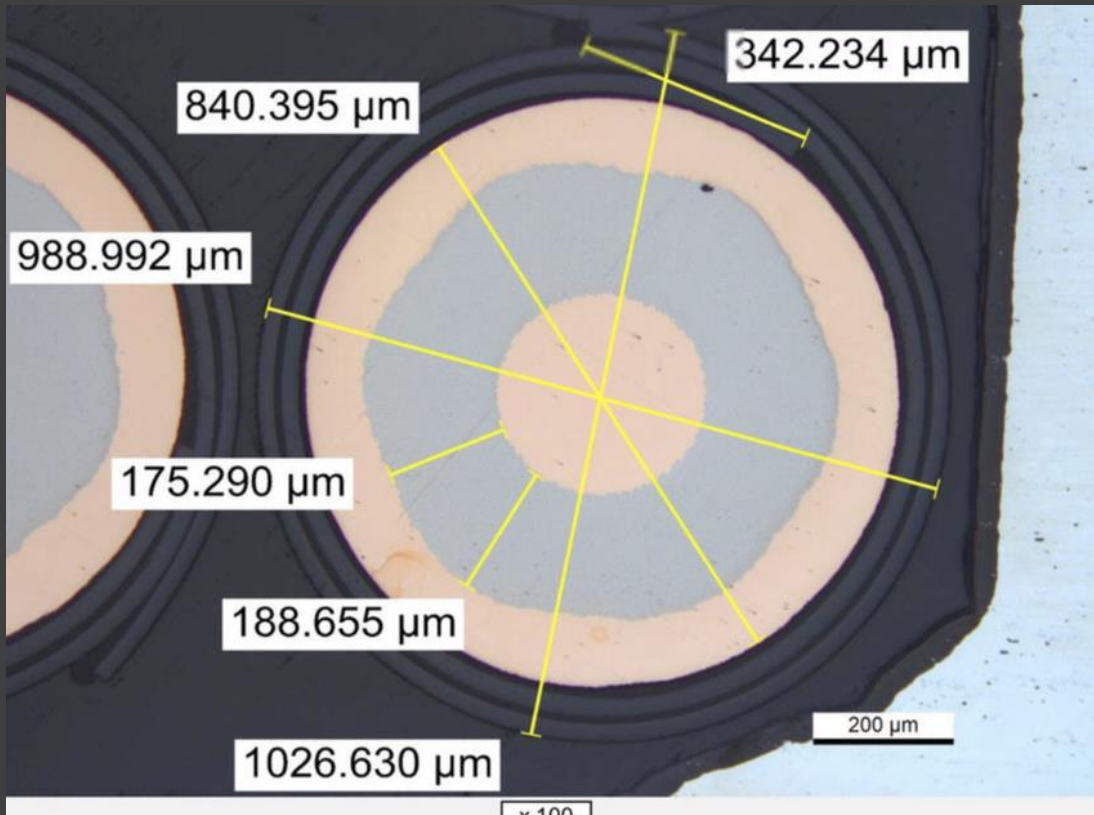
Min thk ?

0.3 mm min design

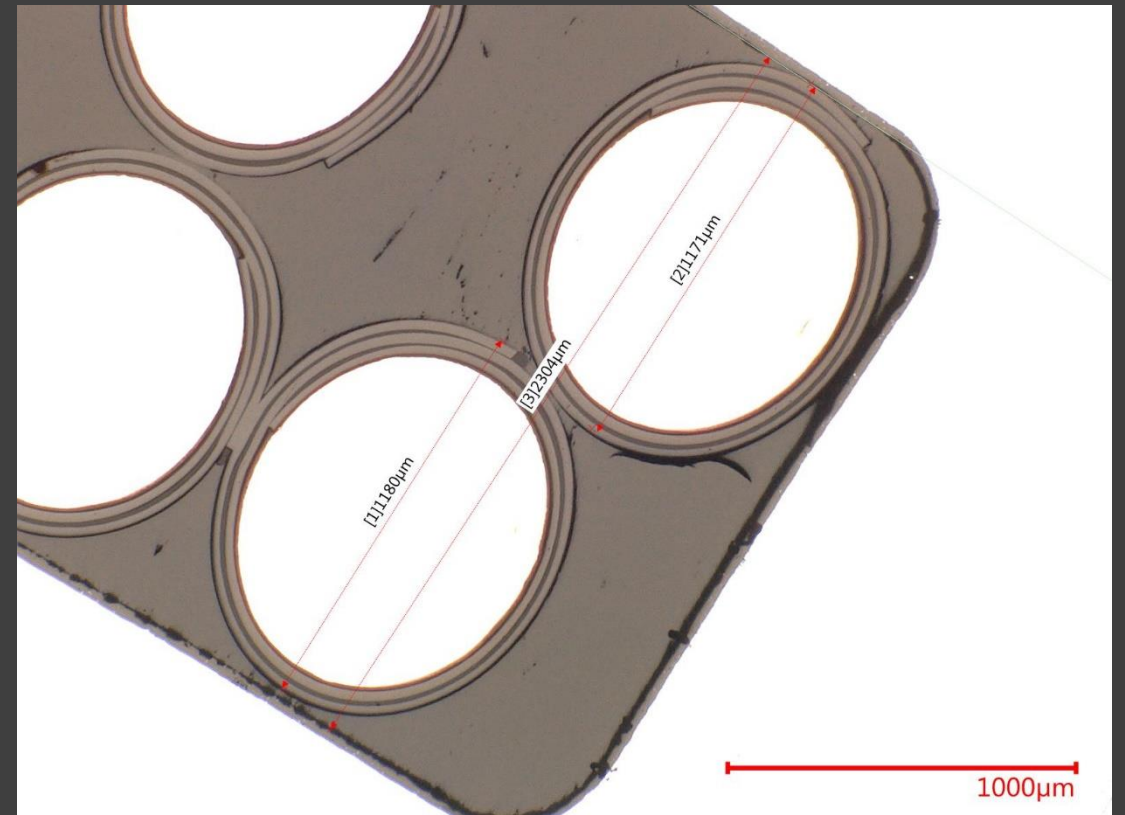




**Original design tests,**



This cut is at 90 deg



The cut is not at 90 deg so gives false value'

CERN wire the first batch insulated in Germany



# Conclusion

We see:

- Mis-placed wires!
- Shrinkage of the resin coursing: Gaps ! Cracks in bulk resin !
- Cuts in the wire insulation.

Notes this magnet has:

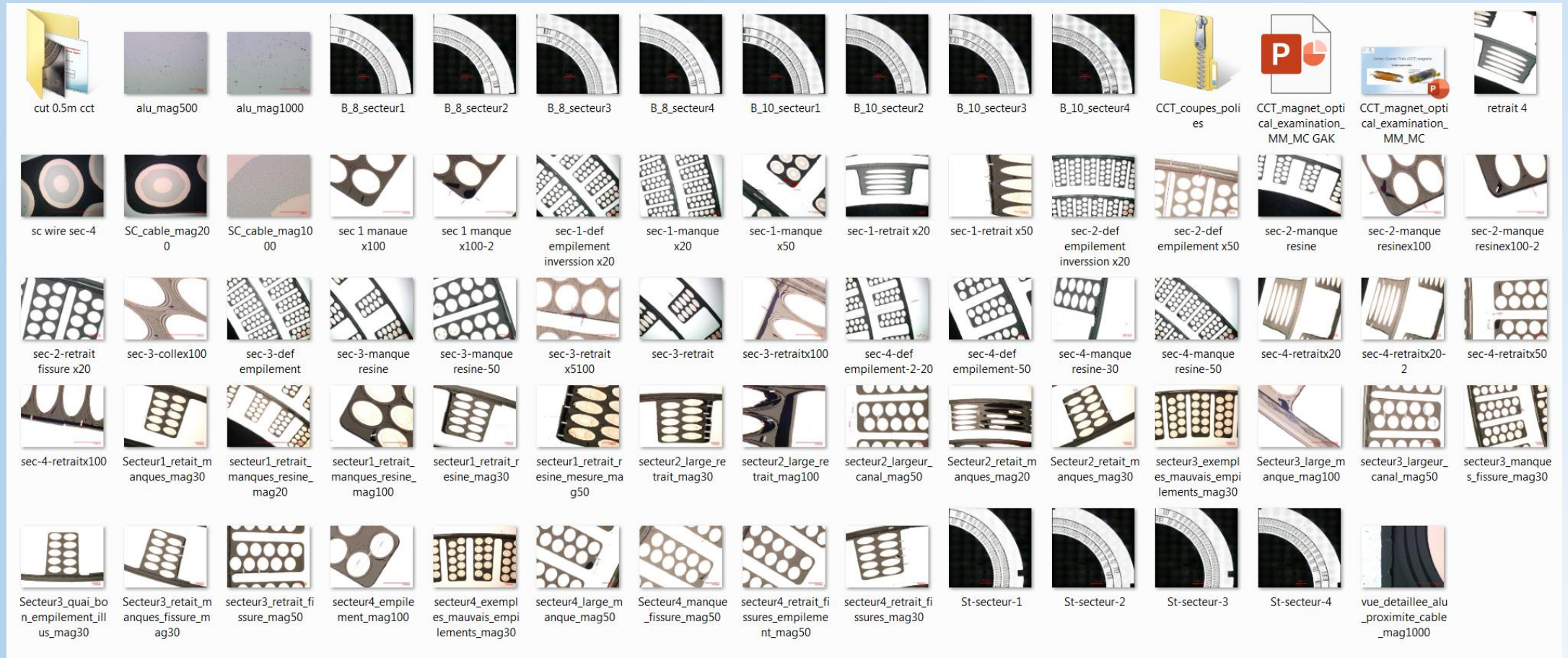
Good field quality (2 or 3 units error)!

high electrical insulation with the three insulation layers (wire kapton tape, resin , anodization,... )  
trained to 590 A = 80% of short sample in 10 quenches. Nominal 394 A

this was the 5 cut through the model, in the new year we will separate the layers to see how the resin has filled over the coil surfaces.

# THE END

## EDMS 2453524

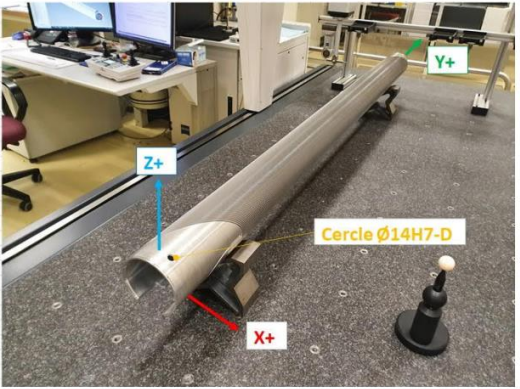


EDMS 2452806  
Job J3067603  
Client GLYN KIRBY  
Contrôleur PUGNAT Dominique  
Machine ZEISS Prismo Ultra 12-24-10  
Précision des mesures 1,2 µm + L/500mm  
Température 20°C ±1°C

Date de la mesure 10/12/2020 16:04  
N° de plan LHCMC BRDC0030  
Désignation OUTERFORMER  
Fournisseur  
N° de pièce 1  
Valeurs rouges 6

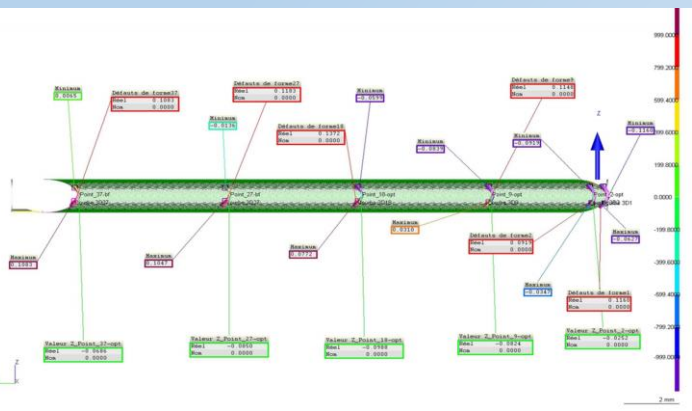
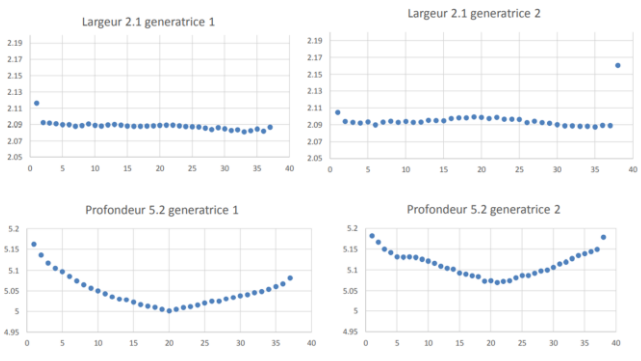
Commentaire

Nom du programme OUTER FORMER\_LHCMC BRDC0030



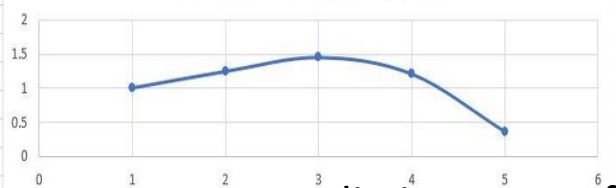
L'axe principale Y+ est l'axe du cylindre A  
L'axe secondaire Z+ est la droite passant par le centre du cercle Ø14H7-D et l'axe Y orientée de 25° suivant Z  
L'origine est suivant :  
- X et Z l'axe A  
- Y le cercle Ø14H7-D

Annexe

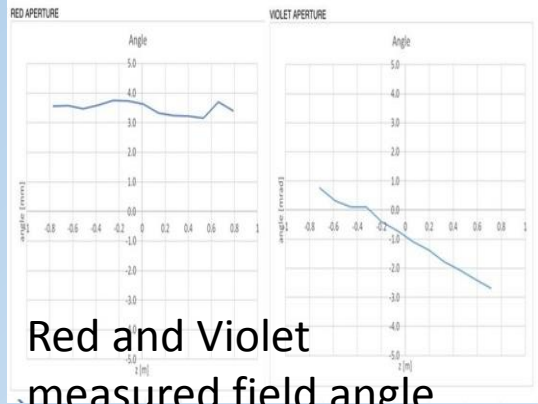


lateral shift [mm] S	0.0686	0.085	0.0988	0.0824	0.0252
r [mm]	68.15	68.15	68.15	68.15	68.15
Angle in [mRad]	1.006603	1.247249	1.449743	1.209098	0.369773

CERN Green aperture outer former dipole Angle from CMM measurement [mRad]

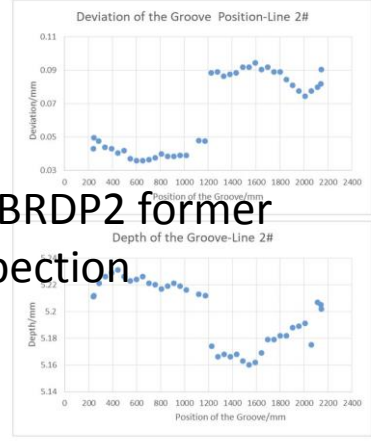


Green aperture prediction, outer former only. Inner yet to be measured

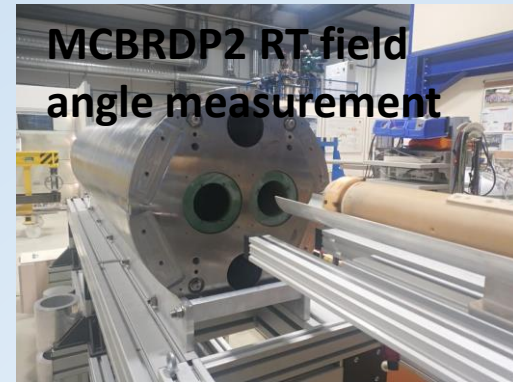


Red and Violet measured field angle

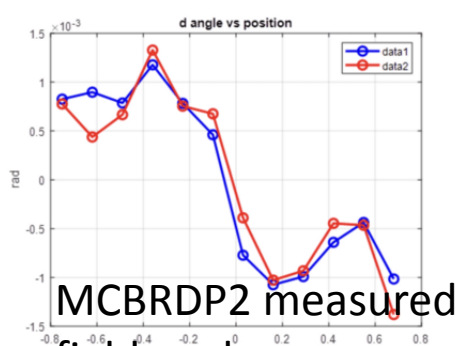
3. Inspection Results



MCBRDP2 former inspection

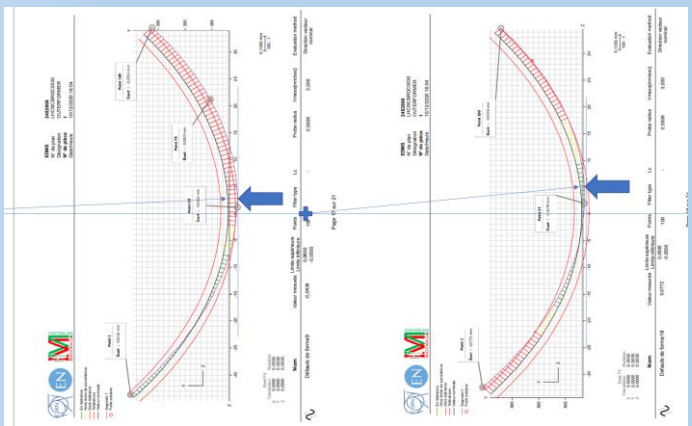


MCBRDP2 RT field angle measurement



MCBRDP2 measured field angle

It good +/- 1mrad



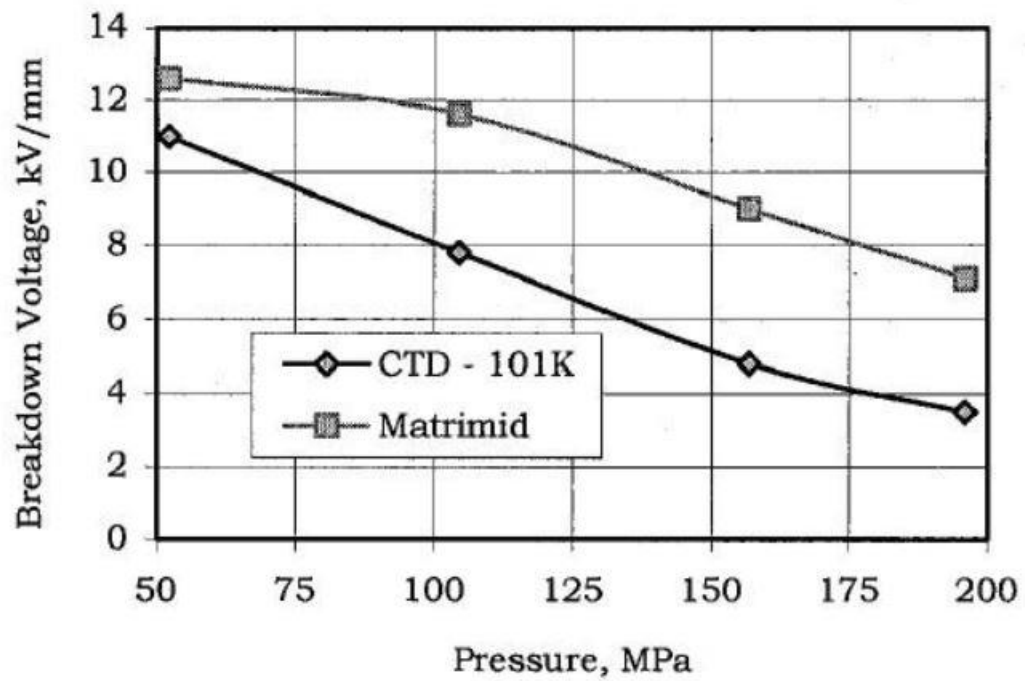


Fig. 8. Dielectric strength of the insulation as a function of pressure.